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Routledge
Taylor & Francis Group

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ABSTRACT

The substantial improvements in development information and communication technologies led many economic and non-economic implications for the countries and in turn motivated the researchers to question the various effects of ICT especially in the light of economic crime. This study explores the short and long run influence of information and communication technologies on the shadow economy in 11 post-transition EU members over 1996-2015 period through second generation panel cointegration and causality tests regarding the cross-sectional dependence. The economic analyses disclosed that ICT indicators and human development had significant effects on the size of shadow economy in both short and long run. It was found that growing ICTs lead to reduction on the size of the shadow economy; in addition, human capital improvement policies serve as an important factor when tackling the shadow economy.

1. Introduction

The informal economy is a significant factor for economic growth. On the one-part informal economy may negatively affect the economic growth by decreasing the government expenditures through lower tax collections through, e.g. tax payers negligence or illegal activities as tax or VAT carousel fraud. On the other side, greater economic growth can be resulted from the existence of informal economy in case it enhances competition and efficiency in the formal sector. However, profits from informal economy can be used to finance even the most serious crime areas, e.g. terrorism, human trafficking, etc. Therefore, the net effect of informal economy on economic growth seems inconclusive, but the first effect is generally more dominant due to high profits[1] and constantly changing *modus operandi* of criminal exploiting ICT which lead to lower detection rates. However, lower detection rates should not be

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interpreted as under-detection or latent criminality. Implementation of the same ICT means in crime detection and prevention has proven to be efficient and successful (European Anti-Fraud Office, No 3/2019.

When analysing the determinants of the informal economy, most authors emphasize tax and social contribution burden (Kundt, 2017; Lesnik et al., 2014; Medina & Schneider, 2017, Schneider et al., 2015; etc.), quality of the public sector's performance (Blackburn et al., 2012; Enste, 2015; Michaela & Clipa, 2016), regulation of the labor market (Fialova, 2010; Fialova & Schneider, 2014; Gasparėniene et al., 2017; Kopytko et al., 2019; Remeikienė et al., 2019), inefficient legal framework (Michaela & Clipa, 2016; Schneider et al., 2015) and low public tax morale (Arli et al., 2015; Michaela & Clipa, 2016; Williams et al., 2010) as most influential ones. However, the mutual links between ICTs and the shadow economy still earn insufficient scientific attention as seen in the related literature.

1.1. Background

Development and spread of ITCs also may contribute to the reduction in cash turnover and thus make monitoring of financial transactions much easier. So ICT can make a contribution to the economic growth and development through decreasing the informal economy. Dincǎ et al. (2019) claimed that the digital technologies and ICT are also used to improve the decision-making process for businesses.

Previous studies (Chen, 2016; Nevzorova et al., 2018; Remeikiene et al., 2017) mainly focused on the interaction between the shadow economy and general technological development when the latter was interpreted as advances in industrial technologies able to change the structure of the national or regional economy, raise economic, ecological and labour efficiency and thus create a greater national, regional or sectoral competitive advantage. However, the relationship between the informal economic sector and the technological advancement represented by ICTs still calls for more comprehensive research. Therefore, our paper aims to make a contribution to the related literature by researching the interaction between ICT development and shadow economy which is a significant determinant of economic growth and a platform for growing virtual criminality with involvement of organized crime groups. Even so, if abuse of Point of Sales terminals emerged in 2017, card skimming rates after introduction of geoblocking bring positive change with the significant drop after introduction of the aforementioned tool since 2014 (Europol, 2018).

In the research, human capital development is also employed as a control variable, because shadow economy generally consists of unqualified workers and therefore, improvements in human capital has potential to decrease the shadow economy (Dell'Anno, 2010), but the effect of human development on the shadow economy is also rarely explored in the relevant literature.

This research investigates the effect of ICT development together with human development on the shadow economy in the EU transition economies experiencing a full economic and institutional transformation. Furthermore, EU accession by the countries had a significant influence on the EU transition economies' telecommunication sector. In line with the EU policies, the telecommunication sector was liberalised

Table 1. ICT development in 11 EU transition economies.

Country	ICT Development Index	
	2002	2017
Bulgaria	2.74	6.86
Croatia	3.19	7.24
Czechia	3.74	7.16
Estonia	3.93	8.14
Hungary	3.49	6.93
Latvia	3.30	7.26
Lithuania	3.17	7.19
Poland	3.34	6.89
Romania	2.48	6.48
Slovakia	3.51	7.06
Slovenia	4.47	7.38

Source: ITU (International Telecommunication Union),), 2009, 2018.

and regulatory measures were taken to raise the competition in the sector. The statistics on the development of ICTs in 11 EU transition economies over the period between 2002 and 2017 are reported in Table 1. The data in Table 1 indicate that over the period under consideration, ICT development index rose nearly twice in almost all EU transition economies. The most significant ICT development can be observed in Slovakia and Romania, while slightly less intensive progress is inherent to Croatia, Latvia, Lithuania and Bulgaria (Bulgaria is a component part of the European Digital Market and therefore a number of ambitious goals were set to improve connectivity and digital services use).

The main purpose of this article is to explore the influence of ICTs on the shadow economy in 11 post-transition EU members over the period 1996-2015. The defined purpose was detailed into the following objectives: 1) to review the results of previous studies on the mutual relationship between ICTs and the shadow economy; 2) to present and substantiate research methodology; 3) to introduce the results of the empirical research on the impact of ICT on the shadow economy in 11 post-transition EU members over the period 1996-2015. The methods of the research include panel cointegration and causality tests. One of the extensively researched issues in economics is the determinants of the shadow economy in the world, because the size of informal economy is important for economic growth and development. But, the influence of ICT and human development on the shadow economy have been rarely analysed in the relevant literature as seen in literature review. Also the sample of the study and the second generation econometric tests employed in the applied section are another novelties of the paper. In the following section, the theoretical and empirical literature is summarized, and then the dataset and the methodology are defined. Section 4 conducts the empirical analysis about the effect of ICT development and human development on the shadow economy. The paper ends up with the concluding remarks.

2. Literature review

In the current age of information, the role of ICTs cannot be underestimated. However, it should not be overlooked that ICTs' effects on the shadow economy can be bidirectional: on one hand, the expanding systems of e-banking reduce cash turnover, and since settlements in shadow markets are commonly made in cash, it can be

Table 2. Review of some previous findings on the influence of ICTs on the shadow economy.

Author(s), year	Research method(s)	Research results
Garcia-Murillo and Velez-Ospina (2014)	Regression analysis, the MIMIC method	ICTs may reduce the shadow economy by providing wider employment and education opportunities and reducing the number of burdensome bureaucratic processes. However, some limitations of the mobile infrastructure were observed
Garcia-Murillo and Velez-Ospina (2017)	Multiple causes statistical model	ICTs empower population, but their effects on society in terms of the shadow economy reduction are not always positive
Bhattacharaya (2019)	Literature review, critical assessment	The impact of ICTs on informal enterprises is uneven because the informal sector itself is heterogeneous
Chandra (2017)	Literature review, the intercom and road system analysis	ICTs are used by local communities to expand informal networks
Rangaswamy (2019)	Literature review, critical assessment	ICTs (in particular, the Internet) serve as a business platform for informal economy
Chacaltana et al. (2018)	Non-exhaustive web search	ICTs are most likely to promote transition to formality in the labor market
Ilavarasan (2019)	Literature review, critical analysis of the informal sector in India	The ICTs do not have any significant impact on the informal economy in developing countries due to predominance of walk-in customers, small size of enterprises and the nonuse of electricity
Masiero (2017)	Theoretical lens	ICTs help citizens obtain digital identities and transact to the cashless economy, but this contribution is marginal

Source: Authors own elaboration.

presumed that proliferation of the modern ICT-based payment systems restrict access to cash as most attractive method of payments (USAID, 2013; AT Kearney, 2013, etc.); on the other hand, informal activities can be promoted by demand generation via ICTs (mobile connections, internet or social networks) (Gasparėnienė et al., 2017). For instance, by employing ICT networks, informal suppliers can offer their products or services to a large circle of potential consumers, while the latter can share the information on where, from whom and for how much particular products or services can be obtained.

The bidirectional effects of ICTs on the shadow economy are confirmed by some previous scientific findings (Bhattacharaya, 2019; Chacaltana et al., 2018; Chandra, 2017; Garcia-Murillo & Velez-Ospina, 2014, 2017; Ilavarasan, 2019; Masiero, 2017; Rangaswamy, 2019) (see Table 2).

Garcia-Murillo and Velez-Ospina (2014, 2017) raise the hypothesis that ICTs may contribute to reduction in the size of the shadow economy because, being multipurpose, they serve as an engine for the search of information on education, employment and public services which, in its turn, empowers population, provides wide opportunities for personal and professional improvement and makes public services easier accessible. However, the results of their studies indicate that ICTs can only party reduce the size of the shadow economy because despite the fact that they are linked to a wider and deeper access to information and other resources, the findings show that they also reduce transaction costs for informal activities, which promotes them being used as comparatively cheap informal business coordination technologies. In addition, the authors state that the ICT (i.e. mobile phones and broadband) infrastructure is unduly limited to substantially decrease the size of the shadow economy – most modern informational, educational resources and public services are accessible

only through most sophisticated digital devices, networks and platforms that are not affordable for a large part of population, in particular in less developed countries. These results are in line with the results provided by Esselaar et al. (2007) and Bhattacharaya (2019) who state that most sophisticated ICTs are rarely used in the informal sector due to their high acquisition and maintenance costs as well as low expected returns to investment.

Bhattacharaya (2019) researches the links between the ICTs and the informal economy through the prism of the use of ICTs for business growth and profit enhancement. The author finds that the largest share of entrepreneurs operating in the informal sector employ ICTs to protect their income rather than enhance their profits which means that ICTs in the informal sector are hardly used for making settlements. This proposes that the expectations to decrease the size of the shadow economy by digitalization of payment systems are not always reasonable as entrepreneurs in the informal sector rely on solidarity networks rather than turn to digital payment systems. Similar findings were obtained by Masera (2017) who states that introduction of the biometric identification systems in India helps citizens obtain digital identities and transact in the cashless economy, but the shift to formality is marginal. Ilavarasan (2019) even notes that advanced ICTs are hardly used in developing countries due to predominance of walk-in customers, small size of informal enterprises and the nonuse of electricity. On the other hand, some earlier studies (Esselaar, e.t al., 2007) propose that more sophisticated ICTs are much more likely to be used by formally operating entrepreneurs, while informal agents mainly stick to mobile phones.

The negative impact of ICTs was also revealed by Chandra (2017). The author's findings show that new technologies can be imaginatively and effectively used by local communities to self-organize and collaborate with a view to making informal networks that allow to avoid compliance with formal regulations.

Chacaltana, et. al. (2018) study proposes that the use of ICTs can promote transition to formality, especially in the lab our market, "via an increasing number of innovative, information-intensive and connectivity-based tools or approaches that we call e-formality policies, which contrast sharply with the traditional manual, physical presence or time-consuming practices". Even if the effects of ICTs on the transition of economic agents to the formal economic sector are not always direct, ICTs at least ensure a higher level of transparency which may promote gradual changes.

On balance, the impact of ICTs on the shadow economy is uneven because, as it was noted by Bhattacharaya (2019), "the informal sector itself is heterogeneous" (p. 2). Informal enterprises in developing countries mainly employ ICTs not for transferring to formality, but for expanding activities by operating in informal networks and protecting their income. It is also the case that small informal entrepreneurs hardly invest in expensive ICT infrastructures due to unbearably high acquisition and maintenance costs. Nevertheless, innovative information and communication tools ensure a higher level of operational transparency and thus may contribute to gradual formalization of currently informal activities.

In the related literature, only a few studies have investigated the effect of improvements in human capital on the size of shadow economy and disclosed that human

development decreased the shadow economy (e.g. Dell'Anno, 2010; Dronca, 2016). In this context, Dell'Anno (2010) explores the effect of various indicators including human capital development on the shadow economy in 17 Latin American states through regression analysis, and discovers an inverted U-curve shape. Dronca (2016) researches the effect of human development on tax evasion in 28 EU member states for 1999-2010 period by regression analysis and discloses that human development decreased the tax evasion.

3. Data and econometric methodology

The effect of ICT development on the shadow economy in 11 EU transition economies during the 1996-2015 period was analysed by panel cointegration and causality analyses. The cointegration analysis enables us to see the long run effect of ICT development and human development on the shadow economy. On the other side, the causality analysis enables us to see the causal interaction among ICT sector, shadow economy, and human development in a multivariate environment. Furthermore, the cointegration analysis regards both cross-sectional dependency and heterogeneity and the causality analysis considers the heterogeneity.

3.1. Data

The dependent variable of shadow economy (SHA) was represented by shadow economy size as a percent of GPD through MIMIC method by Medina and Schneider (2018). On the other side, ICT development was represented by mobile cellular subscriptions (per 100 people) (MOBILE) and individuals using the internet (% of population) (INTERNET) and provided from the database of World Bank (2019a&2019b). Lastly, human development (HDI) as a control variable was proxied by human development index of UNDP (2019) and the index is geometric mean of normalized indices for long and healthy life, knowledge, and living standard. All the variables were annual and the relevant data availability led us to determine the study period as 1996-2015 (See Table 3).

The sample of the econometric analysis consisted of Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia. The econometric analyses were implemented through the software of Stata 14.0 and Gauss 10.0. The main characteristics of the dataset are shown in Table 4. The average of shadow economy size was about 22.92% of GDP in the sample. The average of mobile cellular subscriptions (per 100 people) was about 79.61 and the average of individuals using the internet was about 38.71% of total population in the sample. However, the ICT penetration in the sample varied significantly among the countries.

Table 3. Data definition.

Variables	Description	Source
SHA	Shadow economy size (% of GDP)	Medina and Schneider (2018)
MOBILE	Mobile cellular subscriptions (per 100 people)	World Bank (2019a)
INTERNET	Individuals using the internet (% of population)	World Bank (2019b)
HDI	Human development index	UNDP (2019)

Source: Authors own elaboration.

Table 4. Summary statistics of the dataset.

Variables	Mean	Std. Deviation	Minimum	Maximum
SHA	22.92	5.94	10.47	35.64
MOBILE	79.61	49.71	0.07	164.08
INTERNET	38.71	26.85	0.22	88.41
HDI	0.80	0.05	0.68	0.89

Source: Authors own elaboration.

Lastly, the average of human development was 0.80 and exhibited no considerable variations among the countries.

4. Empirical analysis

In the applied part of the study, cross-sectional dependence was firstly analyzed with the tests in Table 5 and the test consequences were reported in Table 5. The null hypothesis in favour of the cross-sectional independence was denied at 1% significance level. So the aforementioned tests pointed out the subsistence of cross-sectional dependence among three series.

The slope coefficients' homogeneity was analyzed through adjusted delta tilde test of Pesaran and Yamagata (2008) after investigation of cross-sectional dependence and test consequences were reported in Table 6. The null hypothesis suggesting the existence of homogeneity was rejected in the light of p values of both tests. So the slope coefficients of the cointegration equation were heterogeneous.

The stationarity analysis of the study variables was examined with Pesaran (2007) CIPS (Cross-sectionally augmented IPS (Im et al., 2003) unit root test taking notice of cross-sectional dependence and the test consequences were reported in Table 7. The test consequences revealed that all the series except INTERNET were I(1), but INTERNET was stationary at the level.

The cointegration relationship among the shadow economy, the indicators of ICT development, and human development was tested by Westerlund's (2008) cointegration considering the integration levels of the series and subsistence of cross-sectional dependence and the test consequences were reported in Table 8. The null hypothesis suggesting the non-existence of cointegration relationship was rejected in two models. As a result, the finding of a significant long run relationship among the series was reached.

The cointegration coefficients were forecast by the panel AMG estimator of Eberhart and Teal (2010) after detection of cointegration relationship's existence and the estimation results were reported in Table 9. The panel cointegration coefficients disclosed that mobile cellular subscriptions representing ICT development and human development affect the size of shadow economy negatively, but internet usage had no significant impacts on the size of shadow economy.

However, the individual coefficients revealed that mobile cellular subscriptions negatively affect the size of shadow economy in Bulgaria, Croatia, Estonia, Latvia, and Slovakia. On the other side, internet usage of another ICT indicator positively affects the size of the shadow economy in Croatia, Estonia, Hungary, Latvia, and Slovenia, but negatively affects the shadow economy in Bulgaria and Romania. Lastly, human development has a significant decreasing impact on the size of the shadow

Table 5. Cross-sectional dependence tests.

Test	Test statistic	P value
LM (Breusch & Pagan, 1980)	315.2	0.0000
LM adj. (Pesaran et al., 2008)	51.22	0.0000
LM CD (Pesaran, 2004)	15.07	0.0000

Source: Authors own elaboration based on the results of cross-sectional dependence tests.

Table 6. Homogeneity tests.

Tests	Test statistic	P value
$\sim \Delta$	9.805	0.000
$\sim \Delta_{adj.}$	10.862	0.000

Source: Authors own elaboration based on the results of homogeneity tests.

Table 7. Results of CIPS panel unit root test.

Variables	Constant	Constant + Trend
SHA	−1.997	0.177
D(SHA)	−2.141**	−0.619**
MOBILE	−1.098	−0.795
D(MOBILE)	−3.362***	−3.178***
INTERNET	−1.975**	−1.535*
D(INTERNET)	−4.555***	−3.489***
HDI	−1.357	1.382
D(HDI)	−2.761***	−2.145**

Optimum lag length was specified as 1 taking notice of Schwarz information criterion.
***, **,* indicated that it is respectively significant at 1%, 5% and %10.
Source: Authors own elaboration based on the results of panel unit root test.

Table 8. Results of Westerlund's (2008) cointegration test.

Test	Statistic	p-value
Durbin-Hausman Group Statistic	4.173	0.000
Durbin-Hausman Panel Statistic	8.161	0.000

Source: Authors own elaboration based on the results of panel cointegration test.

economy in Croatia, Estonia, Hungary, Latvia, Lithuania, Slovakia, and Slovenia, but positively affects the shadow economy in Bulgaria.

Romania, Bulgaria, Croatia, Lithuania, Latvia, and Estonia respectively have experienced the largest improvement in ICT penetration during the period of 2002-2017 as seen in Table 1. The decreasing impact of the improvements in ICT development on the shadow economy size was experienced in the aforementioned countries except Lithuania. However, internet usage can raise the shadow economy size in case of insufficient regulatory framework and supervision infrastructure. Therefore, the increasing impact of ICT development on the shadow economy outweighed the decreasing impact in Croatia, Estonia, Hungary, Latvia, and Slovenia through internet usage.

Lastly, the EU transition economies have experienced significant improvements in human capital with the effect of EU integration process and globalization. In this context, the improvements in human capital can decrease the shadow economy size regarding the shadow economy mainly including unqualified and unconscious individuals. In the study period, Latvia, Lithuania, Estonia, Croatia, and Romania respectively made the largest improvement in human capital and in turn Croatia, Estonia,

Table 9. Results of cointegration coefficients' estimation.

	Coefficients		
Countries	MOBILE	INTERNET	HDI
Bulgaria	−0.027989**	−0.2134541***	71.07967**
Croatia	−0.0782662***	0.1660005***	−107.6257**
Czechia	0.0073792	−0.017372	−32.89377
Estonia	−0.0874122**	0.2363881***	−127.7974**
Hungary	−0.0152549	0.1565933***	−179.3832***
Latvia	−0.0797677**	0.1124982***	−51.57582***
Lithuania	0.0038833	−0.0412513	−70.27418***
Poland	−0.0549409	0.0732928	−60.3856
Romania	−0.0307736	−0.1540164***	45.13117
Slovakia	−0.0348748***	0.0175896	−32.53109***
Slovenia	0.0215251	0.1963485***	−202.7757***
Panel	−0.0342265***	0 .0484198	−68.09377***

***, **,* indicated that it is respectively significant at 1%, 5% and %10.
Source: Authors own elaboration based on the results of cointegrating coefficient estimation.

Table 10. Results of causality analysis.

Null Hypothesis	W-Stat.	Zbar-Stat.	Prob.
DMOBILE ↛ DSHA	2.90256	3.15054	0.0016
DSHA ↛DMOBILE	4.58000	6.17267	7.E-10
INTERNET ↛ DSHA	4.19230	5.59700	2.E-08
DSHA ↛ INTERNET	2.47018	2.43618	0.0148
DHDI ↛ DSHA	3.71429	4.71964	2.E-06
DSHA ↛ DHDI	1.91105	1.40996	0.1586

Source: Authors own elaboration based on the results of panel causality test.

Latvia, Lithuania together with Hungary, Slovakia, and Slovenia experienced a decreasing impact of human development on shadow economy size.

Consequently, the long run analysis on the effect of ICT development and human capital development on the size of shadow economy revealed that both ICT and human development decreased the size of shadow economy through canalizing the people to the formal economy and enhancing their tax awareness. The findings supported the theoretical considerations for the decreasing effect of ICTs in the literature.

The causal interaction among the size of the shadow economy, the indicators of ICT development, and human development was tested by Dumitrescu and Hurlin (2012) causality test and test results were reported in Table 10. The results revealed a two-way interaction between the indicators of ICT development and the size of the shadow economy and a one-way causality running from human development to the size of the shadow economy. The causality analysis revealed a reciprocal interaction between ICT and shadow economy in the short run. Furthermore, human capital development also had a significant effect on the size of shadow economy.

5. Discussion

Human capital development or social development analysis for the growth of the shadow economy might not be fully comprehensive without discussing the impact of ICT for the development of crime. Even if interconnection of informal economy and crime is not as clear as the one of black market and crime, financial crime, especially

when talking about fraud, contribute to the growth of shadow economy (Đurić, 1999).

Abuse of the ICT for criminal gain is very diverse. What was known as traditional crimes shifted and adapted to digital era. If credit card scam was known back in the 90 s, today we are talking of identity theft and card-not-present fraud (Javelin Strategy & Research, 2017) or even illegal market of fake or "cloned" invoices for the sole purpose of deduction from taxable income (OECD, 2017, p. 19-20). ICT has "< … > transformed the very nature of some 'traditional' types of crime in terms of the way they are committed, their scale and reach affecting many aspects of life from financial transactions and commercial activities to public security < … >" (Sallavaci, 2020, p.2). Nonetheless, the diversity and its impact on modus operandi is not the only difficulty – combating financial crime which abuse or exploit ICT encounter certain legal issues of definition and interpretation interfering with precise scale and impact of these type of offences on shadow economy.

Legal literature provides various definitions of criminal exploiting ICT: "cybercrime", "e-crime" (Plėta et al., 2020a; 2020b; Talib & Sekgwathe, 2012), "digital crime". Even differentiation of certain subcategories has been provided: cyber-enabled and cyber-dependant crimes (Desai, 2019; Furnell et al., 2015; McGuire & Dowling, 2013a). In 2013 conducted review by the UK Home Office provided descriptions on the later stating that: "Cyber-dependent crimes are offences that can only be committed by using a computer, computer networks, or other form of ICT. < … > Cyber-enabled crimes are traditional crimes that are increased in their scale or reach by the use of computers, computer networks or other ICT. Unlike cyber-dependent crimes, they can still be committed without the use of ICT." (McGuire & Dowling, 2013b, p. 5). Financial crimes fall under later category of cyber-enabled crimes, as naturally, the ICT becomes a tool to achieve results quicker, more efficiently or simply by exploiting legal shortcomings.

Aforementioned terminology is not really reflected in international and EU legislation. Moreover, different notions are used which leads to the lack of coherence[2], e. g. Convention on Cybercrime (Council, 2001), as implied by the title, uses the "cybercrime". The same notion is used in other legislative pieces.[3] In contrast Art. 83(1) TFEU, which provides the list of serious crime areas, uses the wording "computer crimes". However, certain issues related to the substantive criminal law arise not due to the different wording but from the lack of the unified terminology on (1) what should be considered cybercrime (currently all criminal offences using ICT can be interpreted as cybercrime) and (2) does all criminal offences which are committed using ICT fall under accepted serious crime area computer crimes.

The first question is related to the body of crime (*corpus delicti*) of the criminal offence. As the Art. 83(1) of TFEU acknowledges computer crimes as one of the serious crime areas, identifying all crimes which use ICT as cybercrime could be in breach of the legal principles of proportionality and ultima ratio. Due to the fact, that the use of ITC does not necessary predetermine the seriousness of the crime. Therefore, the EU legislation should provide if not clear definitions then at least minimum rules on differentiation between cybercrimes and criminal offences which would not be considered as cybercrime and where the use of the ICT could be interpreted as optional element of *corpus delicti*.

The second question (are cybercrime a serious crime) is especially relevant in the light of the newest ECJ (European Court of Justice) decision of 6th of October 2020 (Case C-623/17 XXXX) which restricted Member States on establishing, in their national laws, obligation requiring providers of electronic communication services to transfer and retain, generally and indiscriminately, traffic and location data for the purpose of safeguarding national security, combating serious crime and preventing serious threats to public security. The court throughout the decision uses the definition of "serious crime", therefore it is not clear whether the exceptions established by the decision are applicable to crimes under different legal frameworks, i.e. crimes which does not fall under the category of serious crime area of Art. 83(1) of TFEU.

An excellent example is the Directive (EU) 2017/1371 on the fight against fraud to the Union's financial interests by means of criminal law (Directive (EU) 2017/1371). This legislative piece establishes that Member States should ensure that its jurisdiction covers criminal offences which are committed using ICT accessed from its territory (clause 20 of the Preamble). However, the document itself is not adopted as relating to computer crimes (Art. 83(1) of TFEU), nor the chosen legislative framework is based under the TFEU 83(1), i.e. as serious crime, as it was adopted under TFEU 83(2), i.e. to ensure the effective implementation of a Union policy in an area which has been subject to harmonisation measure.

The definition of "serious crimes" still pertain levels of vagueness and could be interpreted differently in national legal traditions of Member States, assumption can be made that exceptions established by the ECJ should apply to the offences listed in Directive (EU) 2017/1371, as well as, other criminal offences which are committed using ICT given the obligation to transfer and retain data is conducted in compliance with the applicable substantial and procedural conditions. Nevertheless, this decision could lead to future cases before European Court of Justice for violation on the right to protection of data, freedom of expression and information on the basis of the Charter of Fundamental Rights of European Union (Art. 8-11).

In practice providing definition on cybercrime or at least using the notions of cyber-dependent and cyber-enabled crime could prove valuable in reducing opportunities of exploiting differences in national regulations of the Member States (forum shopping). There is a high chance, that what the EU tries to protect by adopting such directives as Directive (EU) 2017/1371 or Directive (EU) 2015/849 on money-loundering could be written off simply because of innovative *modus operandi* brought by the ICT or exploiting legal loopholes in the digital environment (due to fast and still growing ICT). Moreover, absence of legal terminology and categorisation of crime with the ICT element in the EU predispose difficulties in calculation the growth of the shadow economy as well as the ICT impact on increase of the financial crime.

6. Conclusion

The existence shadow economy is a common problem for all the societies and has many economic costs for the economic units against the economic advantages for some economic units. Therefore, revealing the determinants of shadow economy is

important for design and implementation of the right policies. In this regard, the relevant empirical literature has generally focused on the traditional economic and institutional determinants of the shadow economy such as tax burden and regulation burden and missed out the effect of ICT development characterizing the new economy and human capital development on the shadow economy. Therefore, this study investigated the effect of ICT development indicators together with human development on the shadow economy size in the sample of EU transition economies for the period of 1996 2015 regarding their institutional and economic transformation after collapse of Iron Curtain. The presence of shadow economy data limited us to conduct the analysis for the period of 1996-2015. Furthermore, we restrained the sample with EU transition economies regarding the institutional, regulatory, and economic contribution of the EU to the countries.

Traditional financial crimes have shifted and adopted to digital era by exploiting ICT for illegal profits. Nonetheless, current international and EU legislation faces legal difficulties concerning not only identification of all *modus operandi* of offences, but also the definition of "cybercrime". Adoption of the minimum definition of cybercrime could not only contribute in recognition of criminal offences as cybercrime, and the ones where the use of the ICT could be interpreted as optional element of *corpus delicti*, but as well for the purpose of approximation of Member State laws, protection of the EU financial interests and calculation the growth of the shadow economy as well as the ICT impact on increase of the financial crime.

The empirical analysis revealed that both variables of mobile cellular subscriptions and human capital had a decreasing impact on the size of shadow economy in the long run at panel level. However, the individual cointegration coefficients disclosed that the impact of ICT indicators on shadow economy changed from country to country depending on ICT penetration rate and country specific characteristics. The EU transition members of Romania, Bulgaria, Croatia, Latvia, and Estonia making a significant progress in ICT penetration experienced the improvements in shadow economy size with the help of raising ICT penetration. But internet usage can raise the shadow economy size in case of insufficient regulatory framework and supervision infrastructure. Therefore, Bulgaria and Romania experienced a decreasing impact of internet usage on the shadow economy, but Croatia, Estonia, Hungary, Latvia, and Slovenia experienced a positive impact of internet usage on the shadow economy. Lastly, the significant improvements in human development made a decreasing impact on the size of shadow economy.

Furthermore, the causality analysis revealed a mutual interaction between ICT development and shadow economy in the short run. In other words, ICT development affected the shadow economy, in turn shadow economy affected ICT development. Furthermore, human development had a significant effect on the size of shadow economy. Therefore, both ICT development and human development had a significant effect on the size of shadow economy in both short and long run. In the light of the findings, the raising ICT penetration makes a contribution to the reduction of shadow economy. Also, the policies for improvements in human capital is a significant factor of shadow economy reduction.

Notes

1. EMPACT factsheet under sectioin „Cybercrime – non-cash payment fraud"stated that in 2019 fraudulent transactions reported for a value of 5 164 392,60 Eur.
2. This lack of unified terminology in the EU law, is not surprising as the similar issue was established and analysed in the research on serious crime (See: Paoli, 2014). Even though, the definition of serious crime is used quite often, it brings little clarity and is deemed to be inconsistent both in the EU policy documents and academic literature, the latter often confiding on the definitions proposed in their national legal systems. (Paoli et al., 2017, p. 280-281)
3. *E.g.,* Directive 2013/40/EU („cybercrime"is mention a dozen times in the preamble with no distinct characteristics), Directive (EU) 2016/1148; Regulation (EU) No 910/2014; Regulation (EU) 2019/881.

Disclosure statement

No potential conflict of interest was reported by the authors.

Author contributions

Rita Remeikienė, Ligita Gasparėnienė, Yilmaz Bayar, Romualdas Ginevičius contribution is 22,5 percent per person, Ieva Marija Ragaišytė − 10 percent.

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