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THE ROLE OF HUMAN CAPITAL FOR NATIONAL INNOVATION CAPABILITY IN EU COUNTRIES

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Abstract. Innovation is essential for economic growth in developed countries. One of the most important sources of innovation is human capital. In this article, state of human capital in EU countries is investigated in order to show the relationship between human capital and national innovation performance. In the first part, theoretical assumptions of human capital importance for innovation processes are analysed. Secondly, measures of human capital are analysed and a measurement model is presented. This model is applied for investigation of state of human capital in 26 EU countries during 2002–2012. Results showed that quality of human capital is the most important factor for innovation performance. Quality indicators have even higher correlation with innovation in countries with low share of innovative enterprises (enterprises with high-level of new technology acceptance and usage). The aim of research is to analyse the theoretical importance of human capital investment for national innovation capability in EU countries, and to determine human capital aspects that foster innovation performance. Therefore, objectives are as follows: to analyse theoretical assumptions of human capital importance for innovation processes and to present the current state of research; to analyse available human capital measures and create a human capital measurement model; and to analyse state of human capital in EU countries as well as its relationship with national innovation capability.

Keywords: innovation; human capital; education; human capital measurement model; European Union.

Type of the paper: Empirical paper.

JEL Classification: J24, O30.

Introduction

Innovation is essential for economic growth in developed countries. One of the most important sources of innovation is human capital. In this article, state of human capital in EU countries is investigated in order to show the relationship between human capital and national innovation performance. In the first part, theoretical assumptions of human capital importance for innovation processes are presented. Further, measures of human capital are analysed and, a model of human capital measurement is presented. The model for investigation of state of human capital in 26 EU countries during 2002–2012 is applied.

In fact, there are various models that analyse human capital as an element of the economic growth process (Lucas 1988; Barro 2001; Romer 1990). Human capital could have a direct effect on the economy by increasing productivity of labour, as well as an indirect effect on economic growth based on increased innovation capability. One of the best-known economic growth models is the Nelson and Phelps' (1966) model where human capital and technology frontier analysis is introduced. Economic growth is based on the level of human capital as well as on the level of technology improvisation. Countries that are far from technological frontiers could sustain their growth by adapting innovations; however, the speed of adaptation depends on the level of human capital in these countries. Countries that are close to technological frontiers could grow only by introducing innovations and this process is related to the level of human capital. In this model, human capital acts indirectly by increasing the level of technology used, thereby raising productivity. This hypothesis is supplemented by numerous empirical studies (Benos *et al.* 2015; Coe *et al.* 2009; Papalia *et al.* 2011, etc.). What is more, this idea

was progressed in the Barro and Sala-Martin (1996, 2004) model, where regional development is analysed in detail and in Schumpeterian economic growth models where more emphasis is given on entrepreneurship and creative destruction processes. More recent studies (Vandenbussche *et al.* 2006; Aghion, Darlauf 2009) consider that the closer the countries are to the technological frontier, the more important are the innovation processes for their economic growth and that investment in human capital is more significant for the development of domestic innovations, especially in higher education. Therefore, the aim of the research is to analyse human capital importance to national innovation capability in EU countries and to determine human capital aspects that foster innovation performance. The objectives are as follows: 1) to analyse the theoretical assumptions of human capital importance for innovation processes and present the current state of research; 2) to analyse available human capital measures and create a human capital measurement model; 3) to analyse state of human capital in EU countries as well as its relationship with national innovation capability. Research limitations – correlation analysis does not allow to revel in the causal relationships of analysed concepts, it only shows the linear relationship between two variables. In order to show dependence between defined factors more advanced methods should be used.

The Interface between Innovations and Human Capital

In the twenty first century, innovation has become a crucial part of the world. This is to say, that the world is changing due to generation of new knowledge and development of new technologies. Innovation in this paper is defined as being a separate activity through which inventions are carried out in the market for commercial purposes (Snyder *et al.* 2016). For instance, Karoglu and Eceral (2015) claim that innovation is one of the determinants of a company's or a region's growth. Pinto *et al.* (2015) state that innovation could invoke the development of 'new products, new processes, new sources of supply, the exploitation of new markets and/or new organizational forms'. What is more, Lyles (2014) claims that innovation is one of the vital elements of sustainability. Scientists agree that innovations are closely related to economic growth and development. For example, Valentinavičius (2006) says that rapid economic growth is related not only to technological renewal but also to innovation implementation in economics and business. Stepanovas and Ostašenkovaitė (2013) state that innovation is the most important factor of economic growth, which helps to seek high value addition and also encourages economic development. What is more, Stepanovas and Ostašenkovaitė (2013) think that innovation provides an opportunity for production technology renewal and creation of new products and services. According to the scientific literature, it is necessary to focus on innovation as it is considered to be one of the most powerful tools used for the development in different fields. The European Commission conducts annual surveys on the level of innovation development in the EU. The results of the previous survey are presented in Fig. 1.

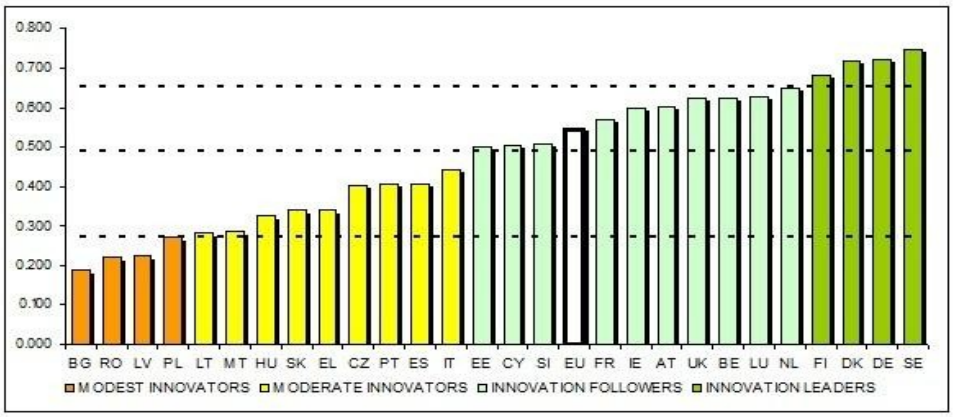


Fig. 1. EU Member States' Innovation Performance (Source: European Commission, 2015)

According to the data in Fig. 1 it can be emphasised that although the mean level of EU countries innovation implementation is quite high and stand for innovation followers level, more than a half of the members of the EU are on the moderate level of innovation development. According to that information, it could be stated that it is necessary to pay attention to the factors that could speed up innovation implementation. In fact, a majority of innovation researches emphasise that innovations are linked to new knowledge creation (e.g. Užienė 2015; Wang 2015; Vick *et al*. 2015; Iturrioz *et al.* 2015; Lyles 2014). The knowledge creation is examined under the human capital concept in the article.

Human capital is a concept that can be investigated as a separate theory, but usually human capital is being investigated as the structural part of intellectual capital. Many authors (Bang *et al.* 2010; Bowman, Ambrosini 2010; Díez *et al.* 2010; Godoy 2008; Hughes 2010; Malgioglio *et al.* 2001; McLean 2006; Pitelis 2009; Wang, Swanson 2008; Zapata 2001) are accentuating the importance of human capital for the successful activities of private or public sector organisations and profit and non-profit organisations. Although the importance of human capital is indisputable, the benefits are not clearly visible, but the importance of human capital is obvious, when it is non-existent. The basis of knowledge and information are employees, who assist in the effective and successful activity as well as in the development and the competitiveness of a respective company. Due to this basis, a company can achieve the desired objectives with the least possible cost.

Human capital can be defined as 'the knowledge, skills, competences and other attributes embodied in individuals that are relevant to economic activity' (OECD 1998, p. 9). Most commonly, human capital is described as knowledge gained through education and training. This understanding was popularised in Becker's (1975) book 'Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education', for which he was awarded a Nobel Prize in Economics (OECD, 2010). Hence, it is necessary to remember that human capital term could be extended in such areas as health, emotions and physical well-being. National intellectual capital researchers analysing human capital include such aspects as opportunities (Alexander, 2006), culture (Pasher, Shachar 2007), health (Malhotra 2003; Pasher, Shachar 2007) and labour qualification (Pasher, Shachar 2007; Lin, Edvinsson 2011). Even more implicit factors such as personal capital which relates to an individual's basic personal qualities and reflects the quality of an individual's psychological, physical, and spiritual functioning (Tomer 2003) are analysed in order to describe the level of human capital. Potelienė and Tamašauskienė (2014) summarised human capital characteristics as education, health, knowledge, competence, skills, talent, motivation, values, national culture and philosophy, labour market conditions, migration tendencies, expertise, experience, intuition, ability to understand national goals, entrepreneurship and ethics. The whole concept of human capital focuses on economic behaviour of individuals, especially the way in which their accumulation of knowledge and skills enables them to increase their productivity and earnings – and in doing so, to increase the productivity and wealth of the societies they live in (Schuller 2001).

Human capital is interpreted in various ways and different features, attributes, and several authors are accentuating peculiarities. For instance, Curado et al. (2011) accentuate a knowledge-based point of view to a company. Knowledge is the main factor of human capital. Employees with a huge knowledge can influence internal and external communication within a company.

In Table 1 the elements of human capital, which are mainly accentuated by various authors, are presented (Bontis 2010; Cabrilo 2009; Chen 2003; Green 2007; Harris 2000; Swart 2006). Stewart (1997) states that human capital is who leaves the company on weekends; human capital is who thinks. According to Stewart (1997), money talks, but does not think. Equipment and machinery work, sometimes even better than humans do, but they do not invent, do not create innovations, improvements and they do not generate ideas. The main purpose of human capital is to create innovations: to generate new ideas, to create new products, services, or goods, to improve existing products, services, or goods, to establish new business processes and so on.

Table 1. The elements of human capital and its benefits (Source: authors' compilation)

Element	Benefits
Knowledge	Helps to perform daily functions
Skills	Help to perform daily functions quickly and effectively
Know-how	Gives an opportunity to work with specific tasks or specific equipment
Education	Helps to understand the essence of the work, to carry out its functions through the knowledge gained from the acquisition of education
Qualification	Reveals the quality of human capital
Motivation	Fosters to work better, faster, and with less errors
Willingness to work	Consequence of motivation, which helps to find the ways of solving raised issues as soon as possible
Learning	Human capital element, which constantly increases knowledge, skills, and qualification of employees
Training	The ability of employees not only to assimilate, but also to convey knowledge to others
Abilities	Personal features of a human capital character /personality trait, which helps or distracts to accomplish given purposes, goals, tasks, or assignments

According to Table 1 it can be noted that human capital has plenty of elements. Interactions between those elements constitute the essential feature of human capital – the ability to use all aforementioned elements and implement company's goals, carry out the objectives of management, stakeholders, and shareholders and to properly, efficiently and quickly perform everyday tasks. The essential function of an effective management of modern human capital – the ability to change, learn, improve, adapt to rapidly changing business conditions and the economic situation.

Methodology

Measurement of human capital is still very complicated due to the intangible nature of this resource. Limitations are even greater in the international context, where it is difficult to find measurements of human capital that are comparable and have a time perspective. There are three main approaches of human capital measurement (Le *et al.* 2005; Mačerinskienė, Viržintaitė 2003): the cost-based approach, the income-based approach and the education-based approach. The education-based approach is most commonly used in macroeconomic studies for at least three reasons (Giménez *et al.* 2015): due to the proposition that formal education is the fundamental source of human capital acquisition, due to strong correlation between this and other acquisition paths and due to the existence of comparable international data. In this article, the education-based approach is used. Most popular indicators of human capital in this approach are average years of schooling, school enrolment rates, adult literacy rates and quality of schooling indicators (Le *et al.* 2005). All those measures have their advantages and disadvantages.

Judson (2002) notes that adult literacy rates could be a good proxy for human capital only in countries where the populace has little education as this measure captures only the elementary level of education. In recent studies it is measured as digital readiness, computer literacy and skills related to new technologies use (INSEAD eLab 2009; Welsum, Lanvin 2012; Jokūbauskienė 2013). In this research, computer and internet use skills are used as proxy for human capital.

School enrolment rates as a measure of human capital represents the flow that adds to the existing stock of education. This measure only tracks investments in human capital more than human capital stock. In this study two indicators are used to describe participation in education.

In economic growth models (Lucas 1988; Rebelo 1992; Barro 1996; Barro, Lee 2011; Benhabib, Spiegel 1994; Krueger, Lindahl 2001; Meschi, Scervini 2014; Morrisson, Murtin 2013) human capital

is measured as educational attainment. This proxy could be based due to the differences in the educational system in countries and due to the quality of the educational system. In this research, human capital proxied by tertiary and secondary education attainment is evaluated.

According to Hanushek and Kimko (2000), quality issues have been overlooked in many studies as proxies use only education attainment indicators. In the presented study, to assess the quality of education international skills assessment tests results are chosen (PISA survey and population digital skills measures measured in Information and Communication Technologies surveys and general rate of satisfaction with education). Satisfaction of education is measured during an academically driven cross-national European Social survey. In this survey, respondents are asked to evaluate the overall state of education in a country. In this research, results of different survey rounds are used (ESS Round 1, ESS Round 2, ESS Round 3, ESS Round 4, ESS Round 5, ESS Round 6). Human capital measurement model and indicators used are summarised in Figure 2.

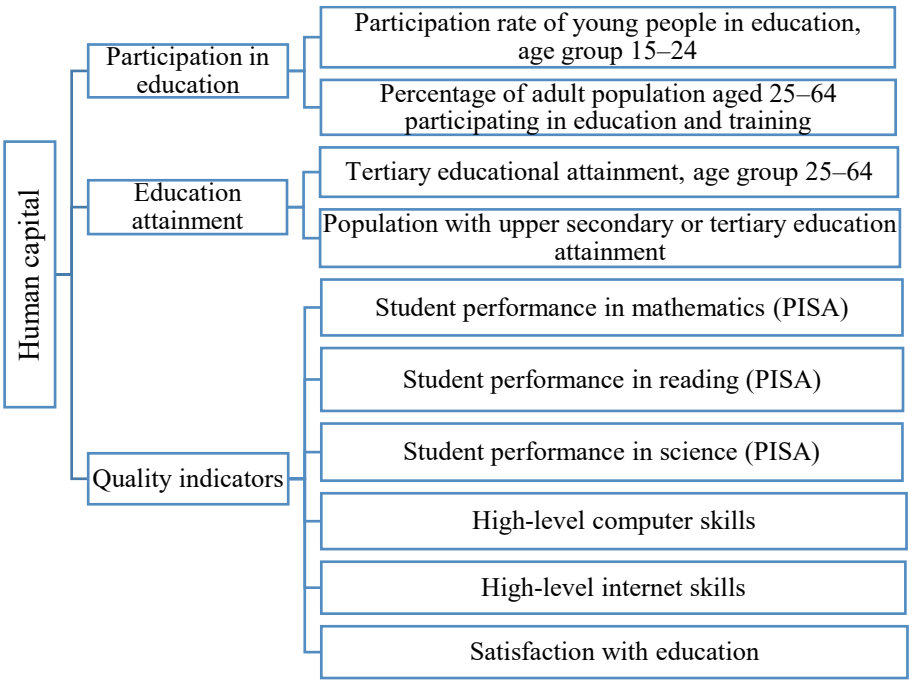


Fig. 2. Human capital measurement model (Source: authors' compilation)

Human capital indicators are divided into three groups. The first group shows participation rates in education; it represents the flow of knowledge acquisition. Second group consists of education attainment indicators and the last group captures quality indicators.

Innovation could be measured by combining several dimensions of technology-related activities (Dakhli, De Clercq 2004). Most commonly used measures are number of patents filed (Jaffe 1989), the expenditures for R&D (Ritsila 1999), the number of innovations reported in trade journals and research periodicals (Acs *et al.* 1994) and data self-reported by the companies (Keeble 1997), technology-based export (Bianchi 2001). All the mentioned measures of innovations have their strengths and weaknesses. In this study, we have chosen to use self-reported number of innovations as indicators of national innovation capability. This measure evaluates innovation by its actual output. Data is collected from national community innovation surveys based on the Oslo Manual, OECD/European Commission, 2005. Measure indicates share of product and/or process innovative enterprises, regardless of organisational or marketing innovation (including enterprises with abandoned/suspended or ongoing innovation activities). Enterprises in all core NACE activities related

to innovation activities (C, D, E, I, J, G51, K72, K74.2, K74.3) are evaluated.

In order to examine the relationship between human capital and innovation capabilities, correlation analysis is performed. This model is applied for investigation of state of human capital in 26 EU countries (Austria, Belgium, Bulgaria, Cyprus Czech Republic, Germany, Denmark, Estonia, Greece, Spain, Finland, France, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Netherlands, Poland, Portugal, Romania, Sweden, Slovenia, Slovakia, United Kingdom) during the 2002–2012 period. The data from Eurostat, European Social survey and PISA surveys results is used. Missing data is imputed by using multiple imputation predictive mean matching procedures within five iterations. For grouping the countries k-mean method of cluster analysis was used.

Results

To start with, an average share of innovative enterprises in each country is presented (see Fig. 3). Countries are grouped into two clusters according to the share of innovative enterprises (country's dependence to cluster is marked with different colours).

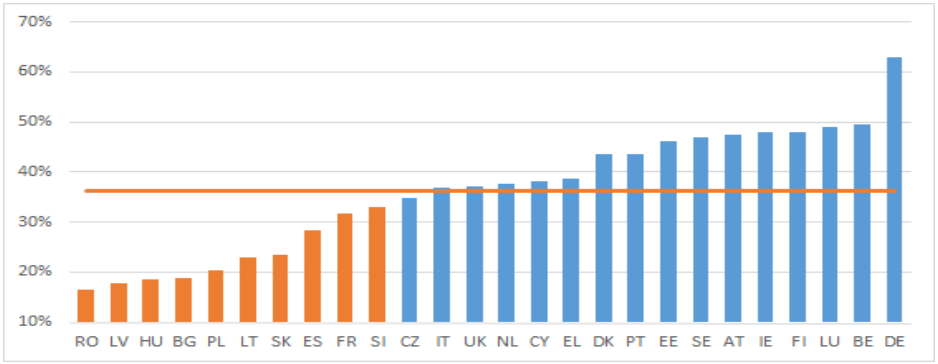


Fig. 3. Share of innovative enterprises in EU countries average of 2002–2012 (Source: Eurostat, 2015)

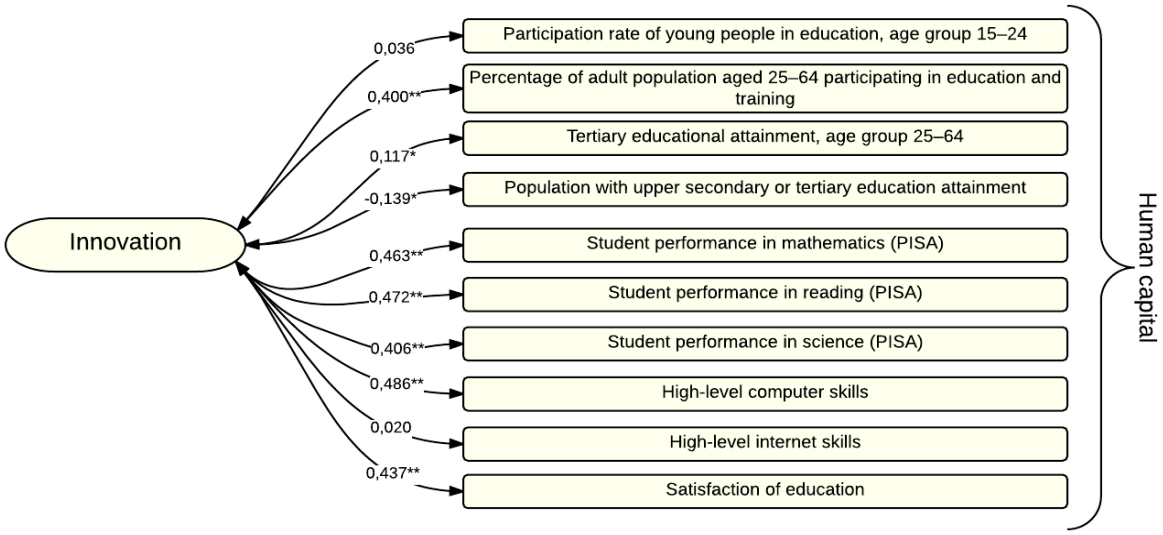
Share of innovative enterprises differs considerably in EU countries. The average share of innovative enterprises in EU is 36%. The lowest share of innovative enterprises are in Romania (16%), Latvia (18%) and Hungary (19%). The highest rate of innovative enterprises are in Denmark (63%).

An analysis of the bivariate correlation coefficients provides some interesting results (Fig. 4).

Education attainment indicators show weak correlation significant at 0.05 significance level with innovation performance in a country. Tertiary education attainment is positively correlated, though share of upper secondary or tertiary education attainment is negatively correlated to innovation performance. Such results show that secondary education in EU countries is not the factor that fosters innovation. Tertiary education might be that factor, but weak correlation shows that other human capital aspects are more important than formal education attainment. This presumption is strengthened by analysing correlation of innovation performance with human capital quality indicators.

Strongest correlation is between high-level of computer skills and innovation performance (0.486**), second strongest correlation is between student performance in reading (PISA) and innovation performance (0.472**). In addition, there is average statistically significant correlation between satisfaction of education and innovation performance (0.437**). It could be noticed that all human capital indicators that have highest correlation with innovations describe the quality of human capital.

This shows the importance of human capital quality for innovation performance. In addition, lifelong learning is important for innovation. Lifelong learning and innovation performance indicators correlation is 0.400 and statistically significant.



**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

Fig. 4. Human capital indicators correlation with share of innovative enterprises in EU countries 2002–2012 (Source: authors' calculations)

Analysis showed that there is no statistically significant relationship between participation rate of young people in education and innovation performance and between high-level of internet skills and innovation performance. From the human capital indicator group reflecting quality, only a share of the population having high internet skills is not related to innovation performance. High-level of internet skills measures the share of individuals who have carried out five of the six internet-related activities. They are as follows: use of a search engine to find information; send an e-mail with attached files; post messages to chat rooms, newsgroups or any online discussion forum; use the internet to make telephone calls; use peer-to-peer file sharing for exchanging movies, music and so on; create a web page. Such competencies are more related to the ability to use already created technologies and most of those skills relate to communication and entertainment purposes This explains why this indicator does not correlate with innovation performance although high-level computer skills are strongly correlated to innovation performance This proxy measures the share of individuals who have carried out five of the six internet-related activities. They are as follows: copy or move a file or folder; use copy and paste tools to duplicate or move information within a document; use basis arithmetic formula (add, substract, multiply, divide) in a spreadsheet; compress files; connect and install new devices, for example, a printer or a modem; write a computer program using a specialised programming language. Those skills are mainly related to individuals' ability to use information in a digital environment, such skills are essential for innovation process.

In order to test if those indicators correlation is different in countries' groups that were identified according to the level of innovation, correlation coefficients were calculated (Table 2).

Table 2. Human capital indicators correlation with share of innovative enterprises in EU countries clusters 2002–2012 (Source: author's calculation)

	Indicator	Low-level of innovation (1st cluster)		High-level of innovation (2nd cluster)		All countries	
		Pearson Correlation	Sig. (2-tailed)	Pearson Correlation	Sig. (2-tailed)	Pearson Correlation	Sig. (2-tailed)
Participation in education	Participation rate of young people in education, age group 15-24	.146	.129	.205	.006	.036	.541
	Percentage of adult population aged 25-64 participating in education and training	.599	.000	-.020	.791	.400	.000
Education attainment	Tertiary educational attainment, age group 25-64 -	-.254	.007	.298	.000	.117	.048
	Population with upper secondary or tertiary education attainment	-.251	.008	.129	.088	-.139	.018
Quality indicators	Student performance in mathematics (PISA) -	.434	.000	.331	.000	.463	.000
	Student performance in reading (PISA)	.313	.001	.299	.000	.472	.000
	Student performance in science (PISA)	.420	.000	.261	.000	.406	.000
	High-level computer skills	.528	.000	.168	.026	.486	.000
	High-level internet skills	.221	.021	-.073	.333	-.020	.736
	Satisfaction of education	.428	.000	.004	.954	.437	.000

Results showed that in countries with low share innovative enterprises more aspects of human capital have significant correlation with innovation performance. In this group, internet skills show significant correlation with innovation level. Only one indicator participation of young people in education is not related to innovation performance. In countries, the group that has high share of innovative enterprises, the participation rate of young people in education is significantly related to innovations. However, in countries with high-level of innovation performance, lifelong learning is not related to innovation performance.

Education attainment indicators in countries with low-level of innovation performance is negatively correlated to innovation performance as in countries with high-level of innovation performance tertiary education attainment is positively correlated to innovation performance and upper secondary education attainment is not related to a country's innovation performance. Such differences in the relationship between education attainment and innovation performance might arise due to differences in the educational system in those countries. Countries having very high education attainment levels has very low-level of innovation.

While analysing the relationship between human capital quality indicators and innovation performance in different countries' groups it could be noticed that correlation coefficients of those indicators are stronger in countries with low-level of innovation performance. In these countries' groups all quality indicators are significantly related to innovation performance. In countries with high innovation performance, high-level of internet skills and satisfaction of education measures are not related to innovation performance.

Conclusions

There are three main approaches for human capital measurement: the cost-based approach, the income-based approach and the education-based approach. At the macroeconomic level, human capital is usually measured by using education-based indicators. Hence, the indicators used in the present study are referenced from an education-based approach. After reviewing those indicators, the human capital measurement model consisting of three groups of indicators was formed. The indicators that

were used in the model formation are as follows: participation in education indicators, education attainment indicators and quality indicators. What is more, the main three indicators were compiled by bringing together more specific elements. In other words, participation rate of young people aged 15–24 in education as well as the percentage of adult population aged 25–64 in education and training are elements of participation in the education category. Tertiary educational attainment (age group 26–64) and population with upper secondary or tertiary education attainment are the elements of education attainment indicators group. The last group is quality indicators and it consists of the following elements: students' performance in mathematics, students' performance in reading, students' performance in science, high-level computer skills, high-level internet-skills and satisfaction of education.

After the human model was created, the correlation analysis was performed to assess the level of relationship between human capital factors and innovation performance. The correlation analysis was conducted within 26 EU countries during 2002–2012. The analysis revealed that quality indicators are mostly related to innovation. This relation is even stronger in countries with low-level of innovative performance. The relationship between education attainment and innovation performance is ambiguous. In countries with low innovation performance, increasing level of education attainment is negatively related to innovation performance. In countries with high-level of innovation, tertiary education attainment is positively related to innovation performance

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