Measurement of digital performance by composite indexes: Analysis of member states EU

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Abstract: Digitalization, digital performance and transformation have become remarkable phenomena as of late. Digital transformation helps increase digital competencies and creates an ecosystem with more technologically advanced products and services, thus becoming an important prerequisite for the competitiveness of economies. However, this transformation has an impact not only on economies, but also on society as a whole, and therefore it has become a complex topic that is being addressed by various European and national agendas. Various development policies are being formed, and the effects of digital transformation on the socio-economic sphere are being examined as technological progress brings with it not only great challenges and opportunities, but also threats to society, economies and individual businesses. In order to assess the level of digital transformation, the European Union processes a number of different composite indicators. This paper concentrates on digital performance and its measurement through selected composite indicators (DESI, EIDES). The aim of this paper is to examine the relationships between these composite indicators and productivity rate (represented by GDP per capita and Total Factor Productivity). Using this analysis, it is possible to capture the position of the Czech Republic within EU member states and form recommendations for improving its position.

Keywords: digitalization, digital performance, composite indexes, EIDES, productivity
JEL Classification: O33, O40

1 Introduction

Technological progress and the swift development of modern technologies is changing the world and impacting the competitive position of individual sectors of the economy and whole countries, business models and the behavior of those participating in market processes (Marszalek & Ratajczak-Mrozek, 2022). Thanks to the massive and global emergence of new technologies, value chains are changing, and new innovative business models are being formed. Digitalization (also sometimes dubbed "the digital revolution") is reshaping almost every part of both company and private life and transforming society (TWI2050, 2019; Vor dem Esche & Hennig-Thurau, 2014). It includes the integration of digital technology not only into economies and namely businesses, but also into all areas of society while fundamentally changing the way in which individuals function (Henriette et al., 2015). In the context of the development of business models, operations and markets, digitalization is viewed in terms of the opportunities that new technologies provide, as it enables various new forms of cooperation between businesses and the individualization of products and services; it also creates new forms of relationships between businesses and clients or employees and brings along new business opportunities (Rachinger et al., 2019). It is becoming the driving force for companies, markets and regions in sustaining competitiveness or growth. Technologies thus have a fundamental influence on the development of society as a whole and the behavior of individual economic entities. The term "digital economy" is used in the sense of a resource for sustaining competitiveness, economic growth and development (Palacká et al., 2021; Miethlich et al., 2020). However, the digital economy also has a more general meaning, e.g. the World Bank (2016) characterizes it as a system of economic, social and cultural relations that are based on digital technologies.

The paper presented here deals with the issue of measuring digital performance with the use of composite indicators. The paper is structured in the following manner: Firstly, the theoretical basis concerning the issue of digitalization, technological progress, digital technologies, digital transformation, etc. is established. Subsequently, applied methods

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and procedures used in the analytical section of this paper are presented. This is followed by a section depicting the primary results and the opening of a discussion on the issue at hand. The Conclusion summarizes the collected findings and outlines issues concerning future development.

The EU processes a whole score of composite indicators through which it assesses the degree of digitalization. Achievement of the established goals of Europe's digital transformation is to be ensured by the "Path to the Digital Decade" program (European Commission, 2021a), a part of which is a monitoring system that stems from the Digital Economy and Society Index (DESI) composite indicator. This index assesses digital performance and measures the progress of EU countries in fulfilling the goals for 2030 (European Commission, 2022b).

Nonetheless, questions remain as to the relationship between the digital performance of individual countries presented via selected composite indicators and their productivity. The goal of this paper is to explore the relationships between selected composite indicators (DESI, EIDES) and the degree of productivity represented by GDP per capita and Total Factor Productivity indicators. Attention will be given namely to the Czech Republic and its position.

2 Theoretical Background

Three terms often appear in relation to technological progress and the development of modern technologies – digitalization, digitization and digital transformation – which sometimes tend to be interchanged. Vor dem Esche & Hennig-Thurau (2014) define digitalization as: *"a major change process with enormous "disruptive power" that effects not only the area of information and communication, but also products, services and distribution channels."* Parida et al. (2019) view digitalization as *"the use of digital technologies to innovate a business model and provide new revenue streams and value-producing opportunities in industrial ecosystems"*. Gartner's Glossary (2021) defines digitalization similarly, viewing it as *"the process of moving to a digital business"*, in which digitalization means the *"use of digital technologies to change a business model and provide new revenue and value-producing opportunities"*. However, digitalization impacts all sectors and companies without exception, and even despite the fact that its impact and effect can vary (Marszalek & Ratajczak-Mrozek, 2022), it has become crucial for securing competitiveness (and in some sectors even survival) into the future (Caputo et al., 2021). This does not only concern business entities, sectors or markets; digitalization also includes the integration of various technologies into our daily lives, e.g. smart devices, mobile devices, smart homes, smart cities or smart mobility. It thus has a broad socio-economic impact. For this reason, digitalization is also viewed as a major driver of growth and sustainability (Bleicher & Stanley, 2017). It should not be equated to digitization, which means the transition from analogue to digital format (Gartner's Glossary, 2021). This deals merely with the digital conversion of existing documents and data, in which we digitize information, not a process. The meaning of digitalization (which thanks to the possibilities of digital technology makes it possible to collect large amounts of data, analyze them, establish trends and provide valuable information for more qualified decision making) is thus much broader and can be identified with qualitative change and specific transformation (Marszalek & Ratajczak-Mrozek, 2022). The term digital transformation is then used as a label for strategic transformations focusing on organizational changes realized via digitalization projects with the goal of enabling significant business improvements (Warner & Wäger, 2019). As Bloomberg (2018) summarizes these differences, we digitize information, but we digitalize the processes and roles on which the operation of a business stands, and we digitally transform a business and its strategy; from a different point of view, digitization and digitalization are about technologies, whereas digital transformation from a business's point of view is about the client.

Digital transformation based on modern technologies is becoming a multidisciplinary issue that various national and international companies focus on in the context of opportunities and benefits, but also potential threats. Even the European Union sees digital solutions as fundamental in ensuring the renewal of Europe and its competitiveness in the global economy. Therefore, digital transformation is one of the EU's priorities. The report on shaping the digital future of Europe (European Parliament, 2021) calls for the utilization of opportunities of a united digital market, improvement of the use of artificial intelligence and the support of digital innovations and skills. In addition to instating technologies and the necessary infrastructure, the acquisition of digital skills is becoming a crucial prerequisite for further development and success. The EU's digital strategy aims to ensure that the digital transformation benefits the wider public and businesses while helping to achieve its goal of a climate neutral Europe by 2050 (European Commission, n.d.a). In 2021, the European Commission presented its vision and the direction of Europe's digital transformation up to 2030, in which it proposes a so-called "Digital Compass" for the digital decade in the EU. This compass has four basic dimensions (European Commission, n.d.b):

- Skills – 20 million specialists in the field of information and communication technologies, equality between men and women, basic digital skills among at least 80% of the population.

- Digital transformation of businesses - instating technologies (75% of companies in the EU using Cloud / AI / Big Data); innovators (growth support for quickly developing businesses and financing to double the number of "unicorn-grade" businesses in the EU); in the later phase, over 90% of small and medium-sized enterprises will achieve at least a basic level of digital intensity.
- Secure and sustainable infrastructures – connectivity (Gigabit for everyone, 5G networks), cutting-edge semiconductors (doubled EU share in global production), data – Edge and Cloud (10,000 climate-neutral highly secure edge nodes), connectivity (first computer with quantum acceleration).
- Digitalization of public services – key public services 100% online, e-Health (access to medical records for 100% of citizens), digital identity (80% of citizens using digital identification).

Digital technologies should be a benefit to society and competitiveness in the long-term, and therefore they play a fundamental role in all EU policies while also receiving financial support. The Digital Europe program, which was adopted in April 2021, is the EU's first financial instrument focused specifically on bringing technology to businesses and people. It aims to invest in digital infrastructure so that strategic technologies can help boost Europe's competitiveness and green transition, as well as ensure technological sovereignty. The Horizon Europe and Connecting Europe Facility programs also allocate significant funds for the development of digital progress. The EU's plan for economic recovery demands that member states allocate at least 20% of the €672.5 billion Recovery and Resilience Facility to digital transition (European Parliament, 2022).

3 Methods

In this study, we focus on the relationship between composite indexes reflecting digital performance and productivity in member countries of the EU. There are different indexes of digital transformation, e.g. the Digital Adoption Index (DAI), Enabling Digitalization Index (EDI), Digital Economy and Society Index (DESI), European Index of Digital Entrepreneurship Systems (EIDES), Digitization Index (DiGiX), etc. Two composite indicators – DESI and EIDES – were chosen for our analysis, as they are not only some of the newest and most widely-used composite indexes at the EU level at present, but they also have a relatively sophisticated and well-described methodology. For the purposes of this study, productivity is measured via two indicators – GDP per capita and Total Factor Productivity. Data were obtained from the World Bank, namely GDP per capita; PPP (constant 2017 international $) was collected from the World Bank database and transformed into a log for the purposes of the analyses. The TFP level at current PPPs was collected from the Penn World Table version 10.0.

The Digital Economy and Society Index (DESI) is composed of four primary components: Human Capital, Connectivity, Integration of Digital Technology and Digital Public Services. For its calculation, a total of 32 indicators were observed. EU countries are found to perform very differently in terms of having the digitalized framework conditions for entrepreneurship. Unfortunately, DESI does not sufficiently reflect this heterogeneity between individual countries, and therefore the need arose to seek out methods to measure both the physical and digital conditions for stand-up, start-up and scale-up ventures in the EU Member States. This led to the creation of the European Index of Digital Entrepreneurship Systems (EIDES), which responds to the need for a tool to better understand and appraise the extent of the digital entrepreneurial ecosystem. Specifically, EIDES is an attempt to measure both the physical and digital conditions for stand-up, start-up and scale-up ventures in EU countries and the UK. EIDES has a total of eight primary components: culture, informal institutions; formal institutions, regulation, taxation; market conditions; physical infrastructure; human capital; knowledge creation and dissemination; finance; networking and support. Over 110 indicators are entered into calculating this indicator.

With regard to the aforementioned facts and consideration to the relatively high linear dependency between DESI and EIDES (corr= 0,864), greater attention was paid to the EIDES indicator in the analytical section. As a supplement to this, the relationship between EIDES and the ability of individual EU member-state economies to transition was analyzed. At the same time, the ability to transition is captured by the Transitions Performance Index (TPI) indicator. This index measures a country's transition to fair and prosperous sustainability. Relationships between composite indicators and productivity are captured using bivariate correlations. Furthermore, the strength of association is presented graphically using scatter plots.

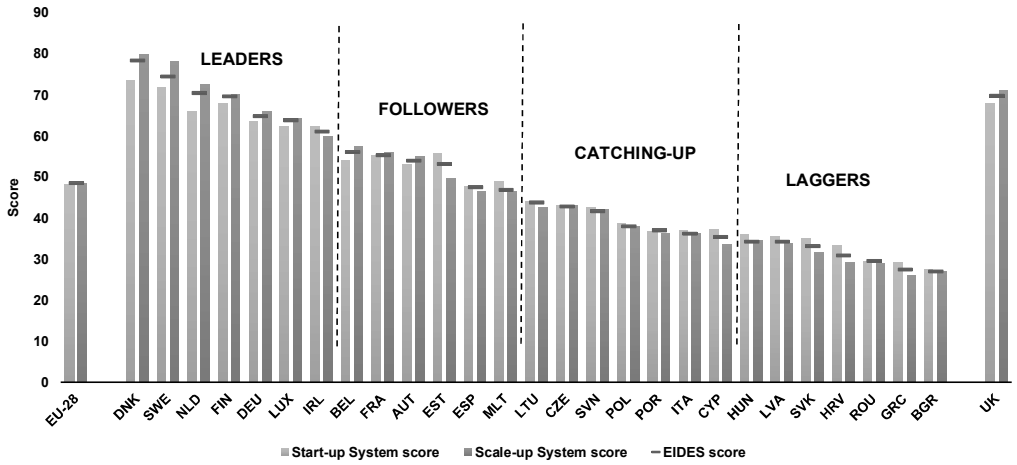
4 Research results

If we look at the Czech Republic in the last DESI report (European Commission, 2022b), we find that the strongest performance is in the dimension of Human Capital. Since 2017, the Czech Republic has made relatively solid progress in its overall DESI score, which grew slightly more than expected by convergence curve, meaning that its score improved

at a marginally higher pace than the score of the Union as a whole. Compared to 2021, the Czech Republic's ranking improved in Digital Public Services and Connectivity but worsened in Integration of Digital Technology.

For market conditions, large countries tend to exhibit higher scores because of their larger domestic markets. However, Sweden, Denmark and Ireland stand out in spite of their smaller domestic markets, ranking alongside the UK and Germany. The Czech Republic is performing well in the Catchers-up group. For the Knowledge Creation and Dissemination pillar, Netherlands ranks on top, followed by Germany and the United Kingdom. The Czech Republic stands out among the bottom half of the pillar ranking (for more, see Autio et al., 2020). Figure 1 provides a summary of EU member states and their ranking into groups according to EIDES scores.

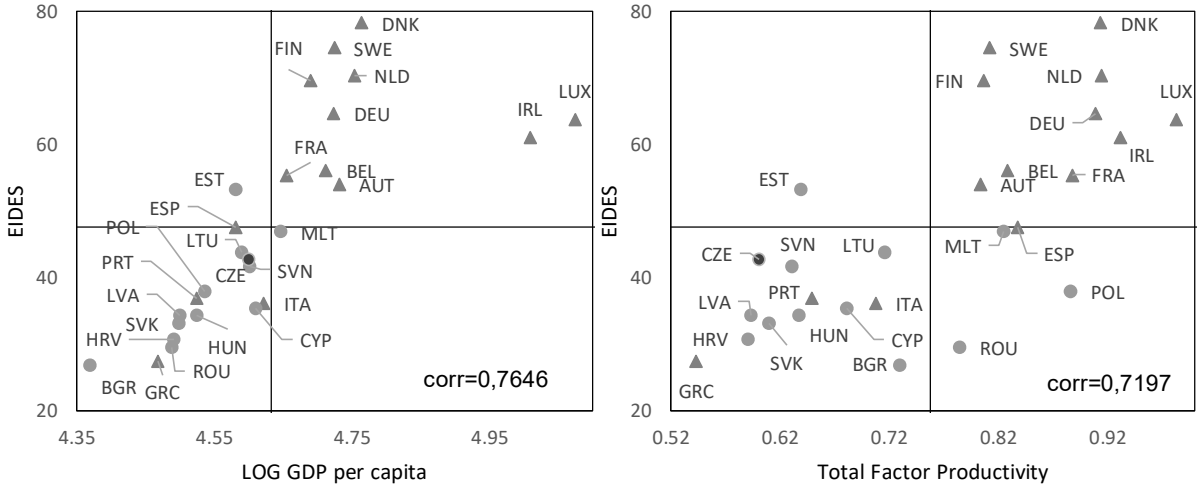
Figure 1 EIDES score by country, 2020



Source: based on data from Autio et al. (2020)

As was already mentioned, productivity and economic growth are important for boosting competitiveness, socio-economic development and tackling poverty. The relationship between digital performance and productivity is depicted using bivariate correlations between EIDES and GDP and total productivity cost – see Figure 2.

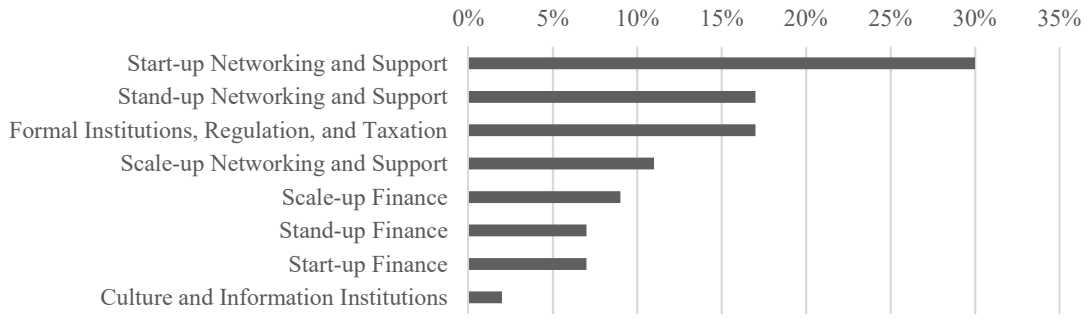
Figure 2 Bivariate correlations between EIDES and productivity



Source: based on data Autio et al. (2020) and World Bank (2022)

The figure shows the existence of a moderately strong linear dependency between EIDES and indicators representing productivity. According to European Commission (2022a), there is a secular stagnation in productivity growth despite the huge potential of the ICT revolution. This productivity puzzle is partly explained by increasing productivity polarization, declining business dynamism and the high cost of human capital for firms adopting new digital technologies. EIDES offers possible scenarios of policy optimization simulation: The allocation of additional resources among pillars to reach a 10% increase in EIDES score – see Figure 3.

Figure 3 The Czech Republic's policy optimization simulation: Allocation of additional resources among pillars to reach a 10% increase in EIDES score

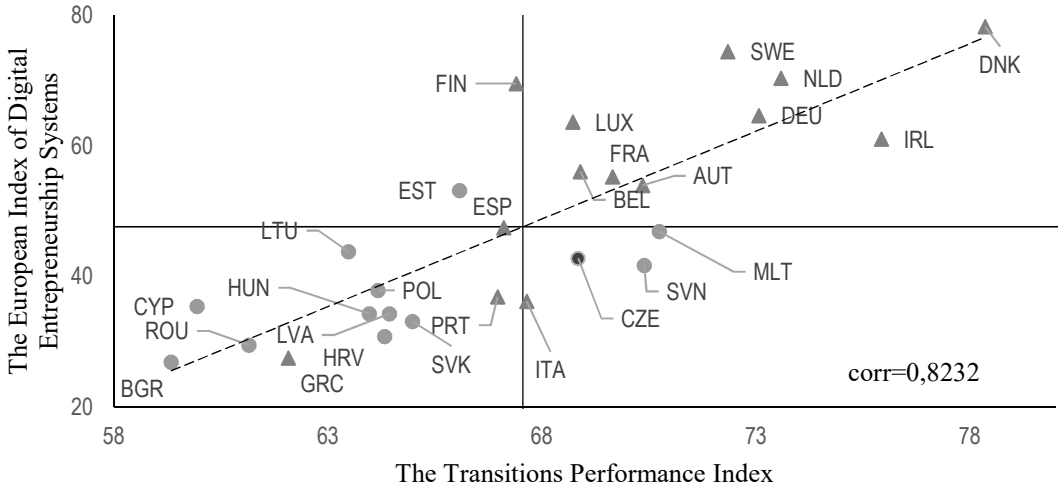


Source: based on data Autio et al. (2020)

It is advisable to allocate resources primarily to Networking and Support (start-up, stand-up and scale-up), i.e. to improve attitudes towards entrepreneurs, strengthen external support for start-ups and also support clusters and value chain development. Improvements in the state of formal institutions, regulation and taxation are also important for the Czech Republic, i.e. important formal institutions and tangible structural conditions (e.g. education level of the population; quality of regulations and entrepreneurship policy interventions; and the availability of resources for entrepreneurship) are important for entrepreneurial activity. Furthermore, the country should support automation, robotization and the use of digital technologies, which are factors targeted by the system program in the area of innovations called The Country for the Future, which is financed by the Czech Ministry of Industry and Trade.

In order for these changes to take place, it is also important to monitor the degree to which the economy is capable of moving towards being sustainable. The Transition Performance Index (European Commission, 2021b) was created in order to capture the ability to transition. The relationship between EIDES and TPI is depicted in Figure 4.

Figure 4 Bivariate correlations between EIDES and TPI



Source: based on data Autio et al. (2020) and European Commission (2021b)

The figure shows a relatively strong positive linear dependency between EIDES and TPI. The results of the TPI scores for the Czech Republic make it evident that it belongs to the group of countries in so-called "strong transition". According to the European Commission (2021b) at the global level, the United Kingdom, Malta, Slovenia, France, Czech Republic, Italy, Japan and Estonia have room for improving their economic transition. There is also room for improvement in the Czech Republic in the area of Proportion of People with ICT Skills, and the country should also focus on heightening the ratio of women in ICT and women employed in the area of R&D, as the Czech Republic has one of the lowest ratios of female researchers among EU member states. Unfortunately, the Czech Republic has a relatively low output per worker. Generally speaking, the country should implement new elements on the labor market with the goal of solving the insufficient offer there – this primarily concerns adopting new digital technologies and utilizing shared work spaces or part-time work.

Exploring the relationships between digital transformation and economic growth is of fundamental importance, and for this reason a score of authors have devoted themselves to this research. For example, Aly (2020) confirmed a positive relationship between the digital transformation index and economic development, labor productivity and job employment. On the other hand, however, it is necessary to consider the time needed for technological progress to manifest itself in the growth of various economies, as pointed out by Park and Choi (2019).

5 Conclusions

Modern technologies have a fundamental effect on the development of the entire society, and it is therefore, necessary to examine their influence and to deal in particular with their impact on economic growth. The development of the selected composite index showed a shift in digitalization in the Czech Republic. Further calculations confirmed the positive relationship between digital performance and productivity. Therefore, it is possible to join the argument that digitalization and digital transformation are important factors enabling the acceleration of development and ensuring economies' growth and competitiveness.

The analysis clearly shows the existence of a moderately strong positive linear relationship between digital transformation and productivity. Despite the massive potential of the digital revolution, there is a secular stagnation in productivity growth. In addition to digital transformation, the economies of the EU should focus on their overall ability to transition, as economies that are successful in adopting new digital technologies and economic transitioning can successfully heighten their productivity. Opportunities are visible in the Czech Republic in the support and development of the following areas: attitudes toward entrepreneurs, strengthening external support for start-ups, and supporting clusters and value chain development. It is also important for the Czech Republic to improve the state of formal institutions, regulation and taxation. In terms of strengthening the economic transition, the Czech Republic should – in addition to adopting new digital technologies – focus on other possibilities of dealing with an insufficient work force on the labor market and also heightening the ratio of ICT employees while also taking the gender dimension into account.

Investments in new technologies and infrastructure, increasing digital competencies, and the development of innovation ecosystems, knowledge transfer and networking continue to be key prerequisites for developing the digital economy. However, for a successful transformation and further progress, it is no less important monitor and measure the digital performance of individual countries regularly and set possible recommendations for particular areas of digitalization for the future.

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