HUMAN CAPITAL, R&D AND GROWTH – SOME EMPIRICAL FINDINGS

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Abstract

Human capital and R&D expenditures are usually viewed as the key determinants of economic development, competitiveness and economic growth in EU. We find an unquestioned and heavy stress on the role of these elements in many EU strategies and policies which should eventually all lead to a "knowledge-based society." However empirical studies undertaken in recent years alert that the role of human capital and R&D in EU countries and regions is not as positive as it is usually regarded. The problem of over-education, asymmetrical impact and inability of human capital to reflect market needs and broken link from R&D to innovations, are the most discussed problems today. In this article we focus on the impact of R&D and science and technology human capital (HRSTC) on economic growth on EU regional level. We control for convergence process and economic structure as well. We conclude that the impact of these two variables on growth is really inconclusive and debate regarding the effectiveness of current related policies should be opened.

Key words: human capital HRSTC, R&D, economic structure, clusters

JEL Code: E240, C210, R150

Introduction

Human capital is considered being one of the key elements of competitiveness and economic growth. This is continuously emphasized by policy makers, many academics and institutions alike. Theoretical basis was laid mainly by Arrow (1962) and Uzawa (1965) and further developed by many others, most notably by Paul Romer (1986) and Robert Lucas (1988). The crucial role of human capital for growth is probably its capability to adopt and create innovations as Nelson and Phelps (1966) pointed out. In other words human capital is a fuel for the research and development (R&D) sector. The usually assumed causality is from human capital to R&D and innovations and from innovations to growth. Although this scheme is widely accepted the empirical results are not very conclusive (see Pessoa 2010 or Sylwester 2001 for example).

Despite of several such inconclusive findings it should be stressed that many others found positive relations (Correa et al. 2013) and human capital and R&D remain regarded as one of the key elements of growth. In this light it is not surprising that after the economic crisis in 2009 the OECD strongly recommended to support R&D (OECD 2011), mainly in business sector. The support was needed indeed mainly because R&D tends to by pro-cyclical (Barlevy, 2007)[1] and leaving it without support would probably prolong the recession. Many countries followed the OECD recommendation and increased financial support for R&D.

However the R&D is naturally strongly dependent on the human capital endowment as mentioned above, especially on the highly qualified labor forces i.e. human resources in science and technology. So to support the R&D means not only to support the R&D projects and businesses but also the human capital involved. This link was of course not overlooked by policy makers and institutions. For the case of EU it was mainly the European Council in Lisbon in 2000 (Lisbon Strategy) which greatly emphasized the role of human capital, R&D and innovation for future growth and this aim is followed till these days. When assessing the R&D and human capital, the crucial indicator of such "knowledge society" is the HRST stock, mainly the HRSTC mentioned above. It is generally assumed that the higher level of human capital stock in science and technology (HRST) the better for R&D and future growth (Eurostat EC 2009). Despite of this quite intuitive idea there are only rare empirical studies dealing with such direct causality – the usual way is to analyze the relation between R&D and growth or human capital and growth as general.

As described above the R&D, human capital, mainly the HRSTC and economic growth should be strongly interconnected. The well understood and widely accepted scheme is that high human capital endowment leads to development of R&D which creates innovations which lead to higher economic growth. However especially in relation to recent economic crises various questions have been raised. For example Ramos (2009) has shown that the high human capital endowment itself is not a guarantee of higher growth and lower unemployment and addressed the problem of over-education in Spain. Also our previous research (Cadil and Petkovova 2013, Cadil et.al 2014) has shown that human capital has questionable impact on employment and growth on regional level in EU NUTS2 regions. Pessoa (2010) concluded that high R&D expenditure do not necessarily lead to higher innovations and growth. Generally we may say that the topic is not settled, especially empirically. Although the overall

[1] The question if R&D is pro-cyclical or counter-cylical is however unsettled. Ouyang (2010) suggests that R&D is counter-cyclical if there is low credit constraint but pro-cyclical while facing tight credit constraint. The recent economic crises was most likely the latter case.

positive impact of human capital and R&D can be accepted, we should be aware that such impact is only conditional. And these conditions are quite clear. The R&D has positive impact on growth only when it really creates innovations which are implemented in real business . Regarding the human capital it has positive impact on R&D and growth only if it is of such quality and structure that satisfies business needs thus leading R&D to innovations.

In this paper we continue with our so far research which focused on impact of human capital on growth, wages and unemployment with relation to economic structure. We focus on the R&D expenditure and R&D related human capital (HRSTC). Our intention is to empirically analyze the assumed positive impact of HRSTC on R&D and growth on regional level. As in previous cases we take the economic structure into account to analyze the impact within similar economic environments.

1 Data and method

Our analysis will mainly focus on the impact of human capital endowment, which is considered to be most important for R&D – the HRSTC on economic growth. We will analyze the situation from several perspectives. First we will use the cross-regional model for basic analysis, using EU27 NUTS2 regions. Then we analyze the impact of HRSTC with respect to economic structure on regional NUTS 2 level. This modification is crucial as we believe that to analyze the real impact of HRSTC we must do it in possibly comparable environments. In other words we should avoid having very different regions in the sample which would lead to distorted results. We employ cluster analysis to divide regions into several possibly homogenous groups. We use very simple cross-section models for all cases with average values time series 2007-2010, using Eurostat database. These models are multiple regressions estimated by standard OLS method which can be described as follows

$$\Delta \ln(y_i) = b_0 + b_1 \ln(hrstc_i) + b_2 \ln(y_{i0}) + \varepsilon_i \quad (1)$$

$$\Delta \ln(y_i) = c_0 + c_1 \ln(RD_i) + c_2 \ln(y_{i0}) + \mu_i \quad (2)$$

$$\ln(RD_i) = d_0 + d_1 \ln(hrstc_i) + \epsilon_i \quad (3)$$

where $\Delta \ln(y_i)$ is average GDP per capita in PPS growth rate, $hrstc_i$ is the average share of human resources in science and technology core stock – the most qualified human capital for R&D and R&D is a share of R&D expenditures on GDP. In model (1) and (2) we had to add

the GDP per capita in PPS in base year 2007 to control for convergence among the regions. Equation (1) analyzes the relation between the R&D human capital and growth. Equation (2) analyzes the positive link between R&D expenditures and growth. Equation (3) then focuses on the relation between R&D expenditures and core Science and Technology oriented human capital.

In the second stage of our analysis we split the group of NUTS 2 regions into several clusters with similar economic structure. We followed our approach (Cadil et al. 2014) here when to identify the economic structure we employed location quotient and Eurostat NACE Rev1 data for EU NUTS 2 regions in time period 2004-2008 covering 5 sectors[2] (Agriculture, Industry, Wholesale services, Financial intermediation and Public Administration). Four clusters with a similar economic structure were defined while employing a standard non-hierarchical method (Timm, 2002). Clusters are naturally not of the same size. Table 1 summarizes the cluster´s characteristics.

Tab. 1: Clusters identification

	Cluster 1		**Cluster 2**		**Cluster 3**		**Cluster 4**	
	mean	std	mean	std	mean	std	mean	std
Agriculture	1,63	0,35	4,30	1,60	0,67	0,23	0,29	0,16
Industry	1,05	0,18	0,97	0,27	1,15	0,24	0,80	0,16
Wholesale services	1,06	0,18	0,92	0,26	1,01	0,14	1,04	0,11
Financial intermediation	0,66	0,19	0,42	0,12	0,85	0,17	1,31	0,32
Public administration	0,96	0,16	0,72	0,14	1,02	0,18	1,19	0,15
Unemployment	9,16	3,58	10,90	3,09	7,41	3,72	6,58	3,08

Note: std - standard deviation
Source: Eurostat, own calculation, Cadil et.al. (2013)

The first cluster can be characterized as group of regions with quite diversified economic basis. Second cluster consists of strongly agricultural regions while the third cluster is mostly industrial. The fourth cluster is a cluster with developed services, mainly financial sector and administration. Highly urbanized areas - big and capital cities are members of this group. We employ robust MM regression which combines a high breakdown point a good efficiency to suppress the weight of outliers which are likely to occur (see Rousseeuw, 2003 for details).

[2] This simplification comes from current data availability. A more detailed breakdown of sectors should be used in future.

2 Results

Table 2 summarizes the results for equation (1) estimates. We can see that the science and technology human capital (HRSTC) endowment has generally positive impact on growth when we focus on all NUTS2 regions. However the R2 is not very high. When controlling for the economic structure we conclude that there is only one cluster where we may find a positive and significant effect of HRSTC on growth – the cluster of service-oriented big cities. We may conclude that generally the HRSTC does not mean higher growth, such link is obviously structurally determined.[3]

Tab. 2: Science and Technology Human Capital and economic growth

		Clusters			
	All NUTS2 regions	1	2	3	4
Intercept	4,84***	4,86***	5,28***	4,69***	4,39***
$\ln(HRSTC_i)$	0,02**	-0,01	0,05	0,02	0,06**
$\ln(y_{i0})$	-0,03***	-0,02***	-0,09***	-0,02**	0,00
R^2	0,15	0,19	0,70	0,03	0,12

Source: Eurostat, own estimates

Regarding the effect of total R&D expenditures on economic growth we see rather inconclusive results. The effects are very weak (close to zero) and statistically insignificant for all the regions and even for all the clusters. This is quite surprising result as R&D is still considered by many experts and policy makers as one of the key determinants of growth. However our results support the opposite findings like the ones of Pessoa (2010), that high R&D expenditures do not necessarily mean higher economic growth.

Tab. 3: R&D expenditure and growth

		Clusters			
	All NUTS2 regions	1	2	3	4
Intercept	4,85***	4,84***	5,39***	4,74***	4,39***
$\ln(RD_i)$	0,00	0,00	0,00	0,00	0,00
$\ln(y_{i0})$	-0,03***	-0,02***	-0,09***	-0,02**	0,02
R^2	0,13	0,19	0,69	0,03	0,06

[3] Our previous research also found out that there is more likely divergence among the EU NUTS2 regions. However in first quarter of 2014 Eurostat made quite huge GDP data corrections which led to such different results in convergence. However the main outcome of our previous research, which points at the insignificance of total human capital endowment, remains the same even when we use revisited data.

Source: Eurostat, own estimates

The last equation estimate in Table 4 reveals positive relation between HRSTC and R&D expenditure for all the cases. In agricultural regions we find low R2 but the overall finding is quite straightforward – the higher is the HRSTC level the higher are R&D expenditures. Of course the causality can be reversal here but it could be a topic of another research.

Tab. 4: Human capital endowment and R&D expenditure

		Clusters			
	All NUTS 2 regions	1	2	3	4
Intercept	-6,38	-3,61**	-1,06	-7,04***	-3,05
$\ln(HRSTC_i)$	2,46***	1,63***	0,76	2,64***	1,69***
R^2	0,42	0,19	0,06	0,29	0,12

Source: Eurostat, own estimates

Conclusion

Although the human capital and R&D expenditures are regarded as key determinants of growth, our empirical findings do not support such view. In our analysis we focused on relations between these two variables and economic growth on EU 27 regional level. We controlled for the effects of common convergence process (poorer regions in EU should grow faster than richer ones according to convergence theory) and economic structure. The letter is important as we believe that the effects of any factors including the R&D and human capital must be analyzed on possibly most homogenous samples.

We may conclude that there is a clear connection between R&D expenditures and HRSTC which is regarded as a core science and technology oriented human capital. However the R&D does not lead to higher growth as expected – the relation is insignificant and close to zero. Moreover the similar result can be found for HRSTC endowment. It is true that the HRSTC leads to higher growth in general, when all the regions are taken into account regardless their economic structure. However when we control for the economic structure we clearly see that the positive relation vanishes for most of the clusters and remains positive only for the cluster of big cities which are oriented mainly on services.

Our findings can be regarded as controversial especially in relation to various EU strategies and policies which stress the importance of human capital and R&D. However we believe that our results could at least help to open a debate about the effectiveness of these policies and human capital and R&D true impact on economy.

Acknowledgment

This paper has been prepared under the support of the University of Economics, Prague - project No. 55/2014 "Analysis of the impact of subsidies on the performance of economic subjects".

References

Arrow. K. J. (1962). The Economic Implications of Learning by Doing. *The Review of Economic Studies, 29*, 155-173.

Barlevy, G., (2007). On the Cyclicality of Research and Development. *American Economic Review, 97*, 1131-1164.

Cadil, J., Petkovova, L., Kaplanova, V. (2013). Human Capital and Regional Development - Structural Analysis. In Loster, T., Pavelka, T. (ed.), *International Days of Statistics and Economics*. Prague, Czech republic

Cadil, J., Petkovova, L., Blatna, D. (2014). Human Capital, Economic Structure and Growth, *Enterprise and the Competitive Environment.* Brno, Czech republic

Correa, P., Andrés, L., Borja-Vega, Ch. (2013). The Impact of Government Support on Firm R&D Investments – A Meta Analysis. *Policy Research Working Paper 6532*. World Bank, Entrepreneurship and Innovation unit.

Kleiknecht A., Montfort, K., Brouwer E. (2002). The Non-Trivial Choice between Innovation Indicators. *Economics of Innovation and New Technology, 11*, 109-121.

Lucas, R.E. (1988). On the mechanics of economic development. *Journal of Monetary Economics, 22*, 3-42.

Nelson, R., Phelps, E., (1966). Investment in humans, technological diffusion and economic growth. *American Economic Review: Papers and Proceedings, 51*, 69-75.

OECD (2011), *OECD Science, Technology and Industry Scoreboard 2011*. OECD Publishing.

Ouyang, M. (2010). Virtue of Bad Times and Financial Market Frictions, *Working Papers 101103*, University of California-Irvine, Department of Economics.

Pessoa, A. (2010). R&D and economic growth: How strong is the link?. *Economics Letters, Elsevier, 107*, 152-154.

Ramos, R., Suriñach, J., Artís M. (2009). Regional economic growth and human capital: the role of over education. *Working Papers 2009/04*. Research Institute of Applied Economics.

Romer, P. (1986). Increasing returns and long-run growth. *The Journal of Political Economy, 94*, 1002-1037.

Rousseeuw, P. J., Leroy, A. M. (2005). Robust Regression and Outlier Detection. New Jersey, USA: John Wiley & Sons.

Sylwester, K. (2001). R&D and Economic Growth. *Knowledge, Technology & Policy, 13*, 71–84.

Timm, N. (2002). Applied Multivariate Analysis, New York, USA: Springer-Verlag.

Uzawa, H. (1965). Optimum Technical Change in An Aggregative Model of Economic Growth. *International Economic Review, 6*, 18-31

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