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INNOVATION, PRODUCTIVITY AND EMPLOYMENT IN CENTRAL AND SOUTH EASTERN EUROPEAN COUNTRIES

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ABSTRACT

Technological development was regarded by Schumpeter (1939) and Solow (1956) as one of the major drives of economic development and productivity. Technical achievements such as electricity and information and communications technologies – now widely referred to as General Purpose Technologies – have reshaped economic processes, spreading from one industry to a number of others and creating potential for further innovative activities. As measured by patent statistics today's leading technology is still information and communications technology, though growth rates in other fields of innovation point to the beginning of a new epoch. The paper investigates how the selected 14 Central and South Eastern European Countries contribute to the world's technological progress with the help of R&D and patent statistics lagging far behind the G7 and even the OECD average. Despite the growing number of new patents, the deceleration of productivity dynamics has been a general phenomenon in both developed and emerging economies since the real economic effects of the 2007-2008 global financial crisis became perceivable. However, despite the moderating pace, productivity and employment growth go hand in hand in the developed countries at the national economy level as was stated by Kaldor (1961) and confirmed by Jones-Romer (2010) and Autor-Salomons (2017). As regards the 14 Central and South Eastern Countries examined we receive contradictory results. The correlation between employment and productivity (measured as real value added per person employed) mostly shows positive values even for growth rates in the majority of the countries in the period between 1995 and 2015. At the same time, panel regressions explaining the growth in employment with productivity dynamics and other control variables reveal a negative relationship between the two key indicators in the case of OLS estimations and the positive effect of productivity on employment can only be confirmed by using the GMM estimation method.

Keywords: Innovation, productivity, employment, patent statistics, emerging European economies.

INTRODUCTION

The paper aims at discovering some innovation characteristics and estimating the relationship between productivity and employment at the national economy level in 14 Central and South Eastern European Countries, namely Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia and Turkey. After a theoretical overview on how economists assess the effect of technology – with special regard to General Purpose Technologies – and innovation on economic development and productivity, the paper provides a brief overview on how the leading technology has changed since the start of the industrial revolution and what current patent statistics suggest about the future's main technologies. The question is addressed whether the use of ICT (Information and Communications Technology) leads to productivity increase and, whatever drives productivity, how it affects employment. Finally, the above issues are discussed at the level of the 14 Central and South Eastern European Countries with special regard to the productivity-employment relationship which is estimated with panel regression methods over the period 1995-2015.

1. Innovation, GPTs and economic development

1.1 Theoretical background

Following on Solow's (1956) theory on technology, a large group of economists regards innovation as one of the main drivers of productivity increase and thus economic development. Schumpeter (1939) considered changes in the inputs of productive factors, changes in the social environment and changes in technology as determinants of economic development. (Hartwell, 1971) His innovation theory focusing on the role of the entrepreneur (Schumpeter, 1926) was formed based on technological achievements which were created during the industrial revolution, as for instance the steam engine and the railways, having an industry reshaping effect. The upswing starts in one or a few branches of industry where innovation assigns the characteristic course of development. Obstacles to the embedding of innovation in a given industry and then others taking it over are removed by the promoters of innovation, so technological development spreads to other industries dragging them into a general growth process and causing revolutionary changes in their development. (Hartwell, 1971) At the same time Schumpeter (1942) also acknowledged that with the evolution of new combinations earlier soultions and skills are squeezed out, become redundant, therefore he called this process in market economies through which innovation dismantles earlier structures as „creative disruption".

Technological innovation is thus widely acknowledged as the major force in productivity and economic growth and as Rosenberg (2014) emphasises the market has a great role in discovering what scientific result or invention can be converted into a saleable product. Innovation that is the appearance of successful products launched in the market largely depends on the institutional background, the quality of human resources, the organisation of labour and the dynamics of competing markets, R&D expenditure and investment activity in general. (ILO, 2008)

Technical achievements such as steam engines and electricity (electric motors) earlier, information and communications technologies (backed by the invention of semiconductors) in our times – now widely referred to as *General Purpose Technologies* – have reshaped economic processes, interwaving the economy and creating potential for further innovative activities. General Purpose Technologies (GPT), as „engines of growth" provide generic functions which enable the functioning of a great deal of existing and potential products and production systems (Bresnahan-Trajtenberg, 1992), as they spread over to other industries („pervasiveness"), improve over time lowering the costs of users („improvement"), make it easier to invent and produce new products and services („innovation spawning"). (Bresnahan and Trajtenberg (1996) as cited in Jovanovic-Rousseau (2005)).

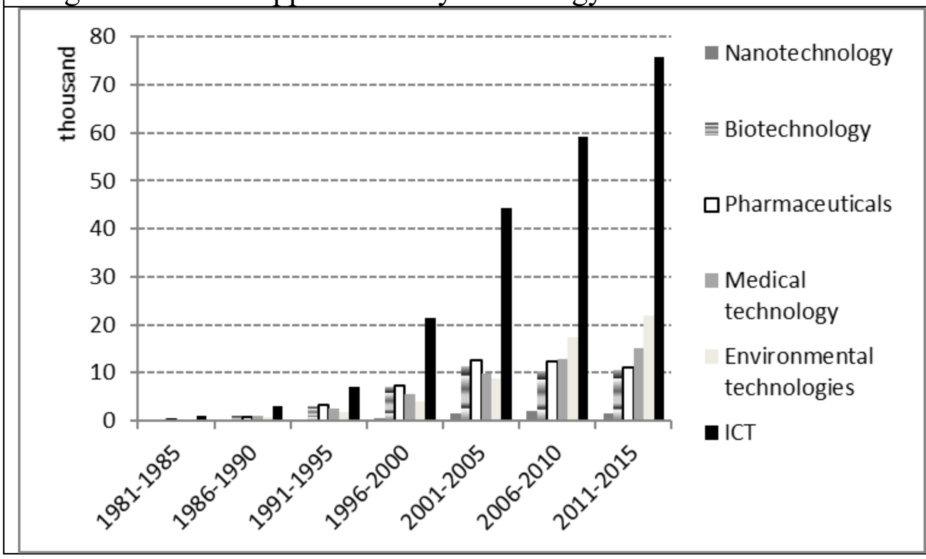
The spread of information and communications technologies (ICT) is regarded as one of the most important technical shifts determining the economic growth potential in the last some fifty years globally. The development of computers already started during the second world war but two essential technological innovations occured in the 1980's which defined the progress of the info-communication industry and therewith that of other sectors adopting these new technological achievements: (1) miniaturisation facilitated by the semi-conductor industry, (2) the arrangement of computers in networks (Verspagen, 2001). Info-communication technologies contribute to growth partly within the industry through increasing efficiency and capital deepening, partly through augmenting total factor productivity in other industries. (Zhen-Wei Qiang et al., 2003) Their external efficiency increasing effects, spinning off to other industries can be attributed to the intensifying performance of computers. Info-communication devices can reduce administrative costs, facilitate the spread of information in a cheaper and more efficient way, support the extensive use of new and more viable business models and the penetration of new markets and products, new solutions for organising production and the society. The empirical justification of the productivity effect of ICT, however, has brought differing results for different time periods and sets of countries. (Mačiulytė-Šniukienėa and Gaile-Sarkane, 2014)

1.2 Measuring innovation at the global level

The measurement of innovative activities is a debated issue, at global level technological development is mostly quantified and used for international comparison with the help of R&D spending and patent statistics. R&D expenditures are the major indicators of efforts and inputs aimed at expanding the knowledge base but formal statistics, recorded in data bases on R&D spending, can only cover a fraction of resources, including human resources, mobilised to produce new knowledge. In contrast, patent statistics better reflect industry level processes. Patent statistics are availabe at both national and international patent offices, their data collection is regulated by law, is based on a wide information basis and centralised which enhances their measurability. (The question emerges of course, whether the expansion of knowledge is well represented by processes and novel solutions recorded according to their practicality.) (OECD, 1996)

Comparing the global patent statistics of the Patent Cooperation Treaty (PCT) data published by the OECD, it is obvious that according to the international technological nomenclature (IPC), the greatest number of patents are submitted in the ICT domain and on the whole, the number of patents shows unbroken dynamics (Diagram 1). The continuously augmenting innovative activity suggests steadily growing productivity, though the pace of the latter has spectacularly subsided since the 2007-2008 global financial crisis as we will see it later.

Diagram 1: Patent applications by technology 1981-2015



Note: Columns represent five-year averages

Source: OECD, PCT patent statistics, inventor applications

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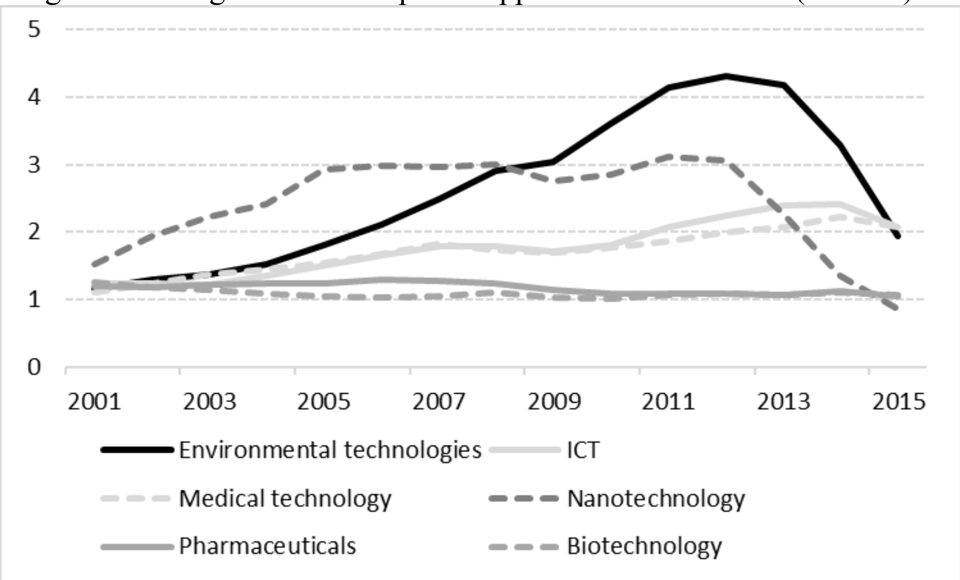
Patent offices classify innovative solutons by industrial branch or technological and scientific domains. In recent years the ascendancy of information and communications technologies has been traceable both in terms of the number and the growth rate of patent applications as regards the technological nomenclature (Diagram 2). A significant increase can be detected in innovative activity in the field of environmental technologies (energetics, climate change related etc.) until 2012 but in the last couple of years medical and biotechnology show a more significant expansion (pharmaceutical technologies seem to have reached their development peak at the beginning of the 2000's).

Diagram 2: The growth rate of patent applications 2001-2015 (2000=1)



Source: OECD, PCT patent statistics, inventor applications

Based on the above we can conclude that innovation in info-communication devices and services is one of the main levers of today's economic development. The statistical proof for the leading innovation of the present period which is also manifested in the statistics is in line with the classification of Freeman and Soete (1997). Using Schumpeter's (1939) theory of business cycles built upon „innovation clusters" (Table 1) as a starting point, which associated *Kondratieff-waves* with the permeation of the main technological paradigma changes, Freeman and Soete (1997) regards the spread of info-communication applications as the dominant technological condition of a new innovation lead economic cycle starting in the 1990's. We can thus think about the key technologies, as Schumpeter suggested, as those, whose evolution spans long technological waves (Bresnahan-Trajtenberg, 1992).

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Table 1: Kondratieff waves since the unfolding of the industrial revolution

Appr. timing	Kondratieff waves	Main energy resource; input	Leading industry
1780-1840	Industrial revolution: factory production for textiles	Water power; cotton	Factory („consumer”) industry
1840-1890	Age of steam power and railways	Steam power; coal, iron	Mining industry, primary heavy industry and transport
1890-1940	Age of electricity and steel	Electricity; steel	Secondary heavy industry and mechanic engineering
1940-1980/1990	Age of mass production (”Fordism”) of automobiles and synthetic materials	Oil; plastics	General services
1980/1990-2020(?)	Age of microelectronics and computer networks	Gas, oil; microelectronics	High-qualified services
2020/2030-2050/2060 (?)	MANBRIC technologies (?) (medico-additive-nano-bio-roboto-info-cognitive technologies).	Renewable energy sources (?); self-regulating systems[1] (?)	Medical human services (?)

Source: own compliation on the basis of Freeman and Soete (1997) and Grinin et al. (2017)

Grinin et al. (2017) identify business cycles of 50-60 years starting from the beginning of the industrial revolution with the help of intervals defined by Freeman and Soete (1997) but with different emphases, and set the period hallmarked by the widespread use of computer technology ten years earlier to the beginning of the 1980’s. Furthermore, they supplement the already defined Kondratieff waves with a sixth one, with the business cycle defined by the so called MANBRIC (medicine, additive, nano-, bio-, robotics, information and cognitive) technologies which will commence in the following decades and will embrace some 30-50 years. Grinin et al. (2017) establish their assumptions on the dynamics of patent statistics in the last decades and the expected innovation needs of medical technological developments invoked necessary for the health care of the aging society. Their combination of the specific innovation fields were primarily underpinned by Eastern Asian countries’ data from where, according to their assumption, the next technological shift will start off. Other researchers put more emphasis on bio-, nano- or ICT technologies or one of their subfields.

[1] Self-regulating systems „can regulate themselves, responding in a pre-programmed and intelligent way to the feedback from the environment; systems that operate either with a small input from humans or completely without human intervention.” Such self-regulating systems are e. g. artificial Earth satellites, pilotless planes, navigation systems laying the route for a driver, life support systems (such as medical ventilation apparatus or artificial hearts), and robots in general, computer programmes and self-driving cars . (Grinin et al., 2017, p. 54)

1.3 Technological development and productivity in different eras
Despite computer technology being widely acknowledged as a GPT of the second part of the 20th century, due to the slowing productivity of the developed countries after the 1970's a lot of theoretical and empirical examinations confuting its intense effect on efficiency were brought to surface in the 1980's and 1990's. Freeman and Soete (1994) come up with two explanations, (1) partly the measurability of the social utility of info-communication devices (in consumer surplus) faces obstacles, (2) partly low interest rates in the 1980's due to lax monetary policy pushed firms to invest in short-term R&D instead of longer-term development. Later Basu and Fernald (2006) investigated the change in US productivity and concluded that although the accelaration of productivity in the 1990's coincided with the price crash of computers and semiconductors which facilitated capital deepening. Nowithstanding, productivity gains at the beginning of the 2000's cannot be attributed to technological development. This latter can be much more interpreted as the retarded effect of the application of info-communication technologies and the allocation of supplementary investments between sectors, a part of which cannot be measured and therefore may not come out in TFP statistics.

Innovation in certain industries thus might not be reflected directly in economic growth and productivity. The phenomenon can be well described by the term coined as *Solow IT productivity paradox.* The development of the IT industry brought a radical structural change in the economy both in the case of production and consumption goods but it did not have a considerable impact on GDP growth and total factor productivity (Jorgenson and Stiroh, 1999, Verspagen, 2001). The phenomenon has found various explanations, like the low share of the IT sector in investment and the delay of the growth effect. Furthermore, Jorgenson and Stiroh (1999) argue that IT is not a technological change indeed but a move along the production function, a technological substitution. In case of substitution benefits deriving from technical innovations are reaped by the consumer and the service provider, in contrast to technological change where the same level of inputs results in higher output (and e.g. a third person will be the beneficiary). In the latter case economic policy should intervene in market processes because of the slow payback and consequently the private sphere would not undertake the additional investment needed. In the case of substitution, investment is stimulated by favourable price signals reflecting the change of demand and supply circumstances.
Futhermore, it is also often raised in the literature that the impact of the information and communication advances on productivity growth will be palpable only in a delayed manner (MNB, 2017).

1.4 Technological development and employment
A hotly debated issue in relation to technological development in recent years has been the potential loss of jobs owing to digitalisation, robotisation, the use of artificial intelligence and internet penetration which especially badly affect the medium-skilled workforce. (Pissarides, 2017) Technological progress can even lead to mass unemployment and significant welfare losses. More and more analyses appear in the economic literature which examine the general negative employment effects of the application of technological advances. The replacement of labour by machines meant a jobb loss for many (just think about the luddites) at the beginning of the industrial revolution and forced those employees to resistance who felt their income source being endangered by the introduction of innovative solutions. The Agrarian sector is one of the best examples of the way technological development undermined employment in an important sector of the economy.

Earlier the dominant economic view set down by Kaldor (1961) (cited by Jones and Romer, 2010; Autor and Salomons, 2017) was that increase in productivity goes hand in hand with growth in employment. According to Kaldor (1961) technical development in transport, production and telecommunication did not hinder labour in having a constant share in national income for a decade. This phenomenon was earlier evaluated as „a bit of a miracle" by Keynes. Many empirical examinations, however, pointed to the fact that since the 90's and especially since 2000 the share of labour income in total income has been continuously diminishing. (Karabarbounis and Neiman, 2013; Piketty 2014; Dao et al. 2017) which is often associated with the neutral effect of the info-communication sector, encompassing all industries, on total factor productivity. Concerning the employment effect of technology in the various sectors of the economy, Bessen (2017) calls our attention to more nuanced relations: employment shows a dramatical increase at the early stages of innovation then starts declining in later stages of maturity. It has been proved by numerous empirical studies that in developed countries not only productivity has lost momentum but the employment contribution of industries applying high technology is also declining. An examination of Autor and Salomons (2017) covering 35 years and 19 developed countries provides evidence on the declinig employment in high-tech industries and the continuously growing employment sparked by increasing productivity at the national economy level. They also reveal that the negative impact of the decrease in employment caused by the increase in productivity within the same industry is less than the positive spill-over effect of expanding productivity on other industries' employment. As a consequence, on average productivity expansion in the period examined by Autor and Salomons (2017) influences job creation in a positive way though its positive impact is moderating, and employment is largely dependent on population growth at the macroeconomic level.

2. Productivity and employment in the OECD and the EU

One of the approaches to measuring productivity is quantifying the joint contribution of productive factors to output – termed as *total factor productivity* (TFP). Comparable international statistics are, however, available in relation to *labour productivity* first of all. These quantify value added to employed workers or to working hours and are better indicators of productivity if value added is calculated at constant prices and purchasing power parity. Such data are available both in the OECD and the Eurostat databases, as we will see later, but these data are of mixed frequency and length, and comprise a limited number of countries. Therefore, I rely on statistics between 1995 and 2017 as this period is close to have a full data coverage.

On the whole, between 1995 and 2017 productivity followed a positive tendency in both the EU and the eurozone based on Eurostat and OECD data (Diagram 3-4), though a slowdown is observable after the outbreak of the 2007-2008 global financial crisis. As regards the employment rate in the 19 countries of the eurozone, the pre-crisis level had not been recovered by 2016. The picture is more favourable in the case of the OECD, G7 and EU 28 where employment statistics have exceeded the 2008 levels by now. The structural break caused by the crisis is even more articulated in employment than in productivity.

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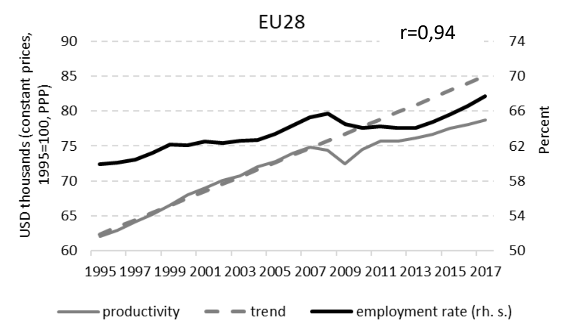
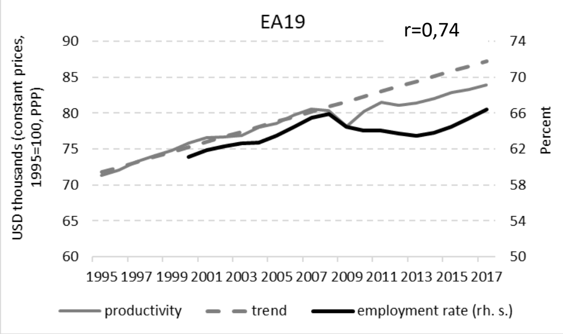
Diagram 3-4: Productivity and employment in the EU 28 and the eurozone 19, 1995-2017





Note: The dashed line depicts a trend calculated using data between 1995-2008
Source: OECD and Eurostat statistics

Though an OECD study revealed a negative correlation between employment and GDP per hour worked based on a data series encompassing 35 years in 2007 (OECD, 2007), it is widely accepted that productivity and employment are positively correlated at the macroeconomic level globally. It does not mean that there might not be trade-off between the two variables in a given country, what is more, in certain industries it is a general phenomenon. As an ILO study (ILO, 2008) established, in countries of the Eastern-Pacific ring productivity and employment grew hand in hand, and in some economies of South-America, the Arabian peninsula and in Africa population growth could bring forth higher dynamics in job creation than in productivity between 1990 and the 2007-2008 global financial crisis. In contrast, Central and Eastern European countries experienced no expansion in employment for a long time despite real economic convergence (ILO, 2008).
In the country groups of the EU and the eurozone we find a positive relationship between employment and efficiency over the entire time horizon of the last 20 years as reflected by the strong positive correlations (Diagram 3-4).

3. Innovation and productivity in the Central and South Eastern European Countries

3.1 Patent and R&D statistics of the selected countries

Innovation activity in the selected 14 emerging countries lags behind the EU, eurozone or OECD average both in terms of R&D spending and the number of patents per population which is in line with the lower than EU and OECD average productivity of these economies (Diagram 5-6).

Diagram 5: R&D and productivity 2001-2015 averages

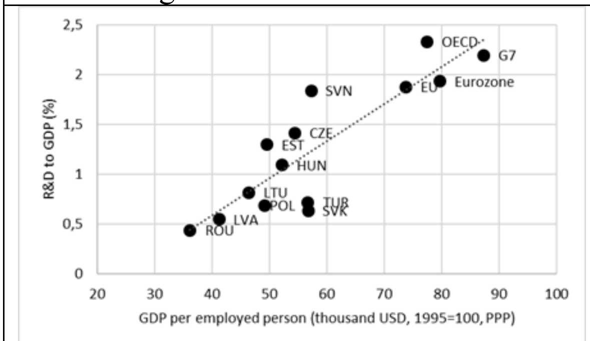
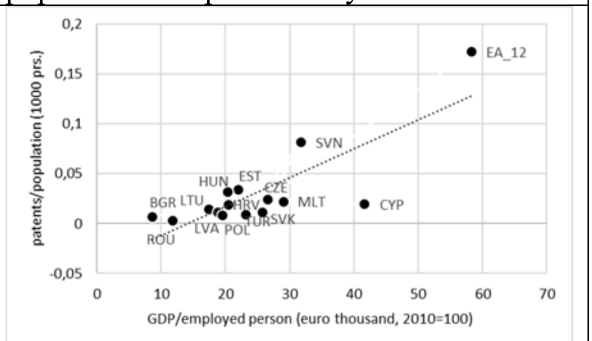


Diagram 6: Number of patents/working-age population and productivity 2001-2015



Note: Data points represent 15-year averages
Source: OECD and Eurostat statistics

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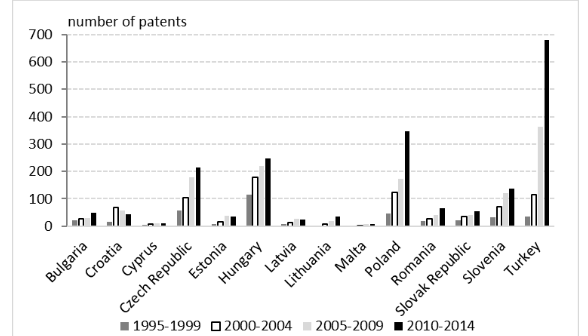
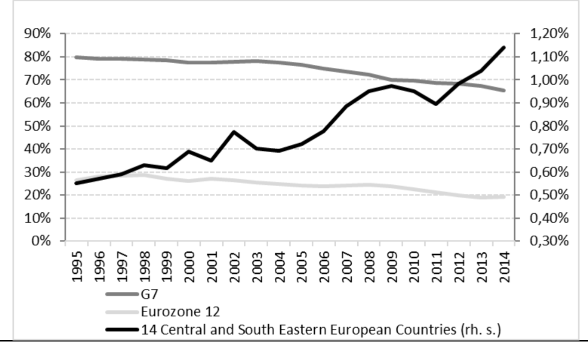
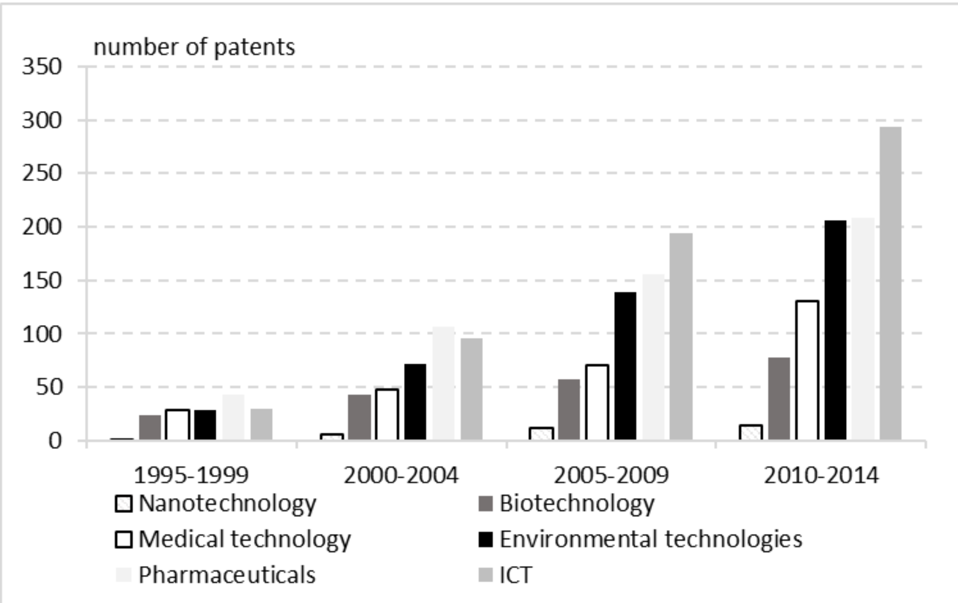
The number of patent applications the inventors submit to international patent offices is insignificant in a global comparison and the number of patents per head of population is below the EU average in these countries. However, their share in total patents (between 0,5 and 1,2% in the last twenty years) registered at the PCT is on an increasing path in contrast to the developed countries represented by the group of the old eurozone and the G7 group of countries (Diagram 7 and 8).

Diagram 7: The number of patents in 14 emerging European countries	Diagram 8: The share in total patent applications at PCT
	

Note: Columns represent five-year averages
Source: OECD, PCT patent statistics, inventor applications

The composition of patent applications is similar to that of the global dataset, at least in respect of the leading technological domain, which is ICT also in the case of the 14 countries examined. The order of the main technologies corresponds to the general tendencies after 2005 with one exception: new patents in the pharmaceutical technology are still at the second place in volume in the 14 emerging countries whereas the technological domain lost importance after 2005 at the global level (Diagram 9).

Diagram 9: Patents by technology in the selected countries



Note: Columns represent five-year averages
Source: OECD, IPC patent statistics, inventor applications

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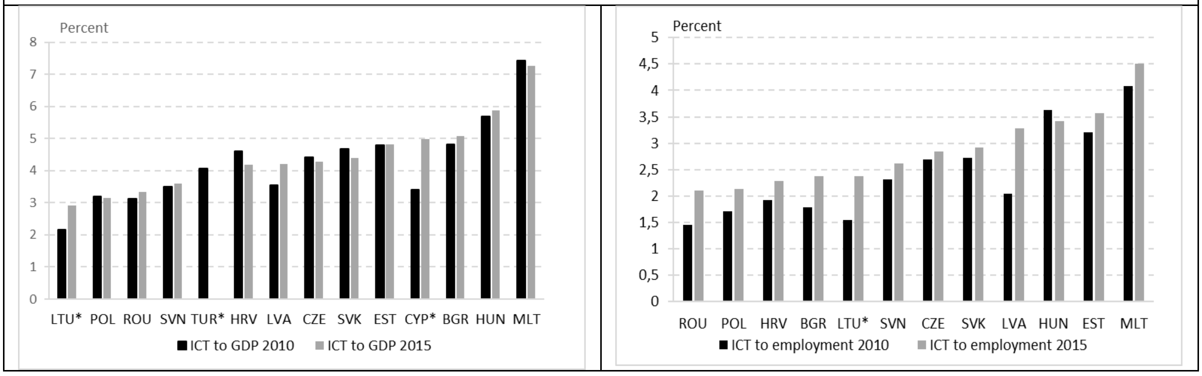
As regards the economic weight of information and communications technologies in the economy, the 14 countries do not underperform the EU average (Diagram 10 and 11). As Eurostat data on ICT to GDP and ICT to employment do not contain EU or eurozone averages, a simple averaging of data available for the various countries gives a magnitude of 4-6% as regards the ICT sector's contribution to GDP and 2,5-3,5% for the sector's share in total employment in the last 15 years. The ICT to GDP and ICT to employment data of the 14 Central and South Eastern European Countries moves approximately in the same data interval with the exception of Lithuania, Poland, Romania and Slovenia mainly with a lower share in GDP (some countries have a somewhat lower share in employment than 2,5% as well).

Diagram 10-11: ICT to GDP and ICT to employment statistics of the 14 emerging European economies in 2010 and 2015

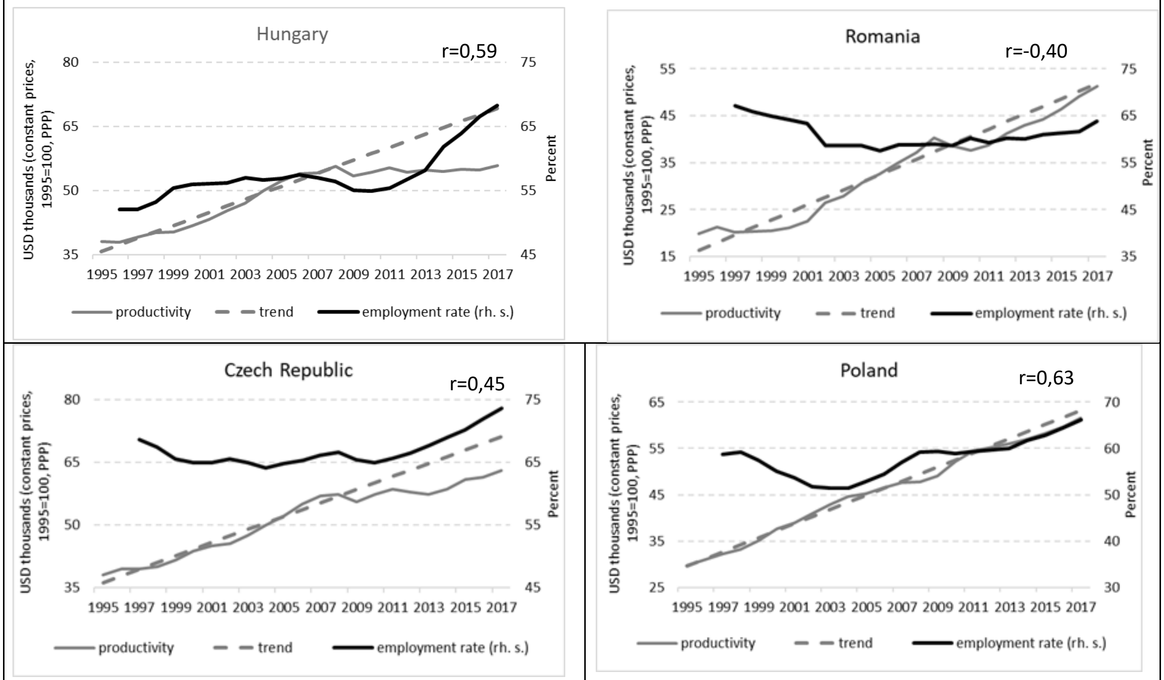


Note: Data for Lithuania in 2010 are 2009 data, Cyprus has only ICT services data, data available for Turkey from Tradingeconomics are from 2008
Source: Eurostat

3.2 Panel regression on productivity and employment in the 14 Central and Eastern European Countries

When comparing arbitrarily four different countries' employment rate and productivity data among the 14 countries examined, we see very dissimilar patterns. In the Hungarian data we find a very strong structural break in 2008, in Romanian data there is a weak negative and in the Czech data a weak positive correlation, whereas in Poland a rather strong comovement between productivity and employment. This foreshadows that we have a rather diverse productivity-employment relationship in the countries under examination (Diagram 12-15). (It is worth noting, though, that correlations calculated with the help of various datasets usually have a positive sign.)

Diagram 12-15: Productivity and employment in Hungary, Romania, the Czech Republic and Poland 1995-2017



Note: The dashed line depicts an additive trend based on data between 1995-2008
Source: OECD and Eurostat statistics

For analysing how productivity influences employment, I used panel regressions on the 14 countries' dataset, first simple OLS estimations then GMM to control for endogeneity in the data. The annual productivity and employment data were differentiated and logarithmised. Employment data were gained from the OECD databasis on total employment, the source of other data, including value added at constant 2010 prices, was the Eurostat databasis. (Patent statistics were also collected from OECD PCT database.) I used the employment and value added statistics of the EU KLEMS data source as well but productivity calculated this way did not bring in statistically acceptable results.

For explaining the change in employment other explanatory variables were included in the OLS regression such as change in population (15-64) in the countries examined, change in employment and productivity in the eurozone 12 (without new member states), R&D and ICT to GDP, change in the number of patents, patents to population and a dummy to account for the structural break after the unfolding of the global financial crisis. The OLS regression confirms that in the EU and the eurozone an increase in productivity is generally followed by an increase in employment as well (one percent change followed by half a percent change). (Appendix 1 and 2). The results of the 14 countries' panel regressions, however, show the opposite. The sign of productivity change when estimating employment is negative in calculations both for a limited number of countries (12) between 1996-2015 and for all the countries (14) between 2001 and 2015. (Table 2 and 3) (Note that OLS regressions only resulted in significant coefficients for productivity if the one-period lagged variable of employment was also included in the regression. If employment in the USA (eurozone and EU statistics) or employment in the eurozone was applied as control variable (panel regression), the productivity coefficient usually turned insignificant.)

Table 2: OLS regression for a panel of 12 countries, 1996-2015

Model 12: Pooled OLS, using 209 observations
Included 11 cross-sectional units
Time-series length = 19
Dependent variable: lndemp

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−0,247031	0,0582514	−4,241	<0,0001	***
lndpop	0,299376	0,137064	2,184	0,0301	**
lndprod	−0,174621	0,0517674	−3,373	0,0009	***
RDGDP_eurozone	0,141465	0,0323648	4,371	<0,0001	***
dummy	−0,0498889	0,00988958	−5,045	<0,0001	***
lndpop_eurozone_korr	−1,37728	0,633143	−2,175	0,0308	**
lndprod_eurozone_korr	1,10184	0,158196	6,965	<0,0001	***
lndemp(-1)	0,389400	0,0624682	6,234	<0,0001	***

Mean dependent var	0,001918	S.D. dependent var	0,027122
Sum squared resid	0,088593	S.E. of regression	0,020994
R-squared	0,420999	Adjusted R-squared	0,400835
F(7, 201)	20,87851	P-value(F)	5,34e-21
Log-likelihood	514,9926	Akaike criterion	−1013,985
Schwarz criterion	−987,2466	Hannan-Quinn	−1003,175
rho	0,120373	Durbin-Watson	1,707011

Table 3: OLS regression for a panel of 14 countries, 2001-2015

Model 25: Pooled OLS, using 210 observations
Included 14 cross-sectional units
Time-series length = 15
Dependent variable: lndemp

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
lndprod_	−0,223388	0,0504105	−4,431	<0,0001	***
lndprod_eurozone_korr	1,11183	0,148905	7,467	<0,0001	***
dummy	−0,00982650	0,00309541	−3,175	0,0017	***
ICTtoGDP	0,00154205	0,000573140	2,691	0,0077	***
lndemp_1	0,469206	0,0574847	8,162	<0,0001	***

Mean dependent var	0,004783	S.D. dependent var	0,027562
Sum squared resid	0,097303	S.E. of regression	0,021786
Uncentered R-squared	0,405119	Centered R-squared	0,387119
F(5, 205)	27,92131	P-value(F)	1,59e-21
Log-likelihood	508,1109	Akaike criterion	−1006,222
Schwarz criterion	−989,4863	Hannan-Quinn	−999,4563
rho	0,072118	Durbin-Watson	1,808392

In the GMM estimation only a limited number of instrumental variables proved to have explanatory power (productivity, population and employment of the eurozone 12 and R&D statistics). In these estimates we see a positive relationship between productivity and employment with almost the same elasticity as in the case of the EU and eurozone estimation (Table 4 and 5).

Table 4: GMM regression for the panel of 12 countries, 1996-2015

Model 1: Iterated GMM, using 220 observations
Dependent variable: lndemp
Instrumented: lndprod
Instruments: const lndprod_eurozone_korr lndemp_eurozone_korr

	Coefficient	*Std. Error*	*z*	*p-value*	
const	−0,0126849	0,00666675	−1,903	0,0571	*
lndprod	0,465373	0,184396	2,524	0,0116	**

Mean dependent var	0,001895	S.D. dependent var	0,026758

GMM criterion: Q = 0,000343172 (TQ = 0,0754979)J test: Chi-square(1) = 0,0754979 [0,7835]

Table 5: GMM regression for the panel of 14 countries, 2001-2015

Model 37: 1-step GMM, using 224 observations
Dependent variable: lndemp
Instrumented: lndprod_1 lndemp_eurozone_korr lndpop
Instruments: const lndpop_eurozone_korr RDGDP_eurozone numberofpatentspopulation_eur lndprod_eurozone

	Coefficient	*Std. Error*	*z*	*p-value*	
lndprod	0,518819	0,209112	2,481	0,0131	**
lndemp_eurozone_korr	−1,68597	0,895290	−1,883	0,0597	*
lndpop	1,15762	1,29186	0,8961	0,3702	

Mean dependent var	0,003948	S.D. dependent var	0,027243

GMM criterion: Q = 9,67599e-009 (TQ = 2,16742e-006)

Note: The above tables contain the best regression results

CONCLUSION

The focus of the innovative activity in the selected 14 Central and South Eastern European Countries follows worldwide trends which is reflected in the composition of their patents statistics in terms of technological classification. They are not lagging behind in the share of information and communications technology in GDP and employment which suggests that ICT, commonly regarded as the General Purpose Technology of our times, plays an important role in these countries' economic efficiency. Nevertheless, their contribution to global innovation (measured in numbers per head of population) is less than the eurozone average and their R&D spending to GDP lags behind EU, eurozone, OECD and G7 averages.

Whereas productivity grows hand in hand with employment at the national economy level in the eurozone and the EU, in the 14 countries examined the relationship between productivity and employment is uncertain as OLS and GMM estimates have contradictory results. To better understand the relationship between the two variables a further revision of different panel data methodologies is recommended.

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Appendix 1: OLS regression for the EU countries

Model 17: OLS, using observations 1996-2015 (T = 20)
Dependent variable: lndemp_EU

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
lndprod_EU	0,536343	0,130239	4,118	0,0007	***
lndpop_EU	1,52797	0,426765	3,580	0,0023	***
dummy	−0,00347004	0,00268536	−1,292	0,2136	

Mean dependent var	0,007274	S.D. dependent var	0,010281
Sum squared resid	0,000777	S.E. of regression	0,006760
Uncentered R-squared	0,746686	Centered R-squared	0,613230
F(3, 17)	16,70343	P-value(F)	0,000026
Log-likelihood	73,18203	Akaike criterion	−140,3641
Schwarz criterion	−137,3769	Hannan-Quinn	−139,7809
rho	0,199659	Durbin-Watson	1,498331

Appendix 2: OLS regression for the eurozone countries

Model 40: OLS, using observations 1997-2015 (T = 19)
Dependent variable: lndemp_eurozone

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
lndprod_eurozone	0,545594	0,0901719	6,051	<0,0001	***
lndpop_eurozone	0,344793	0,414961	0,8309	0,4183	
lndemp_eurozone_1	0,571418	0,125365	4,558	0,0003	***

Mean dependent var	0,007326	S.D. dependent var	0,010560
Sum squared resid	0,000368	S.E. of regression	0,004794
Uncentered R-squared	0,878545	Centered R-squared	0,816848
F(3, 16)	38,57854	P-value(F)	1,49e-07
Log-likelihood	76,14192	Akaike criterion	−146,2838
Schwarz criterion	−143,4505	Hannan-Quinn	−145,8043
rho	0,395990	Durbin's h	2,061018