Spatial characteristics of human resources in the context of innovation- and imitation-based economies

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ABSTRACT.

Technological progress is a dynamic process that, via the application and the widespread use of new technologies, becomes the engine of growth through the achievement of efficiency gains in productivity. Most countries are unable to create new technologies because they do not have the appropriate resources or their institutional environment does not favour to innovation. However, technological progress can also be observed in these countries, by adapting new technologies developed and applied effectively elsewhere. Thus, technological progress can be achieved through independent research and development activities, that is, an innovation-driven way, and through the adaptation of new technologies which are already in use in other countries, i.e. in an imitation-driven way. Human capital is also essential for the creation and adaptation of technology, so the quantitative and qualitative features of the human resources available in a country determine the conditions of technological progress. Our research aims to illustrate spatial characteristics of human resources conditions by the method of spatial autocorrelation highlighted the differences between innovation-based and imitation-based economies.

KEY WORDS: technological progress, spatial characteristics of human resources, innovation-based economics, imitation-based economics

JEL classification codes: O11; O15; O57:

POVZETEK

Tehnološki napredek je dinamičen proces, ki je s širitvijo novih tehnologij zaradi njihovega prispevka rasti produktivnosti gonilna sila gospodarske rasti. Večini držav za oblikovanje novih tehnologij primanjkuje resursov in imajo institucionalno okolje, ki ne spodbuja inovativnosti. Vendar pa lahko te države pridejo do novih tehnologij s prilagoditvijo tega znanja, ki v tujini že obstaja. Sicer lahko pridemo do tehnološkega napredka z lastnimi raziskavami ali tako, da posnemamo tehnologije, ki se že uporabljajo v razvitih državah. Za nastajanje in za posnemanje nove tehnologije je prav tako potreben človeški kapital s svojim količinskim in kakovostnim vplivom na osvajanje tehnologije. Naša raziskava naj prikaže prostorske značilnosti pogojev za delovanje slovaškega kapitala in to z uporabo prostorske korelacije, ki naj prikaže razlike med gospodarstvi, ki temeljijo na inovacijah in gospodarstvi, ki temeljijo na posnemanju novih tehnologij.

KLJUČNE BESEDE: tehnološki razvoj, prostorske značilnosti človeških virov, gospodarstva, ki temeljijo na tehnološkem razvoju, gospodarstva, ki temeljijo na posnemanju tehnologije.

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1 Introduction

There is a consensus among economists that technological progress is the driving force of economic growth. It requires physical and human capital, as well as appropriate institutions to generate productivity growth which leads to economic growth. In the new growth theory models, human capital and knowledge are also given special attention and, in conjunction with it, examine the role of the population in economic growth return to the Malthusian traditions. Romer (1994) rejects the earlier idea that the population, and thus the growth in labour supply, has a positive impact on economic output. Firms will be less motivated to implement work-saving innovations when more workers are involved in production, i.e. the supply of labour is growing. However, Jones (2001) argues, that the growth of the population is not only seen in the growth of labour supply but also in the production of ideas so more people can generate more new ideas.

The ideas embodied in technology as a new form of knowledge, with extensive practical application allow more efficient operation of the economy, leading to growth. The income and technological inequalities between countries can be derived from differences in country-specific conditions of technological progress. Most countries are unable to create new technologies because they do not have the appropriate physical and human resources or the institutional environment do not favour innovation. However, technological progress can also be observed in these countries, by adapting the new technologies developed and applied effectively elsewhere. Human capital is also essential for the creation and adaptation of technology, so human conditions determine the technological development path of the countries. This research aims to illustrate the spatial differences in human conditions between countries which can create new technologies, i.e. innovation-based economies and those ones, which can only adapt them, i.e. imitation-based economies.

2 The role of human resources in technological progress

Solow (1956) pointed out that there is a part of growth that cannot be explained by the accumulation of classical production factors. Therefore, in the long run, economic growth can only be achieved by technological progress which is realized in the growth of total factor productivity. Mankiw, Romer & Weil (1992) developed the Solow model further and it was complemented by human capital. They concluded that the exogenous savings rate coupled with higher levels of human resources generates higher income, so human capital is a determining factor in economic growth. The microeconomic models of endogenous growth theory implicitly assume the existence of institutions that ensure the realization of innovation and the accumulation of human capital (Czeglédi 2004). Examining Asian economic miracles, Lucas (1993) also highlighted that, in the long run, income levels are strongly correlated with the initial stock of human capital. Human capital is the set of skills and capabilities that enable people to create new ideas and apply new technologies. The individual's abilities are shaped and expanded through learning, so human capital can be developed through formal and informal learning, as well as interaction between individuals (knowledge transfers). Simplified, innovation is the embodiment of the knowledge gained through education and professional experience.

Several empirical studies confirm that higher-income countries are typically technologically more advanced, their innovation activity is more intense and they create the majority of the innovations, in contrast with lower-income countries, which are typically technology followers, and can adapt new technologies through the imitation of technological leaders (Acemoglu-Aghion-Zilibotti, 2006; Barro-Sala-i-Martin, 1997; Basu-Weil, 1998; Jerzmanovski, 2007). Thus, in the world's countries technological progress can be achieved through own research and development activities creating new technologies, that is innovation-driven way, and by adapting new technologies that are already effective in other countries, that is imitation-driven way. Emphasizing the role of human capital in technological progress, Caselli and Coleman (2006) pointed out that the technological differences between countries are due to the qualification asymmetry, because innovation requires more skilled workforce, while the less skilled workforce is suitable for imitation. By distinguishing the efficiency of skilled and unskilled labour, the authors can model the world technology frontier. At the frontier, the high-skilled workforce dominates, while far away from the frontier the qualified workforce is replaced by the less qualified one. In higher-income countries, there are more skilled workers, and therefore, these countries choose technology that requires high-skilled labour, whose labour productivity is higher. In contrast, lower-income countries choose technology that is better suited to the unskilled labour force which is better available for them.

3 The differentiation between innovation- and imitation-based economies

In a previous research, based on the theoretical concept on world technological frontier, 139 countries were classified into the categories of innovation- and imitation-based economies (Csugány 2016). A novel index was created to measure the main characteristics of the technological and institutional environment. Based on the relevant literature, the analysis includes 28 indicators from the Global Competitiveness Index published by the World Economic Forum, which have been supplemented by the 5 indicators of the Economic Freedom of the World (EFW). For technological progress, the essential factors are property rights and human capital, while the business, legal and regulatory environment is also important through the possession of power. Through principal component analysis, the examined 33 indicators can be combined into an aggregate indicator which contains only the most important indicators of the institutional environment. Finally, the principal component includes 19 variables, the KMO value is 0.95 (excellent) and the explained variance is 75.798%. The new index makes it possible to measure the impact of property rights, education and research infrastructure, financing arrangements, the role of firms, and the business, legal and regulatory environment created by the government and the market structure. Based on the relationship between the novel index of technological-institutional environment and GDP per capita, the countries can be classified. This differentiation allows us to investigate the differences of the country-specific background in innovation- and imitation-driven countries.

This novel measurement-based classification leads to similar results as the differentiation based on Summary Innovation Index and Global Innovation Index, but the new classification extends to a wider range of countries, so we use this for further research.

4 Empirical results: the spatial characteristics of human resource conditions

This research aims to illustrate the differences in human conditions between innovation- and imitation based economies. As a starting point, we analysed the variables related to human resources from the novel index of technological-institutional environment. There are two variables which represent the HR conditions of technological progress, the quality of the education system and the extent of staff training. The correlation between the quality of the education system and GDP per capita is 0.6353, which means that there is a quite strong relationship between these variables. The correlation coefficient is 0.6853 between the extent of staff training and GDP per capita, which also reflects quite strong, positive relationship. These two indicators show the relevance of the formal education system complemented by corporate trainings in order to create the HR condition for technological progress. Figure 1 shows how countries perform in the field of the quality of the education system based on the natural breaks of this variable.

Figure 1: The location of countries along natural breaks in the quality of education

Source: own construction based on WEF-GCI (2015-16)

The value of Moran I is 0.3683, which means that there is a weak, positive spatial autocorrelation between the quality of education and GDP per capita. Based on bivariate Local-Moran I’s, we can conclude that in China, India and some other southern Asian countries the quality of education is high, while GDP per capita is quite low, so they can catch-up with innovators because of their efficient education system. It is because the skills and abilities of people are developed due to the education. In contrast with this, in Russia the quality of education is low, while GDP per capita is high. It shows that education is not the main source of the economic development. In sum, we can conclude that a good education system is important to realize technological progress either in an innovation- or in an imitation-driven way.

In the next step of this analysis, we examine the human conditions in details, so we differentiate the countries and compare their performance. We used the Global Competitiveness Index 2017-2018 made by World Economic Forum which contains the data of 152 countries. In the previous analysis we classified 139 countries of them, but in GCI 2017-2018 there are no available data in the main field of human resources in Angola, Barbados, Bolivia, Burkina Faso, Côte d'Ivoire, Gabon, Guyana, Macedonia, Suriname, Timor-Leste and there are more than one missing data's related to Haiti. We exclude these countries from the analysis, so it remains 128 countries – 23 innovators and 105 imitators – to analyse human characteristics. The main descriptives of the performance groups are shown in Table 1.

Table 1. The main descriptive of human resource indicators in innovation- and imitation-based economies

Variables	***Innovation-based economies***		***Imitation-based economies***	
	Mean	*Std. Deviation*	*Mean*	*Std. Deviation*
Quality of primary education, 1-7 (best)	**5,4198**	0,5357	**3,7343**	0,8128
Primary education enrolment, net %	**97,7586**	2,4911	**92,0954**	7,8914
Secondary education enrolment, gross %	**117,8099**	19,3821	**81,1317**	25,8924
Tertiary education enrolment, gross %	**67,8741**	22,0979	**38,1367**	26,3235
Quality of the education system, 1-7 (best)	**5,1437**	0,5302	**3,4848**	0,6922
Quality of math and science education, 1-7 (best)	**5,2460**	0,5267	**3,8077**	0,7907
Quality of management schools, 1-7 (best)	**5,5134**	0,4639	**4,0442**	0,6477
Extent of staff training, 1-7 (best)	**5,1733**	0,2549	**3,8060**	0,5028
Availability of scientists and engineers, 1-7 (best)	**5,0047**	0,4610	**3,8057**	0,6098

Note: *Innovation-based economies* are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Israel, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Qatar, Singapore, Sweden, Switzerland, the United Arab Emirates, the United Kingdom, and the United States. *Imitation-based economies* are Albania, Algeria, Angola, Argentina, Armenia, Azerbaijan, Bahrain, Bangladesh, Barbados, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Cape Verde, Chad, Chile, China, Colombia, Costa Rica, Côte d'Ivoire, Croatia, Cyprus, the Czech Republic, the Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Ethiopia, Gabon, Gambia, Georgia, Ghana, Greece, Guatemala, Guinea, Guyana, Haiti, Honduras, Hungary, India, Indonesia, Iran, the Islamic Republic, Italy, Jamaica, Jordan, Kazakhstan, Kenya, Korea, Rep., Kuwait, the Kyrgyz Republic, Latvia, Lebanon, Lesotho, Lithuania, Macedonia, FYR, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Montenegro, Morocco, Mozambique, Namibia, Nepal, Nicaragua, Nigeria, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Romania, the Russian Federation, Rwanda, Saudi Arabia, Senegal, Serbia, the Seychelles, Sierra Leone, the Slovak Republic, Slovenia, South Africa, Spain, Sri Lanka, Suriname, Swaziland, Tanzania, Thailand, Timor-Leste, Trinidad and Tobago, Tunisia, Turkey, Uganda, the Ukraine, Uruguay, Vietnam, Yemen, Zambia, and Zimbabwe

(Source: own calculations based on WEF-GCI 2017-2018)

Table 1 shows that the value of all variables related to HR conditions is higher in innovation-based economies than in imitation-based ones and standard deviation is lower for innovators due to the fewer items. It is worth examining the quantitative and qualitative features of human conditions separately in order to find out which is the area where imitators lag behind. Figure 2 shows the difference of quantitative human conditions between innovators and imitators.

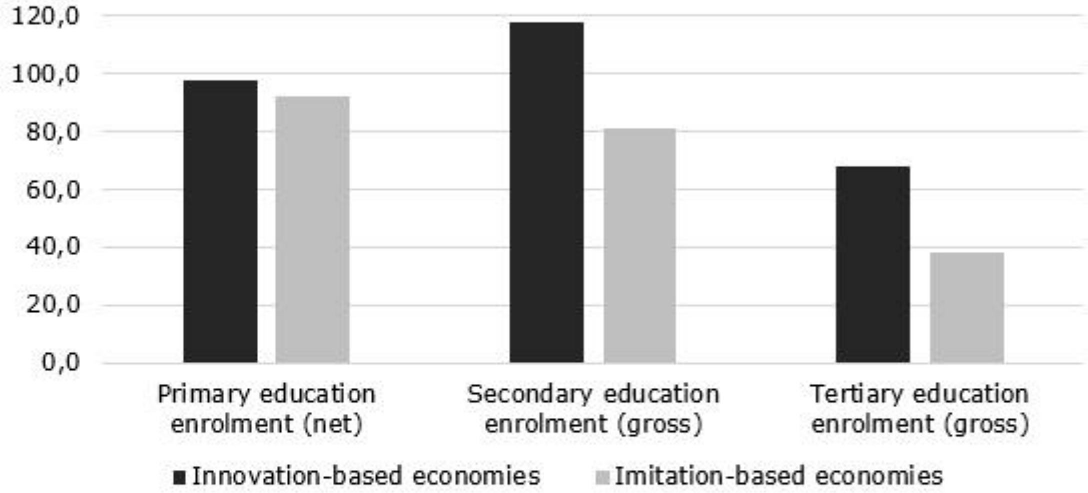

Figure 2: The comparison of quantitative human indicators between innovation- and imitation-based economies

Source: own calculations based on WEF-GCI 2017-2018

The quantitative aspect of human resources can be measured by education enrolment, differentiating primary, secondary and tertiary education. There is no significant difference in primary education enrolment between innovation- and imitation-based economies, but disparities become higher towards higher education. In innovation-based countries, two thirds of the potential population are involved in tertiary education, while this ratio is below 40% in imitator countries. Based on this tendency, we can conclude that well-qualified, higher-skilled workforce is available in innovation-based economies. It is important for research and development activities to create new technologies. The qualitative features measured in a seven-grade scale are shown in Figure 3.

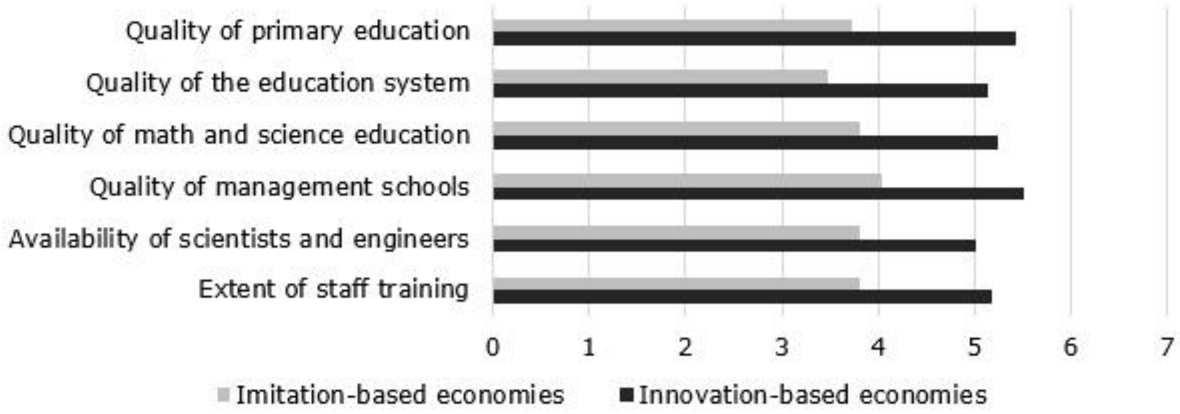

Figure 3: The comparison of qualitative human indicators between innovation- and imitation-based economies

Source: own calculations based on WEF-GCI 2017-2018

The difference between innovation performance groups is more conspicuous in terms of qualitative human indicators. These variables come from the primer research of the World Economic Forum, namely World Executive survey, and each field can be evaluated from 1 to 7 by respondents. It is not surprising that all areas are valued more effective in innovation-based countries than in imitation-based ones. Respondents related to innovators are most satisfied with the quality of the management schools, while the least well-functioning area is the availability of scientist and engineers. This is also explained by the brain drain phenomenon. It is typically geared towards the developed countries from less developed ones, which further complicates the situation of imitators. These problems are so complex that they require further research supplemented by additional factors, for example with the financial background.

5 Conclusion

Human capital is one of the most important resources for technological progress. The quantitative and qualitative characteristics of human resources determine the technological development path of the countries. Most countries are unable to create new technologies because they do not have appropriate resources or their institutional environment do not favour innovation. However, technological progress can also be observed in these countries, by adapting new technologies developed and applied effectively elsewhere. Human capital is also essential for the creation and adaptation of technology. This research aimed to illustrate the spatial differences in human conditions between innovation-based and imitation-based economies. Based on statistical methods, we can conclude that the innovation performance groups differ mainly in the quality of human resources. In addition, disparities in education enrolment become higher towards higher education, which needs to create new technologies.

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