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The impact of digitalization on SMEs GDP contribution

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Abstract

This research investigates the impact of digitalization on contribution to Gross Domestic Product, in the context of the Hungarian National Infocommunication Strategy adopting the European Union's Digital Agenda. 1045 small and medium enterprises were included in the research, using data from years of 2010 and 2018. The level of digitalization was measured by the Digital Economy and Society Index, using both information technology infrastructure-related information, as well as the use of enterprise software applications, particularly Enterprise Resource Planning or Customer Relationship Management systems. The contribution to Gross Domestic Product was measured by headcount, pay costs and turnover as proxies using the financial data submissions of the companies. The results of the partial least squares structural equation modelling suggest that while the firm's current financial position is being the most important factor for its future contribution to Gross Domestic Product, digitalization, especially the adoption of enterprise software systems is also a significant factor to the firm's contribution. Therefore, it is worth pursuing digitalisation for driving economic development. The proposed method could be applied to other Member States, creating the opportunity to understand similarities and differences of their economies.

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Keywords: digitalization; PLS-SEM; GPD contribution.

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1. Introduction

The European Union (EU) has committed to digitally driven growth, developing the Digital Agenda and the Digital Decade policy program, targets, objectives, and projects. The first 10-year (2010-2020) was designed to facilitate the access to digital goods and services for consumers and businesses, enhancing the digital networks and services to flourish under the right conditions. The second 10-year (2020-2030) covers new EU technological and geopolitical ambitions, highlights the changes introduced by digital technologies and focuses on the essential role of digital services and markets. In 2021 the EU created a Digital Compass that suggests actions in four different fields: skills, businesses, infrastructure, and public services [1]. These factors are closely related to each other in boosting the digital economy. The Digital Economy and Society Index (DESI) has been serving as the basis to monitor the Member States' digital progress since 2014. The data are collected and validated by national or EU authorities. "Each year, DESI includes country profiles which support Member States to identify areas that require priority action as well as thematic chapters offering a European-level analysis across key digital areas, essential for underpinning policy decisions." [2]. The EU's Digital Agenda was adopted by the Hungarian government, and as a result, the National Infocommunication Strategy (NIS) was published in 2014. It provided a comprehensive picture about the Hungarian information society and pointed out the main directions to achieve the objectives in relation with the relevant EU' strategies. Despite several improvements achieved, the strategy did not completely fulfil its role, and the DESI report still shows significant gaps to other EU countries.

Small and medium-sized enterprises (SMEs) are the driving force of the European economy, accounting for 99.8% of all businesses and employ more than two thirds of the EU labor force, contribute to more than half of EU value added and have played an important role in the recovery since the financial and economic crisis [3]. The objective is to help to reach at least a basic level of digital intensity at more than 90% of European SMEs. Therefore, investigating the digital progress of SMEs is priority in the EU, and the DESI index is used to monitor this goal. Understanding the relationship between the digital progress and its contribution to GDP could provide additional support to EU's Digital agenda, providing macro-level economic context. This study aims to develop a method, that could be repeated for other EU Member States, by analyzing this relationship for Hungarian SMEs. The analysis uses a merged database and multivariate statistical models (PLS-SEM) to detect the behavioral patterns of SMEs in relation to digitalization. The database is constructed from the financial statements and the Statistics on Information and Communication Technologies (ICTs) and e-commerce survey data of the companies. The survey has been conducted annually by Eurostat as a part of DESI and included in the Eurostat dataset. A cross-section of two years: 2010, and 2018 were chosen for this research, for 1045 Hungarian SMEs. These years were chosen to cover a relatively long period that exclude the financial crisis and the COVID-19 pandemic.

2. Related work

2.1. Digital maturity assessment

Digital transformation covers both process digitization and digital innovation, the former focusing on efficiency improvements while the latter on developing new capabilities [4]. Maturity models are tools that help to assess an organization's capabilities as regards a class of objects and application domain [5], in this case regarding digitalization. Digitalization is a broad term, it may consist of several dimensions, that affect the overall digital maturity of the organization. Berghaus and Back [4] defined nine dimensions: (1) customer experience, (2) product innovation, (3) strategy, (4) organization, (5) process digitization, (6) collaboration, (7) information technology, (8) culture & expertise, and (9) transformation management, of which many of them are related to skills, organisation and process management. Remane and co-authors [6] used factor analysis to reveal important factors of digital maturity. They highlighted of two aggregate dimensions: digital impact and digital readiness. They also clustered the companies participated in their research and identified that some clusters are more affected by digitization than others, depending on the industry they operate in or the products they produce. The application field could also affect the numbers of dimensions. Schuh and co-authors [7] for example, distinguish four dimensions for Industry 4.0: (1) resources, (2) information systems, (3) organization, and (4) culture. Scremin and co-authors [8] define also for manufacturing a three-dimensional model: (1) strategy axis, (2) maturity axis and (3) performance axis. The first dimension assesses the awareness and decision making related to digital technologies, the second the maturity of digital infrastructure and technologies, while the third the benefits the organization gains from digitalization. The second two dimensions are rather similar to Remane and co-authors' [6] aggregate dimensions. Finally, Frank and co-authors [9] approached digital maturity, also for manufacturing firms, from a technological perspective and investigated which technologies have been integrated into the production systems. They found that as firms mature, they adopt more and more technologies: first, technologies that facilitate vertical integration (e.g., PLC control, supervisory control, and data acquisition (SCADA), manufacturing execution systems (MES) and enterprise resource planning (ERP)), followed by virtualization and automation.

Maturity levels are often defined at a five-level scale, described as archetypes. Descriptions of the archetypes could be Beginner – Intermediate – Experienced – Expert – Top performer, sometimes extended with an addition level, below the lowest level [10]. Other definition of the maturity levels could be Promote & Support - Create & Build - Commit to transform - User-centered & elaborated processes - Data-driven enterprise [4]. Our research focused on two dimensions of digital readiness: process digitalization and IT infrastructure. While these dimensions may ignore the organizational aspects of digital readiness, they allow to measure the status of IT infrastructure and digital business applications rather objectively, using the available DESI data.

2.2. Digitalization and GDP contribution

Digitalization could contribute to economic growth in a number of ways. It can increase productivity by more advanced technologies embodied in machinery (e.g., robots or computer-controlled automation), or by organizational software (e.g., electronic data interchange, enterprise resource planning or intranet type workflows), but it can also lead to new products, processes or organizational forms [11]. Olczyk and Kuc-Czarnecka [12] cited that 10% increase of digitalization (DESI score) is connected to a 0.65% to 0.75% increase in GDP per capita. They also proved that DESI can be used as a proxy of economic growth. Parra and co-authors [13] concluded that "the use of internet services by citizens" and "the business integration of digital technologies' have a clear and determined implication on the GDP per capita. Additionally, online sales by SMEs have also strong effects on economic development [14]. There could be however, negative views on the economic impact of digitalization [15]. While the majority of studies report a positive impact, there are also studies that question if digitalization would lead to productivity gains [16,17]. The studies are often performed at macro level therefore the specific impact at company level is difficult to assess. Brasini and Freo's research [11] is unique in that sense that they try to measure the impact of digitalization at micro level, for Italian firms. They used financial data from the AIDA database [18] and survey data to assess the level of digitalization. They were able to obtain data from 256 firms. Their findings did not fully support the expected positive economic impact of digitalization, due to the heterogeneity of the results. They argue that the firms at the bottom of productivity and efficiency may react negatively to digitalization, due to the time required to absorb the investment burden connected to the digitalization. On the other hand, digitalization led to increase in labor productivity in a less heterogenous way.

3. Data and construct

The data for our research was sourced from the Hungarian Central Statistical Office's database, that holds company level responses to the DESI survey as well as detailed annual financial information of the same companies. The benefit of using this data source is that large number of companies could be analyzed, without relying on survey responses. 1045 SMEs had valid data in the dataset. In hindsight, DESI survey questions tend to be simpler than what one would develop for a digital maturity survey instrument, and the questions tend to change over time. The constructs therefore had to be adjusted to suit the available data. There constructs were developed for this research: IT infrastructure, (process) digitalization level and GDP contribution. IT infrastructure covers the shared IT resources consisting of the technical base of hardware, software, communications technologies, the data, and core applications and the human component of skills, expertise, and knowledge. These IT provide the foundation across the entire organization and for the development and implementation of business applications [19]. Process digitalization measures the extent to which business applications are used for both digitizing business processes and to develop new capabilities. GDP contribution measures the impact of the business on the overall GDP.

3.1. IT infrastructure

Our IT infrastructure construct would measure the status of how many computers, mobile computers and internet connected computers were present at the company relative to the number of employees. It is expressed as percentage, with a maximum of 100%, how many of them were connected to the internet – all compared to the number of employees. By applying k-means clustering using the three calculated variables of computer, mobile computer and internet connected computer ratios, three distinct clusters were identified for the 1045 companies. The number of companies are rather evenly distributed among the clusters. (Fig.1). While the construct was evaluated at two points in time, in 2010 and 2018, the latter was not used in the final model. Still, there is a visible increase in the number of computers, especially for the middle cluster.

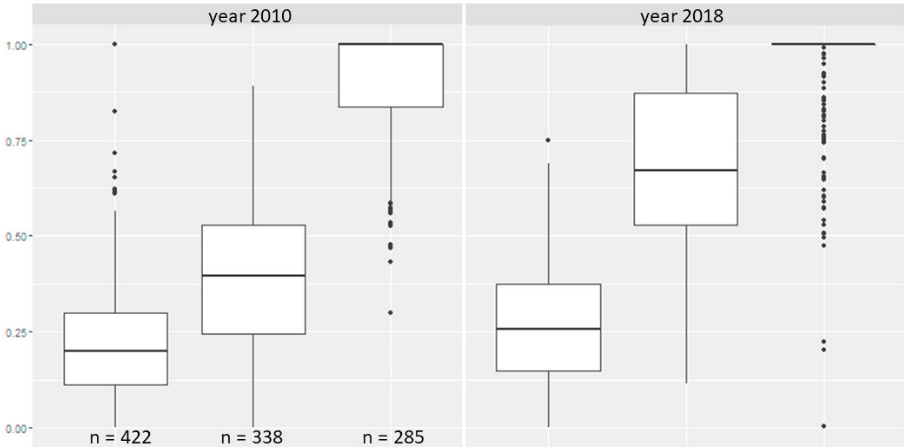

Fig. 1. Computers to employee ratio of the clustered companies.

3.2. Level of digitalization

Our digitalization construct focuses on the implementation of business applications, as the IT infrastructure construct already covers the availability of hardware. This construct takes a simplified view on digital maturity, as it relies on the available DESI questions. In the most recent years DESI has been extended with questions related to novel digital technologies like machine learning or big data, therefore in the future the digitalization construct can be adjusted to better describe maturity. The construct defines 6 maturity levels. At the lowest level (Level 0) no digital applications exist at the company. At Level 1 only basic digital services of a company website are available, followed by Level 2, where customer information is managed using CRM (customer relationship management) or similar software. At Level 3 ERP (enterprise resource planning) software is used to manage business processes. At Level 4 the ERP and the company website is extended with online order functionality, while at the highest level of 5 orders can be customized and / or tracked online (Table 1). The construct was evaluated also in two points in time, in 2010 and 2018. Due to data availability, the 2018 ERP and CRM maturity levels have been approximated using the 2017 and 2019 values.

3.3. Contribution to GDP

The GDP contribution of companies is the value added in the input-output accounts of the producer units [20], the wages and salaries, the supplementary and mixed labor income, the operating surplus (interest payments and depreciation) and the indirect taxes. Employment is also an important factor to measure contribution of small businesses for the US economy [21]. The GDP contribution construct has been created through several iterations using the above principle, and using the data that was available at the Hungarian Central Statistical Office's database. Pay cost (wages and salaries) and personnel cost (supplementary labor income) are key elements of the construct. While headcount could be a redundant element from a GDP contribution point of view, it has been included in the construct, as the level employment is an important measure of the economy. Similarly, material costs, material related services have been included, as they could act as income for other businesses, that fall outside of the analyzed set of companies. Dividends and depreciation had to be eliminated from the final construct, as they did not carry sufficient variance. Finally, turnover has been included in the construct, for similar reasons as material costs, material related services. The construct was evaluated at two points of time: in years 2010 and 2018. The former measures the GDP contribution of the selected SMEs before the Digital Agenda for Europe and the Hungarian National Infocommunication Strategy was launched, while the latter is aimed to measure the impact of the digitalization initiatives and the improvements in digitalization.

Table 1. – Assignment of digitalisation levels.

Question	**Digitalization level**		
Website service: personalized content on the website for frequent and returning customers			Level 5
Service available on the website: on-line tracking of orders			
Service available on the website: online booking or reservation or room reservation		Level 4	
Does your company use an Enterprise Resource Planning (ERP) software package?	Level 3		
Use of a CRM (Customer Relationship Management) software application to collect, store and make customer information available to other business functions	Level 2		
Website service: product and service information (product and service catalogue and price list)	Level 1		
None of the above	Level 0		

4. Results and discussion

PLS-SEM (partial least squares structural equation modelling) was used to understand the relationship between digitalization and GDP contribution. This method is widely used in social sciences and has the ability to create models that can be statistically validated, for complex concepts, multiple variables and relationships. Traditionally survey instruments are developed for the measurement of concepts, using validated scientific research. In this case we had to use those variables that were available in the DESI survey and the financial information and validate the constructs using statistical measures. The data source resulted to a relatively large numbers of sample, 1045 companies had valid data. This is about 5 times more data, that is generally used, and accepted for this type of research, supporting the findings' validity.

Several models have been tested and evaluated to develop the final, statistically valid and reliable model. Digitalization level was modelled as a single indicator construct, that is measured on an ordinal scale of 0-5. IT infrastructure was modelled as a reflective construct of three indicators, that are measured on a cardinal scale of 0-1. GDP contribution was modelled as a reflective construct of six indicators, that are measured on a cardinal scale of the firm's financial indicators in local currency or headcount. The financial indicators were not adjusted for inflation; however, all have shown growth in excess of the inflation, during the period. The calculations were performed in R environment [22], using the SEMinR Package [23].

The reflective constructs were all found reliable, supported by the Chronbach alpha measures. Convergent validity, measured by AVE (average variance extracted) of the GDP contribution 2010 is lower than the required 0.5 and some outer loadings are also lower than the required 0.708 [24]. The indicators with lower values were not eliminated from the model, due to the exploratory nature of the research. (Table 2, Fig. 2). The model's validity was evaluated by bootstrapping, using 5000 samples. It confirmed the validity of the constructs, as all reflective, multi-item constructs' t- statistics suggest their statistical significance. Discriminant validity was assessed using the heterotrait-monotrait

(HTMT) criterion [25]. The results suggest that the GDP contribution 2010 and 2018 constructs have a slightly higher HTMT value than the conservative threshold of 0.85, suggesting that they are rather similar concepts (Table 3). However, as it is lower than 0.90, it was accepted for this research.

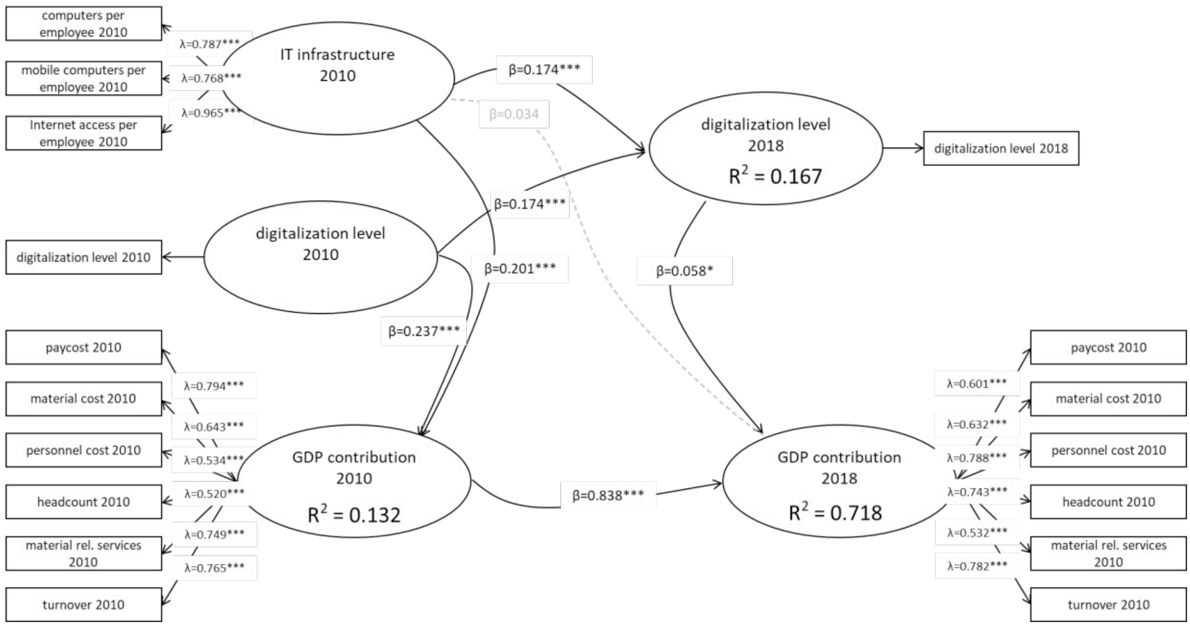

Fig. 2. Results of the PLS-SEM model.

Table 2. Reliability measures of multi-item reflective constructs.

	Chronbach alpha	AVE	rhoA
GDP contribution 2010	0.827	**0.458**	0.847
IT infrastructure 2010	0.879	0.714	0.894
GDP contribution 2018	0.834	0.471	0.851

These path coefficients suggest that the biggest influence on the GDP contribution of the firms in 2018 is their initial GDP contribution in 2018. In other words, those companies that had a higher-than-average GDP contribution initially, were able to maintain their higher-than-average GDP contribution. Given that the overall growth of the financial indicators was in excess of inflation, they were able to demonstrate real growth during the analyzed period. The total path coefficients (Table 4) suggest that IT infrastructure and digitalization levels, especially in the beginning of the analyzed period have a significant influence on the companies' GDP contribution in 2018. The companies, that invested early in digitalization were able to contribute more to GDP than the ones that didn't. It highlights the importance of investing in digital systems like ERP, CRM or online order customization. Companies that were more advanced at the digitalization journey were able to pay more wages and salaries, purchase more material related services achieve higher sales turnover. The results may also suggest, that having just ERP and CRM systems in 2018 is not sufficient anymore. The path coefficient between digitalization and GDP contribution being significantly smaller in 2018 may suggest, that other than ERP and CRM systems are required to drive the firm's success and contribution to GDP. The path coefficient between digitalization levels in 2010 and 2018 also suggests that companies that started their digitalization early have maintained their advantage, they stayed ahead.

Table 3. Discriminant validity (HTMT) measures of the model.

Bootstrapped HTMT			Original Est.	Bootstrap Mean	Bootstrap SD
GDP contribution 2010	→	digitalization level 2018	0.301	0.304	0.032
GDP contribution 2010	→	IT infrastructure 2010	0.382	0.383	0.026
GDP contribution 2010	→	digitalization level 2010	0.312	0.313	0.033
GDP contribution 2010	→	GDP contribution 2018	**0.861**	**0.867**	**0.073**
digitalization level 2018	→	IT infrastructure 2010	0.286	0.286	0.031
digitalization level 2018	→	digitalization level 2010	0.375	0.375	0.030
digitalization level 2018	→	GDP contribution 2018	0.302	0.303	0.032
IT infrastructure 2010	→	digitalization level 2010	0.368	0.367	0.032
IT infrastructure 2010	→	GDP contribution 2018	0.303	0.304	0.033
IT infrastructure 2010	→	GDP contribution 2018	0.323	0.323	0.031

Table 4. Bootstrapped total path coefficients of the model.

			Original Est.	Bootstrap Mean	Bootstrap SD
IT infrastructure 2010	→	GDP contribution 2018	0.144	0.145	0.047
digitalization level 2010	→	GDP contribution 2018	0.217	0.221	0.035

5. Conclusion

This research proposed a method to explore the effect of digitalization on GDP contribution, using publicly available data sets. The EU has committed to digitally driven growth and implemented DESI as an ongoing process to monitor the Member States' progress towards digitalization. This company level data set combined with financial information creates the unique opportunity to measure the economic effect of digitalization. Researchers often need to rely on survey instruments, with its challenges of having sufficient numbers of responses. The other approach, macro level analysis could have limited resolution to understand the interaction between the concepts. The proposed method could overcome of both gaps.

The research analyzed the effect of digitalization for SMEs, being driving force of the European economy. It used PLS-SEM, a widely used method for complex concepts, multiple variables and relationships. Digitalization level of the companies was measured by their IT infrastructure and their business applications, relying on the DESI questions. GDP contribution of the same companies were measured by their value added in the input-output accounts and by additional measures of headcount and turnover. While the PLS-SEM models could be further refined, their results suggest that digitalization, especially the software systems the firm invested in and operates are significant factors to GDP contribution, software systems having some 10% stronger effect than the computer infrastructure. When trying to project the firm's future GDP contribution, the firm's current financial position is the most important factor. However, digitalization, especially the software systems are significant factors to the future GDP contribution, therefore it is worth pursuing this route of development. The model can be improved in the future. As it relies on the data from 2010 and 2018, it does not reflect the usage of Industry 4.0 technologies (big data, IoT and so on). Future improvement could be to refine the financial part to measure the GDP contribution more precisely or the digitalization level variable with adding questions about these technologies.

This research should be refined and replicated to other Member States and other business sizes, to understand the similarities and difficulties between different economies and segments. The data being available in the statistics offices should make the analysis relatively straightforward. One should however prepare for data privacy issues, that our research experienced during the modelling. We struggled with the limited access to data and the transmission of software code and results. This would delay modelling and limit the researchers' ability to develop appropriate, statistically valid model.

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