Assessing Digital Transformation Readiness Using Digital Maturity Indices*

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***Abstract**: Digital transformation and continuous scientific and technological progress allows for increased efficiency in agriculture, animal husbandry, as well as faster and safer food distribution. Monitoring digital maturity is important. It allows us to understand the current state and outcomes of digital transformation. It also facilitates the creation of future steps towards digital progress. This paper explores the notion of digital maturity of countries and the indices used for it with a focus on agriculture. The paper seeks to identify indices by which countries can view their digital maturity, with the aim of further creating adequate policies. Given the importance of the transformation process, the structure of the index was considered in order to determine connections with the main determinants of digital transformation, especially concerning agriculture.*

Keywords. Digital transformation, digital maturity, digital maturity index, agriculture

1 Introduction

Growing competition, which is the result of meeting the growing and more complex market needs, requires new ways of working and creating new value for end users. At the same time, entities consider technological solutions that facilitate communication and that enable the inevitable connection of supply and demand in the market. The sequence of market events and the transition to the fourth industrial revolution (Industry 4.0) has resulted in the emergence of a new paradigm called digital transformation (DT).

It is slowly affecting all industrial areas. Progress in DT is also being made in the agricultural sector through the application of technologies such as the Internet of Things (IoT), Big Data, Cloud Computing and Artificial Intelligence (López-Morales, Martínez & Skarmeta, 2020). The mentioned technological changes require a certain commitment from countries in creating a basis for digital investments and for improving the business climate.

The process of digital transformation is permeated by multidisciplinary activities and requirements (Colli et al., 2018) that include the application of digital technologies to business processes, organizational assets and end products (Jovanović, Dlačić & Okanović, 2018). DT represents significant changes in the current way of doing business such that it changes the form of current business models. In line with the above, the importance of a strategic approach to digital transformation that requires the involvement of various stakeholders inside and outside the organization (de Carolis et al., 2017), which will timely and successfully face current market changes, has been emphasized. Consequently, countries are expected to digitize public administration through web services and other digital services for citizens and entrepreneurs (Tomičić Furjan, Žajdela Hrustek & Pihir, 2018). This in turn creates a stimulating climate for the development of the digital skills necessary to overcome the challenges and barriers in digital transformation (Kutnjak & Pihir, 2019) and establishes a dynamic ecosystem that stimulates quickly adaptable, agile and innovative organizations. The level of digital maturity of a country can be examined by an index. It indicates the readiness of a country to support the digital transformation of companies that operate in it. Namely, if public policies/services are at a high level of maturity, then the transformation is being facilitated and it is more likely that organizations, and consequently the countries in which they operate, will digitally transform more easily.

The complexity of integrating new business models into the established business processes of an individual organization depends on the industry the organization operates in, as well as on the readiness to apply the transformation process in the same industries (Kutnjak, Pihir & Tomičić Furjan). In order for the DT strategy to be adequately and optimally defined, it is possible to see at what stage individual organizations and countries are in terms of their level of maturity.

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Maturity models provide an overview of the situation within an individual entity, and point out areas where additional efforts need to be directed in order for the result of the transformation to be as effective as possible (Schwere et al., 2018).

The aim of this paper is to identify the importance of digital maturity of countries; therefore, the following research questions are asked: RQ1 = What digital maturity indices globally are considered relevant at the country/national level and to their national economies? RQ2 = Can a country's digital maturity index adequately indicate readiness for the digital transformation of organizations in that country? RQ3 = Are there digital maturity indices that indicate the maturity or readiness of a country for the digital transformation of agriculture?

This paper is structured as follows. The introductory part is followed by a presentation of the methodology. The concept of digital maturity is generally presented in the third section. In the fourth chapter, digital maturity in agriculture is highlighted. Chapter five provides an overview of the digital maturity of countries and of the digital maturity index. The connection of the index with the determinants of digital transformation is shown in section six and the findings related to the researched topic are given at the end of the paper in the conclusion.

2 Research Methodology

The process of obtaining answers to the research questions began with a literature review of published scientific papers. Papers were searched for in the relevant databases including Web of Science (WoS), Scopus and Google Scholar for better coverage. The search was made based on two sets of queries: 1) related to research question RQ1 and partly RQ2 with the aim of learning about digital maturity and competitiveness ("digital maturity" OR "digital competitiveness"); 2) related to research question RQ2 and RQ3 aiming to find research about digital maturity, agriculture, Industry 4.0 and digital transformation ("digital maturity" AND "agriculture" AND "industry 4.0"), and ("digital transformation" OR "digital maturity" AND "agriculture"). The research structure and the numbers of selected papers from individual sources, are given in Table 1.

Table 1. Research structure

Source	Search method	Selected papers
WoS	"digital maturity" OR "digital competitiveness"	5
Scopus		6
Scholar		8
WoS	"digital transformation" OR "digital maturity" AND agriculture	6
Scholar	"digital maturity" AND agriculture AND "Industry 4.0"	7
Total		32

In accordance with the above, the literature review is based on the analysis of the selected 32 papers that are relevant to the topic of digital maturity in general, digital maturity of organizations, digital maturity of countries, and the digital maturity of agriculture. In addition to the research shown above, an analysis and review of available indices that examine digital maturity in general and the digital maturity of the agricultural sector were performed.

3 Digital Maturity – Literature Review

The era of digital transformation requires measuring the success of digital performance by organizations and countries in order to see their maturity in dealing with this paradigm. In defining maturity, the literature (Remane et al., 2017) cites two significant concepts: digital impact, which denotes the impact of DT on an organization or country; and digital readiness, which indicates the readiness of an organization or country to overcome upcoming changes. The effects of investing in digital transformation are considered under different methodologies that assess the digital maturity of entities (Pihir, Tomičić-Pupek & Tomičić Furjan, 2018). In general, maturity represents to which degree of completion the desired transformation has been achieved, i.e. the way to achieve certain progress that is of interest and in accordance with the previously set goal (Remane et al., 2017). Digital maturity in turn represents the ability of an entity to respond properly and adapt to a changing digital ecosystem. Entities mature with varying intensity by implementing different transition activities from one stage of maturity to another, up to the moment of full utilization of the digital environment (Mettler & Pinto, 2018). Inevitable technological changes and an increasing amount of knowledge are considered to be the drivers of economic growth. Given that the changes brought about by DT reflect on society as a whole, the task of the manager is to network the organization and society in order to respond to customers' needs (Colli et al., 2018). The diversity of organizations, in terms of their way of doing business, requirements and goals, influences how a transformation plan is defined. It is adapted to the context in which the organization operates (Schwere et al., 2018) and is characterized by uniqueness with respect to the area of implementation (Valdez-de-Leon, 2016). In line with this, we can talk about differential ways of perceiving digital maturity within different organizations and defining their maturity model. The authors (Valdez-de-Leon, 2016) state that there is insufficient readiness and an unclear

path of transformation within telecommunications service providers. Therefore, they have access to maturity models that allow them to position themselves within the current level of maturity, and also to define a plan to advance to a higher level. Production organizations digitize functions within their processes (Colli et al., 2018), (Schumacher, Erol & Sihn, 2016) and introduce innovative services based on collected and analysed data (de Carolis et al., 2017). The health sector looks at ways in which patients can be involved in health service planning and delivery (Meinert et al., 2018) and analyses the extent to which health facilities use technology to improve the patient experience (Mettler & Pinto, 2018). This allows organizations to acquire a certain level of maturity. Educational institutions promote more flexible and creative ways of learning and teaching. They strengthen teachers' digital skills and competencies (Sotiriou et al., 2016) by creating virtual teaching materials whose accessibility extends beyond classical classrooms (Towndrow & Fareed, 2015). In addition, digital maturity is reflected in the readiness to adopt information and communications technology - ICT (Đurek, Begičević Ređep & Divjak, 2017) in areas relevant to the overall business (Đurek, Kadoić & Begičević Ređep, 2018). Organizations whose business is in the field of water services and supply place emphasis on the adoption of new business practices, i.e. virtual offices, conferences and new ways of marketing products to end users (Heinze et al., 2018). Furthermore, public institutions (Pavaloaia, 2019) show a high degree of maturity for the acceptance of ICT. The application of ICT leads to the strengthening of knowledge, skills and abilities of employees, and consequently to an increase in economic productivity. The need for a high level of maturity is also emphasized in the IT departments within organizations (Isaev, Korovkina & Tabakova, 2018) so that they are optimized and ready to provide adequate support to other sectors within organizations. Digital technologies affect all economic spheres and society as a whole and affect changes in the way of life and work of individuals. The availability of technologies enables the transformation of individuals, organizations and the economy (Stoica & Bogoslov, 2018). Within the framework of the fourth industrial revolution, emphasis has been placed on the notion of countries' technological competitiveness and their success in advocating and applying digital technologies with the aim of achieving economic prosperity and general progress (Weresa, 2019). The importance of establishing strategies for the integration of new technologies in the domains of economics and civil society is increasingly emphasized in developed countries (Đurek, Begičević Ređep & Divjak, 2017), which shows willingness to participate in the digital economy. Over the last few years, the literature has provided an overview of various measures of national performance based on indices intended to measure the economic development of a country (Jovanović, Dlačić & Okanović, 2018), and that measure a country's competitiveness, innovation and readiness to accept digital technologies and new ways of thinking and action. The importance of social inclusion in the digital economy and gaining appropriate knowledge and skills to support the use of digital technologies has been emphasized (Stoica & Bogoslov, 2018).

4 Digital Maturity – The Current State in Agriculture

Given the lack of papers related to the digital maturity of agriculture, additional research was conducted to identify the current state of maturity in the sector. Namely, one of the ways to improve the digital progress of the country and achieve a higher level of maturity is certainly the creation of policies that will be suitable and stimulating for the agricultural sector (Trivelli et al., 2019), (López-Morales, Martínez & Skarmeta, 2020). For example, the United States publishes publicly available agricultural datasets (Nolet, 2018) that can further benefit entrepreneurs in developing technologies and adapting their business to climate conditions. Australian policies (Nolet, 2018) are aimed at strengthening the agricultural sector by advocating for the application of digital technologies (Cho, 2018), and at providing financial assistance to agricultural start-ups. In the maturity model of the agricultural sector predictive and prescriptive analytics are emphasised as important aspects (Nolet, 2018). The application of such analytics enables big data management, the implementation of ERP systems in farms, the integration and analysis of data (Soosay & Kannusamy, 2018), the use of artificial intelligence, and integration and the exchange of data among farmers. All of this ultimately leads to learning and innovation in agriculture (Ingram & Maye, 2020). Although countries recognize the importance of investing in digital agriculture (Karacay & Aydın, 2018) to increase digital maturity in general, there are barriers (Cho, 2018) that result in agriculture and other industries lagging behind (Zhang et al., 2019). Some of the main barriers include the lack of access to telecommunications and internet infrastructure (Nolet, 2018), (Ciruela-Lorenzo et al., 2020), slow internet connectivity, lack of publicly available data that is usable (e.g. on climate change, soil, environment) (Brohm & Klein, 2019), (Soosay & Kannusamy, 2018), low level of digital literacy among farmers for the adoption of digital technologies (Trivelli et al., 2019), high representation of the elderly population in the mentioned sector, lack and aversion to apply decision support tools (Ingram & Maye, 2020), etc. These barriers certainly are reasons for the low level of maturity of the agricultural sector (Cho, 2018) and reasons for the inequality relating to agricultural activities in agricultural organizations. Although at early stages countries have recognized the importance

of investing in agriculture and are beginning to see the opportunities (Karacay & Aydın, 2018), (Assante et al, 2018) provided by digital technologies to make the agricultural sector more successful and economically viable (Ciruela-Lorenzo et al., 2020), (Triantafyllou et al, 2019), (Triantafyllou, Sarigiannidis & Bibi 2019), it can be concluded that concrete measures for monitoring good practices and the development of countries are necessary for monitoring their digital performance (Jovanović, Dlačić & Okanović, 2018). Given the still relatively small number of comparable parameters for measuring countries' performance and achievements (Weresa, 2019), various stakeholders have created indices that measure precisely their ability to adopt digital technologies, or their willingness to accept them in general. Several relevant and currently available indices have been developed and are described later in this paper. They are guided by the idea that ICT "is not just a separate economic sector, but the infrastructure of all modern economic systems" (Stoica & Bogoslov, 2018), which certainly positively affects a country's performance. In addition to indices that measure the digital maturity of countries in general, the paper also investigates the existence of a digital maturity index for the agricultural sector within a particular country.

5 Results – The Digital Maturity of a Country (Digital Maturity Indexes)

Digital transformation is a generally accepted paradigm that is rapidly, and under changing market conditions, taking root in the lives of all stakeholders. Digital technology and its possibilities have been used by individuals in everyday life; in the operations of organizations, in creating new values for end users, and it does not bypass the highest state/national bodies. National policies and the connected bodies are those who must ensure the smooth utilization of their capacities in the context of the fourth industrial revolution, i.e. they occupy the market and affect stakeholders on the supply and demand sides. Measuring digital performance by countries and their governments is important to assess their current position and determine the level of digital maturity. It also contributes to defining future policies that will focus on improvements in poorly covered areas. The developed metrics, that measure technological factors, macroeconomic factors and institutional environment for the purpose of monitoring the economic progress of countries correspond to the indices. Some of the identified digital measurement indices are presented later in this paper. The systematization of results allows for a review of eight selected digital indices. Seven of them monitor the digital maturity of countries in general and one index monitors the digital maturity of the agricultural sector within a country. For each index, the description and scope are provided, as well as information on its creator. This in turn provides the answer to the RQ1 related to the identification of relevant indices of digital maturity of states. In addition, an analysis of the coverage of the indices in line with the determinants of digital transformation was conducted (Pihir, Tomičić-Pupek & Tomičić Furjan, 2018) in order to see to what extent a certain index satisfies the basic concepts of DT.

5.1 Digital Economy and Society Index (DESI)

DESI (European Commission, 2019) is a composite index that summarizes indicators of European digital efficiency and competitiveness. It includes 30 relevant digital performance indicators measured from **five areas (dimensions)**: connectivity, human capital, use of Internet services, integration of digital technologies and digital public services.

5.2 Networked Readiness Index (NRI)

NRI (Portulans Institute, 2019) is a holistic framework that allows for the assessment of the multiple impacts of ICT on society and on the development of national economies. It considers the application of ICT and how to use it for the development and competitiveness of countries. The NRI was renewed in 2019 and is based on **four pillars**: technology, people, governance and impact. The NRI framework states that the ability to integrate people and technology into governance structures is a necessary condition for a collective prosperous future.

5.3 Digital Adoption Index (DAI)

DAI (World Bank, 2016) is a composite index created to measure the speed of technology adoption and technological solutions by global countries. It enables the assessment of the digital and technological maturity of countries and looks at the extent to which technologies have been adopted in the following **three segments**: people, business/companies and government.

5.4 Digital Readiness Index (DRI)

DRI (Cisco Systems, 2019) looks at how individual countries are reaping the benefits of digitalization and how a country has progressed in terms of its digital maturity. It enables the identification of strategic forces affecting countries and directs them to improve the overall digital readiness. The index identifies key investments that as such help countries on the path to progress towards better digital readiness. It is a holistic approach that looks at **seven components** of digital readiness: basic needs, human capital, ease of doing business, business and government investment, the start-up environment, technology infrastructure, and technology adoption.

5.5 The Digitization Index (DiGiX)

DiGiX (BBVA Research, 2019) summarizes indicators regarding the degree of digitization and the digital impact on observed countries. It analyses the factors, and the behaviour of economic stakeholders and institutions in order to observe the use of ICT and their direction towards achieving competitiveness and overall well-being. It is based on **six dimensions**: infrastructure, adoption of ICT by users, adoption of ICT by the organization, adoption of ICT by the government, costs and regulations.

5.6 Global Competitiveness Index (GCI)

The GCI (World Economic Forum, 2019) is an indicator of total factor productivity and the portion of economic growth regarding the drivers of productivity, growth and human development in the era of Industry 4.0. It analyses the way in which labor and capital are successfully combined in order for countries to achieve prosperous results. It consists of a total of 103 indicators. These indicators are divided into **twelve pillars**: institutions, infrastructure, ICT adoption, macroeconomic stability, health, skills, product market, labor market, financial system, market size, business dynamics, and innovation.

5.7 Doing Business (DB)

DB (World Bank, 2019) is a set of quantitative indicators on business regulation and the protection of property rights. It considers regulations that affect the improvement of business activity or that limit it. The relevant regulations for the index are organized in the following **eleven domains**: starting an organization, obtaining building permits, obtaining electricity, registering property, obtaining a loan, protecting minority investors, paying taxes and levies, cross-border trade, enforcing contracts, insolvency resolution and labor market regulation. The indicators are used to analyse economic outcomes and to identify necessary reforms within the business environment.

5.8 Digital Maturity Index and Assessment Tool for the Agricultural Industry

The mentioned global digital maturity index is focused on agriculture (Zhang et al, 2019). It includes the following **five pillars**: strategy and culture, capability, data rules, data & analytics, and technology. The index enables the agricultural sector and its participants to assess the current level of digital maturity, to examine their own strengths and weaknesses, and serves as a kind of assistance tool in creating initiatives aimed at improving digital efficiency in the sector. In addition, it provides the agricultural industry with a basis for a systematic review and for the development of a digital strategy in order to make agriculture purposeful and influential in a competitive market.

6. Results - Assessment of maturity in relation to the determinants of digital transformation

As basic determinants of DT, the authors (Pihir, Tomičić-Pupek & Tomičić Furjan, 2018) state:

a) Strategy orientation (guided by a defined vision, leadership and adequate management)
b) Customer centricity (monitoring and forecasting customers' needs)
c) ICT and process infrastructure (adequacy of resources and business process management)
d) Talent, capability and capacity strengthening (investment advocacy with a focus on improving the knowledge and skills of human capital)
e) Innovation culture and organizational commitment (advocacy and application of innovation culture)

The mentioned DT determinants were placed in the context of connecting the identified indices of digital maturity of countries. In this way, an assessment was made on the extent to which each index describes the basic determinants of digital transformation. It was found that digital maturity indices can indicate readiness for digital transformation in organizations in a given country. This in turn answers the RQ2.

It can be concluded that the Networked Readiness Index and the Digital Readiness Index fully cover the domain of DT and its determinants because they overlap in key areas regarding the assessment of the digital maturity of countries with DT determinants. The Global Competitiveness Index covers four of the five determinants of DT without considering the strategic orientation of organizations. The Digital Adoption Index and the Digitization Index each cover three determinants, and it can be seen that none of the mentioned indices in their measurements look at the talents, knowledge and skills in promoting DT within organizations. The Digital Economy and Society Index is fully oriented towards the user's use of digital technologies and considers the technological aspects of countries, while Doing Business is a strategic indicator whose orientation is focused on the organization and legal regulations that enables entities to conduct business activities. Finally, the Digital Maturity Index and Assessment Tool for the Agricultural Industry covers three determinants of DT. It is not customer-oriented and does not follow the area of innovation. Instead, it focuses on data and on the adequate management and use of knowledge concerning data (shown in Table 2). By identifying and evaluating an index focused on the digital transformation of agriculture, the answer to the RQ3 was determined.

Table 2. Systematization of indices aimed at measuring the digital effects on countries

Index	Index creator	Key DT determinants
DESI (European Commission, 2019)	European Commission	
NRI (Portulans Institute, 2019)	World Economic Forum	
DAI (World Bank, 2016)	Microsoft & World Bank	
DRI (Cisco Systems, 2019)	Cisco Systems, Inc.	
DiGiX (BBVA Research, 2019)	Banco Bilbao Vizcaya Argentaria	
GCI (World Economic Forum, 2019)	World Economic Forum	
DB (World Bank, 2019)	World Bank	
Digital Maturity Index and Assessment Tool for the Agricultural Industry (Zhang et al., 2019)	CSIRO	

From the above it can be concluded that the defined digital strategies of a country represent the starting points for ensuring the equal participation of organizations in the digital world. This enables a set of policies whose direction should ultimately contribute to the growth of digital maturity in the economy. This set of policies would contribute to the general spread and availability of the Internet, the availability of infrastructure for partially or fully online business of organizations, and the climate for promoting the development of citizens' digital literacy. Therefore, the backbone of the digital strategy of a country would allow for a democratic system of equal participation where all entities are able to take part in a ubiquitous digital world.

7 Conclusion

The speed of technological change has a significant impact on society as a whole and on the creation of new trends. New technologies are becoming more accessible than ever, and organizations are realizing their importance in business. The fourth industrial revolution and the emergence of digital transformation pose new challenges to organizations, and to the entire ecosystem in which they operate.

In this paper, emphasis is placed on the importance of perceiving DT and new technological changes in countries. A literature review identified eight relevant indices, by which countries can measure their maturity in dealing with new market trends. The identified indices define areas of particular emphasis in which efforts need to be focused on in order to make a country's final results as competitive as possible, depending on the domain to which the indices relate. Furthermore, the paper examines the structure of indices and their compliance with the main determinants of DT. Apart from considering indices that look at digital maturity in general, an index aimed at measuring the maturity of the agricultural industry has been established. The mentioned industry is in the initial phase of digital maturity, which signifies that it is recognized for its potential in digital development. Although there are currently a number of barriers to initiating transformation, an adequate national policy aimed at the development of the agricultural sector would enable a culture of advocating innovation, and accordingly, transformation. Certainly, digitally mature countries (i.e. those that are ready to adapt their policies to current market trends) create opportunities in order to achieve their own global competitiveness, which facilitates the path to their own economic development and competitiveness.

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