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Productivity and Economic Growth in the European Union: Impact of Investment in Research and Development

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Abstract

This paper focuses on investment in research and development as a factor of labour productivity and economic growth. Our analysis confirms the link between expenditure for research and development (expressed in % of GDP) and labour productivity (expressed in the number of hours worked) based on selected data for EU Member States in the period 1995-2013. A causal link between variables of the concave parabola was confirmed, and the value of expenditure for research and development (2.85% of EU GDP) maximising productivity (per hour of work) was determined based on the examined data. In accordance with these findings, EU's target of reaching 3% of GDP spent on research and development to be achieved by 2020 seems in support of reaching maximum productivity in the EU.

Key words: investment in research and development, productivity, economic growth, correlation, panel analysis

Introduction

How to increase the level of productivity and consequently economic growth in comparison to other leading economies in the world such as the USA and Japan remains of the main topics of economic and political discussions in the European Union. Such discussions quickly come across the determinants of growth and productivity. That is why the preceding paper focuses on investment in research and development and explains its role in determining productivity and economic growth.

Theory and empirical literature provide a wide variety of authors, who analyse the relationship among investment in research and development, and productivity and economic growth. There have been several views in the modern theory of economic growth since the middle of the twentieth century. The first, neoclassical growth theory, formalized by Solow (1956, 1957) and Swan (1956), is based on the assumption of exogenous technological progress, while explaining the increasing relation among production factors capital and labour as a main source of economic growth.

On the other hand, endogenous growth theories emphasize production factors such as new knowledge (Romer, 1990; Grossman & Helpman, 1991); research, development and innovations (Aghion & Howitt, 1992); and human capital (Lucas, 1988) as main sources of productivity and economic growth. Arrow (1962) is one of the authors who introduced the concept of learning by doing and defined the technological change as an unplanned outcome of new knowledge, which is generated in the process of learning by doing. Grossman and Helpman (1991) added the notion that modern technological progress requires intentional investment of the private sector in research and development, while the state should neutralize the spill-over effect of the new knowledge. They applied the spill-over effect of knowledge also to the cross-country level as an important source of productivity growth in individual countries and differences among them. Aghion and Howitt (1992) are founders of a group of models, in which research activities are crucial for creating new knowledge, and where new improvements of products and processes generate growth of productivity and economic growth. There are also empirical papers by Coccia (2009) and Zachariadis (2004), who confirmed the positive impact of expenditure for research and development on productivity.

Contrary, Pack (1994) found out that in some OECD countries, productivity declined despite increased expenditure for research and development. The author explained his findings by the impact of production organization and social and institutional characteristics of the economies. A similar approach can be noted in the third standpoint related to the causes of economic growth, which place more interest on noneconomic factors such as: new institutional economics (North, 2003) or the concept of national innovation systems (Lundvall, 1992; Nelson, 1993).

Being aware of the findings of economic theory about the role of investment in research and development for enhancing productivity and economic growth, the EU pays special attention to the expenditure level for research and development. Already, since the 1950s, when the economic and political integration in Europe began, a need for an effective, common research and development policy has been present. The aim is to gain synergy effects of research activities by overcoming the partial national research policies, to avoid the duplication of research and to reach common directions in research and innovations for solving key challenges of European society and to increase effectiveness of investment in research and development.

In 2000, the EU introduced the Lisbon Strategy with special attention to establishing European Research Area (ERA), common internal market for research with free mobility of researchers, scientific discoveries and technologies. The EU maintained ERA as a central element also in the present strategy of Europe 2020 and its leading incentive Innovation Union, which were presented in 2010. Since 1984, the EU has been stimulating research and development activities through five-year framework programs, which are key EU financial instruments for supporting research and development. These framework programs are supplemented by several structural funds on the national and regional levels.

By implementing such support for research activities, the EU strives to become the leading research area in the world, to enhance competitiveness of the European economy and to find solutions for the EU's modern social challenges (such as demographic changes and population aging, healthy food, scarce energy sources, etc.). In the current program period (2014-2020), the framework program Horizon 2020 takes place with the biggest budget in EU history, which is an additional indicator of the importance that the EU places on research and innovations for enhancing the productivity and competitiveness of the European economy.

The paper analyses the impact of expenditure for research and development on labour productivity in EU-28 for the period from year 1995 to year 2013. The original contribution of the paper to the observed economic phenomena is empirically testing the relationship between investment in research and development by taking into account a different set of countries and different time frame, as compared to other similar empirical works (such as Coccia, 2009; Zachariadis, 2004; Hall & Mairesse, 1995; Amendola et al., 1993; Lichtenberg & Siegel, 1991). In addition, we empirically tested the link among the size of investment in research and development and potential maximal productivity, which was done by only a few authors (Coccia, 2009). Furthermore, Pokrivcak and Zahorsky (2016) found empirical evidence of statistically significant impact of investment in research and development in the Czech Republic, Poland, Romania, and Slovenia among all CEE countries. Meanwhile, Gocer at al. (2016) and Gehringer et al. (2016) estimate the effect of investment of research and development on income and economic growth, respectively.

The paper proceeds with a review of the level of investment in research and development in EU member states. The third part explains the data used and methodology applied, which is followed by the presentation of empirical results in section four. The fifth and last section provides the conclusions.

Investment in Research and Development in EU Member States

The indicator for the size of expenditure for research and development is gross domestic expenditure on research and development (GERD) as a % of gross domestic product (GDP). The share of expenditure for research and development in GDP is also defined as R&D Intensity (Eurostat, 2016).

Since investment in research and development presents one of the key determinants of productivity and enhancing competitiveness, the EU Lisbon Strategy had set a goal of devoting 3% of GDP for research and development in year 2010, which was not achieved. According to Eurostat, the share of investment in research and development in GDP in EU reached 1.93% in 2010 (Eurostat, 2016). EU kept the goal of 3 % also in its Europe 2020 Strategy for smart sustainable and inclusive growth with its leading incentive, Innovation Union, which is supposed to be realized by 2020. Individual EU member states set different national goals by 2020 (Table 1). Among them, six states (Belgium, Denmark, Germany, Estonia, France and Slovenia) set the same goal as the EU (3%) while three states (Austria, Finland and Sweden) set a higher goal (Eurostat, 2016). The size of expenditure for research and development in EUR per capita by EU member states is presented in Figure 1.

Taking a look at individual EU member states (Table 1), one can notice the highest R&D Intensity in 2014 in Finland (3.17%), Sweden (3.16%), Denmark (3.04%) and in Austria (2.99%). Nine member states devoted less than 1% of GDP to research and development. These are, besides Greece, many of the members who joined the EU in 2004 or later. However, Slovenia is above EU average with 2.39%, while Czech Republic (2.00%), Estonia (1.46%), Hungary (1.38%) are below EU average but above 1 % of GDP (Eurostat, 2016).

Figure 2 presents comparison of expenditures for research and development in EU-28 and other selected economies: USA, Japan and South Korea. According to Eurostat, EU-28 member states, on average, devoted 1.80% of GDP for research and development in year 2003, although this amount decreased to 1.76% in 2005, it has grown since 2006, with slight fall in 2010, to 2.03% in year 2014. Despite the growing trend in the observed period, the share of GDP devoted for research and development in EU-28 in 2012 was lower than in other selected economies, particularly Japan (3.34%), USA (2.81%) and South Korea (4.03%) (Eurostat, 2016).

Data and Methodology

Data about the size of expenditure for research and development in % of GDP, and data about the labour productivity in EUR per hour, were obtained from the Eurostat database for individual EU-28 member states for the period of 1995-2013.

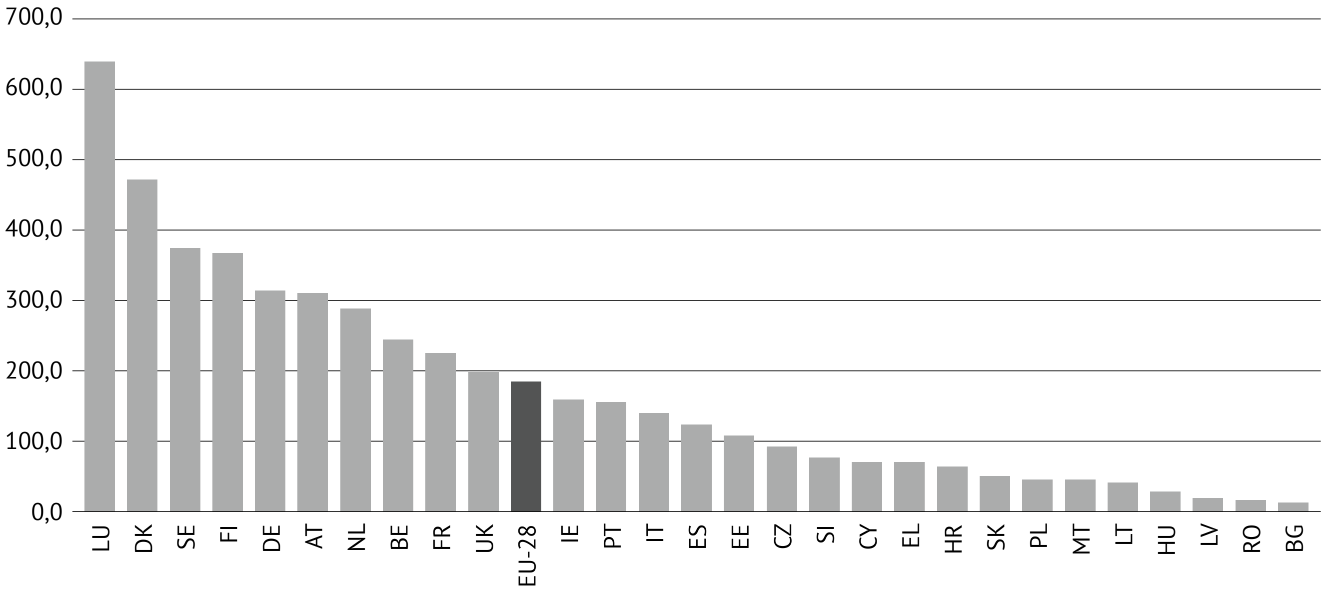
Our empirical analysis of productivity is limited to only one determinant (the expenditure for research and development), even though there are other factors influencing the productivity. The expenditure for research and development are considered as total and not divided to several sectors (government, private, higher education. etc.). Our database consists of EU-28 member states (*N=28*) for the period

Table 1. Expenditure for research and development in EU-28 and target values for 2020

% of GDP	2000	2005	2010	2014	2020 Target
EU-28	1.79	1.76	1.93	2.03	3
BE	1.93	1.78	2.05	2.46	3
BG	0.49	0.45	0.59	0.80	1.5
CZ	1.12	1.17	1.34	2.00	1
DK	2.19	2.39	2.94	3.08	3
DE	2.39	2.42	2.71	2.84	3
EE	0.60	0.92	1.58	1.46	3
IE	1.09	1.20	1.62	1.55	2
EL	n.a.	0.58	0.60	0.83	1.21
ES	0.89	1.10	1.35	1.20	2
FR	2.08	2.04	2.18	2.26	3
HR	n.a.	0.86	0.74	0.79	1.4
IT	1.01	1.05	1.22	1.29	1.53
CY	0.23	0.37	0.45	0.47	0.5
LV	0.44	0.53	0.60	0.68	1.5
LT	n.a.	0.75	0.78	1.02	1.9
LU	1.57	1.59	1.53	1.24	2.3
HU	0.79	0.93	1.15	1.38	1.8
MT	n.a.	0.53	0.64	0.85	2
NL	1.81	1.79	1.72	1.97	2.5
AT	1.89	2.38	2.74	2.99	3.76
PL	0.64	0.57	0.72	0.94	1.7
PT	0.72	0.76	1.53	1.29	2.7
RO	0.36	0.41	0.45	0.38	2
SI	1.36	1.41	2.06	2.39	3
SK	0.64	0.49	0.62	0.89	1.2
FI	3.25	3.33	3.73	3.17	4
SE	n.a.	3.39	3.22	3.16	4
UK	1.73	1.63	1.69	1.72	n.a.

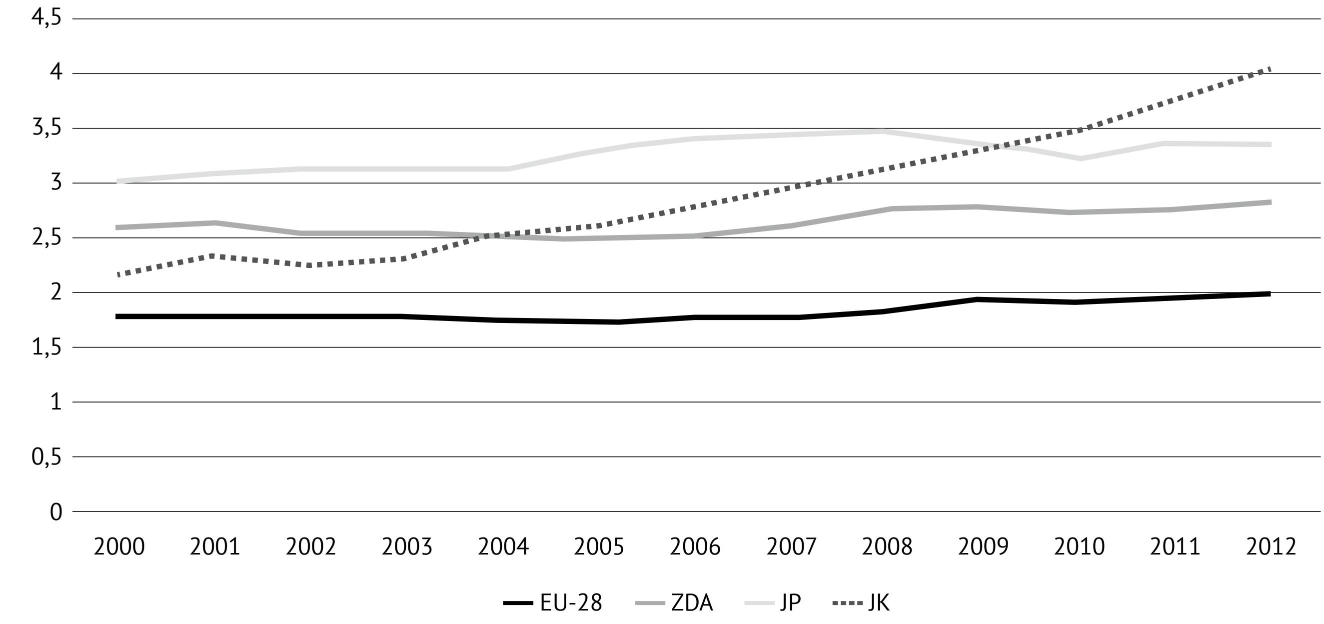
Vir: Eurostat (2016).

Figure 1. Public expenditure for research and development (in EUR per capita) for EU member states in year 2014



Source of data: Eurostat (2016).

Figure 2. Expenditure for research and development, in % of GDP, in EU-28, USA (ZDA), Japan (JP) and South Korea (JK), 2000-2012



Notes: ZDA – USA, JK – South Korea
Source of data: Eurostat (2016).

1993-2013 (*T=19*), resulting in a panel dataset of dimension *NxT* (532). Considering the missing data for some observations, we applied the empirical analysis to the panel data with 454 observations.

The empirical analysis consists of four parts. First, by applying time series data for individual EU member states, we tested what kind of correlation among R&D intensity (expenditure for research and development as a share of GDP in %) and productivity existed in the period of 1995-2013. Second, we explored the effect of time lags in the size of expenditure for research and development in their correlation to productivity. In the third part, we explored the functional relationship among expenditure for research and development and productivity by utilizing a panel data set. Fourth, based on the results from the previous part, the size of expenditure for research and development, which maximises the productivity in the panel of EU member states, was calculated.

Results of the Empirical Analysis

Correlation among expenditure for research and development, and labour productivity in EU-28

The Pearson correlation coefficient *(r_{xy})* defines the direction and strength of correlation among two variables, y_i and x_i. It can be calculated by (Artenjak, 2003, p. 154):

$$r_{xy} = \frac{c_{xy}}{\sigma_x \sigma_y} = \frac{\frac{1}{N}\sum_{i=1}^{N}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i-\bar{x})^2 \cdot \frac{1}{N}\sum_{i=1}^{N}(y_i-\bar{y})^2}} =$$

$$= \frac{\frac{1}{N}\sum_{i=1}^{N} x_i y_i - \bar{x}\bar{y}}{\sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i^2-\bar{x}^2) \cdot \frac{1}{N}\sum_{i=1}^{N}(y_i^2-\bar{y}^2)}}, \quad (1)$$

where c_{xy} is covariance of y and x, σ_x standard deviation of variable x, σ_y standard deviation of variable y, N is the number of observations, $\bar{y}$ is arithmetic mean of y, and $\bar{x}$ is arithmetic mean of x.

The value of the correlation coefficient can be in the interval of $-1 \le r_{xy} \le 1$, where the absolute values of the coefficient present different strength of the correlation among the observed variables (Artenjak, 2003, p. 154):

$|r_{xy}| = 0$, no correlation,

$0 < |r_{xy}| \le 0.50$, weak correlation,

$0.51 \le |r_{xy}| \le 0.79$, moderate correlation,

$0.80 \le |r_{xy}| \le 0.99$, strong correlation,

$|r_{xy}| = 1$, perfect correlation.

Based on the data for the size of expenditure for research and development, and labour productivity, we calculated the correlation coefficients (r_{xy}) for individual EU-28 member states in the period of 1995-2013. Table 2 presents results obtained in SPSS.

In 17 out of 28 EU member states, there is positive and statistically significant correlation among expenditure for research and development and labour productivity. In one case, there is statistically significant negative correlation ($p < 0.05$), while other countries exhibited statistically insignificant correlation among observed variables. Table 3 presents the number of EU-28 member states regarding the direction and strength of the correlation for the significance level of 5%.

Table 2. Correlation coefficients (r_{xy}) among expenditure for research and development, and labour productivity in EU-28

	r_{xy}	p
BE	0.529*	0.020
BG	0.350*	0.042
CZ	0.793**	0.000
DK	0.850**	0.000
DE	0.907**	0.000
EE	0.865**	0.000
IE	0.777**	0.000
EL	0.205	0.523
ES	0.790**	0.000
FR	-0.084	0.734
HR	n.a.	n.a.
IT	0.655**	0.002
CY	0.958**	0.000
LV	0.796**	0.001
LT	0.893**	0.000
LU	0.436	0.178
HU	0.866**	0.000
MT	0.037	0.914
NL	-0.252	0.298
AT	0.988**	0.000
PL	0.451	0.053
PT	0.888**	0.000
RO	0.005	0.983
SI	0.794**	0.001
SK	-0.455	0.050
FI	0.883**	0.000
SE	-0.104	0.711
UK	-0.462*	0.046

Notes:

*Correlation coefficient is statistically significant at 5%.

** Correlation coefficient is statistically significant at 1%.

n.a. – Due to missing data for Croatia, the correlation coefficients were not calculated.

Table 3. Number of EU-28 member states regarding the direction and strength of correlation

	Positive and weak correlation	Positive and moderate correlation	Positive and strong correlation	Negative correlation
Statistically significant at 5%	1	7	9	1
Statistically insignificant	9			

Correlation among expenditure for research and development and labour productivity in EU-28 with time lags

Besides the basic correlation coefficient among the observed variables, we have checked also the effects of time lags in expenditure for research and development on labour productivity by applying Pearson correlation coefficients for periods *(t-1)*, *(t-2)*, *(t-3)*. For labour productivity, the period of 1998-2013 was applied, while for expenditure for research and development, we employed time periods (*t*) 1998-2013, (*t-1*) 1997-2012, (*t-2*) 1996-2011 and *(t-3*) 1995-2010. We calculated Pearson correlation coefficients (r_{xy}) in SPSS for individual EU member states and presented them in Table 4.

Considering the time period *t* (without time lags in expenditure for research and development), there are 16 EU member states with statistically significant positive moderate or strong correlation coefficients. Regarding one, two and three-year lags in expenditure for research and development, there are 14, 13 and 13 EU member states with positive moderate or strong correlation coefficients, respectively. When compared to the correlation without the time lags, one can note that the correlation is stronger with 1-year lag for 10 EU member states, with 2-year lag in 11 states and with 3-year lag in 10 EU member states (out of 16 EU member states with statistically significant positive moderate or strong correlation without time lags). Additionally, it can be noted that 8 out of 16 member states have the highest

Table 4. Correlation coefficients (r_{xy}) in EU-28 with time lags in expenditure for research and development

	r_{xy} *t*	r_{xy} *(t-1)*	r_{xy} *(t-2)*	r_{xy} *(t-3)*
BE	0.308 (p=0.245)	0.265 (p=0.322)	0.316 (p=0.234)	0.510* (p=0.044)
BG	0.495 (p=0.051)	0.436 (p=0.091)	0.186 (p=0.491)	-0.186 (p=0.490)
CZ	0.713** (p=0.002)	0.729**(p=0.001)	0.826** (p=0.000)	0.919** (p=0.000)
DK	0.757** (p=0.001)	0.839** (p=0.000)	0.905** (p=0.000)	0.926** (p=0.000)
DE	0.846** (p=0.000)	0.855** (p=0.000)	0.895** (p=0.000)	0.916** (p=0.000)
EE	0.865** (p=0.000)	0.798** (p=0.000)	0.829** (p=0.001)	0.909** (p=0.000)
IE	0.777** (p=0.000)	0.705** (p=0.002)	0.595* (p=0.015)	0.458 (p=0.074)
EL	0.205 (p=0.523)	0.469 (p=0.067)	-0.086 (p=0.801)	0.383 (p=0.245)
ES	0.764** (p=0.001)	0.854** (p=0.000)	0.922** (p=0.000)	0.962** (p=0.000)
FR	0.329 (p=0.214)	0.189 (p=0.483)	-0.146 (p=0.589)	-0.427 (p=0.099)
HR	n.a.	n.a.	n.a.	n.a.
IT	0.442 (p=0.087)	0.413 (p=0.112)	0.467 (p=0.068)	0.545* (p=0.029)
CY	0.958** (p=0.000)	0.949** (p=0.000)	0.981** (p=0.000)	0.985** (p=0.000)
LV	0.796** (p=0.001)	0.871** (p=0.000)	0.803** (p=0.001)	0.682** (p=0.007)
LT	0.893** (p=0.000)	0.904** (p=0.000)	0.700 (p=0.053)	0.519 (p=0.233)
LU	0.463 (p=0.178)	0.410 (p=0.211)	0.147 (p=0.706)	-0.248 (p=0.554)
HU	0.809** (p=0.000)	0.853** (p=0.000)	0.886** (p=0.000)	0.898** (p=0.000)
MT	0.037 (p=0.914)	0.400 (p=0.175)	-0.573 (p=0.107)	-0.524 (p=0.183)
NL	-0.073 (p=0.789)	-0.294 (p=0.269)	-0.516* (p=0.041)	-0.685** (p=0.003)
AT	0.981** (p=0.000)	0.984** (p=0.000)	0.987** (p=0.000)	0.984** (p=0.000)
PL	0.519** (p=0.039)	0.398 (p=0.127)	0.195 (p=0.469)	0.055 (p=0.841)
PT	0.874** (p=0.000)	0.910** (p=0.000)	0.923** (p=0.000)	0.906** (p=0.000)
RO	0.531** (p=0.034)	0.248 (p=0.355)	-0.212 (p=0.431)	-0.526* (p=0.036)
SI	0.794** (p=0.001)	0.730** (p=0.003)	0.672** (p=0.009)	0.659** (p=0.010)
SK	0.005 (p=0.985)	-0.445 (p=0.084)	-0.723** (p=0.002)	-0.866** (p=0.000)
FI	0.741** (p=0.001)	0.829** (p=0.000)	0.883** (p=0.000)	0.903** (p=0.000)
SE	-0.663** (p=0.013)	0.469 (p=0.067)	-0.188 (p=0.558)	0.242 (p=0.448)
UK	-0.371 (p=0.157)	-0.291 (p=0.275)	-0.336 (p=0.203)	-0.528* (p=0.036)

Notes: *Correlation coefficient is statistically significant at 5%. ** Correlation coefficient is statistically significant at 1%. n.a. – Due to missing data for Croatia, the correlation coefficients were not calculated.

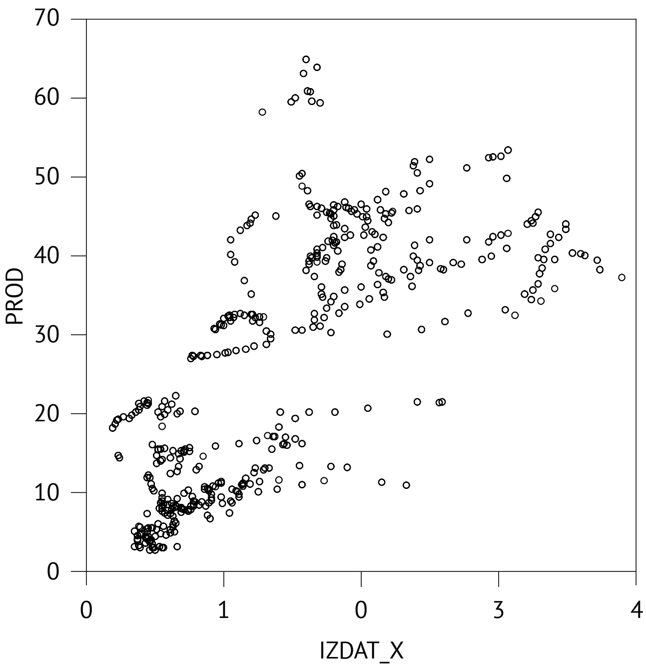
correlation coefficient among expenditure for research and development and labour productivity with 3-year lag (t-3) for expenditure for research and development. While two member states exhibit the strongest correlation among the observed variables with 2-year lag in expenditure for research and development, there are two member states with 1-year lag and four member states without time lags.

Regarding all EU member states included into the analysis, it can be concluded that 15 countries (out of 27) exhibit positive and statistically significant correlation among labour productivity in the current period and expenditure for research and development with 3-year lag. This is followed by 14 countries with positive and statistical significant correlation in the case of 2-year lag in expenditure for research and development, and by 13 countries with positive and statistical significant correlation in the case of 1- year lag in expenditure for research and development.

Nonlinear relation among expenditure for research and development and labour productivity

The scatter plot in Figure 3 displays nonlinear relation among expenditure for research and development in % of GDP (independent variable) and labour productivity per hour of work (dependent variable). Distribution of observations in the diagram illustrates that the best fit would be a parabola (polynomial of degree 2). The estimation of quadratic function was conducted on the panel of EU-28 member states.

Figure 3. Expenditure for research and development in % of GDP (*IZDAT_X*) and labour productivity (*PROD*) in EU-28 in period 1995-2013



Quadratic regression model is in general expressed as (Pfajfar, 2014, p. 167):

$$y_{it} = \beta_1 + \beta_2 x_{2it} + \beta_3 x_{2it}^2 + u_{it}, \qquad (2)$$

where:

i = 1,2,…n (n – number of observations),

t = 1,2,…T (T – number of time units),

y_{it} – dependent variable,

x_{it} – independent variable,

β – regression parameters,

u_{it} – regression error.

Developing our model, we set expenditure for research and development in % of GDP (*IZDAT_X*) as independent variable X_{2it}, while the dependent variable Y_{it} is labour productivity per hour of work (*PROD*). In such a setting the quadratic regression model is defined as:

$$\check{P}ROD_{it} = b_1 + b_2\,(IZDAT\_X)_{it} + b_3\,(IZDAT\_X)_{it}^2, \qquad (3)$$

where:

i stands for number of EU member states, i = 1, 2, …, 28;

t stands for number of observed years in time period of 1995-2013, t = 1, 2, …, 19.

Regarding the main characteristic of our data set, we are dealing with panel data or pooled cross-section time-series data. There are several advantages of panel data in comparison with time-series data or cross-section data. In this context, Gujarati (2011, p. 280) names higher information value and the possibility of considering the heterogeneity of individual observation units (EU member states). Our dataset is considered as an unbalanced panel since number of observations (28 member states) is different from number of time units (19 years). It is also a short panel, as number of cross sections ($N=28$) is higher than number of time units ($T=19$) (Gujarati, 2011, p. 280).

The estimated quadratic regression model with fixed effects resulted in the following results:

$$\check{P}ROD = -6.403 + 34.493\,(IZDAT\_X) - 6.041\,(IZDAT\_X)^2, \qquad (4)$$

t (-4.119) (16.611) (-10.579)

(p=0.000) (p=0.000) (p=0.000)

F 361.074 (p=0.000)

$n=454;\ R^2 = 0.616;\ \bar{R}^2=0.614;\ s_e=9.927.$

Under assumption of heterogeneity of cross section units (EU member states), the regression model with fixed effects was utilized. To test for statistical significance of heterogeneity among EU member states, we employed redundant fixed effect test in EViews and achieved results presented in Table 5.

Table 5. Redundant Fixed Effect Test

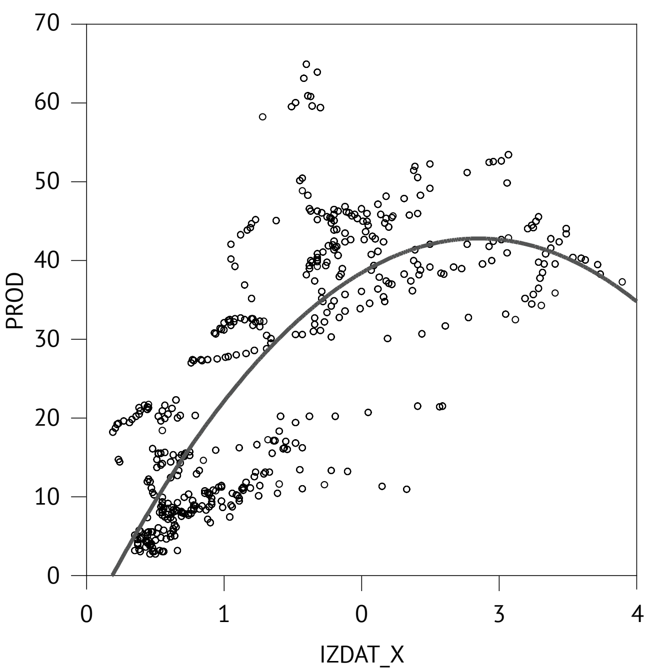
Redundant Fixed Effects Tests
Equation: Untitled
Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	413.053124	(26,425)	0.0000
Cross-section Chi-square	1483.851136	26	0.0000

The values of F and χ^2 statistics are statistically significant at $p < 0.001$, thus, the null hypothesis of redundant fixed effects can be rejected, which means that fixed effects are imperative, confirming the heterogeneity among individual EU member states and the appropriateness of applying the model with fixed effects.

Based on our sample, it can be concluded that the labour productivity, on average, increases for 22.411 EUR per hour of work (34.493 – 2*6.041), if expenditure for research and development is increased by one percentage point. The effect of the independent variable is positive. The value of adjusted determination coefficient ($\bar{R}^2$) in the estimated model shows that 61.4% of dependent variable variance can be explained by the variance of explanatory variable. Graphic results are presented in Figure 5.

Figure 5. Graphic presentation of estimated regression function



The optimal level of expenditure for research and development

The estimated quadratic regression function in Equation 4 displays the positive value of regression coefficient b_2, while the value of regression coefficient b_3 is negative, suggesting that the impact of the independent variable on dependent variable increases at first and later it starts diminishing. As Figure 5 shows, the quadratic function is concave. Maximum value of the estimated regression function can be calculated by setting its first derivative to 0. Thus, the extreme value of the quadratic function can be calculated as:

$$x_{max} = -\frac{b_2}{2b_3} \tag{5}$$

In our case the size of expenditure for research and development that maximises labour productivity is:

$$IZDAT\_X_{max} = -\frac{34.493}{2\,(-6.041)} = 2.85 \tag{6}$$

Considering the optimal value of the independent variable, the value of the dependent variable (labour productivity) is 42.83 EUR per hour of work. It is important to note that the calculated optimal size of expenditure for research and development is very close to the EU target for 2020 (3%) on average and also for many individual member states.

Conclusion

For decades, the European Union has lagged behind economic superpowers, such as the United States of America and Japan. For this reason, the question of how to increase productivity and economic growth came to the forefront of political and economic discourse. The paper focuses on investment in research and development as a factor of productivity and economic growth. Throughout the history of economic theory, different authors studying the relationship between expenditure for research and development on the one hand and productivity and economic growth on the other made various theoretical and empirical contributions. Distinctively, the so-called new growth theory or endogenous growth models strive to explain the sources of technological change, and consequently, their impact on productivity and the economic growth. Thus, one common characteristic of the endogenous growth models is that new knowledge obtained in the production process through learning by doing; knowledge spill-over; and the creation of new types of products, processes, organization, etc, or their high-quality improvements are inextricably linked to research, development and innovation, and are important factors of productivity and economic growth. The EU has placed investment in research and development at the centre of its key strategic documents. The target of reaching 3% of GDP spent on research and development has already been set in the 2000 Lisbon Strategy and remains the main objective in the new strategy entitled Europe 2020 and its flagship initiative, Innovation Union.

This paper confirms the link between expenditure for research and development (expressed in % of GDP) and labour productivity (expressed in the number of hours worked) based on observed data for EU member states in the period 1995-2013. A causal link between variables of the concave parabola was confirmed, and the value of investment in research and development of 2.85% of GDP maximising labour productivity was determined based on the examined data. In accordance with these findings, EU's target of reaching 3% of GDP spent on research and development to be achieved by 2020 seems in support of reaching maximum productivity in the EU. The results are similar to those of Coccia (2009) related to optimal level of investment in research and development, and to those of Gehringer et al. (2016) and Gocer et al. (2016), as they all find empirically supporting evidence of the impact of investment in research and development on productivity and income.

An important limitation of this research is examining the effects of only one explanatory variable. Thus, further research could be focused on adding more potential determinants of productivity and economic growth. Future analysis of this topic could also cover other panel data techniques in discovering the impact of investment in research and development on labour productivity in EU member states.

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Produktivnost in gospodarska rast v Evropski uniji: vpliv vlaganj v raziskave in razvoj

Izvleček

V tem članku smo se osredotočili na vlaganja v raziskave in razvoj kot dejavnik produktivnosti in gospodarske rasti. Za države članice EU smo v obdobju 1995-2013 potrdili povezanost izdatkov za raziskave in razvoj, izraženih v % BDP, s produktivnostjo dela, izraženo na uro opravljenega dela. Ugotovili smo povezanost med spremenljivkama oblike konkavne parabole ter na obravnavanih podatkih opredelili vrednost vlaganj v raziskave in razvoj (2,85 % BDP EU), ki maksimira produktivnost dela. Ob tem lahko navedemo, da je cilj o vlaganjih v raziskave in razvoj v obsegu 3 % BDP, ki si ga je zastavila EU do leta 2020, v podporo doseganju maksimalne ravni produktivnosti v EU.

Ključne besede: vlaganja v raziskave in razvoj, produktivnost, gospodarska rast, korelacija, panelna analiza