Business R&D Expenditure in the ICT Sector: Effects on Business Performance Indicators

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Abstract

Firms in information and communication (ICT) sector are often considered as an important element of business innovation performance in the economy. This paper is focused on examining their share on innovation and total research and development (R&D) expenditure in selected European countries. Moreover, our goal is to test the potential effect of R&D expenditure on selected business performance indicators. We used panel macro-level data from 24 countries during the years 2008-2016. Based on the results of panel regression analysis we found empirical evidence for the positive effect of R&D expenditure on value-added and apparent labour productivity in the ICT sector. This fact could be to some extent attributed to the innovation of products and processes. The highest share of business R&D expenditure in ICT is present in Nordic countries such as Island, Norway and Finland. Firms in ICT appear to be more above-average innovative and represent a significant share of total business R&D expenditure.

Keywords: business R&D expenditure, business innovation, ICT sector, business performance, financial indicators.
JEL classification: O30, G31, M21

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Introduction

The importance of research and development is often emphasized by economists as well as political entities such as European Union. Many economists focus on the positive impact R&D investment has on economic growth (Gumus, Celikay, 2015; Akcali, Sismanoglu, 2015) as well as productivity (Pieri, Vecchi, Venturini, 2018). It has also been proven that R&D investment has positive effect on financial performance of a firm, such as on its profitability (Shen, Yan, Tzeng, 2017; Apergis, Sorros, 2014; Ayaydin, Karaaslan, 2014; VanderPal, 2015) or turnover (Park et al., 2018).

R&D and innovation investment tends to focus in the so-called knowledge-intensive industries. One of the fastest-growing sectors in many countries in the past few decades has been ICT sector (Hanna, 2009). It is therefore not surprising that ICT has been proven to have a positive effect on economic growth (Tolica, Sevrani, Gorica, 2015; Khanna, Sharma, 2018; Sepehrdoust, 2018). Even though many papers focus on the role of R&D and ICT separately, some authors argue that it is important to study the relationship and correlations between these two areas, since they were shown to have complementary effects (Pieri, Vecchi, Venturini, 2018; Khanna, Sharma, 2018). Considering the competitive nature of the ICT sector, ICT firms try to gain the competitive advantage by investing in R&D and innovation. Thus, many authors studying the factors affecting the growth of ICT sector agree that one of the key

driving forces of ICT industry is R&D and innovation (Tolica, Sevrani, Gorica, 2015; Manjón, Mompó, Redoli, 2016; Stejskal, Hajek, Prokop, 2018; Conarella, Miller, 2018).

Authors often focus on the impact of R&D and ICT on growth and profitability separately, comparing the effect of these two variables. Edquist and Henrekson (2017) proved that the ICT and R&D capital have positive impact on value added growth. Mithas et al. (2012) focused on the impact of R&D and ICT investment on profitability on a sample of a number of global firms and founds that while both of these expenditures have positive effect on revenue of a firm, impact of ICT investment is greater than that of R&D expenditure. Estrada and Dong (2019) studied coopetition on a sample of Spanish manufacturing firms and found that R&D investment positively affects ICT investment and ICT investment in turn positively affects profitability. Hall, Lotti and Mairesse (2013) concluded that while both R&D and ICT investment are strongly associated with innovation and productivity, R&D is more important for innovation, while ICT is more important for productivity. The positive impact of both R&D and ICT investment on innovation and productivity was confirmed by many other studies (Martin, Nguyen-Thi, 2015; Álvarez, 2016; Khanna, Sharma, 2018; Pieri, Vecchi, Venturini, 2018).

However, there can also be found studies focused on the impact of R&D investment on various growth variables in the ICT sector specifically. The main findings of these studies are summarized in Table 1.

Table 1
Review of the Studies Focused on Impact of R&D Investment on Innovation, Growth and Profitability of ICT Firms

Authors	Sample specification		Study specifics
	Country	Period, data source	
		INNOVATIVE EFFORTS	
Agramunt, Berbel-Pineda, 2018	Argentina	2011 Questionnaire survey	R&D investment (expressed as innovative effort) is a determinant of innovation
Manjón, Mompó, Redoli, 2016	Spain (Castile-Leon)	N/A Questionnaire survey	The effort made by firm in R&D is one of the main factors leading to innovation
Stejskal, Hajek, Prokop, 2018	Germany	2010 – 2012 Innobarometer	Influence of internal and external R&D expenditure contributes to creation of innovation
		GROWTH	
Das, Kapil, 2015	India	1999 – 2012 Euromoney ISI Emerging Markets IS	R&D intensity does not play important role in firm's growth strategy
Park et al., 2015	Korea	2012 Daejeon Regional Economic Receiving Survey	Innovation effort (including R&D investment) is the factor of firm's successful growth
Schröder, 2012	Germany	2009 – 2010 Questionnaire survey	R&D stimulates growth
Conarella, Miller, 2018	U.S.	1990 – 2013 Compustat database	R&D facilitates growth

		PROFITABILITY	
Warusawitharana, 2015	U.S.	1985 – 2006 Compustat database	Model focused on R&D intensive industries, results show that R&D investment leads to higher profitability, especially in software industry
Koutroumpis, Thomas, 2019	Germany, France, Sweden, UK	2004 – 2013 Orbis/Amadeus dataset	R&D capital in ICT firms has a larger effect on revenue in comparison with non-ICT firms
Lee, Mun, Lee, 2018	Malaysia	2009 – 2015 Bloomberg database	Intangible assets (variable related to R&D investment) is shown to have positive effect on firm profitability

Source: Authors' work

The importance of innovation and R&D can also be seen in the share of innovative firms in the ICT industry in selected EU countries (see Figure 1). Even though the total share of innovative firms in the countries under review ranges from 20 to 60 %, when we narrow it down to ICT sector, this share raises to 30 – 80 %. This shows that R&D and innovation is especially crucial to ICT firms. It is therefore apparent that R&D investment is a key factor of growth and financial performance of ICT firms.

Methodology

With respect to innovation, the ICT sector still has special place within all different sectors. Hence, we focused our attention on research and development expenditure in this sector. Our main goal is to examine the R&D expenditure in European countries and identify potential impact of R&D investments on selected business performance indicators. In line with the aim we developed three research hypotheses as follows:

- H01: The share of innovative firms in ICT sectors is higher than the average of all sectors in economy
- H02: The share of business R&D expenditure in ICT sector is higher in Nordic countries compared to most of the new EU member states.
- H03: Higher business R&D expenditure is positively related to higher apparent labour productivity in ICT sector.
- H04: Higher business R&D expenditure is positively related to higher business value added in ICT sector.

In order to test all four hypotheses and fulfil our main aim we analyse available secondary empirical data. In this section we describe our methodology as well as data in detail. Our dataset consists of macro-level business sector panel data from Eurostat database. Hence, every indicator was captured yearly at country level during the period 2008 - 2016. All variables used in the regression analysis are described in more detail in Table 2.

Table 2
Description of Variables Used in the Analysis

Variable	Description	Source (codes)
BERD on GDP	Business expenditure on R&D (BERD) % of gross domestic product (GDP)	Eurostat (rd_e_berdindr2)
BERD in €	Business expenditure on R&D (BERD) in Euro per inhabitant	Eurostat (rd_e_berdindr2)

Apparent labour productivity	Apparent labour productivity (Gross value added per person employed) - thousand euro	Eurostat
Value Added	Value added at factor cost in production value (in %)	Eurostat
Personnel costs	Average personnel costs (personnel costs per employee) - thousand euro	Eurostat
GDP per capita	GDP per capita in PPP: Volume indices of real expenditure per capita in PPS (EU28=100)	Eurostat

Source: Authors' work

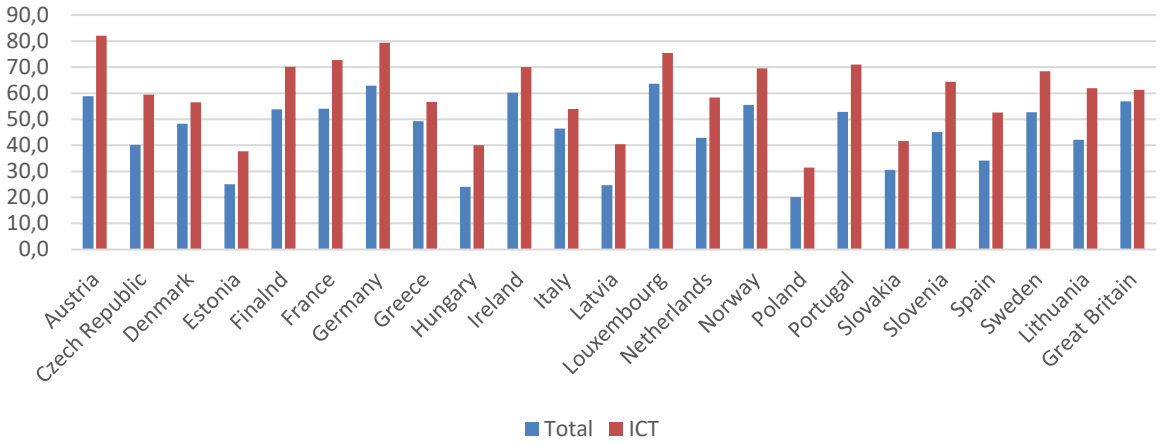
The list of countries in the dataset originally consisted of EU28 countries plus Norway. However, Malta, Cyprus and Luxembourg were excluded from regression analysis due to unavailability of several indicators.

Firstly, we analysed selected indicator related to business innovation and business investment to R&D. In line with our first two hypotheses we are especially focused on the share of innovative firms and share of business R&D expenditure. We compared these indicators among selected European countries and come to several interesting findings. Furthermore, we constructed panel retrogression models in order to examine potential link between business R&D expenditure and selected financial business performance indicators. With respect to our main aim, results of previous studies and data availability we decided to focus on two main indicators: apparent labour productivity and value added at factor cost. We believe that especially these two indicators could be directly or indirectly positively affected by business investment into R&D and potential innovation. Innovation could lead to both higher labour productivity as well as to higher value added in production. However, it is likely that due to often long-lasting innovation processes these potential effects on performance indicators can be delayed by several years. Hence, we also take into account time lagged independent variables. In each case we use either fixed effect or random effect panel regression models. Fixed effects models appear to be more suitable ones in our case. Despite this fact, we also have shown the results of random effects model due to robustness check. Moreover, we used independent variables capturing R&D expenditure in two different forms (as % of GDP and in Euro per capita) in order to further check the robustness. The results of the analysis are described in the next section.

Results and discussion

Based on our aim we examine business R&D expenditures and innovation in ICT sector. In the first part of the analysis, we compare the share of innovative firms in ICT sector with the share of innovative firms in economy in selected European OECD countries. As can be seen in Figure 1, the share of innovative firms (calculated as a share of firms that introduced product/process or marketing/organizational innovation) is higher in ICT sector in all countries.

Figure 1
Total Share of Innovative Firms Compared to Share of Innovative ICT Firms in Selected EU Countries

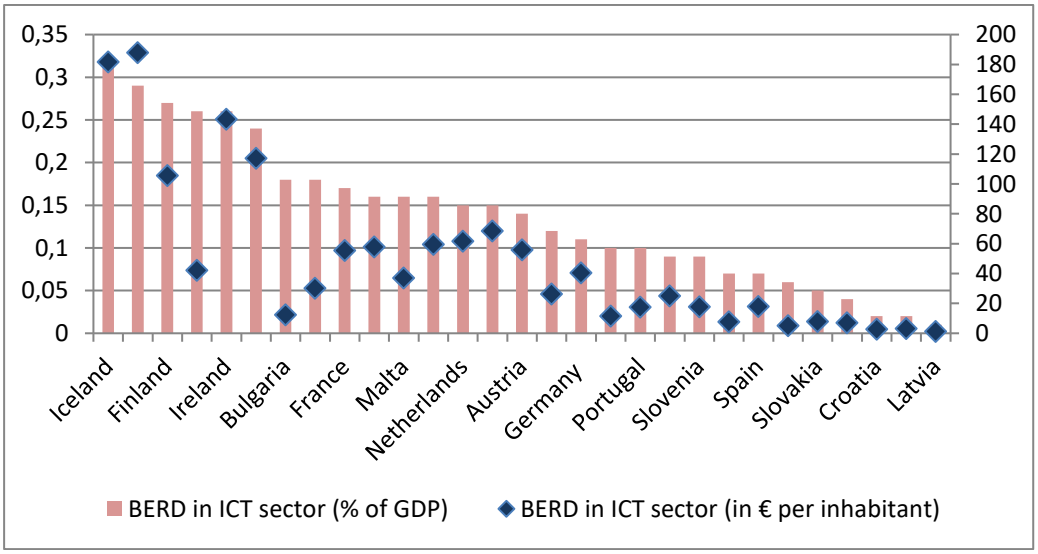


Source: Authors' work based on "Innovation Indicators 2017" OECD database.

Hence, we can say that the ICT sector is in general more innovative then the average of the total economy. This seems to be especially true in Austria where approximately 80% of firms innovated. The differences between ICT firms and total economy are also particularly significant in countries such as Hungary, Poland, Latvia and Estonia, where the innovation performance in general is rather low.

In the Figure 2 we compared business R&D expenditure in ICT. This indicator was captured in euro per inhabitant as well as in percentage of GDP. Business R&D expenditures are especially high in Nordic countries such as Island, Norway and Finland. Relatively high level of business R&D expenditures with respect to GDP is captured in Estonia, Bulgaria and Czechia. On the other hand business R&D expenditures in Latvia, Lithuania, Croatia, Greece and Slovakia are rather low in both indicators.

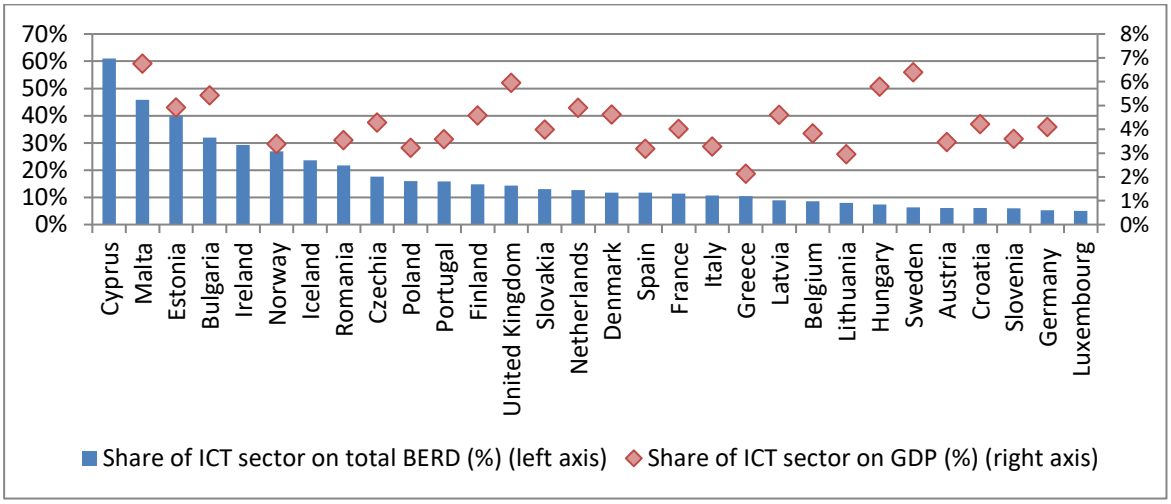
Figure 2
Business R&D (BERD) Expenditures in Selected European Countries in 2016



Source: Authors' work based on Eurostat database (code: rd_e_berdindr2).

We also compared the share of business R&D expenditure in ICT sector to total business R&D expenditure in each country. This is especially interesting when also comparing with the share of ICT sector production on total GDP. Both of these indicators can be seen in Figure 3. However, the data capturing the share of ICT on GDP was not available in Cyprus, Iceland, Ireland and Luxembourg. Despite rather low proportion of ICT sector on total economy in some countries, the share of R&D expenditures in this sector is very high. This is particularly true in Cyprus where approximately 60 % of total R&D business expenditure is spent by firms in ICT sector. Share of ICT sector on total R&D expenditures is also very high in Malta, Estonia, Bulgaria and Ireland. This situation can be on one hand the result of lower R&D investments in other sectors, which seems to be the case of Cyprus, Malta and on the other hand this could be the reflection of very high R&D expenditure in ICT sector despite the rather high business R&D investment in the economy.

Figure 3
Share of ICT Sector on BERD and GDP in 2016



Source: Authors' work based on Eurostat database (codes: rd_e_berdindr2; soc_bde15ag)

The ICT sector represents the highest share of national economy in Malta followed by Sweden and United Kingdom. In all three countries the share of ICT sector on GDP is higher than 6 %.

In order to further proceed in our analysis, we conducted regression analysis. Based on the results we can examine potential relationships between R&D expenditure and selected business performance indicators. Firstly, we focus our attention on apparent labour productivity in the ICT sector. This indicator represents the dependent variable in the first set of regression models. The results of these panel regressions are summarised in the Table 3. We constructed seven fixed-effects regressions and one random effects regression. In order to capture potential delays in the actual impact of R&D expenditures on labour productivity we also use lagged values of main independent variable. The maximum number lags were four due to limited number of observations. This means that we captured the effect of R&D expenditure on labour productivity delayed by one to four years. In addition to the share of business R&D expenditures in ICT sector on GDP we also used the value of R&D expenditures in euro per capita in some regressions. However, the results were very similar in both cases which confirms the robustness of our results. We also used GDP per capita and personnel costs as two control variables. GDP per capita captures the potential effect of economic cycle as well as differences in economic performance between

countries. Personnel costs is a control variable for potential effect of changes in salaries on productivity. These changes in personnel costs may also be the result of innovation and pressure on the use of highly skilled labour. As can be seen in Table 3, business R&D expenditure in ICT sector seems to have a positive effect on apparent labour productivity in ICT sector. This is true in all models, even though in the model with two-year time lag, this effect appears to be statistically not significant. The positive effect on labour productivity is evident even in the same year R&D expenditure has been invested. This effect is significant at 5 % level of significance in this instance as well as with one-year time lag. We also find evidence that this effect can persist for several next years, which is captured by positive and statistically significant effect in third and fourth year. In the case of R&D expenditure in euro per capita this effect is evident in both one- and two-year lags and it is statistically significant even at 1 % level of significance.

Table 3
Results of Panel Regression Models

Dependent variable: Apparent Labour productivity(in %)								
Lags/ years	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
BERD (GDP) Lag=0	24.13*** (2.43)							
BERD(GDP) Lag=1 year		18.26** (3.14)	21.86** (2.21)					
BERD(GDP) Lag=2 years				6.54 (0.83)				
BERD(GDP) Lag=3 years					26,47* (1.70)			
BERD(GDP) Lag=4 years						16.53** (2.06)		
BERD(€) Lag=1 year							0.18*** (8.12)	
BERD(€) Lag=2 years								0.11*** (3.27)
ΔPersonnel costs	0.77*** (3.66)	0.76*** (3.67)	0.70** (2.29)	0.54*** (3.14)	0.56*** (2.98)	0.60** (2.32)	0.96*** (5.38)	0.68*** (3.77)
Log(GDP per capita)	-5.2 (-1.77)	-5.1 (-1.24)	35.4*** (3.93)	-6.4 (-0.64)	-28.7* (-1.69)	-57.7*** (-14.29)	-7.2 (-1.48)	-9.9 (-1.02)
C	84.05*** (4.23)	84.4*** (4.56)	-93.18** (-2.48)	91.68*** (2.09)	187.8 (2.55)	316.8*** (17.99)	89.9*** (4.06)	104.2** (2.44)
Cross-section Fixed effect (FE)/ Random effects (RE)	FE	FE	RE	FE	FE	FE	FE	FE
R2	0.98	0.98	0.21	0.98	0.99	0.99	0.98	0.99
Adjusted R2	0.98	0.98	0.19	0.98	0.98	0.98	0.98	0.98
F-statistic	343.3***	337.3*	13.2***	352.5***	463.9***	403.2***	367.8***	363.3***

Note: symbols (.) denotes t-statistics and */** denotes statistically significant at the 1/5 percent level. Standard errors have been corrected for heteroscedasticity. The maximum number of observations in panel data is 168.
Source: Authors' work based on the data from Eurostat database.

Similarly, we also found positive effect of increase in personnel costs on labour productivity. The variable GDP per capita was mostly statistically insignificant.

In the second set of regression models we use value added as dependent variable. This time we used log of value added due to the fact that value added is the variable expressed in euro and we need to reduce the extreme values and into some extent normalise the distribution of this variable. We assume that higher business R&D expenditure in ICT sector should lead to higher added value in the sector. This again may be more evident with certain time lag. Hence, we again applied also lagged independent variables. The results of regressions are summarised in Table 4. We used eight regressions with fixed effects and one regression with random effects in order to check the robustness. In one case we also used common logarithm of independent variable to capture potential non-linear relationships in log-log form and further test the robustness of our results.

Table 4
Results of Panel Regression Models

Dependent variable: Log(Value added) (in mil. €)									
Lags/ years	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
BERD(GDP) Lag=0	0.374 (1.38)								
BERD(GDP) Lag=1 year		0.92*** (3.34)	0.64* (1.67)						
Log(BERD(GDP)) Lag=1 year				0.05*** (3.98)					
BERD(GDP) Lag=2 years					0.76** (2.05)				
BERD(GDP) Lag=3 years						0.71* (1.95)			
BERD(GDP) Lag=4 years							1.01*** (3.12)		
BERD(€) Lag=1 year								0.002*** (2.68)	
BERD(€) Lag=2 years									0.002*** (3.68)
ΔPersonnel costs	-0.0002 (-0.14)	0.0002 (0.19)	-0.002 (-0.10)	0.0009 (0.006)	-0.0001 (-0.07)	0.002* (1.88)	0.0002 (1.51)	0.09 (0.44)	0.002 (0.94)
Log(GDP per capita)	0.11 (0.46)	-0.03 (-0.11)	0.05 (0.31)	-0.05 (-0.15)	0.33*** (4.11)	0.25** (2.02)	-0.14 (-1.25)	0.09 (0.44)	0.37*** (4.02)
C	3.24*** (3.07)	3.81*** (3.01)	-93.2** (-2.48)	4.09** (3.07)	2.20*** (6.19)	2.60*** (4.58)	4.03*** (8.98)	3.27*** (3.46)	2.09*** (5.32)
Cross-section Fixed effect (FE)/ Random effects (RE)	FE	FE	RE	FE	FE	FE	FE	FE	FE
R2	0.88	0.89	0.04	0.90	0.92	0.92	0.9	0.89	0.91
Adjusted R2	0.87	0.87	0.02	0.88	0.90	0.90	0.88	0.87	0.89
F-statistic	43.1***	46.69*	12.22*	45.69***	47.93***	42.37***	42,6***	43.19***	47.38***

Note: symbols (.) denotes t-statistics and */** denotes statistically significant at the 1/5 percent level. Standard errors have been corrected for heteroscedasticity. The maximum number of observations in panel data is 168.
Source: Authors' work based on the data from Eurostat database.

As we can see the results again suggest the existence of positive effect of R&D expenditure on value added at factor cost in production. As we assumed the effect is not evident in the same period, but R&D expenditure from previous years appears to have positive and statistically significant effect on value added. This is true in the case of all four lagged independent variables. Similarly, positive and significant effect is present for both indicators expressed as percentage of GDP as well as in euro per capita.

Our results help us fulfil our main scientific aim and based on them we can test four main scientific hypotheses as mentioned in methodological section of our paper. With respect to hypotheses we can make these conclusions:

- We cannot reject the hypothesis H01 that the share of innovative firms in ICT sectors is higher than the average of all sectors in economy. In fact, our results strongly suggest that this is true in all selected European countries.
- We cannot reject the hypothesis H02 that the share of business R&D expenditure in ICT sector is higher in Nordic countries compared to the most of new EU member states. Most of the Nordic countries such as Norway, Island and Finland reach the highest business expenditures on R&D in our sample.
- We cannot reject the hypothesis H03 that the higher business R&D expenditures are positively related to higher appetent labour productivity in ICT sector. Our results strongly suggest that this effect is evident in the same period as well as with the certain time delay.
- We cannot reject the hypothesis H04 that the higher business R&D expenditure is positively related to higher business value added in ICT sector. Our results strongly suggest that the business R&D expenditure has positive effect on value added at factor cost in ICT. This time we found evidence for the existence of positive effect of business R&D from previous periods on value added in current period.

Higher business investment in R&D seems to represent a factor positively affecting selected business performance indicators namely labour productivity and value added in ICT sector. These results are in line with the results of several other previous studies. While the positive effect of R&D expenditures on productivity has been previously found for example by Pieri, Vecchi, Venturini {2018), Khanna, Sharma (2018) and Martin, Nguyen-Thi (2015), the positive impact on value added has been reported for example by Edquist and Henrekson (2017). It is likely that the effect on labour productivity can be achieved mostly by innovation of processes in ICT sector. On contrary, increase in value added can be to certain extent explained by innovation of ICT product or services.

Conclusion

Based on our results we can conclude that ICT sector represents an important element of innovation performance in the country, Firms in ICT sector are more innovative than the average of firms in total economy. This is true in all European countries in our sample. Furthermore, the firm's ICT sector account for significant share of total business R&D expenditure in economy in most countries. The highest proportion of R&D expenditures in ICT on GDP was captured in Nordic countries such as Island, Norway and Finland. However, several Eastern European countries such as Estonia and Bulgaria are also performing very well in this indicator despite lower business R&D investment in Euro per capita. On the other hand, countries such as Latvia, Lithuania, Greece, Croatia and Slovakia still have only very small proportion of business R&D in ICT sector.

In line with our findings we can also conclude that business investment in R&D appears to have positive impact on some business performance indicators. In our case we found evidence for positive effect on apparent labour productivity and value added in ICT sector. Both indicators seem to be affected by R&D expenditures in previous years. However, the effect on the productivity was evident also in the same period. We assume that mentioned positive impact of business R&D expenditure on economic performance can be into some extent attributed to process and product innovations. However, more research based on micro level data is needed in this area in order to find more even support for this assumption.

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