

Digitization landscape in the Hungarian food-processing industry

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ABSTRACT

The food industry is the third-largest in Hungary, the first in Hungary in terms of the number of employees, and the first in Europe in the processing industry, as well as a significant user of resources. In order to develop the digitization of the food industry, it is necessary to get a picture of the situation. In this article, the most important functions, features, and aspects of these technologies are examined. Several international organizations are contributing to the measurement of digital transformation. Digital Enterprise Metrics is for the level of a single enterprise digitalization is measured with industry. My research focused on the technological aspects of digitalization. The research-based on a survey. According to the size of the company, the level of digitization increases and there are differences among branches in the food-processing sector.

1. Introduction

The "Food Industry Concept of Hungary 2017-2050" approved by the Government gives priority to the development of the food industry. Strengthening innovation, technological change, and digitalization in the food industry is also crucial for more efficient use of resources, reducing losses, increasing productivity, quality assurance and addressing labor shortages. Experts estimate that 80% of the food industry's problems could be solved by adapting Industry 4.0 and other digitization technologies already in use in other industries, but most food industry players are unaware of new technologies, while developers are not aware of the industry's problems. On the other hand, business success determined by a series of managerial decisions. With the advancement of information technology solutions, several tools are available to assist with large amounts of data processing, flexible querying, visualization, analysis of relationships and trends, and filtering of business process management information based on a pre-developed operating model to effectively support management decisions

In terms of production value, the food industry is the third-largest in Hungary, the first in Hungary in terms of the number of employees, and the first in Europe in the processing industry, as well as a significant user of resources. Agri-food enterprises operate in a complex and dynamic environment (Wolfert et al. 2010) and facing different challenges, such as financial issues, lack of technical skills and investment in the business, etc. (Singh et al. 2019, Zhang 2012). In this sense, several key factors can help food SMEs. Therefore, increasing productivity and efficiency in the food industry is extremely important, and the application of Industry 4.0 and digitization offers many new opportunities. In this way, new products, new services, new solutions, and approaches can be developed to use resources better, improve quality parameters, create new skills, and competencies.

However, the cloud begins to form a major stream of business environments. Businesses are increasingly questioning "when and why" is there a need for the cloud, and at the end of the acceptance process, the "how" is being sought (KPMG 2013). According to Botos's study, micro-enterprises in the agricultural sector do not look for cloud services or big data, because the enterprise management system is not used either (Botos et al. 2015).

The planned Hungarian digitalization strategy focuses on the entire food economy from the chain of raw material production to the final consumer, to the issues of industrial food processing. At present, this is the area of the Hungarian food processing industry where a solution should be found as soon as

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possible to the problems of increasing productivity, resource efficiency, labor shortages, skills shortages and which can bring tangible benefits the fastest.

Today, a wide range of management support systems and tools are available for the efficient operation of the company. The prerequisite for the application of these systems is the appropriate digitization of enterprises and their digital readiness. However, in order to develop the digitization of the food industry, it is necessary to get a picture of the situation. At what level are businesses, what tasks, what decisions, what functional areas are the current tools used, how do they judge the applicability of systems and tools and what plans do they have for developing digitization?

In this article, the most important functions, features, and aspects of these technologies for managerial decision support were examined: network infrastructure and Internet usage; use of integrated enterprise information systems (ERP); management information systems (MIS); opinions on some of the most important information technologies in business intelligence tools (BI) and Industry 4.0.

2. Literature review on measuring digitalization

2.1. The importance and impact of digitization

Across industries around the world, digital transformation is changing the way organizations of all sizes do business. Harnessing the power of the 3rd Platform (cloud, mobility, social business, and big data and analytics), organizations leverage new digital competencies to transform every step of the value chain. For organizations to remain competitive in this quickly unfolding digital era and beyond, IT must embrace digital transformation and the requisite infrastructure needed to achieve it.

While organizations are leveraging new digital competencies to revolutionize product and service delivery, it is important to remember that digital transformation is not a technology initiative but a business strategy. Advances in digital technologies are embedded in all sectors of the economy and contribute to improving productivity, reaching new markets, reducing costs, changing business processes, creating new business opportunities and new jobs.

Despite the ever-increasing saturation of manufacturing with information and communication technologies, most collected data is only used for its original purpose. This limits the potential of this data because it is almost never analysed for more complex information (Friedemann et al. 2016).

The process of digitalization has created opportunities for new products, technologies, and processes (Chinoracký & Čorejová 2019). An environment is needed that allows the integration of the systems forming a System-of-Systems (SoS). The vision of the overall contribution from the research community in manufacturing and logistics systems, over the next few years, is to bring together researchers and practitioners presenting and discussing topics in modern manufacturing modeling, management and control in the emerging field of Industry 4.0-based resilient and innovative production SoS and supply networks (Panetto et al. 2019).

Tokody (2018) examined whether there is any general or formalized technology that could be equally used in various fields, and which could help to achieve digitalization in everyday life, also in the industry or in manufacturing. Mourtzis et al. (2018) suggested an Open Platform Communications – Unified Architecture (OPC-UA) communications standard to provide a macroscopic and microscopic view of machine shops, towards the Machine Shop 4.0 concept. The proposed system is validated in a Laboratory case study. Dachs et al. (2019) investigated the relationship between the location of production activities and digital manufacturing technologies, also known as Industry 4.0 (I4.0). I argue that I4.0 supports backshoring because it provides higher productivity and flexibility which offers an incentive for firms.

Jaaton (2016) focuses on the role of accountability within information management, particularly in cloud computing contexts. The key to this notion is that an accountable Cloud Provider must demonstrate both willingness and capacity for being a responsible steward of other people's data.

Biagi & Falk (2017) presents new empirical evidence regarding the impact of ICT/e-commerce activities on labor demand. The data is based on new and unique data for 10 European countries for the

period 2002–2010. A key feature of the empirical analysis is the use of several types of advanced ICT activities, such as enterprise resource planning (ERP) systems, mobile internet access, and e-commerce practices. The main result of the study is that the increase in ICT/e-commerce activities over time has not led to a decline in jobs. This holds true for both manufacturing and service industries, as well as for SMEs and large firms. For ERP systems and websites, there is some evidence of positive effects.

According to Pacheco et al (2019) the significance of small companies to the global economy and their intrinsic difficulties. The main barriers involving the transition towards Sustainable Product-Service Systems in manufacturing Small and Medium-sized Enterprises as well as the strategies to overcome them. Findings reveal that internal barriers associated with intrinsic characteristics of SMEs become still more sensitive during the transition (e.g., limited financial resources, the lack of competences, follower mentality and resistance to change).

Wong et al (2019) investigated the effects of relative advantage, complexity, upper management support, cost, market dynamics, competitive pressure and regulatory support on blockchain adoption for operations and supply chain management among Small-Medium Enterprises (SMEs) in Malaysia.

Currently, the agri-food sector takes advantage of modern machinery, tools, and emerging information and communication technologies (ICTs) that consider the Internet of Things (IoT) capabilities. These implementations have given way to a new era of agri-food production called ‘Agri-Food 4.0’, where automation, connectivity, digitalization, the use of renewable energies and the efficient use of resources are predominant in this sector (Miranda et al. 2019).

Manufacturing digitalization and the growth of big data promises to foster more responsive supply chains and to close gaps between manufacturers and consumers, leading to highly-connected manufacturing operations, mass customization and more sustainable production (Zaki et al. 2017).

An elaborate business model is the fundament of every firm as it describes the manner of functioning. In the course of the new developments of digitization technologies such as Big Data and Data Science, business models and processes have changed tremendously and new business models pop up as never before. Although theory and practice show increased interest in the potentials of new business models through digitization, prior research has not demonstrated yet the main driver of its significant use (Härting et al. 2018). Cisco worked with IDC to develop a five-stage Digital Network Readiness Model to help organizations envision a clearer path to a network that can support all their digital aspirations (Greene et al. 2017).

Several authors have examined some sectors and segments of the Hungarian agri-food sector. Botos et al (2018) investigated the use of ICT in a preliminary study. Füzesi & Herdon (2010) and Herdon & Füzesi (2011) examined product tracking implementations and quality assurance solutions for information systems in the meat industry. Herdon et al (2012) presented a prototype of a Digital Business Ecosystem for SMEs.

2.2. Measuring digitization

As the digital transformation spreads across every sector and affects every aspect of society, measuring its distinct features and dynamics will become increasingly challenging. New approaches will be needed – and the digital tools and footprints created by digital activities can form part of the solution. The digital transformation is also being felt across all dimensions of data production and use. For example, qualitative information is increasingly becoming a source of quantitative evidence.

Several international organizations are contributing to the measurement of the digital transformation through initiatives, some of which are described in the G20 Toolkit for Measuring the Digital Economy. These include, but are not limited to, work on key ICT indicators within the Partnership on Measuring ICT for Development led by the ITU, UNCTAD and the United Nations Educational, Scientific and Cultural Organization (UNESCO) Institute for Statistics (UIS). The OECD works closely with several of these organizations, including the World Trade Organisation (WTO) on the issue of measuring digital trade, and the IMF on measuring the implications of the digital economy for macroeconomic statistics (OECD 2019). Kotarba (2017) covers an analysis of metrics used to measure digitalization activities.

Readiness is a developmental stage that describes inclination, willingness, and preparedness to perform an action. Meanwhile, digital is defined as the device and application of digital technology. Thus, digital readiness is defined as inclination and willingness to switch to and adopt digital technology and the readiness to create new innovative opportunities by using this technology in order to bring an individual, organization, industry, and country to achieve their goals faster and with greater results.

There is a need to develop indicators that can show how far businesses in different sectors have progressed in the digital transformation journey, i.e. how digitally mature they are. The digital maturity indicator combines four components to provide a comprehensive picture of how digitally mature Swedish companies are (OECD 2017). The four components are systems for enterprise resource planning (ERP), systems for customer resource management (CRM), social media, market and integration (systems for e-invoice, e-sales, and supply chain).

According to the PMG study, five domains define your digital business aptitude. First, they have a clear vision of what digital means to their business and they have embedded their strategy with digital DNA. Second, a critical mass of digital talent, third, digitized core internal processes, fourth, flexible and agile, lastly, they have re-designed theirs.

Digital Economy Metrics is commonly viewed that the term “digital economy” was introduced by Don Tapscott in his publication: *The digital economy: promise and peril in the age of networked intelligence* (Tapscott, 1997). Digital Density Index (DDI) is developed by Oxford Economics and Accenture jointly a Digital Density Index (DDI) measuring how digital technologies impact economic growth (Macchi et al. 2015). Digital Economy and Society Index (DESI) is developed within the framework of “Europe 2020 Strategy”, the European Commission introduced a performance measurement system to track the evolution of the EU member states in digital competitiveness (European Commission, 2016). Digital Society Metrics can be described as a society in which the usage of ICT is common across demographic parameters of the population. Digital citizens function in the digital economy using the available digital public and commercial infrastructure for conducting life activities.

Digital Industry Metrics for the purpose of this paper, the term “digital industry” is defined as the application of digitalization in any type of industry. It is, therefore, not limited to the ICT/new technology sector that produces digital solutions, but it covers all manufacturing or service delivery where such digital solutions are used. Digital Enterprise Metrics is for the level of a single enterprise digitalization can be measured with industry metrics presented in the previous section. However, there is a large additional measurement area that is not covered explicitly by the IDI. Additional KPIs describe the status and performance of eCommerce and digital customer dialog in an enterprise.

Ruiz-Rodríguez et al. (2018) constructed a synthetic index of digital development (Enterprise Digital Development Index –EDDI-) and analyzed the countries in the EU and Spanish regions. The variables of the index come from the “Community survey on ICT usage and e-commerce in enterprises” of Eurostat. Many companies fail to understand that the use of digital technologies requires different preparations. One of them is the requirement of an adequate level of digital readiness provides a viewpoint of the adequacy of existing models. Nasution et al (2018) describe future directions to evaluate the readiness of companies.

3. Material and Methods

The research goal defined the research method. The use of information and decision support tools to support management was at the heart of the assessment of the situation of the digitalization of food business enterprises. The research (in 2019) examined the role and relationship of integrated enterprise information systems (ERP) or decision support, business analysis tools (BI), which are used independently of one another in the Food Industry 4.0 technology change. The preparation and implementation phases of the survey are shown in Figure 1. The anonymous online questionnaire was filled by Hungarian food industry companies, which contain 6 question groups with 44 questions. The question groups focused on the main IT topics in the digitalization transformation. The survey was only

possible with a questionnaire survey. The preparation and implementation phases of the questionnaire were as follows.

Questions groups were:

- General enterprise information
- IT infrastructure and Internet usage
- Enterprise information systems (ERP)
- Using Management Information Systems (CIS)
- Using Business Analytics (BI) Tools
- Industry 4.0

Within the above question groups the following types were used: Yes/No, List (radio), Multiple choices, Array (5 point choice), Date/Time, Array (Yes/No/Uncertain), Array dual scale, Short free text.

The research tools were LimeSurvey, Mailing List Server Publishing on Web sites, Excel, Power BI (Desktop, Publishing Server to distribute the results).

Phases of research	2018	2019						
	December	January	February	March	April	May	June	July
Phase I: Preparing the Survey								
Study of literature								
Mapping related statistical databases and surveys								
Contents Planning								
Peer review of the questionnaire								
II. Phase: Development of the online survey								
Selecting an online survey system (LimeSurvey is a cloud service provider in Germany)								
Create an online questionnaire								
Testing the questionnaire with company professionals								
Modifying the questionnaire								
III. Phase: Implementation (April-May 2019)								
Create a mailing list on a university server								
Sending invitations by email (~ 4500 food processing companies) and posting the invitation on NAK, AKI website								
Checking progress								
Statistical evaluation of the survey								

Figure 1. The research phases

Limesurvey is a professional questionnaire engine with a pre-installed environment and database. Once one entered the system, he can create the questionnaire he wants to do by first defining the frame of the questionnaire, then the question groups, and the questions themselves (Figure 2). The used survey tools and evaluation flow are shown in Figure 3.

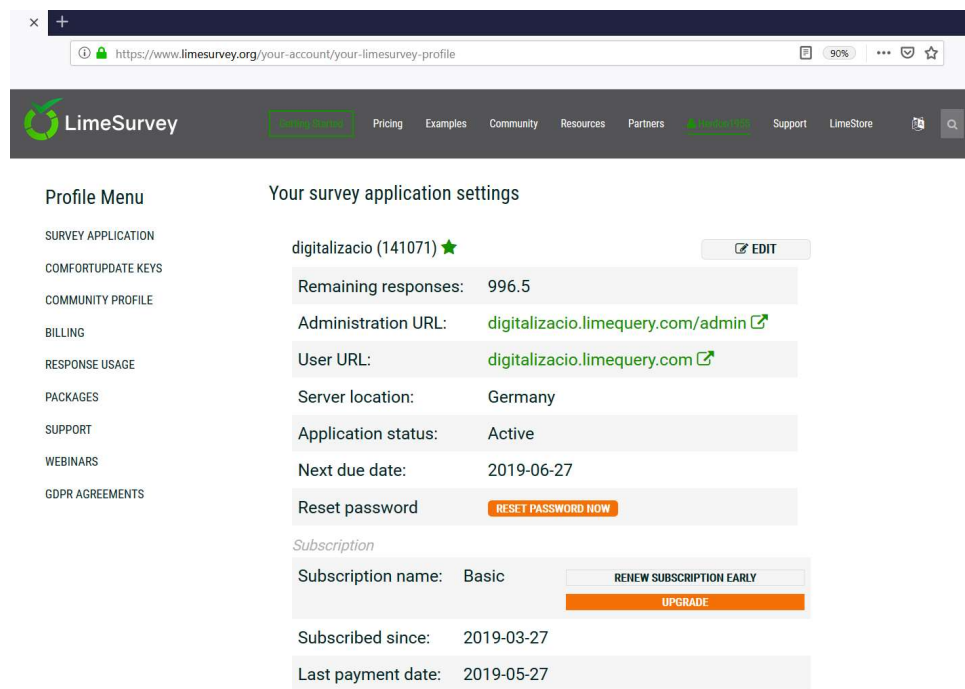


Figure 2. Lime Survey settings

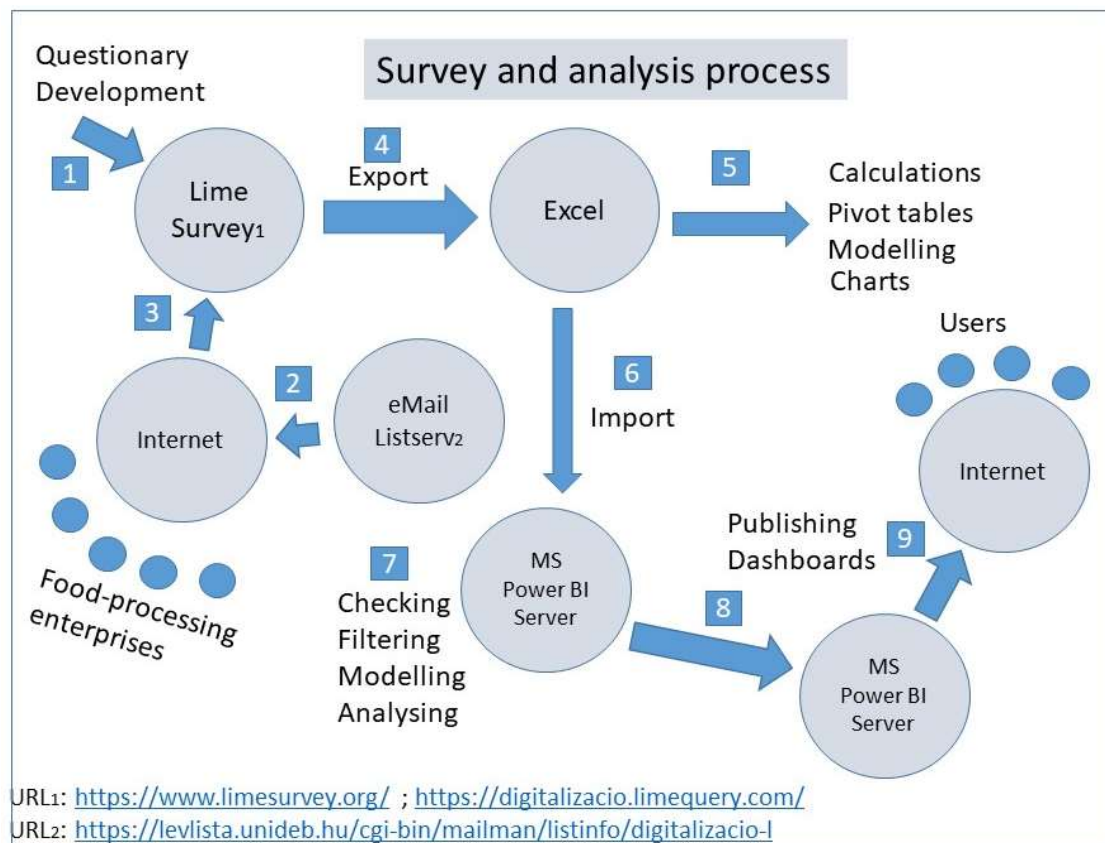


Figure 3. The used tools and processes

The surveyed population consisted of Hungarian food processing companies. During the examination, I tried to obtain a representative sample. Because the sample was sent to all enterprises

from the entire population, respondents were randomly selected, so each sampling unit had the same chance of responding (to the sample).

The general requirement for sample selection, as described above, is that the sample is representative of the population from which it was taken, that is, to reflect well the composition and characteristics of the population. So I aimed for a representative sample with the same characteristics as the primary population. The aim was to ensure that the sample population reflects the characteristics of the sample population. Table 1 shows the sample size and degree of representativeness.

Some feature of the respondents:

- Sent requests via e-Mail Listserv: 4000; Access the on-line Questionnaire: 390; The number of the filled questionnaire: 205
- Number of the fillers by position (this question was optional): Top manager 71, Middle manager 39, Administrative worker 30, IT professional, 15 Other 8, Operational leader 7.

Table 1. The survey sample by branches.

Branch code	Branch	Number of enterprises B	Number in the sample A	Percentage B/A
104	Manufacture of vegetable and ani	60	7	12%
109	Production of feed	100	12	12%
105	Milk Processing	100	11	11%
106	Manufacture of grain mill products	100	10	10%
101	Meat Industry	500	38	8%
108	Manufacture of other food products	600	44	7%
103	Processing of fruits and vegetables	500	27	5%
107	Manufacture of bakery and farinac	1200	36	3%
110	Beverage industry	1400	33	2%

Considering the size distribution of respondents by size category (Table 2), three-quarters of micro enterprises have sales below HUF 50 million, while the small part of small enterprises are between HUF 100 million and HUF 1 billion, while in the case of medium enterprises Part One has net annual sales of more than HUF 1 billion. 93% of large companies have sales of over 1 billion HUF.

Table 2. The sample by Annual Revenue / Company size.

Annual net sales / Company size	Micro-	Small-	Middle-	Large-	All enterprises
<2 million HUF	9	1	0	0	10
2-10 million HUF	17	0	1	0	18
10 and 50 million HUF	22	3	1	0	26
50-100 million HUF	8	6	1	0	15
100-200 million HUF	3	21	2	0	26
200-500 million HUF	6	22	1	0	29
500 million HUF and 1 billion HUF	0	21	4	1	26
>1 billion HUF	0	13	28	14	55
Altogether	65	87	38	15	205

The number of food-processing companies can be seen in Figure 4. The map of Hungary shows the geographical distribution of the company. The circle and the numbers on the table show the numbers of the enterprises.

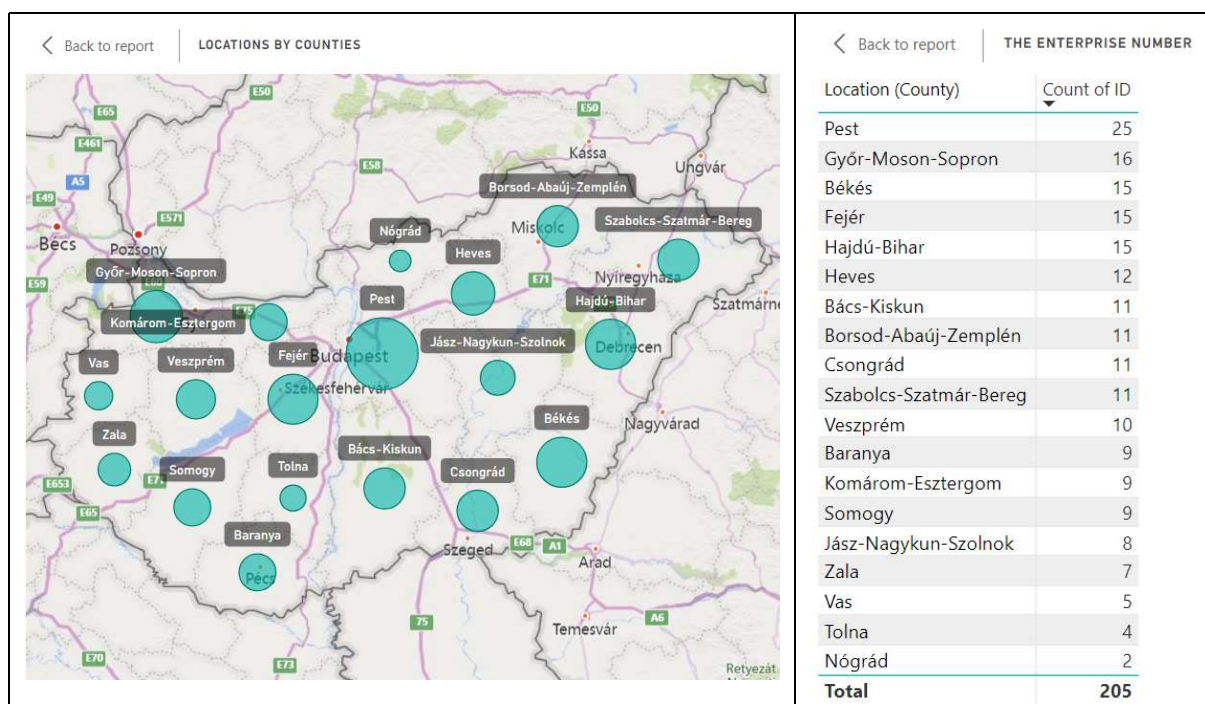


Figure 4. Geographical locations of the companies in the Sample (N=205) (Created by Power BI)

4. Results

My research focused on the technological aspects of digitalization. More methods developed to measure the digital readiness on different levels from global, macroeconomic, industry end enterprise levels. The following levels of digitalization and methods with samples of relevant metrics are covered.

4.1. The structures of the developed model to measure the readiness

The Digital Economy and Society Index (DESI) measures the progress of EU countries towards a digital economy and society. As such, it brings together a set of relevant indicators on Europe's current digital policy mix (European Commission 2019). The DESI has a three-layer structure. It is composed of five principal dimensions, each divided in a set of sub-dimensions, which are in turn composed by individual indicators. The dimensions are 1 Connectivity, 2 Human capital, 3 Use of internet services, 4 Integration of digital technology, 5 Digital public services.

Some dimensions, sub-dimensions and individual indicators are more relevant than others, and for such a reason they were given higher weight in the computation of the final index score for each country.

Table 3 presents the overall weights attributed to the main DESI dimensions, which reflect the EU's digital policy priorities.

Table 3. Structure of the DESI

DESI Dimension	Weight
1 Connectivity	25%
2 Human Capital	25%
3 Use of Internet Services	15%
4 Integration of Digital Technology	20%
5 Digital Public Services	15%

The questions (and their sub-questions) what contains the data and used to create a DE-FS structure were the following in the survey (Table 4):

Table 4. The questions (* with their subquestions in the questionnaire).

ID of Question	Question
8	Does your company have a local (internal) computer network? *
9	What type of Internet access does the company have? *
10	What is the Internet used for business purposes? *
12	Does your business have a website? *
14	Does your company have a subscription to any of the following cloud-based services? Free services are not included! *
15	Does your company have an integrated or independent corporate governance information system? *
21	Please indicate which activities are supported (or in which area of the company operation) the corporate governance information system is regularly used. *
24	Does your company have a management information system? *
29	What are management information systems used for? *
31	Do you use business intelligence tools/applications? *
32	Evaluate which business analytics technologies are relevant to your company! (1 = Not relevant, 5 = Very relevant) *

The information technological aspect for companies links to the connectivity, use of internet services and the integration of digital technology. I used these aspects to evaluate the companies and branches for the Hungarian food-processing companies by the created Digital Enterprise Index for Food-processing Sector (DEI-FS). The DEI-FS has a three-layer structure as depicted in Table 5. It is composed of 3 principal technological dimensions, each divided in a set of sub-dimensions, which are in turn composed by individual indicators.

Table 5. The structure of Digital Enterprise Index for Food-processing Sector DEI-FS.

Dimension	Weight	Sub-dimension	Weight	Indicator	Weight
1 Connectivity	0.42	1a Wired Broadband Internet	0.15	Fixed Broadband Internet Access	1.00
		1b Mobile Broadband Internet	0.35	Wireless Internet Access	1.00
		1c Internal local computer network	0.50	Operating an Internal LAN	1.00
2 Use of Internet Services	0.25	2a Transactions	1.00	Purchasing Products, Services (Electronic Purchasing)	0.50
				Sale of products, services (e-commerce)	0.50
3 Integration of Digital Technology	0.33	3a Business Digitization	0.15	Electronic Information Sharing (Advertising / Marketing)	0.40
				Website Operation	0.30
				Using a Subscription Cloud Service	0.30

		3b E-commerce	0.10	Electronic Procurement / E-Commerce	1.00
		3c ERP	0.25	Using Enterprise Management Information System (ERP)	0.55
				It is used regularly in at least 10 areas of company operations	0.15
				Used in at least 5 but less than 10 areas of enterprise operations	0.15
				Used in less than 5 main functional units of enterprise operations	0.15
		3d Executive Information System	0.25	Using a Management Information System	0.55
				Analyzing aggregate data	0.15
				Making plan-fact comparisons	0.15
				Time series analysis	0.15
		3e BI Tools / Applications	0.25	Using Business Intelligence Tools / Applications	0.50
				Using BI/Analytical functions*	0.50

*Using BI/Analytical functions: This indicator consists of the following sub-indicators (using the following tools): Analysing; Monitoring, controlling; Forecasts; Graphic Visual Dashboards; data warehouse; Data Mining Tools; Complex Analysis Technologies; Cloud-Based BI; Using Mobile Based BI with 0,05 weight).

12 questions and their sub-questions related to the indicators which are in Table 3. The weights were determined using DESI and other methods as well as literature references. Of course, it is possible to change the weights in the hierarchical weight structure in the created calculator.

In DEI-FS, the aggregation of indicators into sub-dimensions, of sub-dimensions into dimensions, and of dimensions into the overall index was performed from the bottom up using simple weighted arithmetic averages following the structure of the index (Table 5).

As an example, the top-level DEI-FS score for enterprises, branches, enterprise groups E was calculated using the formula: $DEI-FS(E) = Connectivity(E) \cdot 0.25 + Use\ of\ Internet\ Services(E) \cdot 0.15 + Integration\ of\ Digital\ Technology(E) \cdot 0.2$

Where $Con(E)$ is the score obtained by enterprise E in the Connectivity dimension, and so on for the remaining dimensions in the formula.

4.2. The rank by enterprise size

Figure 5. below shows the level of development of enterprises within the enterprise size categories with the modified “DEI-FS” index. We can observe that as the size of the company increases, the level of development also increases, so it can be said that large enterprises (68%) and medium-sized enterprises (52%) are the most digitally advanced. The average level of development of all enterprises is 41%. Below this is the indicator for micro-enterprises (29%), while the average for small enterprises is the average for all enterprises.

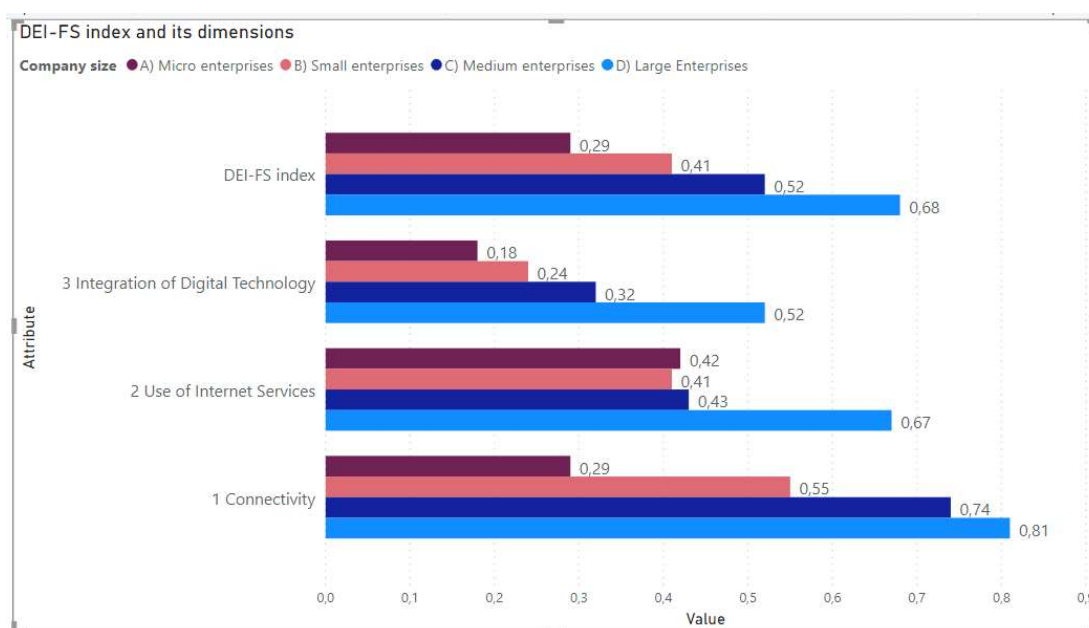


Figure 5. The digital development level by " DEI-FS " index within the size category (N=205)

4.3. The rank of the braches and regions

Examining the level of development by sector, Figure 6 shows that the most advanced sectors are the production of oil, the production of other foodstuffs, the production of mill products and the processing of vegetables and fruits. The most backward in this respect (not counting the fish processing and tobacco production sectors, where 1-2 fillings came) are dairy, bakery, pasta, and feed production.

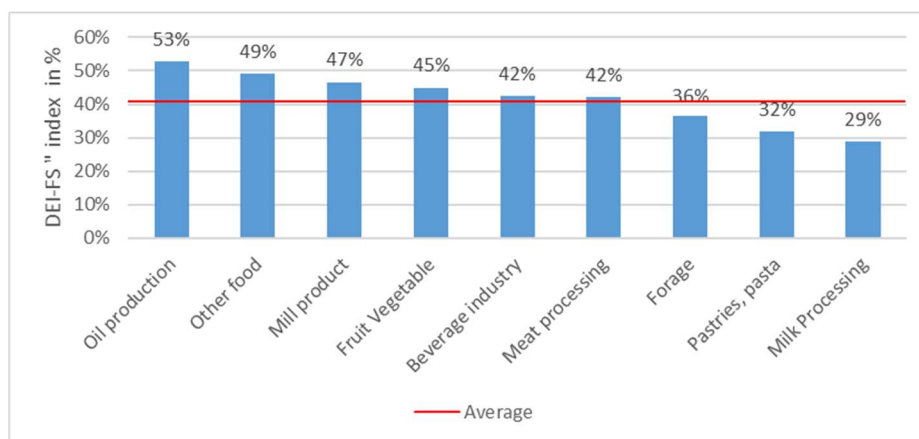


Figure 6. The digital development level of branches by " DEI-FS " index (N=205)

The three tools of the analysis were the Lime Survey (this was used for preliminary statistical analysis of the survey data), Microsoft Excel (partly for data cleansing and preliminary analysis, transformations), the third tool was the Power BI (data modeling, analysis, reports dashboard- ok). One of the tiles in the industry comparison report (Figure 7) shows the values of the DEI-FS index dimensions by industry. The complex index and your indicators have been studied in detail, and a number of qualitative characteristics have been analyzed with the Business Intelligence Tool.

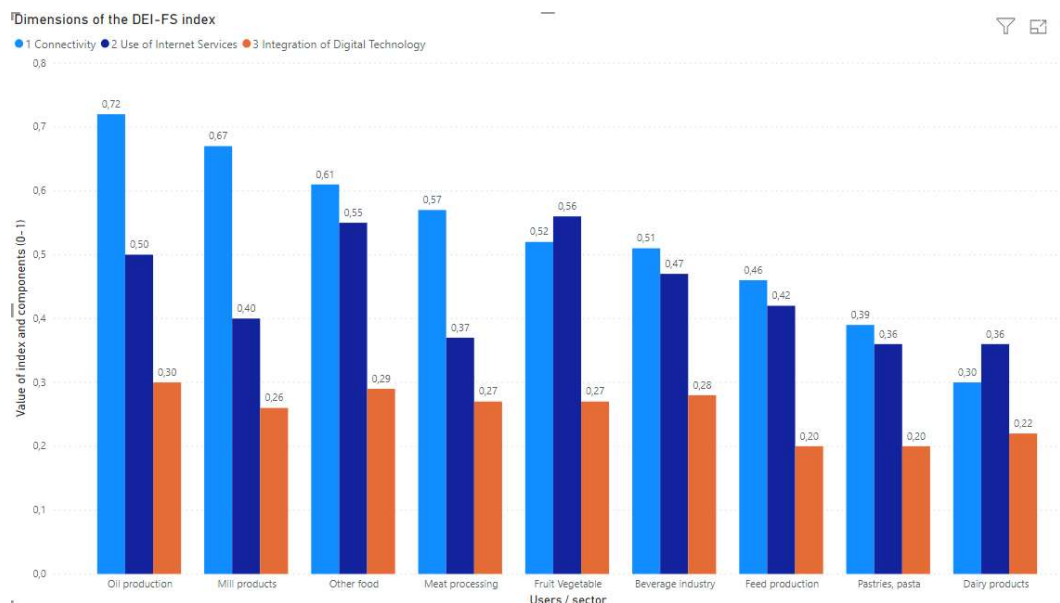


Figure 7. The dimensions of the DEI-FS index by sector branches (N=205) (Made with Power BI)

The development by regions is shown in Figure 8 which shows that the most backward regions are Western and Southern Transdanubia. However, the other regions are not much more developed than average.

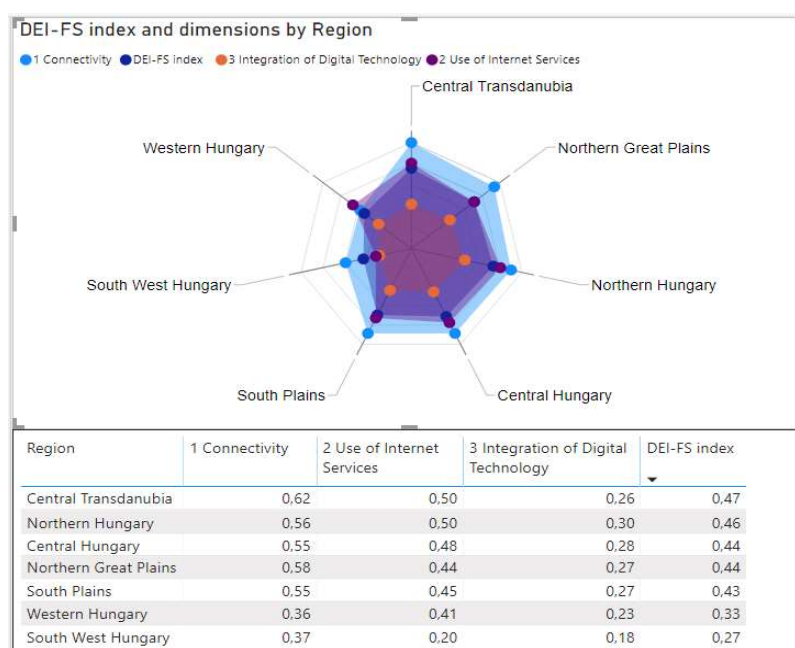


Figure 8. The digital development level of regions by " DEI-FS " index (N=205)) (Made with Power BI)

5. Conclusion

The complex rating index shows differences in development between company size, industry and country regions. The survey is considered representative, suggesting that it may be suitable for self-evaluation of individual companies or for the use of a calculator simulator in which individual weights can be set at intervals. On the other hand, the developed system may be suitable for analyzing progress over time, repeating the survey every year, and publishing the Dashboard interactively with the Power BI or other BI systems.

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