Digital Inequalities

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The proliferation of digital technologies in most countries brings significant benefits from their use. These so-called digital dividends have a positive impact on economic growth, widening the scope for socio-economic development. However, their unequal distribution across countries makes digital technologies not equally beneficial to all countries and entities, and is gradually deepening the digital divide resulting in a gap in terms of between-countries income inequalities. These can be afterwards translated into other socio-economic characteristics of the countries. In the paper, we evaluate the digitization level of EU countries within the panel of 62 world's countries. Using the data envelopment analysis (DEA) method, we examine the extent to which unequal distribution of digital readiness across countries translates into the level of their economic performance. At the same time, we identify potential digital enhancements to bring the country closer to efficiency.

Keywords: digital inequalities, socio-economic development, data envelopment analysis, economic growth

Introduction

Economic development in both global and regional dimensions is increasingly influenced by the rapid development of information and communication technologies, by the use of big data, metadata, digitization, and the development of artificial intelligence. The mentioned processes bring unprecedented dynamics of changes in economic processes, institutional structures, ways of creating wealth (and its distribution), social and cultural relations. The creation of new intelligent digital networks penetrates all spheres of society – it is changing forms of well-being, the nature of work, the conditions for applying to the labour market, the way people interact, the nature of economic-political decisions.

A country's ability to create conditions for economic growth and increase its competitiveness is increasingly conditioned by the level of its digital maturity. At the same time, maintaining a high level of digital progress depends on the country's economic level; economically advanced countries generally reach higher digital levels. According to the European Commission (2017), digitization allows higher productivity through the whole economy, which conducts to lower prices and higher real income, while increased real income tends to higher standards of living. Some researchers though point out that digitalization itself does not ensure increasing returns in productivity and that has negative impacts on social domains not limited to labour demand.

The development of digital processes is particularly important because there is a close link between the level of digitization and the country's economic performance. Digitally developed countries are usually leaders in the creation, management and use of digital technologies, and use these technologies very effectively. They are able to continually create new digital impulses and create new demand for digital technologies. Maintaining a high level of digital progress promotes the growth of their economic performance, which subsequently supports the development of digital innovations and technologies, creating a positive growth circle. Low levels of digitization makes a country less attractive to investors.

The reverse side of unprecedented opportunities and benefits of digital infrastructure, applications and meta-data include many challenges and dilemmas that digital technology brings. New asymmetries arise, the so-called 'digital divide,' in terms of unequal conditions in access to information and communication technologies, resulting in very different impacts on performance and competitiveness of companies, regions, countries. It has the potential to create inequalities both on occasions and in output (income, wealth).

In this article, we will focus on the macroeconomic aspect of the impact of digitalization on inequality in the output, which will be evaluated with GDP per capita. We examine the interconnection of digital levels and economic performance evaluating the extent to which the effective absorption of individual elements of the digital maturity to the economic development of the country. Considering economies as entities that employ resources in order to deliver desirable outcomes, the question of efficiency of such transformation arises. The nonparametric method used allows to determine best practice countries forming efficiency frontier that acts as benchmarks for evaluation. For inefficient subjects, sources of potential improvement could be identified.

Literature Review

Digitization penetrates all spheres of society, creating strong impulses for economic development, brought to the fore by unprecedented dynamic changes in economic processes, institutional structures, ways of wealth creation (and distribution), social and cultural relations. Significant digital innovation creates room for improving efficiency in the use of growth factors, enhancing institutions and services, expanding space to improve quality of life for inclusive and environmentally sustainable growth. Digitalization is the first lever of growth for companies, it improves productivity because digitizing and automating a number of processes within companies enable them to focus on high value-added tasks and the rise of digital tools improves their competitiveness and enables them to better know and understand their customers in a favour of well-being (Garnier, 2018). Micro-level performance of the firms translates into the nation-wide macro level. Draca, Sadun, and van Reenen (2006) provide a survey of the empirical evidence that digitally mature countries tend to have rather high level of competitiveness and performance.

Countries that have firms acting as developers of platforms and managers of digital technologies are those most likely to reap the benefits that arise from the digital economy – i.e. better prospects in terms of long-term growth, job and wealth creation, and lasting positive effects on productivity and competitiveness. Their populations and firms are those that tend to benefit the most from the indirect effects of being in a richer, open, and innovative environment (Arbache, 2018). Understanding the process of digital transformation involves accepting that this transformation affects all industries; that the digital gap between developed and developing countries has been inverted as time has gone by, while users in the latter countries are becoming increasingly relevant and influential players. Although the majority of organizations are already adjusting and reorganizing to adapt to the demands of this new digital economy, not all of them are at the same stage of digital development (Cerezo, Magro, and Salvatella, 2014). Control over digital space facilitates benefits in the global competition, as well as a large part of the global market domination. World Economic Forum (2012) states that 'the economic impact of digitization accelerates as countries transition to more advanced stages.' The ongoing digital transformation promises to spur innovation, generate efficiencies across a wide range of activities, and improve well-being as information and knowledge become more widely available and democratized (OECD, 2017).

The most valuable factor in the digital economy is intellectual capital, innovative ideas and intangible assets, while the importance of tangible assets recedes into the background. As a result, demands for education and skills are increasing. In the context of the need to restore productivity growth, the focus has recently been on increasing the share of intangible investment in total investment (Thum-Thysen, Voigt, Bilbao-Osorio, Maier, and Ognyanova, 2017) This has a strong potential to influence factor efficiency and growth of total factor productivity (TFP). Intangible investments improve productivity and capital, increase the growth impact of innovation, counteract declining returns and account for up to one fifth of the labour productivity growth in the EU (Corrado, Haskel, Jona-Lasinio, and Iommi 2016). The growing share of intangible components in the final value of goods, coupled with the increasing ease of access to digital technologies, platforms, and advanced capital goods, are radically transforming our understanding of the production and distribution of wealth. It is no exaggeration to predict that firms will increasingly rely on artificial intelligence for basic routines and for more complex tasks (Arbache, 2018). In the future, the factors that enable economies to invest in information and monetize new knowledge and discoveries will be key drivers of growth. So, for example, IP policy is likely to be of increasing importance along with broadband/communications equipment. Digital technologies can have considerable impacts on productivity growth (Czernich, Falck, Kretschmer, and Woessman, 2011), but only when investments in ICT (Information and Communication Technologies) are combined with investments in complementary assets, such as skills, organizational changes and process innovations, i.e. knowledge-based capital (OECD, 2004).

Digitization also facilitates the creation of new and better products and services with fewer resources, reduces physically demanding efforts and exposure to dangerous activities in the workplace. Much of this is yet to come. For those embracing this revolution with technological know-how, the digital economy offers plenty of opportunities: for IT-savvy workers, for creative people, for SMEs, for traditional industries, for disadvantaged regions, etc. (European commission, 2017). Discounting sensors and other digital devices and their gradual miniaturization allows their involvement in mass production processes, transport and energy networks, households, health care, financial institutions, etc. (European Commission, 2017). According to the *Harvard Business Review* (2017), digital technology, automation, artificial intelligence and metadata could influence about 50% of the world economy, while the current technology can automate more than a billion jobs (14.6 billion US dollars in the form of wages).

On the other hand, digitization poses serious risks to many areas. It brings a lot of uncertainty, 'disrupts society ever more profoundly and, as a result, concern is growing about how it is affecting issues such as jobs, wages, inequality, health, resource efficiency and security' (World Economic Forum, 2018). Inflexible management of digital processes would push the country into a digital backwater narrowing its potential for socio-economic development. The speed of development of digital processes and the ability to manage them creates room for digital inequalities between countries. Digitalization, like previous technological advances, will have repercussions on labour markets. Some jobs will be replaced, some will be created, and many will be transformed. A more efficient use of human energy brings a high risk of replacement of routine work activities, generally performed by low-skilled labour force, increasing thus social inequality. For the moment, it is impossible to estimate the job replacement and job creation effects with any degree of certainty. For some developed countries, a preliminary assessment was carried out by Eichhorst, Hinte, Rinne, and Tobsch (2016). Though for every job destroyed by the Internet, 2.6 jobs is created (McKinsey Global Institute, 2011), new jobs may not go to the same people as the old ones, and may not go to the same geographic areas (European Commission, 2017). In this way, digitization can affect the positive or negative range of inequalities.

Empirical work supporting the decision-making process on the macroeconomic level has so far employed parametric regression analysis focusing predominantly on the impact of digitalization on performance, e.g. Katz and Koutroumpis (2013), Kretschmer (2012), Gruber, Hatonen, and Koutroumpis (2014). Since digital readiness plays a critical role in determining countries' future growth paths, a suitable supportive benchmarking analytical method is needed to identify shortages. With this regard, a non-parametric benchmarking tool is more appropriate providing a routine for multidimensional assessment. Policy-makers could thus concentrate efforts and utilize public funds in the most efficient manner. The next section explains the measurement of digitalization maturity and progresses to efficiency assessment.

Data and Methodology

A common feature of the assessment of digitization is the assessment of the quality of support and the pace of development of digital technologies, potential of the digital economy and digital impulses. The process of shaping the digital industry is also examined along with its attractiveness to the market and access to the digital market. In assessing the quality of digital transformation, most of the focus is placed on examining the educational level of the country and its scientific and research potential. Great importance is also given to assessing the quality of the institutional framework, as the potential of the digital economy and digital impulses is highly diversified in individual countries due to divergent regulations, economic development and economic policies.

Success of managing the digital transformation process in all its aspects reflects the level of digital competitiveness that has recently been explored by the International Management Development Institute (IMD). IMD perceives digital competitiveness as an economy's ability to adapt to digital technologies that accelerate change across the public and private sectors within the whole society. On the basis of hard and soft data, it evaluates 50 criteria that include organizational, institutional and structural aspects conditioning the digital development of the country and that make it possi-

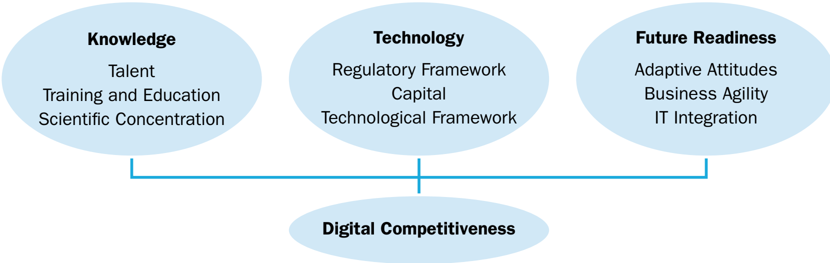

Figure 1 Model of Digital Competitiveness (adapted from IMD, 2017)

ble to assess its strengths and weaknesses. The Compilation Scheme of The World Digital Competitiveness Index (Figure 1) is based on three basic factors into which individual criteria are incorporated.

From the IMD point of view, the development and absorption of digital technologies is essential for the development of the intangible infrastructure of a country, which is assessed through a sub-factor of knowledge. The focus is primarily on the ability to discover, understand and use new technologies. The assessment of the availability of researchers and scientists (the level of outflow of high-tech researchers and the ability to attract highly skilled workers from abroad) is assessed, the level of research spending on development, the quality of scientific-research capacity (given the concentration of knowledge creation needed for the digital transformation of the economy).

The quality assessment of the technology environment is geared to the country's ability to develop digital innovation and technology. Within the technological environment, the extent to which supportive regulatory framework creates the conditions for the effective functioning of business dynamism and innovation is examined. The availability of capital and the level of investment in technological development is also assessed. The degree of investment risk in the country under assessment, and the extent and quality of physical technology infrastructure is taken into account. Finally, the level of high-tech production is considered in the country. The last factor in digital competitiveness reflects the economy's readiness for future development, the success of adaptation to innovative ideas and technologies, and it assesses the level of agility in the country, as well as the level of integration of digital technologies into the economy. The country's position in digital competitiveness reflects the success of its digital transformation. The maximum value of the World Digital Competitiveness Index (100) is assigned to the most digitally available country. The IMD evaluates 63 countries as part of the global digital competitiveness assessment. Quality of individual sub-factors and their components determine the efficiency of digital potential into economic performance transformation. The question that arises is to what extent the digital quality measured by the level of digital competitiveness translates into the economic achievement of European countries or whether there is a potential for improvement in this 'transformation process.'

With the multidimensional measure of digitalization at hand, we proceed to examine how efficiently this resource translates into the economic outcome. Quantitative assessment could be facilitated by conceiving a transformation process with economic performance as output reinforced by digital capacity as multidimensional input. Other determinants are contained in the black box of the technology of transformation. The goal is to assess the efficiency of that transformation. In general, for evaluating technical efficiency of the processes involving quantities for which no market prices exist, data envelopment analysis (DEA) models are often used. In DEA, a black box technology (transformation) efficiency is defined as the ratio of the outgoing and entering quantities permitting possible multidimensionality of both. Typically, efficiency scores range between 0 and 1, the latter score value being ascribed to the relatively efficient subjects. These best practice entities make up the *efficiency frontier.* Against that boundary, all the other subjects are then benchmarked. The efficiency score reflects production of the output, given the amount of inputs. In our proposed model, countries (entities under evaluation) with higher scores would achieve higher levels of wealth, given the level of their digital competitiveness.

The assessment itself involves solving an optimization problem employing output-oriented SMB model (Tone, 2001):

$$\rho = 1 + \frac{1}{m}\sum_{r-1}^{s} s_r^{-1}/x_{i0}, \tag{1}$$

$$x_0 = X\lambda + s^-, \tag{2}$$

$$y_0 = Y\lambda + s^+, \tag{3}$$

$$\lambda, s^-, s^+ \geq 0,$$

where X and Y denote input and output data matrices, $x0$ and $y0$ are inputs and outputs of the country under evaluation. Objective function ρ represents the efficiency score while λ act as intensive variables generating the efficiency frontier. Slacks s^+ and s^- represent deviations from the best practice performance. In this setting, efficient units' (countries) score is unit, efficiency score of the rest is given by $1/\rho$. Thus all the subjects under evaluation can be ordered by their performance. Moreover, decomposition of inefficiency is possible to identify potential for improvement in specific domains of assessment. The technology is assumed to exhibit constant return to scale.

In our model, GDP per capita is acting as an output proxy for economic performance, data is placed in matrix *Y*. (IMF, 2018). The input data (matrix *X*) entering the model – three components of the digital quality – come from the IMD World Digital Competitiveness Ranking (2018). Taking a global perspective, we assess the European countries within the set of the world's countries, allowing for benchmarks to be found outside of Europe itself.

Results and Discussion

The efficiency of transforming the digital maturity of a country into its economic performance depends on the quality of the individual factors that enter the design of the digital competitiveness index. As shown in Figure 2 (figures in brackets), the United States is the digitally most competitive, which has replaced Singapore in this position. From European countries, the Scandinavian countries, Switzerland, the Netherlands and the United Kingdom rank best in terms of digital competitiveness. Significant improvements in the relative position of digital competitiveness have been achieved by Bulgaria, Austria and Romania over the last five years. The negative development of digital competitiveness is the deterioration of several countries, especially Greece (a 35-digit deterioration in the digital competitiveness index), as well as Hungary and Slovakia, whose positions have dropped by 10 seats. Slovakia is the last third within the assessed countries, currently 50th. Of the EU countries, only Greece and Cyprus report lower digital competitiveness. According to the European Commission, the potential of the EU digital economy is currently hampered by the incoherence of the European political framework, causing many European countries to lag behind the most digitally dispersed economies in the development of digital networks that underlie the digital economy and business. If we look at the percentage of digital transformation potential in the economic performance of the countries under review, in Figure 2, we see that, in addition to the US and Singapore, only four European countries managed to effectively implement the transformation process – Denmark, Luxembourg, Norway, Switzerland. Six countries form the benchmark boundary (reaching the value of one). However, Denmark, Switzerland and Luxembourg only act as peers for themselves, which is considered a sign of outlying data in DEA literature. Other countries' distance from the efficiency frontier is much more differentiated.

Sweden and Finland are relatively close to the border of the effectiveness within the EU countries. These least-penalized countries achieve roughly the same level of inefficiency or penalties, as the level of efficiency of transforming digital competitiveness parameters into economic performance achieved by Cyprus, Hungary, Greece, Romania and Slovakia. Regarding the structure of potential improvement, the lowest level of improve-

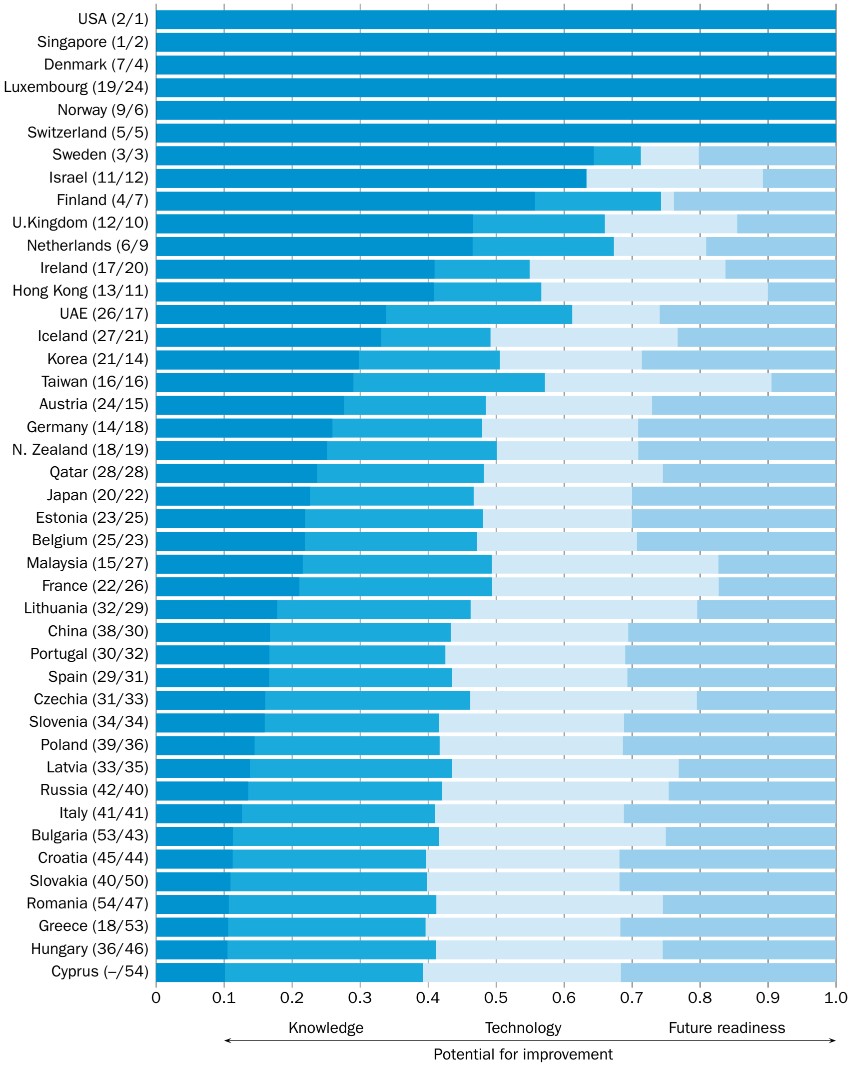

Figure 2 Efficiency of the Digital Quality-to-Economic Performance Transformation (numbers in brackets represent change in rank between 2017 and 2018; authors' calculation based on IMD, 2018)

ment is in education. The most digitally competitive countries are increasing the demands on intellectual capital, quality of education and digital skills. Within penalized countries, only Israel has managed to fully transform education into its economic performance. Education has contributed very little to the overall level of penalization in Sweden, but also in Ireland, Finland, Iceland and the United Kingdom. Many EU economies achieved a very high degree of penalties in education. Hungary, Romania, Bulgaria, Latvia, as well as Cyprus, Greece and Slovakia, have the lowest ability to discover and exploit new technologies and to support the development of research capacities for digital transformation.

Technology, i.e. the ability of countries to develop digital innovation and technology and to promote innovative dynamism is one of the sub-factors of digital competitiveness, the percentage of transformation in economic performance is the lowest within the countries surveyed. At least, it penalizes those Nordic countries that are not on the border of efficiency, as well as the Netherlands and the United Kingdom. Among EU countries, Romania, Bulgaria, Hungary, Latvia and Lithuania are the least effective at transforming the technology sub-factor into their economic performance. In the area of economic readiness for future development, Taiwan, Hong Kong and Israel are lagging behind effective countries at least. Within the EU, the United Kingdom, Ireland and France achieve the lowest distance from the most effective countries. The least disposed countries in the region are Croatia, Slovakia, Greece, Cyprus and Poland.

Conclusions

Despite the fact that the EU sees huge growth potential in the successful digital transformation of its countries and creates platforms for its support and development, the position of most of its countries in digital competitiveness has deteriorated over the past 5 years. The lagging of most EU countries behind the most digitally competitive countries suggests their lack of preparedness for the challenges of the digital age in all sub-factors. These facts make the extent of inefficiency in transforming digital maturity into economic performance conditional. The potential for improving countries that are below efficiency is mainly in the digital age of people and businesses. Inefficient countries must create the conditions for increasing the level of digital education, improving the quality of mathematical and technological knowledge, and creating the conditions for attracting highly qualified students and workers to the country.

A prerequisite for the growth potential of the education sub-factor is to increase spending on research, development and investment in education, in particular digital education. In the technological environment, inefficient countries need to address bottlenecks in technology development and application, science and research legislation, technology development funding, investment risks, the development of the telecommunications sector, and the scope of broadband wireless connectivity. From the perspective of improving the effective transformation of digital quality into economic performance, inefficient countries need to focus mainly on digital challenges in the future, adapt rapidly to the global digital environment and increase protection against cyber threats.

The unsatisfactory position of several Member States in digital competitiveness is, on the one hand, slow or slowing. No progress (or decline) in all of its areas, on the other hand, tells that more competitive digital countries are moving much faster and more vigorously in the development of the digital society. Among EU countries, Cyprus, Hungary, Greece, in particular, are achieving a low level of digital maturity transformation into economic performance, a possible underpinning of economic development in the future. These are countries whose position in digital competitiveness has deteriorated significantly over the past five years. Despite the fact that the level of digital competitiveness is low in Romania and Bulgaria, it is positive that both countries have seen a significant improvement in their position over the period under review.

Overall, however, we can see that many EU countries are limited in their economic performance by the level of digital maturity. There is, therefore, a real threat that the current digital inequality between digitally competitive and digitally less disposed countries will eventually deepen the inequality between them.

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References

Arbache, J. (2018). Seizing the benefits of the digital economy for development. Retrieved from: https://www.ictsd.org/opinion/seizing-the-benefits-of-the-digital-economy-for-development

Cerezo, P., Magro, C., and Salvatella, J. (2014). Digital transformation and its socioeconomic impact. Retrieved from http://www.rocasalvatella.com/sites/default/files/articulo/rs-transf_digital_eng_1.pdf

Corrado, C., Haskel, J., Jona-Lasinio, C., & Iommi, M. (2016). *Intangible investment in the EU and US before and since the Great Recession and its contribution to productivity growth* (EIB Working Papers 2016/08). Kirchberg, Luksemburg: European Investment Bank.

Czernich, N., Falck, O., Kretschmer, T., & Woessman,L. (2011). Broadband infrastructure and economic growth. *Economic Journal, 121*(552), 505–553.

Draca, M., Sadun, R., van Reenen J. M. (2006). *Productivity and ICT: A review of the evidence* (CEP Discussion Paper No. 749). London, England: London School of Economics and Political Science.

Eichhorst, W., Hinte, H., Rinne, U., & Tobsch, V. (2016) *How big is the gig? Assessing the preliminary evidence on the effects of digitalization on the* *labor market* (IZA Policy Paper No. 117). Bonn, Germany: Institute of Labor Economics.

European Commission. (2017). *A concept paper on digitisation, employability and inclusiveness the role of Europe.* Retrieved from https://ec.europa.eu/newsroom/document.cfm?doc_id=44515

Garnier, C. (2018). *Digitalization: A well-being and growth factor.* Retrieved from: https://www.dunforce.com/en/digitalization-well-being-and-growth/

Gruber, H., Hatonen, J., & Koutroumpis, P. (2014). Broadband access in the EU. *Telecommunications Policy, 38,* 1046–1058.

Harvard Business Review. (2017, 12 July). 60 countries' digital competitiveness, indexed. Retrieved from https://hbr.org/2017/07/60-countries-digital-competitiveness-indexed

IMF. (2018). World outlook database. Retrieved from https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx

IMD. (2017). IMD World digital competitiveness ranking 2017. Retrieved from https://www.imd.org/wcc/world-competitiveness-center-rankings/world-digital-competitiveness-rankings-2017

IMD. (2018). IMD World digital competitiveness ranking 2018. Retrieved from https://www.imd.org/wcc/world-competitiveness-center-rankings/world-digital-competitiveness-rankings-2018

Katz, R., & Koutroumpis, P. (2013). Measuring digitization: A growth and welfare multiplier. *Technovation, 33,* 314–319.

Kretschmer, T. (2012). *Information and communication technologies and productivity growth: A survey of the literature* (OECD Digital Economy Papers No. 195). Paris, France: OECD Publishing.

McKinsey Global Institute. (2011). *Internet Matters: The Net's Sweeping Impact on Growth, Jobs and Prosperity.* Retrieved from https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/internet-matters

OECD. (2004). *The economic impacts of ICT: Measurement, evidence and implications.* Retrieved from http://dx.doi.org/10.1787/9789264026780-en

OECD. (2017). *Going digital: Making the transformation work for growth and well-being.* Retrieved from https://www.oecd.org/mcm/documents/C-MIN-2017-4%20EN.pdf

Thum-Thysen, A., Voigt, P., Bilbao-Osorio, B., Maier, C., & Ognyanova, D. (2017). *Unlocking investment in intangible assets* (European Commission Discussion paper 047). Retrieved from https://ec.europa.eu/info/sites/info/files/economy-finance/dp047_en.pdf

Tone, K. (2001). A slacks-based measure of efficiency in data envelopment analysis. *European Journal of Operational Research, 3*(130), 498–509.

World Economic Forum. (2012). *The Global Information Technology Report 2012.* Retrieved from http://www3.weforum.org/docs/Global_IT_Report_2012.pdf

World Economic Forum. (2018). Understanding the impact of digitalization on society. Retrieved from: http://reports.weforum.org/digital-transformation/understanding-the-impact-of-digitalization-on-society

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