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DOES TECHNOLOGY MATTER FOR COMBATING ECONOMIC AND FINANCIAL CRIME? A PANEL DATA STUDY

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Abstract. In this paper we analyze the influence of technology on the level of the economic and financial crime, using data for 185 countries over the 2012–2015 time period and controlling for many important variables. First, we find that on average, the size of the economic and financial crime in low income countries is about double compared to that of high income countries, while their Research and development expenditure (as % of GDP) are about four times lower than in high income countries. We find clear evidence that increased technology reduces the size of the economic and financial crime. In addition, we find that Research and development expenditure (% of GDP) matter more in reducing the economic and financial crime in low income countries than they do in high income countries. Our main findings are generally stable after conducting some robustness checks. From a policy perspective, our study may prove to be of great use to decision makers of the states, to government and non-governmental enterprises and to potential investors within different markets.

Keywords: technology, economic and financial crime index, corruption, shadow economy, money laundering.

JEL Classification: O17, O32, O38, H11, H26.

Introduction

Although sustained efforts have been made to combat economic and financial crime by governments around the world, it still remains a major problem in society. Global Financial Integrity (2020) estimates the approximate illicit financial flow (trade misinvoicing, smuggling, tax evasion, etc.) over the ten-year period 2008–2017 to get to 8.7 trillion USD for the world

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countries. Regarding corruption, the recent data from Transparency International (2020) show that even though there is some progress, most countries still fail to control public sector corruption. Therefore, the corrupting role of big money in political party financing and the undue influence it exerts on the political systems must be urgently addressed by governments (Transparency International, 2020). Referring to the cost of corruption, Lagarde (2016) reveals that 2 percent out of the worldwide gross domestic product is paid in the form of bribes yearly, summing up 1.5 to 2 trillion USD per year globally. Furthermore, Achim et al. (2018) find that 19 percent of European countries' GDP is lost in shadow economy.

Starting from the premise that information and communication technologies (ICTs) have indeed impacted all partners engaged in the fight against corruption (ranging from public authorities to the private sector and the media), Adam and Fazekas (2019), particularly focusing on developing countries, consider ICTs to be effective in controlling corruption. However, the authors find that this positive effect is closely related with political parties, public governances and civil society groups. Wickberg (2013) provides multiple examples of various technological innovations meant to target the reduction of corruption phenomena: technologies are used for reporting administrative abuses and corruption and for facilitating the lodging of complaints, via websites, hotlines or phone applications (people's experiences of bribery and electoral fraud); ICTs are used for monitoring the access to information, the public budgets and the social services, political life, the judiciary and even illegal logging from forests; ICTs are used for extensive data collection; ICTs are used for campaigning, social mobilization and citizen-to-government interaction and nonetheless, ICTs prove themselves extremely useful in several E-government initiatives (E-procurement, E-judiciary, E-taxation, Financial transactions and electronic identification). So, information and communication technologies are one of the forces shaping the twenty-first century, because ICTs have great potential to act as democratic media and the scope of ICT-enabled anticorruption initiatives is large (Serrat, 2017).

The political rulers have to determine the causes for the corruption phenomena, in order to be further able to combat them. In the present work, among other previous explanatory variables (economic development level, tax burden, public administration and audit quality) we examine the role held by technology in reducing the size of the economic and financial crime.

In terms of the interaction between adopting technologies and the level of economic and financial crime there are two controversial strands in literature. The first and main strand in literature finds that a higher degree of technology adoption reduces the level of frauds. For instance Bird and Zolt (2008) investigate the way in which different levels of technology may influence fiscal administration in developing countries. According to Slemrod (1990) and Bird and Zolt (2008) technology changes may increase the quantity and quality of the information flow available to taxation officials facilitating a better coordination and may decrease the costs of taxpayer compliance through improving services to taxpayers (e.g. various programs or applications which directly determine the level of tax liabilities). The results consist in higher efficiency tax administration systems by increasing the level of collected revenues and therefore the level of tax avoidance decreases. Regarding these, Immordino and Russo (2018) conduct a survey over 25 European countries from 2000 to 2012 and find an indirect relationship between VAT evasion and bank payments through various card types.

On the other hand, the researchers validate a direct relationship between VAT evasion and ATM cash withdrawals. Thus, Immordino and Russo (2018) conclude that cashless payments determine a decrease of the tax evasion phenomena because in this way several traces are left that would make it difficult to activate in the underground environment. Moreover, technology may discourage corruption engaged activities by reducing the interactions between the taxpayer on the one hand and the representative of the tax authorities on the other hand (Slemrod, 1990; Bird & Zolt, 2008). Similar findings are obtained by Goel et al. (2012) that establish internet diffusion to be associated with less corruption.

Williams (2013) emphasizes the need for investment in technology in the regulatory process of the financial market where it detects uprising problems, thus reducing frauds in the financial markets. This way Williams (2013) uses the "regulatory technologies" notion and examines in detail two such technologies. In the financial sector, financial fraud poses more and more threats, which generate big negative effects (Sadgali et al., 2019). Most financial institutions have been implementing internal investments in anti-money laundering solutions to fight fraud activities. In this view, data mining approaches have been developed and are considered "well-suited techniques for detecting money laundering (ML) activities" (Le-Khac et al., 2009). Considering that an understanding of the principle elements of fraud is the foundation for any antifraud activity, Sadaf et al. (2018) test, through cross-sectional linear regression models, the influence of governance, competitiveness and other institutional variables upon the number of accounting frauds. Using Control of Corruption as an independent variable, Sadaf et al. (2018) validate that boosted political stability and controlled corruption may reduce the number of frauds in several countries. Another relevant paper that focuses on the issue of frauds is the study of Máté et al. (2019), which proves, through OLS regressions, that higher levels of auditing and accounting standards, increased levels of governance capital, advanced financial freedom and the use of common law are positively related to reported fraud cases.

Regarding anti-fraud technologies, the detection of credit card fraud uses various money laundering techniques, especially those of artificial intelligences while for detecting frauds in financial statements the best performing methods are probabilistic neural network and genetic algorithm (Sadgali et al., 2019). Similar technologies consist in computerized data mining programs, machine learning and several tools for risk profiling which are used to trace illicit funds for money laundering or terrorist acts (Levi & Wall, 2004; Amoore & de Goede, 2005; de Goede, 2008; Williams, 2013). In addition, it is very important to have an integrated analytical approach to antifraud technology in order to improve customer fraud experience constantly (Zoldi, 2015). This target may be achieved through fraud alerts that contact the cardholder for approval (using various channels such as voice, email or SMS) in real time, anytime a suspicious transaction is detected (Zoldi, 2015).

Within organizations, complex forensic auditing programs and tools using data mining processes and risk profiling techniques are used to detect the vulnerabilities and fraud risks in relationship with the customers (Williams, 2013). Similarly, Okunogbe and Pouliquen (2018) find that Tajik firms, which adopt electronic tax filing, have lower compliance costs, spending five fewer hours per month on fulfilling tax liabilities. They also find that for firms previously more likely to evade, e-filing doubles tax payments. Related to this, Elgin and Oyvat (2013)

find that internet usage decreases the shadow economy using a panel database made of 152 countries that are analyzed throughout the 1999–2007 time period, and this relationship interacts with GDP per capita in a powerful manner. Thus, as GDP per capita increases, this negative correlation reduces. Also regarding the types of investments in organizations, Suh et al. (2018) investigate whether organizational investments work for countering occupational fraud on a sample of 392 Korean banking employees, and then, where to focus the investment if it does work. They find that investing in ethical culture is more effective in preventing occupational fraud than the investments in monitoring control. Regarding technology transfers, the paper of Bilgin et al. (2011) comprising 2400 Chinese enterprises throughout the period 1999–2002 find that companies may enhance their productivity by using foreign technologies from technologically advanced economies and by importing more capital goods.

Another strand in literature finds a positive relationship between the level of investments in technologies and the size of the economic and financial crime. The usage of modern technologies, besides bringing along positive drawbacks to the company, also attracts fraudsters to misuse the technology for financial benefits in the shape of cybercrime (Ali et al., 2019; Gogolin, 2010; McAfee, 2018; Ryman-Tubb et al., 2018). Through the misuse of high IT technologies, cybercriminals may have many opportunities to commit crimes from a large physical distance, using different jurisdictions and identities, thus being difficult to become detected by prosecutors (Ali et al., 2019). As a result of adopting new technologies, the cost of global cybercrime went up to $608 billion in 2017 compared to only $445 billion in 2014 (McAfee, 2018). Moreover, bankcard frauds cause huge financial losses to companies and various entities. According to Robertson (2016), the global card fraud losses rose three times over the period 2010–2015. In 2020, the worldwide losses from frauds with bank cards are expected to achieve the level of $31.67 billion. Further on, these huge amounts of money are used to finance crimes such as terrorism and the weapons and drugs' industries (Ryman-Tubb et al., 2018).

In this view, Remeikiene et al. (2018) introduce the term digital shadow economy referring to the illegal activities operating in digital space. As a result of digital economy, everyday tax evasion can be facilitated even more by taxpayers using readily available technology to evade taxes while in its classical manner it can be undertaken simply by accepting under the table cash or keeping a separate set of books (Dejong, 2018). Using high-technologies under the form of software such as "zappers" and "phantomware" is meant to reduce the company sales figures without leaving any trace on the book records. This type of fraud (called "electronic sales suppression") is very difficult to be detected by the tax authorities. Similar findings are obtained by Hamilton and Stekelberg (2017) that validate a positive relationship between investments in IT technologies and favorable corporate tax outcomes. More exactly, they find that firms with high-quality IT are able to avoid more taxes while simultaneously incurring less tax risk compared to firms with less advanced IT systems.

An explanation regarding the high level of digital fraud undertaken in the context of increased IT technologies consists in the fact that the pace of technical enforcement ability to deal with these crimes (Gogolin, 2010). Digital skills are perishable unless kept current and thus digital crime investigation is very expensive. To keep the pace, digital crime investigation requires high investments in training and also digital and physical infrastructures (Gogolin, 2010).

Under these aforementioned circumstances, we are interested in testing the following research hypothesis:

Hypothesis. *Increased levels of technology conduct towards reduced levels of economic and financial crimes.*

Nonetheless, a positive influence of investments in IT technologies on tax avoidance is found and the explanations must reside in the countries' level of development. Thus, the efficiency of using high technologies in the tax administration process differs among developed and developing countries (Bird & Zolt, 2008; Elgin & Oyvat 2013; Gnangnon, 2020). For instance, Elgin and Oyvat (2013) investigate the relationship between the degree of internet usage and the dimension of the shadow economy and they find that internet usage, the level of the shadow economy and GDP per capita are strongly interconnected. In this view, the increase of Internet usage rates are associated with increased tax reforms in developing countries (Gnangnon, 2020). However, in developing countries the development of technologies is not considered a "magic bullet" for improving fiscal administration and reducing tax evasion (Bird & Zolt, 2008). Despite the significant technological investments adopted in the last 40 years in these countries, they still register low levels of tax collections in their GDPs and high levels of fiscal non-compliances. This is happening because developing countries face many more difficulties and challenges in their administrative tax systems related with many patterns of economic environments which are not ready for the absorption of technology changes (Slemrod, 1990). The first patterns which characterize developing countries refer to the higher size of agricultural and informal sector which determine higher underreported taxes. Then, the lower development of the financial sector of an economy consisting of mainly cash or barter exchanges, makes it impossible to trace all transactions (Bird & Zolt, 2008). In addition, a successful reform in tax administration cannot be applied without revising the whole organizational system. Thus, high improvements in tax administration require changes for the re-organization and re-engineering of the whole system (Engelschalk, 2005; Bird & Zolt, 2008) which is often difficult for developing countries due to the numerous economic and social problems these countries face. Another challenge which developing countries face consists in low levels of administrative capacity characterized by inadequate and low skilled human capacity. This determines a low efficiency in using high technologies and thus the efficiency of tax administration (reflected in obtaining a higher level of collected revenues) is unchanged, despite the high technology investments.

From this perspective, it is reasonable to investigate the extent to which the dynamics between technological development and economic and financial crime may depend on the level of national income. All in all, we ask the next research question:

Research question. *How is the impact of technological development upon economic and financial crime different in high income countries compared to low income countries?*

To achieve our objective, we build an index which measures the development of the economic and financial crime phenomenon of each country. Then we run a panel regression for the 185 worldwide countries over the 2012–2015 period to examine the influence of technology on the size of the economic and financial crime, also using several important controls.

We find clear evidence that expanding technology reduces the dimension of the economic and financial crime. The estimations are conducted on the two groups of countries as they greatly depend on their level of development (high or low income countries). Our results significantly differ between these two groups of countries. Thus, we may conclude that although there are many common determinants for the economic and financial crime phenomena, there also exist others that are highly related to the national development.

The remainder of the paper is organized on subsections as follows: Section 1 comprises the methodology, data and variables. Section 2 presents our results. Section 3 sums our analysis up and discusses the findings. Last Section synthetizes our conclusions and includes some limitations, policy implications and avenues for future research ideas.

1. Methodology and data

1.1. Description of the variables

1.1.1. Dependent variable: economic and financial crime index

According to both US Legal (2019) and Europol (2019) economic and financial crime refers to illegal acts committed by an individual or a group in order to get financial or professional advantages. Thus, the main reason behind such crimes consists in getting economic gain. Internationally there doesn't exist a common definition valid in all the countries regarding the economic and financial crime phenomena (Letia, 2014, p. 13). For instance, US Legal (2019) reveals that cybercrimes, tax evasion, robbery, selling of controlled substances and abuses of economic aid are all examples of economic crimes. On the other hand PricewaterhouseCoopers (2016) associates the economic and financial crime concept with the followings acts: asset misappropriation, cybercrime, bribery and corruption, procurement fraud, accounting fraud, human resources fraud, money laundering, infringement, tax fraud, mortgage fraud, competition/antitrust law infringement, espionage and others. Thus, we may conclude that both the definition and especially the measurement of economic and financial crime are challenging attempts.

Starting from the theoretical literature backgrounds and the specialized practice, we define the economic and financial crime as a set of illegal acts (crimes) committed by persons or legal entities with the purpose of producing or intermediating the development of economic and financial benefits. The economic and financial crime is characteristic to businesses and it may appear in the form of corruption, fraud, tax evasion, money laundering etc. Also, illegal businesses such as human or drugs trafficking and gambling produce (or mediate) economic and financial benefits for certain stakeholders, therefore they are included in the area of economic and financial crime, as components of the shadow economy.

If the concept of economic and financial crime is to be operable, it needs to be narrower (Rider, 2015, p.4). Therefore, following the purpose of measuring it, we start with the main three components of the economic and financial crime: corruption, shadow economy and money laundering. In order to measure these three phenomena we use the following variables:

a. For corruption (C) we include the Corruption Perception Index, which aggregates data from different surveys on the perception of corruption registered in the public sector

in different countries of the world. This index is drawn up annually on a range from 0 (very corrupt), to 100 (very clean), for 180 countries, starting from the year 1995.

b. For shadow economy (S) we consider the database elaborated by Schneider (Medina & Schneider, 2018), in which the size of shadow economy is computed as a weight within the GDP, for 158 countries, starting from the year 1991.
c. For money laundering (L), we utilize the Basel AML (Basel Anti-Money Laundering Index), which assesses the risk of money laundering and terrorist financing in over 129 worldwide countries. The Basel AML score is calculated starting from 2012.

Further, because all these three indexes contain data measured through different methods we use their standardized values in order to obtain homogenous data that would be subject to aggregation. Then, we build the *economic and financial crime index* (*CSL*) as an arithmetic average score of these main categories of economic and financial crime (corruption-C, shadow economy-S and money laundering-L (Achim & Borlea, 2020, pp. 38–40). Thus, the economic and financial crime score (CSL) ranges between level 0, reflecting the lowest size of economic and financial crime and level 1, reflecting the highest size of economic and financial crime. Such a score can be used to measure the level of economic and financial crime that characterizes a particular nation, allowing comparative analyses between countries as well. Alternatively, to substantiate our results within several robustness checks, an aggregated score through exploratory factor analysis (principal components analysis) is also built.

1.1.2. Independent variable: technology

According to Oxford Learner's Dictionaries (2020), technology represents "the application of scientific knowledge for practical purposes, especially in industry". This term is also associated with "machinery and equipment developed from the application of scientific knowledge" or "the branch of knowledge dealing with engineering or applied sciences". According to KPMG (2017), technology is highly related to the third industrial revolution and the fourth industrial revolution. The third industrial revolution is about digitization and a key feature of the third industrial revolution is the Internet. The fourth industrial revolution generally is a simple extension of the Third. What makes the concept of the fourth industrial revolution different from the third is artificial intelligence (the concept here is to create computer systems or robotics that can do anything a human can do) and the second uses the notion of 4D (which is an extension of 3D technology).

Technology is measured in literature in various ways: degree of internet usage (Elgin & Oyvat, 2013), investments in IT technologies (Hamilton & Stekelberg, 2017; Bird & Zolt, 2008); investment in technology (Williams, 2013). World Bank (2020) lists, among the Science & Technology indicators, the following: Charges for the use of intellectual property, payments/receipts (BoP, current US$); High-technology exports (as % of manufactured exports and as current US$); Patent applications (for nonresidents and for residents; Research and development expenditure (% of GDP); Researchers in R&D (per million people); Scientific and technical journal articles; Technicians in R&D (per million people); Trademark applications (direct nonresident, direct resident and total).

For the purpose of our paper we select three variables as proxies of technology, namely: a) Research and development expenses, as % of GDP (R&D); b) the score of Technology adoption; and c) High-technology exports, % of manufactured exports (see Table 1 for details).

1.1.3. Control variables

Considering various studies we also include some determinant factors of economic and financial crimes which are used by the literature as control variables, such as *economic development* (Husted, 1999; Schneider & Klingmair, 2004; Tsakumis et al., 2007; Achim et al., 2018), *governance* (Medina & Schneider, 2018; Richardson, 2008; Torgler & Schneider, 2007), *tax burden* (Dreher & Schneider, 2010; McGee, 2012; Schneider & Klinglmair, 2004; Torgler & Schneider, 2007), *audit quality* (Drezewski et al., 2012; Vaithilingam & Nair, 2009; Nikoloska & Simonovski, 2012), *unemployment rate* (Dell'Anno & Solomon, 2008; Dobre et al., 2010; Williams & Schneider, 2016; Medina & Schneider, 2018), *press freedom* (Brunetti & Weder, 2003; Kalenborn & Lessmann, 2013; Lv, 2017; Florescu & Cuceu, 2019) or *shadow economy* (Heshmati, 2016, p. 131), *religion* (Heinemann & Schneider, 2011; Ko & Moon, 2014; McGee et al., 2015) and *legal origin* (La Porta et al. 1997, 2008; Lv, 2017).

A synthetic presentation of the variables and their proxies is presented in Table 1.

Table 1.Variables and data

Variables	Way of expressing	Units/scale	Sources
Dependent variable			
Economic and financial crime index (CSL)	CSL is determined as an aggregation index between the standardized values of corruption, shadow economy and money laundering, where:	The scores range from 0 (lowest level of financial crime) to 1 (highest level of financial crime)	Own calculations
	Corruption is determined from the *Corruption perception index* (C) which measures the perceived levels of corruption in the public sector for the world countries.	The score ranges from 0 (highly corrupt) to 100 (very clean)	Transparency International (2020)
	Shadow economy (*S*) is determined as percentage of GDP, for the world countries.	% in GDP	Medina and Schneider (2018)
	Money laundering (*L*) is determined as a risk of money laundering and terrorist financing, more exactly the Basel AML Index is used.	The score ranges between 0 (Low risk) to 10 (High Risk) level in money laundering/ terrorist financing	Basel Institute on Governance (2020)
Independent variables			
Technology	*Research and development expenditure*, as % of GDP (R&D) Expenditures for research and development are current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development. Weighted average.	% in GDP	World Bank (2020)

Continue of Table 1

Variables	Way of expressing	Units/scale	Sources
Technology	*Technology adoption* (TA)	Weighted score of technological readiness (technological adoption and ITC use) which ranges between 1 to 7, from least to most agile company to adopt existing technologies to enhance the productivity of its industry.	World Economic Forum (2020)
	High-technology exports (% of manufactured exports) (HTE) High-technology exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery. Weighted average.	% of manufactured exports	World Bank (2020)
Control variables			
Economic development	*GDP per capita* (*GDP*)	in US dollars	World Bank (2020)
Governance	*Worldwide Governance Indicators* consist in six dimensions of governance such as: Voice and Accountability (VA); Political Stability and Absence of Violence (PS); Government Effectiveness (GE); Regulatory Quality (RQ); Rule of Law (RL); Control of Corruption (CC). We use GOV_composite obtained through PCA.	Ranges from –2.5 points (weak) to 2.5 points (strong) in governance performance	World Bank (2020)
Tax burden	*Fiscal freedom* provided from Index of Business Freedom.	The score ranges from 0 to 100, where 0 is the least fiscal freedom and 100 is the maximum degree of fiscal freedom.	Heritage Foundation (2020)
Audit quality	*Strength auditing and reporting standards* (*SAR*) from Global competitiveness index. It is rated by answering to the following question: „In your country, how strong are financial auditing and reporting standards? [1 = extremely weak; 7 = extremely strong]".	The score ranges from 1 worst to 7 best.	World Economic Forum (2020)
Unemployment rate	Total unemployment (modelled ILO estimate). Unemployment refers to the share of the labour force that is without work but available for and seeking employment.	Percentage of total labour force	World Bank (2020)

End of Table 1

Variables	Way of expressing	Units/scale	Sources
Press freedom	Freedom of the press	The score measures the ranked countries on a scale from 0 to 100, with the freest media scoring close to 0. Basically the higher the score, the less freedom the press has in that country.	Freedom House (2020)
Religion	Different types of religion: Protestant, Catholic, Muslim and Other religion	A set of three variables that identifies the percentage of a country's population in the 1980s that follows Protestant, Catholic, Muslim or Other religions.	La Porta et al. (1997, 2008)
Legal origin	*Dummy variable* (English Common Law, French Commercial Code, German Commercial Code, Scandinavian Commercial Code; and Socialist/ Communists laws)	The dummy variable which takes the value 1 if a national's legal system is of English, French, German, Socialist or Scandinavian origin, and 0 if otherwise. These dummy variables are used, considering English as the reference category.	La Porta et al. (1997, 2008)

The present paper further uses the classification of countries by their levels of economic development, as high income countries and low income countries. We use the categorization established by the World Bank (2015) in two groups: low income states (including the low and middle income economies) and high income states (including the high income countries). The presentation of the two subsamples is presented in the Appendix.

1.2. The model

We investigate the impact of technology upon the economic and financial crime using several controls such as economic development, tax burden, governance, audit quality, unemployment, press freedom, religion and origins of legal form. The data cover a sample of 185 countries over the 2012–2015 time period. All variables – except origins of legal form, which are time-invariant regressors – have the dimension of individuals (countries) and time. We are restricted to this period because of the restrictions of available data used for building the economic and financial crime score (as an aggregated score of corruption, shadow economy and money laundering-CSL index). Thus, even if on one hand the data on corruption are aimed at a large number of years, on the other hand the data on money laundering are valid only from 2012 and those regarding the underground economy until 2015.

We estimate panel regression models in which the economic and financial crime is seen as a function of technology proxies and several control variables, as mentioned above. The general form of our model is:

$$\text{Economic and financial crime (CSL)}_{it} = \beta_0 + \beta_1 \text{Technology}_{it} + \beta_{(j)2} \text{Controls } (j)_{it} + \varepsilon_{it}, \quad (1)$$

where Economic and financial crime $(CSL)_{it}$ – the aggregation index between the standardized values of corruption, shadow economy and money laundering, for country *i* in year *t*; $Technology_{it}$ – Research and development expenditure for country *i* in year *t and then* Technology adoption for country *i* in year *t*; Controls $(j)_{it}$ – the j-th Control variable for country *i* in year *t*; β_0 – intercept; β_1 – regression coefficient that will indicate the extent to which the independent variable $Technology_{it}$ is associated with the dependent variable CSL_{it}, if β_1 is found to be statistically significant; $\beta_{(j)2}$ – regression coefficient for the *j*-th variable in the vector of Controls; *j* – ranges, for the vector of Control variables, from economic development, governance, to tax burden, audit quality, unemployment rate, press freedom, religion and legal origins; ε_{it} – residual or prediction error for country *i* at year *t*.

2. Results and discussions

2.1. Descriptive statistics

The main descriptive statistics of our variables are presented in Table 2. For our sample, the economic and financial crime score has an average value of 0.4753 points for the full sample, ranging from 0 (Finland) to 1 point (North Korea, Somalia and Afghanistan). The lowest levels for the economic and financial crime score reside among the Northern European countries (Finland, Norway, Sweden, Denmark, Iceland, The Netherlands, United Kingdom and Ireland) and several East Asian and Pacific countries (New Zealand, Australia and Singapore). Then, the highest levels of economic and financial crime score are found in Afghanistan and the majority of Sub-Saharan African countries (South Sudan, Sudan, Zimbabwe, Guinea-Bissau, Central African Republic, Cambodia, Nigeria, Congo Democratic Republic, Guinea, Kenya and Uganda).

One may easily note that the average value of the economic and financial crime score is about double in the low income states' subsample compared to the high income states' subsample. Other similar findings highlight higher levels of economic and financial crimes in the low income countries compared to the high income countries. For instance the study of Achim et al. (2018) conducted on two groups from the European Union countries, finds that European Union members (which are generally represented by developing countries) have an average level of shadow economy of 25.42% (calculated as a percentage in GDP), while among the old members (developed countries) the percentage is significantly lower, of only 14.48%. The study of PricewaterhouseCoopers (2018) points out that in developing countries 15% of the analyzed financial entities expect an increase in the resources invested in fraud detection in the next two years, while only 9% is found for developed countries. The same study finds that in developing countries 58% of the studied financial entities (financial companies, insurers, mutual funds, various dealers and others) have dealt with the fight to combat money laundering in the last two years, while only a more reduced percentage of 48% is found for developed countries.

Table 2. Summary statistics, the entire sample (All), the high income countries' subsample (High income) and the low income countries' subsample (Low income)

Variables	Obs	Mean	Std. Dev.	Min	Max
Economic and financial crime index_All	725	0.4753	0.2173	0	1
Economic and financial crime index _High income	211	0.2479	0.1149	0	0.6669
Economic and financial crime index _Low income	514	0.5686	0.1768	0.2106	1
R&D_All	355	1.0306	1.0088	0.0124	4.2887
R&D_High income	178	1.6085	1.0973	0.044	4.2887
R&D_Low income	177	0.4494	0.3982	0.0124	2.0564
Technology adoption_All	574	4.7450	0.7234	2.9198	6.1987
Technology adoption _High income	203	5.3916	0.5065	3.6932	6.1987
Technology adoption _Low income	371	4.3912	0.5616	2.9198	5.8624
GDP _All	700	14338.78	20307.09	244.1965	116612.9
GDP _High income	208	38463.93	23041.41	9057.113	116612.9
GDP _Low income	492	4139.537	3528.672	244.1965	15695.9
Governance_All	732	<0.001	0.9979	–2.3505	2.1694
Governance_High income	216	1.1449	0.728	–1.4576	2.1694
Governance _Low income	516	–0.4792	0.6421	–2.3505	1.044
Tax burden_All	702	77.6653	12.1387	39.1	99.9
Tax burden _ High income	210	73.2623	16.1685	39.1	99.9
Tax burden _ Low income	492	79.5447	9.3415	46.2	98.8
Audit quality_All	576	4.6163	0.8756	2.204	6.7269
Audit quality _ High income	200	5.3355	0.6511	3.766	6.4857
Audit quality _ Low income	376	4.2338	0.7266	2.204	6.7269
Protestant_All	704	11.909	20.447	0	97.8
Protestant_ High income	212	18.483	28.3938	0	97.8
Protestant_ Low income	492	9.0764	15.0145	0	64.2
Catholic_All	712	30.8207	35.6637	0	97.3
Catholic_ High income	216	35.9222	36.5917	0.1	97.3
Catholic_ Low income	496	28.5991	35.0577	0	96.6
Muslim_All	712	24.23	36.2778	0	99.9
Muslim_ High income	216	13.2674	30.704	0	98.9
Muslim_ Low income	496	29.004	37.4915	0	99.9
Other_All	704	33.0565	32.4403	0	100
Other_ High income	212	32.9086	31.977	0.9	98.5
Other_ Low income	492	33.1203	32.67	0	100
Unemployment All	716	7.9846	5.9706	0.16	31.016
Unemployment _ High income	212	7.9289	5.1465	0.16	27.466
Unemployment _Low income	504	8.0081	6.2897	0.299	31.016
Press freedom _All	728	49.7445	23.221	9	97
Press freedom _ High income	204	32.6519	23.0903	9	91
Press freedom _ Low income	524	56.3988	19.6029	15	97

In the same time, the average level of Research and development expenditure (% of GDP) for all countries is about 1 percent for the full sample, ranging from 0.0125 (Syria) up to 4.28 (Israel). The highest levels of research and development expenditure (as % of GDP) are found in Israel and South Korea (4.2), Japan, Sweden and Switzerland (3.2), Finland, Denmark and Austria (3.0), United States (2.7), Belgium (2.4) and Australia (2.0). Opposite, the lowest levels of research and development expenditure (as % of GDP) are found in the great majority of African countries (Syria, Lesotho and Madagascar) and Latin American & Caribbean countries (El Salvador, Guatemala and Honduras). We may also note that, on average, for low income countries this percent is about four times lower than for high income countries. Large existing standard deviations of variables impose a careful interpretation of our results.

In order to intuit the relation between the economic and financial crime and the level of technology we plot them against each other (Figures 1, 2). One can notice that Figures 1 and 2 reflect negative correlations between financial crime and technology (expressed by Research and development expenditure, as % of GDP – R&D and by Technology adoption).

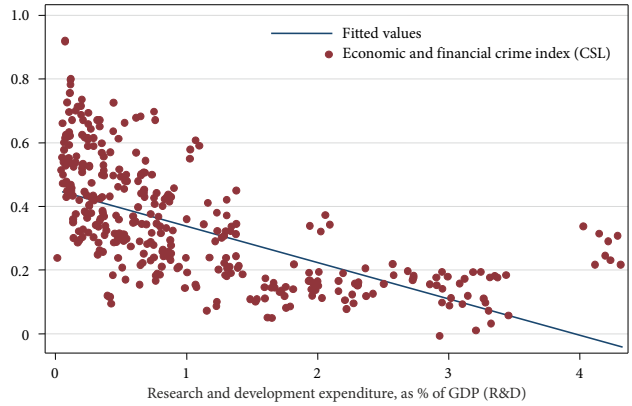

Figure 1. Plots of Economic and financial crime index (CSLindex) against technology expressed as Research and development expenditure, as % of GDP (R&D)

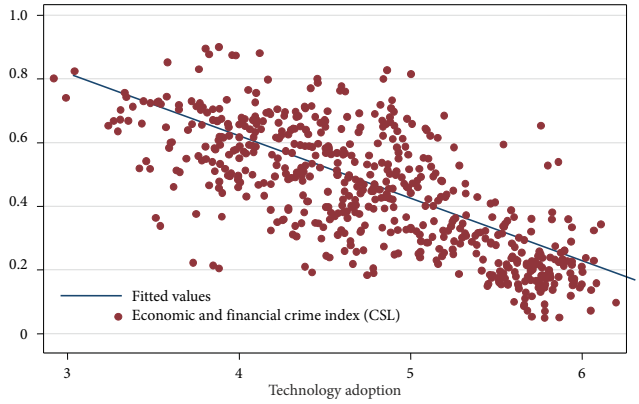

Figure 2. Plots of Economic and financial crime index (CSLindex) against technology expressed as Technology adoption (TA)

2.2. Empirical results

2.2.1. Basic results

The main results are built using the forward estimation multiple regression technique. At first we explicit our economic and financial crime index as a function of Research and development expenditure, as % of GDP (R&D) or Technology adoption (TA), the variables of interest. Then, the other independent variables are added, in the decreasing order of their explanatory power for the economic and financial crime index and simultaneously controlling for multicollinearity. The religion and legal origin control variables are added in the end, for obtaining an optimal Pooled-OLS regression for our unbalanced panel data.

The Main results tables (Tables 3 and 4) also estimate, on separate columns, the multiple regression through the Fixed Effects Model (FEM) and the Random Effects Model (REM). Bolded in the top line of each table is the estimation technique validated as optimal through the Hausman test. The general form of FEM and REM models is presented in Equations (2) and (3) below.

$$\text{Economic and financial crime (CSL)}_{it} = \beta_1 \text{Technology}_{it} + \beta_{(j)2} \text{Controls } (j)_{it} + \beta_{0i} + u_{it}, \quad (2)$$

where β_{0i} $(i = 1 \ldots n)$ – the unknown intercept for each entity (n country-specific intercepts); u_{it} – the error term.

$$\text{Economic and financial crime (CSL)}_{it} = \beta_1 \text{Technology}_{it} + \beta_{(j)2} \text{Controls } (j)_{it} + \beta_0 + u_{it} + \varepsilon_{it}, \quad (3)$$

where u_{it} – between-entity error; ε_{it} – within-entity error.

When the F test probabilities are low, the adequacy of FEM is sustained, against the null hypothesis that supports the pooled OLS models. The Breusch-Pagan test favors the alternative hypothesis that the REM is adequate, in opposition to the pooled OLS technique. Furthermore, the Hausman test generally has low p-values, rejecting the null hypothesis H_0 that the REM is consistent and accepting the alternative H_1 of the FEM as appropriate (FEM is bolded out in Table 3 models (2) and (2') and Table 4 models (2), (2') and (2")). On the other hand, in Table 3 REM is supported, suggested by the Breusch-Pagan and Hausman tests applied on the low income countries' subsample (model (3")).

Table 3 estimates the economic and financial crime index as a function of R&D and other valid control variables for the entire sample of 185 worldwide countries, and for the resulting two subsamples of 54 high income countries and 131 low income countries respectively.

For the entire sample, the R&D coefficients are negative and significant for OLS (1) and REM (3) models. For model (1), as the value of R&D increases with 1%, the mean of economic and financial crime index decreases by 0.0361 units, ceteris paribus. For model (3), the economic and financial crime index decreases with 0.0277 units for each 1 point increase in the R&D expenses of nations, ceteris paribus. The predictive accuracy of the OLS model (1) is high for an Adj. R^2 of 0.8293. Although tests indicate the FEM as the best technique, the coefficient estimated for R&D is not significant (model (2)).

Therefore, our results confirm our research hypothesis that a *higher level of technological development determines a reduced dimension of economic and financial crime.* Our results are in line with those of Bird and Zolt (2008), Immordino and Russo (2018), Goel et al. (2012),

Table 3. Regression results for *Economic and financial crime* (*CSL*) as a function of *R&D* and other explanatory variables

	Entire sample			High income countries			Low income countries		
	OLS	FEM	REM	OLS	FEM	REM	OLS	FEM	REM
	(1)	(2)	(3)	(1')	(2')	(3')	(1")	(2")	(3")
R&D	−0.0361***	0.0058	−0.0277**	−0.032***	0.0013	−0.0213**	−0.0968***	−0.00001	−0.1075***
Governance_composite	−0.1175***	−0.0239	−0.1221***	−0.1839***	0.0456	−0.152***	−0.1424***	−0.1303**	−0.1493***
LogGDP	−0.0132*	−0.0084	−0.0169	0.066***	−0.02	0.0348**	−0.0117	0.0691	0.0024
Press freedom	0.0012***	−0.0019*	0.0001						
Audit quality	−0.0258**	−0.0173	−0.02*						
Tax burden	−0.0008	0.0006	0.0008	−0.0001	0.0005	0.0005			
Unemployment	−0.0009	0.0039	0.0007	0.0014*	0.0059**	0.0021	−0.0024	0.0047	−0.0019
Protestant	−0.00009		−0.0004	−0.0006***		−0.0008	−0.0003		0.00004
Catholic	0.0001		0.0003	−0.0005***		−0.0004	0.0007**		0.0007
Muslim	−0.0005***		−0.0004	−0.0016***		−0.0014***	0.0005*		0.0006
Socialist legal origin	−0.0528***		−0.045	−0.0205		−0.0262	−0.0367		−0.0365
French legal origin	−0.0277*		−0.0245	−0.0043		0.0053	−0.0562*		−0.0585
German legal origin	0.0792***		0.0855	0.0787***		0.0745***			
Scandinavian legal origin	0.0182		0.0602	0.0175		0.032			
Constant term	0.7649***	0.5341**	0.6566	−0.1163	0.302	0.089	0.6347***	−0.145	0.5136***
Obs.	311	311	311	166	166	166	163	163	163
	R^2 = 0.8370	within R^2 = 0.0529	within R^2 = 0.0144	R^2 = 0.8713	within R^2 = 0.0543	within R^2 = 0.0006	R^2 = 0.5950	within R^2 = 0.0551	within R^2 = 0.0211
	Adj R^2 = 0.8293	between R^2 = 0.0191	between R^2 = 0.8196	Adj R^2 = 0.8613	between R^2 = 0.1139	between R^2 = 0.8709	Adj R^2 = 0.5711	between R^2 = 0.0455	between R^2 = 0.5933
		overall R^2 = 0.0073	overall R^2 = 0.8230		overall R^2 = 0.0913	overall R^2 = 0.8569		overall R^2 = 0.0486	overall R^2 = 0.5888

Note: ***designates the 1% significant coefficients, **designates the 5% significant coefficients and *designates the 10% significant coefficients.

Elgin and Oyvat (2013), Okunogbe and Pouliquen (2018) and Suh et al. (2018) who also validate an indirect relationship between technological development and various types of economic and financial crime. Actually, Slemrod (1990) and Bird and Zolt (2008) find that increased technologies conduct to higher efficiencies of the fiscal systems, further reducing the dimension of evasion in taxes. For a sample of European countries, Immordino and Russo (2018) establish that VAT evasion decreases as the card payments and cash withdrawals increase. From the perspective of tax collection, Okunogbe and Pouliquen (2018) say that adopting superior technologies under the shape of e-filing conducts towards a doubled collection of receipts, and further on the tax evasion phenomena are contracting. Moreover, Elgin and Oyvat (2013) find that capital investments into better internet usage rates decrease the dimensions of the shadow economies. Regarding corruption, Slemrod (1990), Bird and Zolt (2008) and Goel et al. (2012) also find that technologies have the potential of reducing the level of corruption by decreasing the direct interaction instances between taxpayers and the representatives of the taxing authorities. For the prevention of money laundering, several researchers (Levi & Wall, 2004; Amoore & de Goede, 2005; de Goede, 2008; Sadgali et al., 2019; Zoldi, 2015) find that high technological investments like data mining, artificial intelligence and risk profiling tools are used to trace illegal funds in areas such as terrorist financing, thus the money laundering phenomenon is contracted. On top of all these, Suh et al. (2018) validate that investing in ethical culture has the contraction of occupation frauds in the banking domain as an outcome.

As expected, the coefficients for the government aggregated proxy (Governance_composite) and for the economic development variable (LogGDP) are negative and significant for the entire sample, proving the negative relationship between them and our economic and financial index CSL. Basically, the more developed a nation is and the better its government interface, the lower its economic and financial crime score becomes. Our findings are similar to those of Husted (1999), Tsakumis et al. (2007), Achim et al. (2018), Aniței and Lazăr (2016, p. 16) and PricewaterhouseCoopers (2018) who find a close connection between the level of countries' economic development and the occurrence of frauds and illegal activity. They find that a high economic development conducts to a better law enforcement and this way the incidence of bribes, shadow and money laundering activities is reduced. On the other hand, in developing countries and countries in transition lower sizes of corruption, shadow economy and money laundering are found.

Furthermore, the better the government interface of a country is, the lower its economic and financial crime score becomes. Our findings are in line with those of Dreher, Kotsogiannis and McCorriston (2009), Chong and López-de-Silanes (2007), Vaithilingam and Nair (2009), Ardizzi et al. (2014) and Schwarz (2011) who validate a negative influence of governance quality on the economic and financial crime. They establish that an increase in the efficiency of the legal institutions and governance system has an important role in decreasing the size of the shadow economy, corruption and money laundering phenomena.

Validating the expectations, we find that Audit quality also has a negative influence upon the economic and financial crime score. Our findings are in line with various studies (Wijayati et al., 2016; Tandean & Winnie, 2016; Vaithilingam & Nair, 2009; Drezewski et al., 2012; Nikoloska & Simonovski, 2012) who find an important role held by audit quality in preventing economic and financial crimes. For instance, Drezewski et al. (2012), Vaithilingam and

Nair (2009) and Nikoloska and Simonovski (2012) prove that adopting strong auditing and reporting standards increases the chances of detecting malicious transactions, thus reducing the size of illegal money laundering activities (Drezewski et al., 2012; Vaithilingam & Nair, 2009; Nikoloska & Simonovski, 2012). Similar results are found by Wijayati et al. (2016) who prove that accounting and auditing standards as well as corporate governance transparency reduce corruption chances. On the same view, Tandean and Winnie (2016) find that the audit committee and their performance reduce the dimensions of tax evasion.

The effect of Press freedom upon economic and financial crime is positive and significant in regressions (1) showing that the more freedom does the press have in a certain country, the less corruption, shadow economic phenomena and money laundering situations there are. As the freedom of press ranking of a nation increases by one position reflecting a more restricted press, the CSL economic and financial crime score of that country increases by 0.0012 units on average, everything else unchanged (Table 3 – model (1)). Our results are similar to the papers of Brunetti and Weder (2003), Kalenborn and Lessmann (2013), Florescu and Cuceu (2019), Heshmati (2016, p. 131) who find a negative impact of press freedom upon corruption and shadow economy phenomena.

Tax burden and Unemployment coefficients are not significant when the entire sample is analyzed.

Regarding religion, we have clear evidence that countries where Muslims prevail are less inclined to violate the laws and thus the level of the economic and financial crime index decreases (model (1), Table 3). Thus, at a 1 point increase in the percent of Muslims within the population, the economic and financial crime score decreases on average by 0.0005 units. We have some evidence that Catholics are positively related with the economic and financial crime (their coefficient is positive in all the regressions from Table 3 for the entire sample, however it is not statistically significant). Our results are in line with those of Murtuza and Ghazanfer (1998), Mutaşcu (2012) and Heinemann and Schneider (2011) who also find evidence that Muslim prevalent countries are associated with reduced sizes of shadow economies. This finding is somehow similar with the results of Gronbacher (1998), Schansberg (1998) and Ko and Moon (2014), who find that Catholics are associated with higher levels of tax evasion and corruption, respectively.

The legal origin dummy variables include five different legal origins: English (reference category), Socialist, French, German and Scandinavian. The economic and financial crime score is larger in countries with German legacy and lower in countries with French and Socialist legacies, while the Scandinavian legal origin control isn't significant.

In developed countries, the coefficient of R&D is still negative and significant at 1% (OLS model (1')) and 5% level (REM model (3')). So, the increase of R&D expenditure and the advance of technology determine the decrease of criminality in high income countries as well. Our results are in line with the literature that validates an indirect relationship between technological development and types of financial crimes (Bird & Zolt, 2008; Elgin & Oyvat, 2013; Immordino & Russo, 2018; Goel et al., 2012; Okunogbe & Pouliquen, 2018; Slemrod, 1990; Suh et al., 2018).

Further, several control variables are added on the forward estimation technique. First, Governance_composite exerts a negative impact on the economic and financial crime score of high income countries as well, which is in line with the literature (Dreher et al., 2009;

Chong & López-de-Silanes, 2007; Vaithilingam & Nair, 2009; Ardizzi et al., 2014; Schwarz, 2011). On the other hand, LogGDP, when significant, has positive influences upon the economic and financial crime index, which contradicts our expectations (models (1') and (3') in Table 3). Thus, an improved level of development for high income countries rises the level of economic and financial crime. Despite the fact that these findings contradict our expectations they are in line with those of Caselli and Michaels (2013) and Wu and Schneider (2019). The results may be explained through the findings of Wu and Schneider (2019) who detect a U-shaped relation between the size of the shadow economy and the GDP per capita. Therefore, the researchers prove that the shadow economy tends to expand when the economy surpasses a given development threshold. They explain these results by the fact that "when the economy advances to a new level at which income of skilled workers becomes high enough and one household member can easily cover the whole family's daily expenses, demand for informal work is likely to increase due to work flexibility or other desirable perks". Researchers also find oil-exporting countries to be situated in the right part of the U-shape. Similarly there are studies which determine that corruption highly appears in the natural resources' economies. For instance, Vicente (2010) analyzes changes in perceived corruption in Sao Tome (which recently found oil) with the one in Cape Verde (which didn't), and discovers large increases in the development of corruption following the oil discovery moment. Also regarding wealth under the oil discovery, Caselli and Michaels (2013) find a direct relationship between economic growth rates and corruption. In addition, they find that a higher level of wealth may actually determine increased possibilities to obtain benefits that make corruption flourish.

The coefficients of Unemployment are positive and significant only for the high income countries in models (1') and (2'), Table 3. Thus, the higher the rate of unemployment, the higher the level of the CSL economic and financial crime score which is in line with the main literature research findings (Dell'Anno & Solomon, 2008; Bouzid, 2016; Williams & Schneider, 2016; Medina & Schneider, 2018; Sahnoun & Abdennadher, 2019). Thus, we find unemployment to be a significant determinant for the economic and financial crime in developed countries. According to Schneider and Williams (2013), the increase of the number of unemployed people determines the increase of the number of people working within the shadow economy because they have more spare time.

Regarding religions, we find a negative and significant effect of the Protestants share upon the economic and financial crime index of high income countries (Model (1'), Table 3). We find that Protestantism reduces the level of economic and financial crime which is in line with our expectations (Murtuza & Ghazanfer, 1998; Mutaşcu, 2012; Heinemann & Schneider, 2011). Indeed, Protestantism is an individualistic religion which is less tolerant of illegalities than countries in which hierarchical religions are dominant (Ko & Moon, 2014). Our finding is in line with Lv (2017) who also validates a negative influence of the Protestant religion variable upon the level of corruption. Nonetheless, we find negative implications of the Muslim and Catholic variables (Model (1'), Table 3), meaning the increase of the Muslims' and Catholics' weights respectively within the population of high income countries decreases the economic and financial crime index of that country.

Regarding legal origins, the economic and financial crime score is higher in developed countries with German legacies than in countries with a British legal background. Like for the entire sample, Scandinavian is not significant. It's important to report the Adj. R^2 of

model (1') of 0.8613 on the Pooled OLS model, so R&D and the other control variables explicate 86.13% of the criminality residing in high income countries, reflected by our CSL economic and financial crime score. The signs and significances of most variables are mostly kept between model (1') OLS and model (3') REM.

For the low income countries, the R&D coefficients are negative and significant at 1% level of significance (OLS and REM models). Moreover, the panel diagnosis that we carry out validates REM as the preferred estimation technique for the economic and financial crime index having a negative and significant coefficient of 0.1075 for R&D in the multiple regression model (Model (3") REM). Naturally, the increase of technological investments reflected through R&D determines the decrease of the economic and financial index. Compared to high income countries, one may observe that the coefficients of R&D in absolute values are approximately three to six times higher for low income countries than for high income countries (models (1"), (2") and (3") compared to models (1'), (2') and (3'). It shows that a unitary increase in R&D results in a three to six times higher reduction of the economic and financial crime index in low income countries compared to high income countries. Concluding, in order to reduce the economic and financial crimes with one unit, the increasing technologies matter more in low income countries than they do in high income ones. Similar findings are obtained by PricewaterhouseCoopers (2018). The other control variables kept within the multiple regressions are the Governance_composite, LogGDP, Unemployment, the different religious variables and the legal origins dummies. For low income countries, the influence of LogGDP is negative but it is not statistically significant. Thus we may say that the level of development from low income countries matters less for engaging in criminal activities than for the case of high income countries. This finding is similar with those of Gnimassoun and Massil (2016) who prove that although some determinant factors for corruption are common to most countries, there are some others that are specific to their particular level of economic development.

When significant, Governance_composite and Unemployment exert a negative influence upon the CSL economic and financial crime index of low income countries. If in high income countries we estimate a positive sign for the coefficient of Unemployment variable, for low income countries we obtain a negative but not significant coefficient. Thus, the increase of unemployed people can lead to a reduction of the people who work in the informal sector (Tedds & Giles, 2002). The negative relationship between the unemployment rate and the economic and financial crime index can be explained throughout the discussion on the architecture of the social security system and it objectives, the structure of the payment rates and the offered incentives to work (Adema, 2006; Bajada & Schneider, 2009). Thus, the social security system needs to ensure financial support for the unemployed, to provide labor market support programs and many other benefits (Adema, 2006). Under these circumstances, for low income countries, increasing Unemployment may reduce the incentives for engaging in illegal activities, because in the unstable economies people are content with a small but certain level of revenues which comes from their social security system, and further on, they are unlikely to risk working in the shadow for a supplementary net income.

Regarding the Religion variables, we obtain the coefficients of Catholic and Muslim as being statistically significant (however at an only 10% level of significance). Thus, we find positive coefficients for Catholics and Muslims in low income countries, reflecting a positive

influence exerted by Catholics and Muslims upon the economic and financial crime index. These results are in line with those of Gronbacher (1998), Schansberg (1998) and Ko and Moon (2014) who also find that Catholics favor corruption (Ko & Moon, 2014) and tax evasion (Crowe, 1944; Gronbacher, 1998; Schansberg, 1998). However, regarding the influence of the Muslims' share, compared to the literature, we obtain contradictory evidences for its positive influence (Model (1"), Table 3).

From the point of view of the origins of the legal systems of low income countries, the economic and financial crime is lower in countries that have a French legacy as compared to countries that have a British legal origin. The coefficient for Socialist is negative but it is not significant, and the German and Scandinavian legal origins variables are omitted due to collinearity reasons within this subsample of low income countries (Model (1"), Table 3).

Table 4 uses Technology adoption as a technology proxy for the sample of 185 countries and then for high income and low income countries respectively. The independent variables are Technology adoption and then several controls are added applying the Pooled OLS estimation for unbalanced panel data (models (1), (1') and (1")). Regressions use the FEM technique (models (2), (2') and (2")) while regressions (3), (3') and (3") are estimated through the REM technique, although the coefficients for Technology adoption are not significant except for the very last model.

In Table 4 model (1) when Technology adoption increases with one value-unit, the economic and financial crime index is larger on average by –0.084, so a decrease of 0.084 units is obtained. The amount of variance in economic and financial crime index explained by Technology adoption and other control variables is of 72.08%. For both sets of countries, Technology adoption has an indirect relationship with the economic and financial crime index, in line with our expectations (models (1'), (1") and (3")). As in the case of using R&D, the coefficients of Technology adoption for low income countries are somehow higher than for the high income countries (model (1") compared to (1')).

As expected, the more developed a nation is, the lower its CSL economic and financial crime score, for the full sample (models (1) and (3), Table 4). When LogGDP increases with one unit, the economic and financial crime score registers a decrease of 0.054 units on average, ceteris paribus. Our findings are in line with those obtained when technology is expressed through R&D, for the same analyzed full sample (Table 3). Comparable results are also obtained by Husted (1999), Tsakumis et al. (2007), Achim et al. (2018), Aniței and Lazăr (2016, p. 16) and PricewaterhouseCoopers (2018) who find a negative relationship between the level of economic development of a country and the occurrence of fraud. Similarly with the previous results (Table 3), we find that the influence of development for the low income countries is rejected from our models, meaning that it is not a determinant for the economic and financial crime index (models (1"), (2") and (3"), Table 4). Thus, our systematic results confirm that some determinants are similar between countries, while others are specific to the level of economic development (Gnimassoun & Massil, 2016).

Regarding press freedom, similarly as in the case of using R&D (Model (1), Table 3), the positive influence of it upon the economic and financial crime score is validated. Press freedom has a positive and significant coefficient for Pooled OLS and REM regressions, for the entire sample and the subsample of low income countries (Models (1), (3), (1") and

Table 4. Regression results for *Economic and financial crime* (*CSL*) as a function of *Technology adoption* and other explanatory variables

	Entire sample			High income countries			Low income countries		
	OLS	FEM	REM	OLS	FEM	REM	OLS	FEM	REM
	(1)	(2)	(3)	(1')	(2')	(3')	(1")	(2")	(3")
Technology adoption	−0.084***	0.0099	−0.0184	−0.1313***	0.0277	−0.0213	−0.0976***	0.0183	−0.0259*
LogGDP	−0.054***	−0.0096	−0.0722***	−0.0028	−0.0213	−0.0238			
Press freedom	0.0026***	−0.001	0.0021***				0.0021***	−0.0008	0.0015**
Audit quality									
Tax burden				0.0003	0.0006	0.0008			
Unemployment	−0.0006	0.005**	0.0017	0.0022**	0.0057***	0.0048**	−0.0048***	0.0043	−0.0028
Protestant	−0.0003		−0.0007	−0.0016***		−0.002**	0.0001		−0.0001
Catholic	0.0006***		0.0005	−0.0006***		−0.0009**	0.0011***		0.0009
Muslim	−0.00006		0.00004	0.0003		0.0002	0.0006**		0.0006
Socialist legal origin	−0.0474***		−0.0163	−0.0553**		0.0152	−0.057**		−0.038
French legal origin	−0.014		0.0091	−0.0163		0.0262	−0.0624***		−0.0477
German legal origin	0.0164		0.007	0.0307*		0.0525			
Scandinavian legal origin	0.0011		0.0002	0.0128		0.0532			
Constant term	1.1939***	0.4885**	1.0395***	0.9914***	0.2238	0.554***	0.8886***	0.4772***	0.5858***
Obs.	536	536	536	187	187	187	356	356	356
	R^2 = 0.7265	within R^2 = 0.0176	within R^2 = 0.0005	R^2 = 0.7011	within R^2 = 0.0716	within R^2 = 0.0203	R^2 = 0.3315	within R^2 = 0.0117	within R^2 = 0.0103
	Adj R^2 = 0.7208	between R^2 = 0.0972	between R^2 = 0.7049	Adj R^2 = 0.6823	between R^2 = 0.0317	between R^2 = 0.5898	Adj R^2 = 0.3161	between R^2 = 0.1953	between R^2 = 0.2773
		overall R^2 = 0.0991	overall R^2 = 0.6977		overall R^2 = 0.0360	overall R^2 = 0.5676		overall R^2 = 0.2048	overall R^2 = 0.2736

Note: ***designates the 1% significant coefficients, **designates the 5% significant coefficients and *designates the 10% significant coefficients.

(3"), Table 4). So, the more freedom does the press have, the lower the economic and financial crime score of nations is. Resembling results are found by Brunetti and Weder (2003), Kalenborn and Lessmann (2013), Florescu and Cuceu (2019), Heshmati (2016 p. 131) who also obtain a negative influence of press freedom on the criminal activities like corruption and shadow economy.

Further, the influence of Unemployment upon technology for the full sample, when technology is expressed through the Technology adoption variable is found either negative (Model (1)), or positive (Models (2) and (3)). However, the recent study of Sahnoun and Abdennadher (2019) concludes after an extensive review that the existing connections between the shadow economy and the unemployment rate are still puzzling (Tanzi, 2002; Tedds & Giles, 2002; Dell'Anno & Solomon, 2008). Significant and positive coefficients for Unemployment are obtained for high income countries, in all the three models (1'), (2') and (3'). Thus, for high income countries, by using Technology adoption as proxy for technologies, we obtain clear evidences that the higher the unemployment rate, the higher the economic and financial crime index as well. These findings are in line with those of Dell'Anno and Solomon (2008), Bouzid (2016), Williams and Schneider (2016), Medina and Schneider (2018), Sahnoun and Abdennadher (2019), Schneider and Williams (2013) who also document that the increase of unemployment leads to an increase in the number of people who work in the black economy, thus enlarging the shadow economy. For the low income countries, similarly to the case of using R&D (models (1"), (2") and (3"), Table 3), in the case of using Technology adoption as well, Unemployment exerts a negative and significant influence (Model (1"), Table 4). These findings are in line with those of Tedds and Giles (2002), Adema (2006) and Bajada and Schneider (2009) who demonstrate that larger figures for the unemployment rates of people can lead to smaller amounts of people who work in the informal sector and this choice mainly depends on the discussion around the higher benefits of the social security system compared with rather low benefits and higher risks which people would obtain when working in the shadow.

For the remaining control variables (religion, legal origin), the signs and significances are generally maintained.

2.2.2. Robustness checks

To reinforce our results, we perform several robustness checks that include the following aspects, on turn: (1) we consider an alternative variable for the dependent variable; (2) we consider an alternative measurement for our main independent variables, R&D and Technology adoption; (3) we estimate our main models on alternative sub-samples.

(1) First robustness testing uses an alternative measure for the economic and financial crime index (CSL). As CSL_{it} has been initially computed as the simple average of the standardized levels of corruption, shadow economy and money laundering for country i in year t, for this robustness checks section we have determined it as an aggregated variable through exploratory factor analysis (principal components analysis). We've extracted one single unrotated factor, denoted **CSL_composite.** The results reported in Tables 5 and 6 show that our basic results are stable.

As such, Table 5 estimates CSL_ composite as a function of R&D through the multiple

Table 5. Robustness checks: alternative measure for *Economic and financial crime* (*CSL_* composite) as a function of R&D

	Entire sample			High income countries			Low income countries		
	OLS	FEM	REM	OLS	FEM	REM	OLS	FEM	REM
	(1)	(2)	(3)	(1')	(2')	(3')	(1")	(2")	(3")
R&D	−0.1905***	0.0785	−0.1049	−0.1084***	−0.0521	−0.0949*	−0.4476***	0.3362	−0.3934**
Governance_composite	−0.5722***	−0.1131	−0.5411***	−0.8696***	−0.1861	−0.8532***	−0.5626***	−0.5923*	−0.6225***
LogGDP	−0.1191***	−0.3800***	−0.203***	0.3177***	−0.4166*	0.1735	−0.1563***	0.1479	−0.1202
Press freedom	0.0072***	−0.0054	0.0034						
Audit quality	−0.1391**	−0.0661	−0.0776						
Tax burden	−0.0044	0.0007	0.0029	0.0029	0.0034	0.0018			
Unemployment	−0.0033	0.0111	0.0034	0.016***	0.0367*	0.0212**	−0.0074	0.0195	−0.0055
Protestant	−0.0011		−0.003	−0.0035*		−0.0029	−0.0093*		−0.0051
Catholic	0.0007		0.0021	−0.0022**		−0.0019	0.005***		0.0055**
Muslim	−0.0028***		−0.002	0.0259***		0.0224	0.0023		0.0023
Socialist legal origin	−0.3229***		−0.2506*	0.0676		−0.0837	−0.2721**		−0.2209
French legal origin	−0.1452*		−0.1319	0.2564**		0.1729	−0.4145**		−0.4063*
German legal origin	0.4029***		0.3788	0.6345***		0.5555***			
Scandin legal origin	0.2033		0.3978	0.3623**		0.2534			
Constant term	2.0271***	3.4652***	1.8667***	−3.6883**	2.4698***	−2.2592*	1.7802***	−1.4644	1.3666**
Obs.	311	311	311	115	115	115	163	163	163
	R^2 = 0.8349	within R^2 = 0.0853	within R^2 = 0.0441	R^2 = 0.8919	within R^2 = 0.1197	within R^2 = 0.0236	R^2 = 0.5751	within R^2 = 0.0505	within R^2 = 0.0122
	Adj R^2 = 0.8271	between R^2 = 0.5465	between R^2 = 0.8305	Adj R^2 = 0.8768	between R^2 = 0.4318	between R^2 = 0.9187	Adj R^2 = 0.5501	between R^2 = 0.0244	between R^2 = 0.6071
		overall R^2 = 0.5243	overall R^2 = 0.8231		overall R^2 = 0.4390	overall R^2 = 0.8835		overall R^2 = 0.0153	overall R^2 = 0.5693

Note: ***designates the 1% significant coefficients, **designates the 5% significant coefficients and *designates the 10% significant coefficients.

regressions validated in (Model (1) OLS for the entire sample, Model (1') OLS for high income countries and Model (1") OLS for low income countries respectively). The alternative FEM and REM models are also estimated, and the one supported by the Hausman test is bolded out. Mostly significant, the estimated coefficients for R&D are negative, reinforcing the fact that the higher the technology investments of a country are, the lower its criminality is, measured as an aggregated composite variable this time. As in the case of our main results obtained by using R&D as a proxy for technology (Table 3) we also notice higher levels of the R&D coefficients in absolute values for low income countries compared to those obtained for high income countries (of approximately four times, model (1") versus model (1')). Therefore, a one unit variance in R&D has a lot stronger effects on the economic and financial crime index of low income countries compared to high income countries (about four times).

For the entire sample, Gov_composite, LogGDP and Audit quality, when significant, have a negative influence upon CSL_ composite, and Press freedom has a positive coefficient, just like they do in the Main results from Table 3. For the subsample of 54 high income countries, Table 5 validates the negative influence of Gov_composite upon CSL_composite, and the positive influences of LogGDP and Unemployment, similarly to Table 3 from our basic results. For the subsample of 131 low income countries, Gov_composite revalidates its negative influence proven in Table 3, while the negative coefficient for LogGDP becomes significant, for the first time (Model (1") for low income countries, Table 5). Regarding Unemployment, the significant and positive coefficients are found only for high income countries (Model (1'), (2') and (3') for high income countries) which is in line with our main findings (Model (1'), (2') and (3'), Table 3). However, both for the entire sample and for the low income countries' subsample, the estimated coefficients of Unemployment are not significant, although the negative signs from Table 3 are kept. Among religions, just like for the main results (Models (1), (2) and (3), Table 3), only Muslim has a negative and significant coefficient, for the entire sample (Model (1), Table 5). For high income countries, our negative signs of Protestants and Catholics remain significant at this first robustness check, and we get a positive sign for Muslims here (Model (1') for high income countries, Table 5) compared with our main results (Model (1'), Table 3). For low income countries, again the positive coefficient of Catholics remains significant (Model (1") and (3") for low income countries, Table 5) as in the case of the main results (Model (1"), Table 3). In addition, this first robustness check gets significant and negative coefficients of Protestants (Model (1") for the low income countries, Table 5). Furthermore, the coefficients from Muslims for the low income countries (Model (1") and (3")) are positive (as in the case of our main results-Model (1"), Table 3) but not significant this time.

The estimated coefficients for the legal origins variables keep all their signs and significances from Table 3. In addition, this first robustness check conducts to getting significance for the negative coefficients of Socialists for low income countries (Model (3"), Table 5)

Table 6 estimates CSL_composite as a function of Technology adoption through multiple regressions and then, alternatively, FEM and REM models, and they support our main results. When significant, the estimated coefficients for Technology adoption are always negative, reinforcing the fact that the higher the technology adoption value of a country, the lower its criminality composite variable (CSL_composite). LogGDP exerts a negative influence upon

Table 6. Robustness checks: alternative measure for *Economic and financial crime* (*CSL_ composite*) as a function of *Technology adoption*

	Entire sample			High income countries			Low income countries		
	OLS	FEM	REM	OLS	FEM	REM	OLS	FEM	REM
	(1)	(2)	(3)	(1')	(2')	(3')	(1")	(2")	(3")
Technology adoption	−0.4366***	−0.0156	−0.1431**	−0.7259***	0.0263	−0.2159***	−0.5119***	0.0098	−0.1804**
LogGDP	−0.3018***	−0.2973***	−0.401***	−0.0801	−0.4264***	−0.3191***			
Press freedom	0.014***	−0.0018	0.0114***				0.0111***	−0.0003	0.0089**
Unemployment	−0.002	0.0137	0.006	0.0142**	0.0156	0.0169*	−0.0249***	0.0124	−0.0166
Tax burden				0.0022	0.0033	0.0031			
Protestant	−0.0028		−0.0041	−0.0079***		−0.0096**	−0.0004		−0.0016
Catholic	0.0034***		0.003	−0.0034***		−0.0043**	0.0058***		0.0049
Muslim	−0.0008		−0.0003	0.0021		0.0016	0.0028*		0.0026
Socialist legal origin	−0.308***		−0.1562	−0.4163***		−0.1829	−0.3775***		−0.2833
French legal origin	−0.1185*		−0.0215	−0.1073		0.0804	−0.4105***		−0.3356*
German legal origin	0.0401		0.0163	0.1389		0.2195			
Scandin legal origin	0.0735		0.0875	0.0828		0.2738			
Constant term	4.0251***	2.5577***	3.517***	3.6304***	2.7615**	3.2348***	2.3327***	0.3469	0.9266**
Obs.	536	536	536	187	187	187	356	356	356
	R^2 = 0.7360	within R^2 = 0.0245	within R^2 = 0.0128	R^2 = 0.7085	within R^2 = 0.0918	within R^2 = 0.0557	R^2 = 0.3385	within R^2 = 0.0015	within R^2 = 0.0004
	Adj R^2 = 0.7305	between R^2 = 0.5572	between R^2 = 0.7293	Adj R^2 = 0.6901	between R^2 = 0.2788	between R^2 = 0.6419	Adj R^2 = 0.3233	between R^2 = 0.0927	between R^2 = 0.3085
		overall R^2 = 0.5527	overall R^2 = 0.7166		overall R^2 = 0.2785	overall R^2 = 0.6147		overall R^2 = 0.0941	overall R^2 = 0.3009

Note: ***designates the 1% significant coefficients, **designates the 5% significant coefficients and *designates the 10% significant coefficients.

CSL_composite for the entire sample of countries (see models (1) – (3) in Table 6, similar to Table 4) and for the high income countries' subsample (in Table 4 these coefficients weren't significant). Similar to our previous main results, Press freedom exerts a positive influence upon CSL_ composite, for the entire sample and the low income countries' subsample, just like in Table 4. The positive influence of Unemployment for high income countries (Table 4) is re-emphasized by the results obtained for the high income countries' subsample from Table 6, models (1') and (3'), while the negative influence is also maintained for the low income countries' subsample in this second robustness check reflected by Table 6, model (1"). The negative influences of Protestants and Catholics for the high income countries remain significant when the economic and financial crime is measure as a criminality composite variable (Table 6), while the Catholic and Muslim variables maintain their positive influence in the case of low income countries. For the legal origins variables, Table 6 shows that CSL_composite for the entire sample is lower in countries that have Socialist legacies than in countries with British legal origins, like for the case of CSL (Table 4). Supplementary, a negative significant coefficient is obtained for French, which wasn't the case for our main results. For high income countries, CSL_ composite is lower in countries with a Socialist legacy as compared to the reference category but the positive significant coefficient of German from Table 4 isn't revalidated through Table 6. For the subsample of low income countries, Socialist and French have a negative significant coefficient, so the results from Table 4 are robust.

(2) We further consider **High-technology exports** as an alternative measure to our main independent variables, R&D and Technology adoption, in order to explore if the effect of technology on criminality is driven by the choice of technology proxies. The High-technology exports variable represent high-technology exports as a percentage of manufactured exports of countries, as provided by the World Bank (2020). High-technology exports represents products with large R&D intensity, such as in the industries of aeronautics, computing pharmaceutical issues, science devices and electrical machinery (expressed in weighted average). Our main results operate with R&D (Table 3) and Technology adoption (Table 4) as technology proxies. Those results are robust because when High-technology export is used as another proxy for technological advance and it is used to explicit CSL, our basic results stand strong, as Table 7 shows.

The variables kept within the multiple regression modelling of the CSL economic and financial crime index as a function of High-technology export and some of the control variables previously used for our basic results are LogGDP, Audit quality, Unemployment, Press freedom and Tax burden. The impact of High-technology export upon economic and financial crime (measured as CSL) is negative (all the models from Table 7, from model (1) up to model (3")). Thus, the higher the high-technology exports, the lower the economic and financial crime scores of countries, regardless of the tested sample (the entire sample, high income countries, low income countries) and the chosen modelling technique (Pooled OLS, FEM or REM). Economic development shows that the higher the GDP of a certain country, the lower its economic and financial crime scores, for the entire sample, results that are similar to the ones from Table 3 and Table 4. The negative impact of Audit quality upon the economic and financial crime scores within a multiple regression has been previously validated in Table 3, for the entire sample, when using R&D as a proxy for technology.

Table 7. Robustness checks: alternative measure of technology – High-technology export. Regression results for *Economic and financial crime* (*CSL*) as a function of alternative measure of technology – *High-technology export* and other variables income countries

	The entire sample			High income countries			Low income countries		
	OLS	FEM	REM	OLS	FEM	REM	OLS	FEM	REM
	(1)	(2)	(3)	(1')	(2')	(3')	(1")	(2")	(3")
High-technology exports	−0.0012**	−0.0017**	−0.0018***	−0.0035***	−0.0058***	−0.0039***	−0.0026***	−0.0019**	−0.0024***
LogGDP	−0.053***	0.0033	−0.0656***	−0.0263*	−0.0366	−0.0249			
Audit quality	−0.0918***	−0.0051	−0.0387***				−0.0895***	−0.0097	−0.0558***
Unemployment	−0.0038***	0.005*	−0.0022	0.0023*	0.0012	0.0027	−0.0058***	0.0057	−0.006***
Press freedom				0.0029***	−0.0048**	0.0007	0.0022***	−0.0006	0.0017**
Tax burden				0.00001	0.002	0.0012			
Protestant	−0.0009**		−0.0016**	−0.001**		−0.0018*	0.0001		−0.0005
Catholic	0.00008		0.00001	−0.0007***		−0.001*	0.0009***		0.0006
Muslim	−0.00001		−0.00003	−0.0016***		−0.0011	−0.00003		0.00001
Socialist legal origin	−0.047***		−0.0239	0.0125		0.0163	−0.0671***		−0.0601*
French legal origin	−0.0276*		−0.0133	0.0377**		0.0457	−0.0927***		−0.0759**
German legal origin	−0.0451*		−0.028	0.0576***		0.0654			
Scandin legal origin	−0.0464		−0.0073	0.0038		0.04297			
Constant term	1.3983***	0.3847*	1.253***	0.5027***	0.7053**	0 .4823*	0.8863***	0.5753***	0.7759***
Obs.	451	451	451	181	181	181	272	272	272
	R^2 = 0.7302	within R^2 = 0.0306	within R^2 = 0.0051	R^2 = 0.5826	within R^2 = 0.1452	within R^2 = 0.0915	R^2 = 0.5242	within R^2 = 0.0326	within R^2 = 0.0080
	Adj R^2 = 0.7235	between R^2 = 0.0012	between R^2 = 0.7374	Adj R^2 = 0.5528	between R^2 = 0.0143	between R^2 = 0.5355	Adj R^2 = 0.5079	between R^2 = 0.0692	between R^2 = 0.5723
		overall R^2 = 0.0010	overall R^2 = 0.7078		overall R^2 = 0.0132	overall R^2 = 0.5363		overall R^2 = 0.0622	overall R^2 = 0.5091

Note: ***designates the 1% significant coefficients, **designates the 5% significant coefficients and *designates the 10% significant coefficients.

This time, when using High-technology export, the negative influence of Audit quality also remains robust for the entire sample and, in addition to this, it becomes significant for low income countries (Table 7). Furthermore, Unemployment has a different impact on the two subsamples of countries: it has a positive impact for high income countries and a negative impact for low income countries (just like in Table 3 and Table 4). For low income countries, Press freedom has a positive impact upon the CSL economic and financial crime score, so the more freedom does the press have, the less criminality there is, similar to our main results. Within this robustness check phase, Protestants are found to negatively influence the economic and financial crime score of high income countries (Table 7) which is in line with our main results from Table 3 and Table 4. In addition to this, the negative coefficients of Protestants from our main results (Table 4) for the entire sample now become statistically significant (Table 7). The negative influence of Catholics for high income countries which is found in our main results (Table 3 and Table 4) is maintained when the High-technology export is used as another proxy for technologies (Table 7).

Comparing the results from Table 7 to our main results, we notice that the legal origins variables mostly validate their previously attributed significances: for the entire sample of countries, Table 7 shows that economic and financial crime is lower in countries with a Socialist, French or German legacy as compared to the British reference category, although when regressed against R&D only the Socialist and French variables obtained a negative and significant coefficient and when regressed against Technology adoption, only the Socialist did. Furthermore, for high income countries, Table 7 shows that the CSL economic and financial crime index is higher in countries with a French, German or Scandinavian legacy as compared to the British reference category. This result has been previously confirmed through Table 3 and Table 4 for the German legal origin. For low income countries, Table 7 shows that the CSL economic and financial crime score is smaller in countries with a Socialist and a French legacy as compared to the English one. In Table 4, for low income countries, the German and Scandinavian legal origins variables are omitted due to collinearity reasons within the modelling of low income countries' data.

(3) For strengthening the robustness of our main results, split or additional samples could be used (Hair et al., 2010). We decide to extract **alternative random subsamples** from the entire sample used in the Main Results section in order to test our main regressions. Table 8 presents the estimations of our economic and financial crime index as a function of R&D or Technology adoption and the main control variables for a halved subsample from the entire sample of 185 countries. The estimated coefficients for R&D and Technology adoption respectively are negative, supporting our main results. When significant, the main control variables mostly keep their signs. Both OLS models are strong, with powerful adjusted coefficients of determination.

Table 8. Robustness checks. Random subsample. R&D and Technology adoption as *dependent variable* Regression results for *Economic and financial crime* (*CSL index*) as a function of R&D/Technology adoption

	Random subsample R&D – as a dependent variable			Random subsample Technology adoption – as a dependent variable		
	OLS	FEM	REM	OLS	FEM	REM
R&D	–0.0332***	–0.0639	–0.0405**			
Technology adoption				–0.0819***	0.0125	–0.0366**
Governance_composite	–0.1431***	–0.0718	–0.1258***			
LogGDP	–0.0013	0.0386	–0.0015	–0.0511***	0.0048	–0.0631***
Press freedom	0.0008	0.0027	0.0012	0.0023***	–0.0002	0.0028***
Audit quality	–0.0164	–0.0103	–0.0117			
Tax burden	–0.0002	0.0002	–0.00008			
Unemployment	0.0009	0.0042	0.0017	–0.0003	0.0019	0.0006
Protestant	0.00009		0.0002	–0.0002		–0.0001
Catholic	0.0002		0.0003	0.0006**		0.0005
Muslim	–0.0006**		–0.0005	0.00009		–0.0001
Socialist legal origin	–0.0572***		–0.0345	–0.0515**		–0.0259
French legal origin	–0.037*		–0.0263	–0.0036		0.0138
German legal origin	0.0913***		0.1153**	0.0295		0.0268
Scandinavian legal origin	0.0195		0.0329	0.0065		–0.0025
Constant term	0.5686***	–0.018	0.488***	1.1522***	0.3291	1.0119***
Obs.	163	163	163	274	274	274
	R^2 = 0.8102	within R^2 = 0.0524	within R^2 = 0.0249	R^2 = 0.6753	within R^2 = 0.0049	within R^2 = 0.0031
	Adj R^2 = 0.7922	between R^2 = 0.5926	between R^2 = 0.7865	Adj R^2 = 0.6617	between R^2 = 0.5487	between R^2 = 0.7131
		overall R^2 = 0.6078	overall R^2 = 0.8044		overall R^2 = 0.4898	overall R^2 = 0.6636

Note: ***designates the 1% significant coefficients, **designates the 5% significant coefficients and *designates the 10% significant coefficients.

3. Discussions

Our findings prove the clear influence of an increasing technology upon a reduced economic and financial crime phenomena. The findings are similar to many reported studies who also find an indirect relationship between technological development and several economic and financial crimes.

Basically, we find that at a 1 point increase in the Research and development expenditure (% of GDP) and at a1 point increase in Technology adoption, the CSL economic and financial crime score decreases on average by 0.1142 units and 0.1958 units, respectively (Models (1) in Tables 3 and 4). When we discuss the two subgroups of countries (high income and low income countries), our parted estimations are extremely useful. Thus, we find that the average value of economic and financial crime is about double in low income countries compared to high income countries while the average of technology measured through Research and development expenditure (% of GDP) in low income countries is about four times lower than in high income countries. Our empirical findings show that Research and development expenditure (% of GDP) matter more in reducing the economic and financial criminality in low income countries than they do in high income countries. Indeed, we find that a one unit increase of the Research and development expenditure (% of GDP) results in a four times higher decrease of the economic and financial crime for low income countries than for high income countries. Somewhat similar results are found by Gnangnon (2020) who finds that the Internet access in the developing countries has a higher positive effect on tax reform as compared to other countries. However, the Technology adoption and High technology exports variables don't exert different influences upon these two subgroups of countries.

Regarding the influence of control variables we find clear evidence for the role exerted by economic development, quality of governance, tax burden, unemployment, audit quality, press freedom, religion and legal origins upon the economic and financial crime index. However, with few exceptions, the influences of these control variables highly differ among these two subgroups of countries.

Thus, we find clear negative influences of economic development (LogGDP) on the CSL economic and financial crime index for the entire sample and the subsample of low income countries, meaning that a higher level of economic development leads towards lower levels of economic and financial crime which is in line with our expectations and with the large literature (Husted, 1999; Tsakumis et al., 2007; Achim et al., 2018; Aniței & Lazăr, 2016, p. 16; PricewaterhouseCoopers, 2018). However, for developed countries we validate a positive impact of economic development upon the economic and financial crime, meaning that boosted economic development creates incentives for breaking the law and getting benefits. Thus, when financial satisfactions are very high and one person may cover all the expenses of his/her family, the remaining family members may choose to work in the shadow due to the flexibility of informal work, fiscal advantages or other benefits (Wu & Schneider, 2019). These high income economies often dispose of many natural resources like oil and the occurrence of frauds and oil-related frauds are well known and widespread (Vicente, 2010; Caselli & Michaels, 2013; Wu & Schneider, 2019).

Press freedom exerts positive influences in all our analyses because it hampers the incentives or the will to engage in economic and financial crimes, which is in line with the literature (Brunetti & Weder, 2003; Kalenborn & Lessmann, 2013; Florescu & Cuceu, 2019; Heshmati, 2016, p. 131).

We obtain some evidence of the important role of audit quality in preventing economic and financial crimes, when we analyze the entire sample and the subsample of low income countries. The important role played by Audit quality in reducing the economic and financial

crime is also highlighted by other research findings (Vaithilingam & Nair, 2009; Tandean & Winnie, 2016; Wijayati et al., 2016; Drezewski et al., 2012; Nikoloska & Simonovski, 2012). Interestingly, we don't have evidence for the influence of Audit quality for the subsample of high income countries.

For the tax burden of worldwide countries we obtain negative and significant coefficients meaning that a higher tax burden (and thus lower tax freedom) increases the size of the economic and financial crime score, because the lack of satisfaction in the taxation system and the exorbitant fiscal pressure lead towards increased levels of tax evasion. This is in line with a large strand of literature: Schneider and Klinglmair (2004), Putniņš and Sauka (2015), Chong and López-de-Silanes (2007) and Schwarz (2011). However, in developed countries we obtain positive coefficients for Tax burden, thus, the more fiscal freedom there is, the higher the economic and financial crimes scores are. The explanation for this sign resides in the combined way in which economic and financial crime needs to be analyzed. Actually, it is not high tax rates that increase criminality levels, but the application of the tax system and the regulations of governments actually do. Other findings also highlight the positive coefficients of tax pressure on the tax evasion and shadow economy (Stankevičius & Vasiliauskaitė, 2014; Achim et al., 2018).

Unemployment is found to negatively influence the economic and financial crime when the entire sample and the subsample of low income countries are analyzed, and it exerts a positive influence for the subsample of high income countries. Indeed, for high income countries, under the higher quality of governance and better human resource policies, increases in unemployment rates lead to a boost of the economic and financial crime phenomena because people move from a formal economy towards an informal time as they have more free time. These results are in line with those of Dell'Anno and Solomon (2008), Schneider and Williams (2013), Bouzid (2016), Williams and Schneider (2016), Medina and Schneider (2018) and Sahnoun and Abdennadher (2019). However, for low income countries (which represent the majority in our sample thus explaining the negative sign obtained for the entire sample), a negative relationship between the unemployment rate and the economic and financial crime index could be justified through the objectives of the social security systems, payment rates and incentives to work (Adema, 2006; Bajada & Schneider, 2009).

Regarding religion, we obtain different influences when different samples of countries are used. Thus, when the entire sample of countries is used, we find that countries dominated by Muslims and Protestants are less inclined to break the law and thus the level of the economic and financial crime index decreases, while in the countries with a higher proportion of Catholics, there exists more economic and financial crime. This is in line with the studies of Murtuza and Ghazanfer (1998), Mutaşcu (2012), Heinemann and Schneider (2011), Gronbacher (1998), Schansberg (1998) and Ko and Moon (2014) who also find evidence that predominantly Muslim nations are associated with smaller levels of the economic and financial crime index and Catholic countries are associated with higher levels of the economic and financial crime phenomena.

However, when we split the initial sample in two subsamples (high income and low income countries), different signs are found for the influence of Religion. Thus, we have clear evidences that the share of Muslims increases the level of economic and financial crime both

for high income and low income countries. In this view, we also find some positive evidence of the influence of the Protestants' weight from the low income countries subsample. The share of Catholics also influences CSL differently among the two groups. Thus, we obtain a negative sign of the Catholic variable for high income countries and a positive sign of it for low income countries.

The CSL economic and financial crime index generally increases under the German legacy and decreases in countries with French and Socialist legacies, having the British legal background as a reference category. The Scandinavian legal origin variable is not statistically significant. However when we conduct our analysis separately on the two subsamples of countries, the signs are maintained only for the Socialist legal origin. Regarding the other legal origins, the economic and financial crime increases under the French legacy in high income countries but decreases in low income countries, as compared to countries with a British legal background. The coefficients of German legal origin are not significant for developing countries while for the Scandinavian origin they become significant only for high income countries. The basic results of the present study are generally robust when we conduct a wide series of robustness checks (alternative measure for the economic and financial crime, on one hand, and for the technology on the other hand and running our main models on alternative sub-samples).

Conclusions

In this paper, we explore the impact of technology on the size of the economic and financial crime, using unbalanced panel data from 185 countries over the 2012–2015 time period and controlling for many other important variables. We find clear evidence that increasing technology reduces the size of economic and financial crime. In addition, we find that Research and development expenditure (% of GDP) matter more in reducing the economic and financial criminality in low income countries than they do in high income countries.

Regarding the influence held by the control variables we find clear evidence about the roles of economic development, quality of governance, tax burden, unemployment, audit quality, press freedom, religion and legal origins upon the economic and financial crime index of countries. However, with few exceptions, the influences of these control variables highly differ among the two subgroups of countries. Thus we may conclude that although there are common determinant factors of the economic and financial crime phenomena, there also are influences that are highly related to the level of economic development of countries.

Originality is related to conducting our analysis on the two subsamples of countries from which we may extract specific findings related to the level of economic development. Nonetheless, the robustness checks we perform are complex and they strongly support our main findings.

Regarding policy implications, on top of the many benefits of technology investments and development, one more may be certainly added: the reduction of economic and financial crime under the form of corruption, shadow economy and money laundering. The present

study thoroughly validates this idea. Furthermore, because of the many control variables it uses and the two subsamples of worldwide countries it separately tests, several policy adjustments may be sketched, according to the existing different types of impact.

Economic development exerts a different influence upon the economic and financial crime index of countries, lowering the economic and financial crime of low income countries and boosting the economic and financial crime of high income countries. Unemployment on the other hand needs to be reduced in high income countries in order to decrease their economic and financial crime index, while an increased unemployment rate registered by low income countries seems to have the reduction of their economic and financial crime as a side effect. Governments of high income countries should consider that the less tax freedom they confer, the lower their economic and financial crime index would become. Then, the decrease of the economic and financial crime index of low income countries can be attained by increasing the freedom of their fourth power in the state, the press. Religions and legal origins come with some effects upon the economic and financial crime phenomena as well. The implications are many and these findings can prove to be of a great use to decision makers of the states, to government and non-governmental enterprises and also to potential investors within different markets.

One inherent limit is the fact that econometric modelling relies mainly on the multiple regression analysis technique and slightly on exploratory factor analysis (principal components analysis). In the future, we intend to surpass this limit by using other data analysis techniques: a cluster analysis of countries for evaluating the structure of relationships and structural equation modelling for multiple relationships of dependent and independent variables and even the parametric modelling of data (polynomial fitting). Moreover, cross-sectional data could be collected through a detailed survey carried out on individuals, in order to reveal the perceived corruption phenomena people have interfered with and the role played by the ICTs they use for their reduction. Nonetheless, we are considering some other macro available technological development proxies and even a self-built composite, a new digitization index that would aggregate the many existing technological proxies into a single variable. Another future research direction could be the implementation of the corruption – technologies nexus through a real-time platform, having various outputs, ranging from tax collection effectiveness to the regional development level of various eActivities and prospects for the evolution of corruption under several potential scenarios.

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APPENDIX

The sample countries classified as 'high income' and 'low income'

High income countries (54)	High income (54)	Australia, Brunei New Zealand, Singapore, South Korea, Austria, Czech Republic, Denmark, Ireland, Italy, Israel, Qatar, Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, UK, Bahamas, Puerto Rico, Trinidad and Tobago, Uruguay Kuwait, Malta, Saudi Arabia, United Arab Emirates, USA, Hong Kong, Japan, Belgium, Croatia, Cyprus, Estonia, Finland, France, Germany, Greece, Iceland, Luxembourg, Barbados, Chile, Bahrain, Oman, Canada, Macao, Taiwan, Equatorial Guinea.
Low income countries (131)	Upper middle income (50)	Albania, Algeria, Angola, Argentina, Azerbaijan, Belarus, Belize, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, Gabon, Grenada, Hungary, Iran, Iraq, Jamaica, Jordan, Kazakhstan, Lebanon, Libya, Macedonia, Malaysia Maldives, Mauritius, Mexico, Montenegro, Namibia, Panama, Peru, Romania, Saint Lucia, Saint Vincent and the Grenadines, Serbia, Seychelles, South Africa, Suriname, Thailand, Tonga, Tunisia, Turkey, Turkmenistan, Venezuela.
	Lower middle income (47)	Armenia, Bhutan, Bolivia, Cambodia, Cameroon, Cape Verde, Congo Republic, Côte d´Ivoire, Djibouti, Egypt, El Salvador, Georgia, Ghana, Guatemala, Guyana, Honduras, India, Indonesia, Kiribati, Kosovo, Kyrgyzstan, Laos, Lesotho, Mauritania, Moldova, Mongolia, Morocco, Nicaragua, Nigeria, Pakistan, Papua New Guinea, Paraguay, Philippines, Samoa, Sao Tome and Principe, Senegal, Sri Lanka, Sudan, Swaziland, Syria, Timor-Leste, Ukraine, Uzbekistan, Vanuatu, Vietnam, Yemen, Zambia.
	Low income (34)	Afghanistan, Bangladesh, Benin, Burkina Faso, Burundi, Central African Republic, Chad, Comoros, Congo Democratic Republic, Eritrea, Ethiopia, Haiti, Kenya, Korea (North), Gambia, Guinea, Guinea-Bissau, Liberia, Madagascar, Malawi, Mali, Mozambique, Myanmar, Nepal, Niger, Rwanda, Sierra Leone, Somalia, South Sudan, Tajikistan, Tanzania, Togo, Uganda, Zimbabwe.