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DOES THE FOREIGN DIRECT INVESTMENT ENHANCE DIGITAL READINESS?

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Abstract

Paper focuses on studying the role of foreign direct investment in improving technology and digitalization in central and southeast European countries. Frontier technology readiness index is a measure which is positively affected by investment. Apart from the foreign direct investment, 12 variables are used in panel regression analysis. The variables represent different areas, such as the performance of the economy, international trade, labour, education, research and digital infrastructure. The data used consist of 17 cross-sectional units – countries from central and southeast Europe and 12 time series – period 2008-2019 for which the Index is available. The result indicates that the FDI inflow has positive and statistically significant effect on the score of the Index. It means that the higher the FDI inflows to a country, the higher the Index score. In other words, foreign direct investment might be considered as the factor enhancing the digitalization, technology improvement and country readiness to use, adopt or adapt advanced technologies. The result confirms the technological spill-over effect of foreign direct investment to host economy.

Key words: *digitalization, Frontier Technology Readiness Index, foreign direct investment, central and southeast Europe*

JEL Classification: *F21, O33, O52*

1. Introduction

The current development shows the necessity for digital transformation, meaning shift to digital environment and the adoption of advanced technologies. It is clear that countries that already launched this process have a comparative advantage compared to the countries that are lagging behind in the use of technologies and digitalization. The state of the digitalization and technological level differs also within European countries, even those in the same region. One of the factors that would affect the technological progress and the digitalization in a country is the foreign direct investment inflow. The positive impacts of the FDI inflow are investigated by many researchers. One of the positive impacts commonly found in FDI analysis is technological spill-over effect that is considered as the

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improvement of the technologies and enhancement of digital progress in host economies. The higher the FDI inflow to a host economy, the better technologies would be implemented, and country would achieve higher technological development and digitalization. To measure the country readiness to launch, adopt and adapt advanced technologies, United Nation Conference on Trade and Development (UNCTAD) has established the Frontier Technology Readiness Index (FTRI) that has several sub-indexes and is created by considering several indicators. The FTRI measures how a country is prepared to adopt new technologies considering variables as internet users, internet speed, speed, years of schooling, high skill employment, publications, patents, high tech export, digitally deliverable services export or access to finance by domestic credit to private sector. In this regard, we would assume that the FDI inflow has a positive impact on the FTRI, which would represent the level of the technology and digitalization in a host county or investment. Even though the Index is not able to capture all aspects of digitalization and technologies, it is a very good parameter that is available for all analysed countries using the same measurement methodology, avoiding differences in methods to measure or evaluate technological level and digitalization across countries.

This paper focuses on the analysis of the role of the foreign investments (represented as FDI inflow to host country) as the determinant of the digitalization development (represented by the FTRI) in central and southeast European countries. The concept of the paper is based on the general assumption that FDI inflow positively affects the level of technologies used in host countries due to technological spill-over effects coming from foreign affiliation to domestic firms, or due to necessity of domestic firms to adopt new and innovative production in order to compete with companies with foreign ownership. The paper is structured as follows. First part provides the literature review of the digitalization, technological progress and development and the role of the foreign direct investment. Second part deals with the methodology of the paper and data description. The results and discussion part focus on the output of the analysis. The last part summarizes the main findings of the paper.

2. Literature review

The research on the Foreign direct investment is extensive and the area is well investigated. Foreign direct investment has often a crucial role in the transformation process of economies, including adopting new and advanced technologies that were not used formerly in host countries of investments. The technology spillovers resulting in the economic growth are evident and proved by many authors (e.g. Asongu and Odhiambo 2020; Borensztein, De Gregorio and Lee 1998; Blomström and Kokko 1997 and 2002; Combes, Kinda, Ouedraogo and Plane 2019; Dimelis and Louri 2004; Gherigi and Voytovych 2018; Javorcik 2004; Khan, Asteriou and Jefferies 2023 or Sadik and Bolbol 2001). The feature of the FDI has changed over the past years. There are still market seeking, resource seeking and efficiency seeking FDI, but in the current digital environment, the technology-seeking investment is on the rise. The study by Kim and Choi (2020) indicates that there is a curvilinear relationship between FDI inflow and technological capability of the host country. FDI is especially high when host countries have extremely high technological capability or extremely low technological capability (Kim and Choi 2020, p. 13). Such result is different as commonly a linear relationship between the FDI and technological level is assumed. However, the result might be affected by the motives of investors. If investments are resource or efficiency-seeking and technologies are imported to the country, there is no necessity for a well-developed technological capacity or infrastructure. Otherwise, if investments are technology-seeking or knowledge-seeking, the technological capacity is required.

The foreign direct investment might be driving force to enhance and support digitalization process in host economies by launching new technologies and close the digital divide between home and host countries. However, the promoting agencies and governments must be willing to provide conditions allowing those investments flowing into a country and be helpful in building adequate infrastructure. Attracting more foreign direct investment into the digital economy will not only be a key strategy for economic recovery after the Covid-19 pandemic, but it will also be a key strategy in building the digital infrastructure, digital entrepreneurship, and digital literacy, which are crucial for success in the new digital world (Satyanand 2021, p. 5). The world is characterized by a clear distance between hyper-digitalized and under-connected economies (Nguyen 2023, p. 2). The divide is significant in some sectors, such as frontier technologies and digital data (Nguyen 2023, p. 2). The digital economy benefits firms in both developed and emerging markets – as long as the country has a strong ICT infrastructure (Eden 2016, p. 6). Foreign direct investment will not flow to host countries with weak telecommunication infrastructure, even if other areas are developed. The frontier technologies

necessary to adopt include automation and robotics, internet of things, 3D manufacturing, cloud computing, blockchain or artificial intelligence. Ha and Huyen (2022) found that that digitalization plays a critical role in promoting FDI inflows in both short term and long term (Ha and Huyen 2022, p.1). They have used the feasible least square estimation for 23 European countries for two periods – 2015-2019 and 2020 (i.e., during the pandemic). In a policy brief for the Western Balkan, Mrdović (2023) stated that international players have helped to advance digital infrastructure, promote digital skills, and assist in the execution of digitalisation programmes. This was not only thanks to the financial support, but also by improving the technical know-how and knowledge exchange. Creating a digital-friendly investment climate may require specific policies, regulations and measures (Eden 2016, p. 16). Such environment would increase country digital competences and attract more FDI in the digital economy associated with other FDI benefits. FDI brings not only a capital, but also knowledge, and technology, which increase the digital capacities of investment host county (Eden 2016, p. 1). The role of the FDI in improving digitalization in very important. As noted by the UNCTAD, one way to grow the digital economy and increase digital competitiveness is through attracting FDI. The digital economy has important implications for investment, and investment is crucial for digital development (UNCTAD 2017, p. 158). The relation between the FDI and digitalization is mutual. The FDI inflows require some satisfactory level of digital infrastructure and at the same time, the foreign investments improve the level of digitalization.

Despite the possibilities that technological and digital advances allow, the digital transformation has not spread uniformly throughout the world, nor has it caused the same effects in all countries equally, as some have benefited more than others (Parra, Pérez-Pons and González 2012, p. 182). The adoption of advanced technologies and digitalization is the factor affecting the performance of economies. Parra, Pérez-Pons and González (2012) found that Digital Adoption Index is significant variable affecting the economic growth (Parra, Pérez-Pons, and González 2012, p.187). They analysed the group of 176 countries during two periods – 2014 and 2016 – using the GMM estimation method. Authors provide estimation for the overall sample and then differently for Europe, Asia, Americas and Africa. When analysing Africa and Americas, the Digital Adoption Index resulted to be non-significant. Zhang, Zhao, Cheng, Li, Wang, Yang and Tian (2022) also examined the relations between the digital economy and the economic growth for "Belt and Road" countries that consists of 31 countries from Europe and Asia (the list might be found in Zhang, Zhao, Cheng, Li, Wang, Yang, and Tian, 2022, p. 7). Firstly, they developed a comprehensive evaluation system of digital economy consisting of different categories as digital infrastructure, digital economy openness, digital technology innovation environment and competitiveness (Zhang, Zhao, Cheng, Li, Wang, Yang, and Tian, 2022, p. 4). These categories include several indicators that characterize each category. The authors used several variables determining the GDP of a country, including the digital economy development score. For this purpose, a panel regression analysis with fixed effect was used, as well as GMM method. The digital economy development that was established by authors has been found to have positive and statistically significant impact on the economic growth.

3. Data and methodology

The literature review and studies by international organizations provide various determinants and factors affecting the level of technologies that are established and rooted in a country. At the same time, literature identifies factors, which might be significant to enhancing technological development. For the analysis, the Frontier Technology Readiness is used as the measure of the technologies used in a country and the readiness of a country to use advanced technologies. The index is then considered also as the level of digitalization in a country as it includes indicators related to digitalization. We used the index as we assume that FDI itself automatically does not increase digitalization and technological improvement in a country. In case of countries, which transitioned from centrally planned to market economies, the FDI has spread to different industries and economic sectors, including sectors without important technological aspect, e.g. manufacturing. However, the FDI inflow to countries has created preconditions for future technologically aimed investments, e.g. to development centres or other research units. In addition, the spill-over effects of the FDI are not immediate but appear after some time. The index is available since 2008 until 2019 and captures 158 countries and is comparable between all countries. It means that index, unlike some other digitalization indexes, e.g. DESI, is available for all analysed countries. For years 2021 and 2023, the score of the Index has only two decimals, while for years 2008-2019, six decimals were provided, and the ranking was not done by the UNCTAD (United Nation Conference on Trade and Development). Therefore, we include only 2008-2019 period in the econometric analysis. In addition, the period since 2019 was affected by the

Covid-19 pandemic, thus we provide the descriptive analysis of the rank for available years in 2021 and 2022.

The Frontier Technology Readiness Index was established by the United Nation Conference on Trade and Development. The Index was developed to assess the country readiness for using, adopting and adapting new technologies. It includes 5 sub-indexes, which are ICT deployment, skills, R&D activity, industry activity and access to finance (UNCTAD, Technology and Innovation Report 2021 p. 144). The short description of sub-indexes and indicators used are summarised in Table 1. The overall index is calculated by assigning the weights generated by the principal component analysis (PCA) with rotation to the three principal components, and then it is standardized and normalized within the range of 0 to 1 (UNCTAD, Technology and Innovation Report 2021, p. 147).

The focus of the analysis is to study whether the foreign direct investment inflow to analysed central and southeast European countries has positive impact on the level of digitalization, technologies and the precondition of the use of new or advanced technologies. We assume a positive and statistically significant variable of the foreign direct investment inflow, thus the higher the FDI inflow to a country, the higher FTRI has country achieved. This assumption would also confirm the positive technology spill-over effects of the FDI on a host economy.

The goal of the paper is to identify and assess the role of the foreign direct investment in affecting the technology readiness of central and southeast European countries.

To study the significance of the foreign direct investment in affecting the technology and digitalization representing by the FTRI, a regression model with 13 variables was used. One of the variables is the FDI inflow. Other exogenous variables represent factors that might have effect on the state of the digitalization in a country – these variables are described in Table 2. Variables represent different areas affecting digitalization, such as the performance of the economy, international trade, labour, education, research or digital infrastructure as well as the international capital flows represented by the inward foreign direct investment. The variables used in the estimation are not included in the FTRI indicators. We consider the FTRI as the

Table 1. Description and indicators used in the Frontier technology readiness index

Sub-index	Description	Indicator	Source	No. of countries
ICT deployment	The level of ICT infrastructure. The use and adoption of artificial intelligence, big, data, block-chain and internet technologies. The ICT infrastructure represents the quality of infrastructure give presumptions for the use of advanced technologies and their effective use.	Internet users (% of population)	ITU	210
		Mean download speed (Mbps)	M-Lab	194
Skills	Adoption and use of technologies requiring qualified and skilled people. The index considers two types of skills – practical and formal training and learning by doing.	Expected years of schooling	UNDP	191
		High-skill employment (% of working population)	ILO	185
R&D activity	R&D activities are needed for adoption and adaption of technologies, as those require adjustment and modification for the use in particular country or industry.	Number of scientific publications on frontier technologies	SCOPUS	234
		Number of patents filed on frontier technologies	PatSeer	234
Industry activity	Adaption of frontier technologies in industry related activities. Technologies are mostly used in high-tech manufacturing, finance and ICT.	High-tech manufacturers exports (% of total merchandise trade)	UNCTAD	216
		Digitally deliverable services exports (% of total service trade)	UNCTAD	186
Access to finance	Better access for funding the private sector to adopt new technologies enhances the technological development.	Domestic credit to private sector (% of GDP)	WB/IMF/OECD	213

Source: UNCTAD, 2021, Technology and Innovation Report 2021, pp. 144-145

expression or measure of the level of the digitalization and technology in a country, i.e., as the creation of readiness to accept technologies by the country.

We use the panel data consisting of 17 cross-sectional data – 17 central and southeast European countries within the period of 2008-2019 for which is the FTRI available. We do not have full sample of data, as several various missing observations for particular years or countries. Countries captured in analysis are Bulgaria, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland. Romania, Slovakia, Slovenia, Albania, Bosna and Hercegovina, Croatia, Greece, Montenegro, North Macedonia and Serbia. The data source is UNCTADstat the statistics of the World Bank – World Development Indicators. All monetary variables are adjusted to constant prices of 2015 base year in USD.

To estimate the role of the FDI in affecting the level of technology and digitalization, a panel regression with fixed effects was used, that includes 13 exogenous variables and endogenous variable FTRI. We expect that foreign direct investment inflow that will have a positive and statistically significant impact on the level of technology and digitalization represented by the FTRI.

The main research question of the paper is to examine if the foreign direct investment inflow into central and southeast European countries affects the level of digitalization represented by the Frontier technology readiness index. Based on the research question, three hypotheses were formulated.

Hypothesis 1: The digitalization expressed by the Frontier Technology Readiness Index has improved in the central and southeast European countries since 2008.

Hypothesis 2: The global position of central and southeast European countries expressed by the ranking in frontier technology readiness index has improved since 2008.

Table 2. The list of variables used in the model

Variable	Description	Measure	Indicator	Source
FTRI $_{i,t}$	frontier technology readiness index	values 0 – 1	-	UNCTADstat
FDI $_{i,t}$	foreign direct investment, inflow to host country	mil. USD, constant prices 2015	international capital flows	UNCTADstat
GDP $_{i,t}$	gross domestic product	mil. USD, constant prices 2015	performance of the economy	UNCTADstat
ICT_SERVICES_EX $_{i,t}$	international trade in ICT services - export	% of total trade in services	international trade	UNCTADstat
ICT_SERVICES_IM $_{i,t}$	international trade in ICT services – import	% of total trade in services	international trade	UNCTADstat
ICT_GOODS_EX $_{i,t}$	international trade in ICT goods - export	% of total trade	international trade	UNCTADstat
ICT_GOODS_IM $_{i,t}$	international trade in ICT goods – import	% of total trade	international trade	UNCTADstat
EPR $_{i,t}$	employment to population ration	% of population, 15+	labour	World Bank - World Development Indicators
ENROL $_{i,t}$	tertiary school enrolment	% of gross	education	World Bank - World Development Indicators
RD $_{i,t}$	expenditure on research and development	% of GDP	research	World Bank - World Development Indicators
RES $_{i,t}$	researchers in R&D	per million people	research	World Bank - World Development Indicators
SERVER $_{i,t}$	secure internet servers	per 1 million people	digital infrastructure	World Bank - World Development Indicators
PHONE $_{i,t}$	mobile cellular subscriptions	per 100 people	digital infrastructure	World Bank - World Development Indicators
BROADBAND $_{i,t}$	fixed broadband subscriptions	per 100 people	digital infrastructure	World Bank - World Development Indicators

Source: Authors' own elaboration.

Hypothesis 3: Foreign direct investment positively affects digitalization in the central and southeast European countries.

4. Results and discussion

First, we analyse the FTRI for the group of central and southeast European countries. As mentioned above, the data for the Index are available for period 2008-2019 (158 countries) and the rank for the countries is available for 2021 and 2022 (166 countries). Considering the effort of countries to improve digitalization and to support digital economy in studied countries, we would expect the improvement in the development of the overall FTRI and increasing value of the index. The increase in the value of the FTRI was found in 14 countries. Countries with higher improvement in the FTRI are Albania, Poland and Serbia. The FTRI has increased by 0.134242 point in Albania, by 0.131695 point in Poland and by 0.129616 point in Serbia. Slovakia, on fourth place, is far behind with

Table 3. The ranking of the central and southeast European countries based on their FTRI 2008 – 2019 (the overall world position given in parenthesis)

Country / Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Bulgaria	11 (43)	11 (44)	11 (43)	11 (41)	9 (39)	11 (42)	11 (43)	11 (43)	11 (42)	10 (42)	12 (46)	12 (51)
Czechia	1 (26)	1 (26)	2 (28)	1 (27)	2 (28)	1 (27)	1 (30)	1 (30)	2 (30)	1 (26)	1 (25)	1 (26)
Estonia	4 (30)	6 (35)	6 (33)	5 (31)	3 (31)	3 (31)	3 (32)	3 (32)	4 (33)	5 (33)	3 (29)	3 (29)
Hungary	3 (28)	2 (28)	1 (26)	3 (29)	1 (27)	2 (29)	2 (31)	9 (39)	6 (35)	4 (32)	5 (34)	6 (37)
Latvia	5 (32)	4 (30)	3 (29)	2 (28)	7 (35)	7 (36)	7 (36)	8 (38)	8 (39)	6 (36)	7 (38)	9 (40)
Lithuania	8 (38)	5 (32)	10 (42)	8 (37)	11 (43)	8 (37)	4 (33)	5 (34)	5 (34)	8 (39)	8 (39)	8 (39)
Poland	7 (37)	9 (39)	8 (37)	9 (38)	4 (32)	10 (39)	10 (40)	2 (31)	1 (27)	2 (29)	2 (28)	2 (28)
Romania	12 (44)	10 (42)	4 (31)	6 (33)	6 (34)	6 (35)	5 (34)	6 (36)	9 (40)	11 (43)	10 (42)	10 (45)
Slovakia	6 (35)	7 (37)	7 (35)	7 (35)	8 (36)	5 (34)	9 (38)	10 (42)	10 (41)	7 (38)	6 (35)	5 (36)
Slovenia	2 (27)	3 (29)	5 (32)	4 (30)	5 (33)	4 (33)	6 (35)	4 (33)	3 (31)	3 (30)	4 (32)	4 (33)
Albania	17 (103)	17 (95)	17 (98)	17 (79)	17 (81)	17 (81)	17 (82)	17 (87)	17 (89)	17 (86)	17 (85)	17 (85)
Bosnia and Herzegovina	16 (71)	16 (71)	16 (73)	16 (69)	15 (68)	15 (68)	16 (77)	15 (69)	14 (76)	16 (72)	16 (79)	16 (80)
Croatia	10 (42)	12 (45)	12 (45)	12 (44)	12 (44)	12 (48)	12 (47)	12 (47)	12 (48)	12 (45)	11 (43)	13 (52)
Greece	9 (40)	8 (38)	9 (38)	10 (39)	10 (40)	9 (38)	8 (37)	7 (37)	7 (38)	9 (40)	9 (40)	7 (38)
Montenegro	14 (60)	15 (64)	15 (65)	15 (66)	16 (73)	16 (73)	15 (68)	16 (74)	16 (79)	14 (68)	15 (73)	14 (70)
North Macedonia	15 (61)	13 (55)	13 (54)	14 (52)	14 (59)	14 (63)	14 (67)	14 (68)	15 (77)	15 (71)	14 (67)	15 (73)
Serbia	13 (56)	14 (56)	14 (63)	13 (51)	13 (51)	13 (51)	13 (54)	13 (51)	13 (53)	13 (48)	13 (51)	11 (47)

Source: Authors' own computation, UNCTADstat

the improvement by 0.078689 points. Considering the average annual growth rate in the FTRI between 2008-2019, the first place belongs to Albania (3.64 %), the second place goes to Serbia (2.10 %) and third to Poland (1.67 %). Only two more countries have the average annual FTRI growth higher then 1 % - Bosnia and Herzegovina (1.07 %) and Slovakia (1.01 %). The Index has not improved between 2008 and 2019 only in Slovenia, Latvia and Hungary, however it somewhat decreased. The drop in the value of the index in Slovenia was only 0.00057 points, in Latvia 0.01321 points and in Hungary the index decreased by 0.01808 points. In terms of average annual growth rates, the average decline was – 0.01 % in Slovenia, - 0.17 % in Latvia and -0.22 % in Hungary.

Analysing the data on the development of the Frontier technology readiness index in central and southeast European countries in period of 2008-2019, we accept the Hypothesis 1. Thus, the digitalization has improved in the analysed region during this period, with some countries performing better than others.

The performance of the analysed central and southeast European countries expressed by the FTRI are summarised in the Table below. We aligned countries based on their FTRI score for years 2008-2019. As seen, the most technologically and digitally developed countries are Czechia, Hungary, Estonia, Poland and Slovenia. Otherwise, the countries with a low scores Albania, Bosnia and Herzegovina, North Macedonia and Montenegro.

Considering the ranking, the position of countries for 2021 and 2022 is directly calculated by UNCTAD. The overall position across included countries as well as the ranking within the central and southeast countries is highlighted in Table 4. The best score for the latest reported year was achieved by Poland is 27th in the worldwide rank of countries (from 166 assessed and included in the FTRI). The second is Slovenia and the third is Estonia. The worst score and ranking have Albania, Bosnia and Herzegovina and North Macedonia. The situation at the bottom of the ranking as well as for the top performers among central and southeast European countries is very similar to period 2008-2019, which was calculated above. Only noticeable change is in the position of Czechia, which was most of the time leader in digitalization and innovation, but it has dropped by 3 places to the 4th position within the central and southeast European countries in 2022.

Table 4. The ranking of the central and southeast European countries based on their FTRI score 2021 – 2022 (the overall world position is shown in parenthesis)

Country / Year	2021	2022
Bulgaria	12 (51)	10 (43)
Czechia	1 (26)	4 (30)
Estonia	3 (29)	3 (29)
Hungary	6 (37)	5 (36)
Latvia	9 (40)	6 (38)
Lithuania	8 (39)	8 (41)
Poland	2 (28)	1 (27)
Romania	10 (45)	12 (45)
Slovakia	5 (36)	7 (39)
Slovenia	4 (33)	2 (28)
Albania	17 (85)	17 (88)
Bosnia and Herzegovina	16 (80)	16 (76)
Croatia	13 (52)	9 (42)
Greece	7 (38)	11 (44)
Montenegro	14 (70)	14 (59)
North Macedonia	15 (73)	15 (74)
Serbia	11 (47)	13 (50)

Source: Authors' own calculation; UNCTAD, 2021; UNCTAD, 2023

When considering the world rank of central and southeast European countries during the overall available period of 2008-2022, only 5 countries have improved their global rank, while the rank of two countries in 2022 has not changed in comparison to 2008, and the rank of 8 countries has declined. The best improvement was achieved by Albania (15 places) and Poland (10 places), while the deepest fall was by North Macedonia (13 places) and Hungary (8 places). Countries without the change in the rank include Bulgaria and Croatia.

Previous analysis has clearly shown that the position of central and southeast European countries has not improved globally and the rank of most countries has declined. Even countries having better scores in the index, have been outperformed by other countries, which outperform the central and southeast European countries in general. Therefore, we reject Hypothesis 2.

Next, we will explain the use and the expected impact of exogenous variables on the endogenous variable. Also, we will provide panel unit root tests for

variables to test whether they meet the conditions of stationarity. The results of the unit root test as well as the decision of the use level or first difference (respectively second difference) of variables are provided in Table 5. The assumed effect of the exogenous variables to endogenous variable FTRI is shown synoptically in Table 6.

We assume that the foreign direct investment inflow (FDI $_{i,t}$) improves the technological level and the digitalization in a host country, as the investments bring new advanced technologies. An example of such FDI inflow might be the privatization of telecommunications in former centrally planned economies that was associated with modernization of the communication infrastructure and services. In addition, greenfield investments usually also support the deployment and use of modern technologies in production processes or in the service sector. Gross domestic product (GDP $_{i,t}$) would have positive impact on the FTRI. The higher the GDP country is able to produce, the higher is the probability that country has applied and is using advanced technologies and digitalization is more advanced, than in countries with lower GDP. The idea is that countries with lower GDP need to cover basic expenditures and they may have less funds available to enhance the technological progress and digital development. Relating to the variables of international trade, thus export and import of ICT services and ICT goods (d_ICT_SERVICES_EX i,t, d_ICT_SERVICES_IM i,t, d_ICT_GOODS_EX i,t, d_ICT_GOODS_IM i,t), we assume that the export of ICT goods and services has a positive impact on the level of technology used and digitalization, as firms operation in the ICT that are able to produce products or provide services in ICT have high level of technological and digitalization progress. On the other hand, we assume that the import of ICT goods and ICT services is improving technologies and enhances digitalization. The employment to population ratio (EPR i,t) is expected to have a positive relationship with the technology and digitalization development. When the employment is increasing, the higher is the probability that more

Table 5. Stationarity test – panel unit root test

Variable	Method				Include in test equation	To be used in the equation
	Levin, Lin and Chu t		Im, Pesaran and Shin W-stat			
	Statistic	Prob	Statistic	Prob		
FTRI $_{i,t}$	-5.02093	0.0000	-1.86668	0.0310	Individual intercept	LEVEL
FDI $_{i,t}$	-7.78561	0.0000	-6.31342	0.0000	Individual intercept	LEVEL
GDP $_{i,t}$	-12.8607	0.0000	-4.71997	0.0000	Individual intercept and trend	LEVEL
ICT_SERVICES_EX $_{i,t}$	-10.2371	0.0000	-6.14560	0.0000	Individual intercept	1st DIFFERENCE (d_ICT_SERVICES_EX $_{i,t}$)
ICT_SERVICES_IM $_{i,t}$	-15.2353	0.0000	-9.59075	0.0000	Individual intercept	1st DIFFERENCE (d_ICT_SERVICES_IM $_{i,t}$)
ICT_GOODS_EX $_{i,t}$	-10.7439	0.0000	-7.78433	0.0000	Individual intercept	1st DIFFERENCE (d_ICT_GOODS_EX $_{i,t}$)
ICT_GOODS_IM $_{i,t}$	-12.0847	0.0000	-8.39869	0.0000	Individual intercept	1st DIFFERENCE (d_ICT_GOODS_IM $_{i,t}$)
EPR $_{i,t}$	-7.63102	0.0000	-3.26383	0.0005	Individual intercept and trend	LEVEL
ENROL $_{i,t}$	-4.98503	0.0000	-2.48434	0.0065	Individual intercept	LEVEL
RD $_{i,t}$	-9.62515	0.0000	-5.77445	0.0000	Individual intercept	1st DIFFERENCE (d_RD $_{i,t}$)
RES $_{i,t}$	-8.49167	0.0000	-5.11016	0.0000	Individual intercept	1st DIFFERENCE (d_RES $_{i,t}$)
SERVER $_{i,t}$	-7.69888	0.0000	-3.04053	0.0012	Individual intercept	2nd DIFFERENCE (dd_SERVER $_{i,t}$)
PHONE $_{i,t}$	-4.16572	0.0000	-2.04773	0.0203	Individual intercept	LEVEL
BROADBAND $_{i,t}$	-9.96643	0.0000	-6.15356	0.0000	Individual intercept	1st DIFFERENCE (d_BROADBAND $_{i,t}$)

Source: Eviews, authors' own computations.

Table 6. Assumed impact of the exogenous variables

Variable used in estimation	Area of variable	Assumed impact of the variable	Explanation of the use
FDI $_{i,t}$	international capital flows	Positive	
GDP $_{i,t}$	economic performance	Positive	
d_ICT_SERVICES_EX $_{i,t}$	international trade	Positive	
d_ICT_SERVICES_IM $_{i,t}$	international trade	Positive	
d_ICT_GOODS_EX $_{i,t}$	international trade	Positive	
d_ICT_GOODS_IM $_{i,t}$	international trade	Positive	
EPR $_{i,t}$	labour	Positive	
ENROLL $_{i,t}$	education	Positive	
d_RD $_{i,t}$	research	Positive	
d_RES $_{i,t}$	research	Positive	
dd_SERVER $_{i,t}$	digital infrastructure	Positive	
PHONE $_{i,t}$	digital infrastructure	Positive	
d_BROADBAND $_{i,t}$	digital infrastructure	Positive	

Source: authors' own elaboration.

workforce uses digital technologies as well as more people are employed in the ICT sector. Enrolment to tertiary education (ENROL i,t) gives the precondition of educated and skilled labour force that is not only using digital technologies, but works in the ICT sector and is responsible for their development. Thus, the higher the enrolment ratio, the better score in the FTRI is expected. Expenditure on Research and Development (d_RD i,t) represents the percentage of the GDP that country spends on R&D activities. The higher the ratio, the higher the FTRI score would be expected, as the expenditures would result in improving digitalization and technologies. The same assumption is applied when considering the variable Researchers in R&D (d_RES i,t). The next three variables represent the digital infrastructure in a country (dd_SERVER i,t, PHONE i,t, BROADBAND i,t). The more secure servers, more mobile phones and fixed broadband subscribers live in a country, the higher level of digitalization and technology would be assumed. Thus, we expect positive coefficients for those three variables.

Based on the result of the conducted unit root test, we use variables at level, 1st or 2nd difference base on the stationarity tests. The regression equation is then as follows:

$$FTRI_{it} = c_i + \beta_1 * FDI_{it} + \beta_2 * GDP_{it} + \beta_3 * ICT\_SERVICES\_EX_{it} + \beta_4 * ICT\_SERVICES\_IM_{it} + \beta_5 * ICT\_GOODS\_EX_{it} + \beta_6 * ICT\_GOODS\_IM_{it} + \beta_7 * EPR_{it} + \beta_8 * ENROL_{it} + \beta_9 * d\_RD_{it} + \beta_{10} * d\_RES_{it} + \beta_{11} * dd\_SERVER_{it} + \beta_{12} * PHONE_{it} + \beta_{13} * d\_BROADBAND_{it} + u_{it} \quad (1)$$

Based on the testing statistics provided in the estimation, the fixed effect model was appropriate to use. Testing statistics for stationarity are shown in Table 7.

Table 7. Fixed / Random effects statistics

Correlated Random Effects - Hausman Test			
Test cross-section random effects			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	148.660757	13	0.0000
Redundant Fixed Effects Tests			
Test cross-section fixed effects			
Effects Test	Statistic	d.f.	Prob.
Cross-section F	22.645674	(15,87)	0.0000
Cross-section Chi-square	184.456027	15	0.0000

Source: Eviews, authors' own computations.

The results of the regression analysis, as seen in Table 8, partially confirm our assumptions. Due to the use of the 2nd difference for the variable SERVER and due to the lack of data, Albania was not included in the analysis. The studied time series captures 8 years. Thus, we have panel of 16 cross-sectional data and 8 time series. The test, shown in Table 8, indicates the use of the fixed effect model, which is more appropriate as the random effects or pooled OLS models.

Table 8. Result of the regression analysis

Dependent Variable: FTRI				
Method: Panel Least Squares				
Total panel (unbalanced) observations: 116				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	0.625371	0.083957	7.448675	0.0000
FDI	3.85E-06	8.32E-07	4.626286	0.0000
GDP	-9.74E-08	1.75E-07	-0.555867	0.5797
D_ICT_SERVICES_EX	-0.007295	0.003302	-2.209268	0.0298
D_ICT_SERVICES_IM	-0.001471	0.002327	-0.632269	0.5289
D_ICT_GOODS_EX	-0.010467	0.003822	-2.738339	0.0075
D_ICT_GOODS_IM	0.001989	0.004674	0.425494	0.6715
EPR	0.002559	0.001051	2.434281	0.0170
ENROL	-0.000768	0.000440	-1.744378	0.0846
D_RD	0.000804	0.018146	0.044298	0.9648
D_RES	1.48E-05	1.32E-05	1.121578	0.2651
DD_SERVER	2.50E-08	4.55E-07	0.054876	0.9564
PHONE	-0.000687	0.000363	-1.893153	0.0617
D_BROADBAND	0.004165	0.003202	1.300680	0.1968
Effects Specification: Cross-section fixed (dummy variables)				
R-squared	0.965617	Mean dependent var		0.620392
Adjusted R-squared	0.954552	S.D. dependent var		0.096233
S.E. of regression	0.020516	Akaike info criterion		-4.722947
Sum squared resid	0.036617	Schwarz criterion		-4.034550
Log likelihood	302.9309	Hannan-Quinn criter.		-4.443497
F-statistic	87.26245	Durbin-Watson stat		1.648954
Prob(F-statistic)	0.000000			

Source: Eviews, authors' own computation.

The results who that the variable FDI has a statistically significant and positive coefficient. We might confirm that the foreign direct inflow to central and southeast European countries is associated with the higher score in the Frontier technology readiness index meaning better preparedness for adopting advanced technologies as well as enhancing digitalization related with the use of information and communication technologies that are included in the FTRI sub-indexes. The FDI inflow might be considered as the inception, or trigger, to use advanced technologies in a host economy provided by transnational corporation that has brought those technologies to a country. Consequently, technologies spread also among host county companies, improving the technological progress and digitalization. The spill-over effects of foreign direct investment are then further affecting the performance of the economy and the level of digitalization and technology. From this point of view, to increase the technological and digital development, countries need to adopt measures to support and enhance the inflow of foreign investment. Such support should be aimed at such FDIs that operate in technologically advanced fields.

Unexpectedly, the variable representing the performance of the economy – GDP – is not statistically significant. This suggests that the readiness for advanced technologies and digitalization is not affected by the volume of goods and services a country is able to produce or provide. This result might be also the answer why not most developed countries achieve the highest scores in the FTRI, but some of developing

countries have relatively high score in the Index. The GDP is thus not directly related to the technological readiness in the short run. However, we assume that in the long run, the increasing performance would determine the technological level in a positive way.

Another statistically significant variables are export of ICT services and ICT goods. Both variables have positive coefficients meaning that the higher the change in percentage of ICT goods on total trade or higher the percentage of ICT services on total trade in services, the better FTRI score achieved. This means that the country with higher percentage of ICT goods and services from its export is technologically and digitally more developed. Such result was expected, as technological and digital goods and services to be exported from a country had to be produced or provided by using advanced technologies or digital tools. On the other side, variables of ICT imports are not statistically significant. We might claim that the import of the ICT goods and services is not improving the technological and digital readiness of analysed countries, as the country is just using goods and services, and does not produce them itself (i.e., domestic subjects are not necessary to produce or provide them). In other words, if the country is able to import ICT goods and services, the lower intention the country has to produce them domestically and there is no necessity for the country to improve technologically and digitally.

The labour indicator used in the analysis – employment to population ratio – is statistically significant, with a positive impact on the FTRI. It indicates that the higher the share of employed population, the better score in the Index the country achieves. This result might be related to the performance of a country. Developed countries have high GDP that is associated with high employment to population ratio, or low unemployment. When high share of the labour force is employed, population has more funds for using digital technologies, but also for their development. Thus, the digitalization and advanced technologies are more spread and country readiness for advanced technologies and digital economy is higher.

The studies variable tertiary school enrolment is also statistically significant and has a positive effect, which is in line with our expectations. The more of the population is enrolled in universities, i.e., the higher education, the better Index score the country achieves. Better educated population might be condition for the improvement of digitalization and technology usage.

Two variables representing research –expenditures on R&D expressed as % of GDP and share of researchers in R&D are not statistically significant. We assumed that these variables would have a positive impact on the digitalization and technological readiness, but this assumption was not confirmed. Based on this result, we might assume that for central and southeast European countries the expenditure on R&D and number of researchers in R&D are not crucial factors affecting their readiness for adopting advanced technologies and enhancing process of digitalization. Such result might come from the efficiency of the sources used for the R&D and from the labour productivity and results of R&D researchers, who are lacking behind the results of researchers in more developed countries. Therefore, researchers from the analysed areas need to catch-up with their colleagues and achieve improvements in their field of research.

We used three variables that capture the digital aspect of the economy – secure internet servers, mobile subscriptions and fixed broadband subscriptions. We found that only mobile subscriptions (PHONE) variable is statistically significant. We assumed that most of the internet connection in analysed countries is via the mobile networks and therefore, the mobile subscription is the most important, while servers and fixed broadband are less important for the digitalization and technology used.

We conclude that five out of 13 exogenous variables are statistically significant and all of them have the assumed impact on the digital and technological readiness of central and southeast European countries. Most importantly, the variable foreign direct investment inflow, which we have focused on, is one of the statistically significant variables. Based on the results, we might claim that the inflow of a foreign direct investment to central and southeast European countries has a positive impact on their digitalization and technological development, and the volume of the FDI is positively related with the higher score of the Frontier technology readiness index. Therefore, we accept the Hypothesis 3 and might state that the FDI is the determinant of the digitalization development expressed using the Frontier technology readiness index.

The results showed that analysed countries need to improve in several fields of digitalization and the use of technologies. We consider the most crucial is the support of the government and public and related public agencies to provide continual support in terms of strategic planning and management of technological adoption. There is the need for strategic and operational plans to increase the technological and digital development of central and southeast European countries. Based on the strategic documents, the measures to enhance digitalization and improve the technological development might be undertaken independently of the ruling party or government. Such stability is desirable.

Another important recommendation is the selection of FDI based on the industry, sector or field of business, with the focus on technologically advanced and digital areas. During the transition of centrally planned economies to market economies, countries have practically provided investment incentives almost to all foreign investments to improve their position and attract foreign investors, which has helped them with restructuring processes of their economies. However, situation has changed, and countries would select investors to support now. The emphasis should be on providing only those investments that are sustainable for a long period and are bringing in high value added.

Another important recommendation relates to the expenditure on R&D. Based on the results, expenditures on R&D have not affected technological readiness as the results above have shown. We assume that more important than the volume of expenditures on R&D is the effective use of the funding. The principle of effectiveness or the value for money should be applied also in this area.

The last recommendation we would like to emphasize is the support of technically and digitally oriented education aimed at the practical use of digital technologies. Currently, those who can work and use digital technologies, unlike those who are not, are at an extensive advantage. This might be applied to individuals, firms as well as countries. Therefore, countries should adopt measures relating to the education process to train digitally literate citizens who will return this investment back in the form of more productive labour force.

5. Conclusions

The digitalization and the use of advanced technologies is considered as the factor enhancing the economic growth, the performance of economies and increasing the well-being of citizens. The Covid-19 pandemic has underscored the importance and necessity of digitalization, as almost all activities, if it was possible, were moved to digital environment.

Not all countries are prepared for the digitalization and the use of advanced technology same. Some countries already launched and support digitalization and technological development, some are still in process and are progressively introducing some digital elements to their economies. The indicator that measures the level of country readiness for digitalization and use of advanced technologies is the Frontier technology readiness index that has several indicators and sub-indexes. The focus of the paper was to identify, whether the foreign direct investment inflow to central and southeast European countries has a positive impact of the score of the Index, i.e., that FDI inflow enhances the technological and digital level of those economies. The analysis was done using panel regression with fixed effects. The sample consists of 12 time series, since 2008 until 2019 based on the availably of the FTRI, and 17 cross-sectional units representing the analysed countries. Exogenous variables used in the regression, except for the FDI, include variables representing economic performance, international trade, labour, education, research and digital infrastructure. The results have shown that the foreign direct investment inflow has a positive and statistically significant impact on the FTRI. It means that the higher the FDI inflow, the higher the FTRI score achieved. This result would be also interpreted as the positive spill-over effect of the FDI inflow on the technology used, digital level and readiness to launch, adopt or adapt advanced technologies in host countries of investment.

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