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Grażyna Kozuń-Cieślak
Kazimierz Pulaski University of Technology and Humanities in Radom
e-mail: g.kozun@uthrad.pl
ORCID: 0000-0001-5836-2766

DOES THE EFFICIENCY OF PUBLIC INVESTMENT IN HUMAN CAPITAL AFFECT THE COUNTRY'S ECONOMIC DEVELOPMENT?

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Abstract: Modern theories of economic growth emphasize the meaning of the investment in human capital as the most profitable. Although the positive relationship between public investment in human capital and the country's economic development is commonly accepted, the answer to the question of whether the efficiency of this investment is crucial for welfare, is no longer so obvious. The aim of this study is to recognize the relationship between the technical efficiency of public spending on human capital and the economic development in the sample of 28 EU states. For this purpose DEA method was applied to evaluate the efficiency of public expenditure on healthcare and education in order to build human capital. Then, DEA scores were correlated with countries' economic development indicators expressed by GDP *per capita*. The study proves that the commonly accepted dependency between the potential of human capital and countries' welfare is not reflected in the correlation between countries' GDP *per capita* and the DEA efficiency of public investment in human capital.

Keywords: human capital, efficiency, DEA, economic development.

1. Introduction

The concept of human capital has its roots in the history of economic thought, as reflected for example in Smith (1776), where people and their acquired abilities were considered on a par with traditional assets (land and fixed capital), as important components of national wealth. Thanks to the seminal works by Schultz (1961), Becker (1964) and Mincer (1974), the human capital concept regained recognition in the 1960s as the crucial factor of economic growth. According to the OECD definition, human capital is the knowledge, skills, competencies and other attributes embodied in individuals or groups of individuals acquired during their life and used to produce goods, services or ideas in market circumstances, facilitating the creation of personal, social and economic well-being (OECD, 1998, 2001). The OECD definition is all-embracing as it incorporates various skills and competencies that are acquired through learning and experience but may also include innate abilities. Some aspects of motivation and behaviour, as well as the physical, emotional and mental health of individuals are also regarded as human capital in this broader definition (Boarini, Mira d'Ercole, and Liu, 2012).

Human capital is one of the most important factors determining a country's wealth and economic development. The modern theories of economic growth emphasize the meaning of the long-term investment in human capital as the most profitable. Such investment increases productivity, generating higher income for workers, businesses and even countries, and runs a lower risk of putting people out of work than other forms of investment, strengthens the foundations of democracy and limits the influence of populist ideologies. Thus it contributes to the inclusion of the national economy in the global trend of developing a new economy based on information and communication technologies (Kozuń-Cieślak, 2011). The so-called "new growth" models developed by Lucas (1988), Romer (1990) and Barro and Sala-i-Martin (1995) suggest that investment in human capital does not just improve labour quality at a point in time, but can also lead to technological progress and innovation, i.e. positive 'externalities' that increase the productivity of other factors. The complex inter-relationship between well-being and human and social capital was widely discussed for example in the OECD publication (OECD, 2001).

A country's human capital is mainly built through the educational and healthcare systems, both mostly funded by public money. According to EUROSTAT data on-line in all EU member states (except Cyprus) the percentage share of government schemes and compulsory contributory health care financing schemes in total current health expenditure is over 50%. In 20 EU countries, this share ranged from 70% to 85%, as shown by the latest data from 2017. Education represents an even larger share of public expenditure in the total expenditure in each EU economy. In 2016 the general government spending on education (all ISCED 2011 levels excluding early childhood educational development) exceeded 80% of the total educational spending in each EU country.

Public investment in human capital can accelerate economic growth and as such is a crucial policy in its promotion. Although the positive relationship between public investment in human capital and a country's economic well-being is commonly accepted, the answer to the question of whether the technical efficiency of these investments is crucial for welfare is no longer so obvious.

The aim of this study is to recognize the relationship between the technical efficiency of public spending on human capital (expressed by the set of selected education and health indicators) and the economic development (expressed by GDP *per capita*, used as an approximation) in the sample of 28 European Union member states.

2. Data and methods

2.1. Research framework

The first stage in achieving the purpose of this study is the assessment of the technical efficiency of investment in human capital, understood as the output-input relationship. The Data Envelopment Analysis will be applied as the quantitative method to evaluate the technical efficiency (the basics of DEA method will be described in the next subsection). The assessment of the efficiency of public spending on human capital at country level involves some difficulty with the selection of the appropriate input-output periods. This is because the results achieved by the healthcare system as well as by the educational system obtained in every single year do not arise directly from the inputs incurred in that year. Therefore, the indicators used in this study represent the arithmetic averages of the input-output data over a ten-year period (2008-2017). The study covers 28 EU member states.

The human capital potential at country level was assessed within two broad areas (components) which remain under the strong influence of the state, i.e. *education* and *health*.

The component *education* reflects the potential of society's knowledge, defined as the collection of information, views and beliefs attributed to cognitive or practical values. The educational level of society is affected by an organized process of scientific knowledge acquisition, its use and distribution. Since the specificity of the effects of the education system is that they are visible only in the long term, and they result from multiple activities at different levels of education, they are very difficult to measure and it is difficult to assess the level of knowledge of a given society. In this study, three diagnostic features (measures) were chosen to describe the potential of knowledge in the examined economies i.e.: *Gross secondary enrolment rate,* the *PISA index* and *Patent applications*.

For more on the measures to assess the national education system and the level of knowledge in society, see for example: Afonso and Aubyn (2005), Sutherland, Price, Joumard, and Nicq (2007), Agasisti (2011), Aristovnik (2011), Jaffe, Trajtenberg, and Fogarty (2000), Jatte, Trajtenberg, and Henderson (1993), Acs, Anselin, and Varga (2002), Furman, Porter, and Stern (2002), Atun, Harvey, and Wil (2007).

The component *health* reflects the condition of the main economic resource, namely human resource, as only a healthy society is capable of creating national wealth. According to the WHO definition, health is the fullness of physical, mental and social wellbeing.

Therefore, health should be treated not as the "absence of a disease", but as a positive value of economic importance in the context of the socio-economic development of the country. To assess the condition of society's health is not a simple matter as even its definition itself contains immeasurable elements. To describe the health potential in the surveyed countries, the following three measures were selected: *Infant mortality rate, Self-reported unmet needs for medical examination, Life expectancy at birth.*

For more on the measures to assess the national health care system performance, see for example: Asandului, Roman, and Fatulescu (2014), Hadad, Hadad, and Simon-Tuval (2013), Joumard, André, and Nicq (2010).

Table 1 shows the description of the human capital indicators selected for this research. They represent DEA output indicators.

Table 1. Human capital indicators – description, source and scope

Human capital indicators	
Indicator	Definition, source and scope
1	2
Gross secondary enrolment rate (GSE)	The ratio of the number of students (as at the beginning of the school year) at the secondary education level (regardless of age) to the population in the age group defined as corresponding to this educational level. Secondary level of education can be seen as the level which generates awareness of the need for further upgrading of qualifications and for activities aimed at self-development, and simultaneously creates a predisposition to draw personal benefits resulting from the progress of civilization. World Bank: 2008-2016
Programme for International Student Assessment index (PISA)	Gives information about the skills of students who are 15 years old. PISA stands for the Programme for International Student Assessment – an international study coordinated by the OECD. The research examines students' skills organized into three areas: reading and reasoning in the humanities (*reading literacy*), mathematics (*mathematical literacy*), and reasoning in science (*scientific literacy*). These three areas are considered to be decisive when it comes to the possibilities of further development both, individual as well as social and economic. The PISA program examines the extent to which students in the final phase of the uniform universal education have the capital of knowledge and skills needed in today's world of adult life, including the labour market. OECD: 2009, 2012, 2015
Life expectancy at birth (LE)	One of the most frequently used health status indicators. Increases in life expectancy at birth can be attributed to a number of factors, including rising living standards, improved lifestyle and better education, as well as greater access to quality health services. EUROSTAT: 2008-2017
Infant mortality rate (IMR)	The number of infant deaths (i.e. children aged 0-1 years) compared to 1000 live births. Perinatal care is an important part of health care for the whole population, and its quality is a sensitive measure of the state's health policy. Any shortcomings in this area are revealed clearly by the infant mortality rate. This indicator is considered to be an indicator of society's health and the level of health services. EUROSTAT: 2008-2017

1	2
Self-reported unmet needs for medical examination (UNME)	The percentage of the respondent's own assessment of whether he or she needed the respective type of examination or treatment, but could not enjoy it because of any of three reasons: too expensive, too far to travel or a too-long waiting list. This indicator expresses the capacity and accessibility of the healthcare system from the patient's perspective. EUROSTAT: 2008-2017
Patent applications to the European Patent Office (PA)	Society's inventive activity and the country's capacity to exploit knowledge and translate it into potential economic gains. In this context, indicators based on patent statistics are used to assess the inventive performance of countries or regions, as a patent represents a codification of inventive activity rely on the novelty, utility and inventiveness (expressed per million inhabitants). EUROSTAT: 2008-2017

Source: own elaboration.

As two indicators, namely *Infant mortality rate* and *Self-reported unmet needs for medical examination* are de-stimulants (which means that a higher value of the indicator describes a worse situation in the examined phenomenon), it is necessary to convert them into stimulants. Hence finally these indicators take the form of: IMR* = 1000-IMR and UNME* = 100-UNME.

The quality of human capital in every country is strongly connected with the financial outlays directed to both the healthcare and educational systems. The public sector plays a key role here. The level of public investment in creating human capital will be expressed by two monetary indicators (in terms of the purchasing power parity), i.e.: *Public expenditure on education per capita (PEEpc)* and *Public healthcare expenditure per capita (PHEpc)*, which represent DEA inputs (data source and scope: World Bank: average of 2008-2017).

At the second stage of the research, the DEA efficiency scores obtained using *DEA solver* will be correlated with the countries' economic development indicators expressed by GDP *per capita*, as their approximation (the average of 2008-2017 in terms of the purchasing power parity) to detect the relationship between the two measures.

2.2. Data Envelopment Analysis as the quantitative tool

Data Envelopment Analysis is a non-parametric method based on linear programming techniques. DEA evaluates the technical efficiency and aims at estimating the relationship between the inputs and outputs of homogeneous objects. The main advantage of the DEA technique is that it does not require the specification of a particular functional form of technology. It is a powerful quantitative method for evaluating the relative efficiency when there are multiple inputs and outputs.

DEA introduced by Charnes, Cooper, and Rhodes in 1978 (Charnes et al., 1978), and based on the work of Farrell (1957), offered a basic DEA model, which is the radial CCR model, with the assumption of constant returns to scale (the anagram arises from the first letters of the providers' names). The DEA-CCR model was extended to constitute technologies that reveal variable returns to scale by Banker, Charnes, and Cooper in 1984 (Banker et al., 1984), called DEA-BCC.

DEA identifies a frontier, based on which relative performance among all the decision-making units (DMUs) in the sample can be compared-the DEA benchmarks the analyzed DMU only against the best ones that form the frontier of efficiency (productivity frontier).

An object (DMU) is recognized as 100% efficient (DEA score = 1) when comparisons with other units in the sample do not offer evidence of inefficiency in the use of any input or output. If any object is not at the frontier, it indicates inefficiency; its distance from the frontier defines the inefficiency level and a DEA score <1. Over the years simple DEA models have been developed through several modifications which permit the users to have a better fit of the appropriate DEA variant to the specific needs of the researchers (for the mathematical foundations of DEA, refer to: Charnes et al., 1994; Cooper et al., 2007; Emrouznejad and Tavana, 2014).

Using the linear programming technique, the various DEA models intend to provide efficiency scores under different orientations (input vs. output) and assumptions of returns-to-scale (constant vs. variable).

Over the years, simple DEA models have been enhanced by several modifications that enable users to have a better fit of the appropriate DEA variant to suit their research needs. In this study, the super-efficiency and non-oriented slack-based DEA model under the assumption of the variable returns to scale (DEA SE-NO-SBM-V) was applied. Its mathematical expression is as follows (Tone, 2002):

$$\delta^{DEA-SE-NO-SBM} = \min_{\phi,\psi,\lambda} \frac{1+\frac{1}{m}\sum_{i=1}^{m}\varphi_{io}}{1-\frac{1}{s}\sum_{r=1}^{s}\psi_{ro}}$$

subject to:

$$\sum_{\substack{j=1\\ j\neq o}}^{n} x_{ij}\lambda_{jo} - x_{io}\varphi_{io} \leq x_{io} \qquad (i = 1, \ldots, m),$$

$$\sum_{\substack{j=1\\ j\neq o}}^{n} y_{rj}\lambda_{jo} - y_{ro}\psi_{ro} \geq y_{ro} \qquad (r = 1, \ldots, s),$$

$$\varphi_{io}, \psi_{ro}, \lambda_{jo} \geq 0$$

where: $\delta^{DEA-SE-NO-SBM}$ – efficiency score of the DMU*o* (o = 1…, n); x_{ij} – amount of the *i-th* input of the DMU*j* (i=1,…, m); y_{ij} – amount of the *r-th* output of the DMU*j* (r = 1, …, s); λ_{j0} – the intensity factor associated with the DMU*j* and designated for the analysed DMU*o* (j = 1, …, n).

Weighted by lambda coefficients, the sum of the inputs (outputs) of the DMUs, which are the reference objects for the DMU*o*, show the recommended value of the inputs (outputs) of the DMU*o,* at which it becomes efficient,

φ_{j0} – indicates the required percentage reduction of the *i-th* input,

ψ_{j0} – indicates the required percentage increase of the *r-th* output.

The formula of the DEA SE-NO-SBM-V model facilitates ranking the relative efficiencies of multiple systems (here: 28 countries) at consuming multiple inputs (PEEpc, PEHpc) in order to produce multiple outputs (human capital status indicators expressed by: GSE, PISA, PA, LE, IMR, UNME).

3. Results and discussion

3.1. First stage of the research – DEA efficiency results

The DEA calculations allowed for establishing the ranking of 28 EU member states due to the results of transforming public expenditure on health and education into the domestic human capital. Table 2 shows the details dealing with DEA super--efficiency scores obtained by the every single state in the sample.

Out of the 28 analysed countries, 21 were assessed as relatively efficient (DEA scores between 1 and 1.081) while the remaining 7 were recognized as inefficient (DEA scores from 0.53 to 0.95). The coefficient of variation for the analysed sample was 0.15, which means rather low diversity. Germany was assessed as the leader of the ranking. Among 11 post-communist EU members 9 were recognized as DEA--efficient (the exemption applies to Romania and Lithuania).

The group of DEA inefficient states includes: Lithuania which showed the highest efficiency gap of 47%, Portugal with a gap of 39%, Ireland which should improve its performance by 35%, the United Kingdom – which also needs changes to reduce its efficiency gap – 27%, Denmark and France should strive for better results by approximately 25%, and Romania where the inefficiency is smallest – 5%.

The DEA solver allows to project values of the input and output variables that are necessary to achieve the DEA efficiency frontier. Table 3 shows the results of this projection.

According to the data in Table 3, the inefficiency in Denmark, France, Ireland and the United Kingdom results mainly from the high level of public expenditure on health and education. A necessary condition for improving the efficiency of these countries is the reduction of input indicators even by 14% to 23%. Additionally, Ireland and the UK should improve the indicators of patent applications (PA) by respectively 136% and 55%, while France needs to increase its gross secondary enrolment (GSE) by 18%.

In turn, in Lithuania, Portugal and Romania the indicators of patent application are the only significant sources to improve their ranking. For example, Lithuania

Table 2. DEA efficiency stores in transforming public expenditure on health and education into human capital

Rank	DMU	DEA score	Rank	DMU	DEA score
1	Germany	1.0808	15	Greece	1.0031
2	Bulgaria	1.0537	16	Slovakia	1.0020
3	Latvia	1.0520	17	Austria	1.0006
4	Belgium	1.0348	18	Malta	1.0005
5	Spain	1.0347	19	Italy	1.0003
6	Sweden	1.0271	20	Czech Republic	1.0001
7	Finland	1.0210	21	Luxembourg	1.0000
8	Cyprus	1.0206	22	Romania	0.9500
9	Poland	1.0096	23	France	0.8457
10	Hungary	1.0065	24	Denmark	0.8437
11	Estonia	1.0046	25	United Kingdom	0.7268
12	Slovenia	1.0042	26	Ireland	0.6535
13	Netherlands	1.0035	27	Portugal	0.6122
14	Croatia	1.0033	28	Lithuania	0.5306

Source: (*DEA solver*, 2008).

Table 3. Input-output projection for DEA efficiency improvement

Inefficient DMU	Input-output projection for DEA efficiency improvement (%)							
	PEEpc	PHEpc	GSE	PISA	UNME*	IMR*	PA	LE
Denmark	–16	–14	0	0.9	0	0	0	1.6
France	–8	–18	18	0	0.6	0.1	0	0
Ireland	–17	–23	0	0	0.6	0.0	136	0.0
Lithuania	0	0	0	0.9	0	0	527	3.0
Portugal	0	0	0	0	0	0	380	0.2
Romania	0	0	2	0.7	2.1	0.2	27	0
United Kingdom	–2	–17	0	0	0	0.1	55	0.4

Source: (*DEA solver*, 2008).

should strive to increase the PA indicator by more than five times and Portugal almost fourfold.

Summing up the first stage of the study, it can be said that based on the proposed model for assessing the technical efficiency of public expenditure on health and education in building human capital (using the DEA method), 75% of EU member states were assessed as efficient. The remaining 25% of countries showed DEA inefficiency from 5% to 47%. In the case of four countries, the sources of inefficiency should be seen primarily in the excessive spending on health care (Denmark, France, Ireland, the UK), while in two countries (Denmark and Ireland) it is the excessive expenditure on education. However, taking into account the output indicators, it is necessary to improve first and foremost, patent applications, which applies to five countries (mainly to Lithuania and Portugal, but also Ireland, the UK and Romania).

It should be emphasized here that when one estimates efficiency using the DEA method, the so-called technical efficiency is determined, which shows the extent to which the expended funds have been transformed into the "potential of health and knowledge" of a society (expressed in terms of selected diagnostic features). Therefore the country most efficient technically is not necessarily the one in which the level of health care and the quality of education system are the highest. Conversely, the lowest technical efficiency does not mean the worst level of health care, or the least educated society – it just means that certain funds (inputs) in other country would be used in a better way, gaining better results expressed as a fixed set of output indicators.

The comment above does not undermine the sense of assessing the technical efficiency of public expenditure, but merely emphasizes that technical efficiency is not an inherent value but rather a means to achieving a goal (a desirable outcome). Referring to this, Wildavsky said that: "technical efficiency does not tell you where to go, only that you should arrive there with the least possible effort" (Stone, 1998). For more on the twofold conceptualization of the term 'efficiency' (technical vs. substantive approach), see for example (Kozuń-Cieślak, 2017).

This is especially important when assessing the public sector, as the efficiency criterion need not be understood as a key objective and thus can be supplanted by other values (legality, transparency, integrity, democracy, social justice, intergenerational solidarity). Achieving these objectives may reduce the technical efficiency or even clash with the pursuit of them. Additionally, public sector entities always have multiple goals and establishing their hierarchy is very difficult (Denhardt, 2000; Kang, 2003; Wilson, 1989).

3.2. Second stage of the research – Pearson correlation results

The second stage of the study was to determine whether there is a relationship between the efficiency of public investment in human capital and the level of a country's economic development. For this purpose, the Pearson correlation coefficient (PCC) between DEA scores and GDP *per capita* (PPP) for 28 EU countries were estimated. The PCCs were also estimated for GDPpc and all DEA input and output indicators.

The Pearson coefficient proves that the two measures mentioned above are independent (PCC = –0.02), despite the fact that there are very strong correlations between countries' GDPpc and DEA input indicators, as well as a substantial relationship for the most output indicators used to calculate the DEA scores (Table 4).

Table 4. Pearson correlation coefficients

Pearson Correlation Coefficient (PCC)	Public spending on human capital		Human capital indicators						DEA score
			Health component			Education component			
	PEEpc	PHEpc	UNME*	IMR*	LE	GSE	PA	PISA	
GDPpc (PPP)	0.93	0.87	0.51	0.49	0.59	0.27	0.57	0.33	**-0.02**

Source: own calculations.

As the calculations showed, the GDPpc of the examined countries is very strongly associated with the level of expenditure per the statistical citizen on health care (PCC = 0.87) and education (PCC = 0.93). The relationships between the GDPpc and life expectancy indicator, patent applications, infant survival and satisfied needs for medical examination are also significant (respectively: 0.59, 0.57, 0.49, 0.51). A weaker relationship was found between the GDPpc and the secondary enrolment rates (0.27), as well as student skills assessment (0.33).

The above analyses confirm that there is a feedback relationship between a country's economic development and the potential of its human capital, which is in line with Mincer (1981), who proved that human capital is both a factor and an effect of economic growth. According to the World Development Report (2019), countries become richer as more human capital is accumulated. Human capital complements physical capital in the production process and is an important input to technological innovation and long-term growth. As a result, between 10 and 30 percent of differences in *per capita* gross domestic product (GDP) are attributable to the cross-country differences in human capital. This percentage could be even higher when considering the quality of education and the interactions between workers with different skills. Additionally, by generating higher incomes, human capital accelerates the demographic transition and reduces poverty. For these reasons, governments have an important role to play in building human capital.

4. Conclusion

The study proves that the commonly accepted dependency between the potential of human capital and countries' welfare is not reflected in the correlation between the economic development of a country and the technical efficiency of public investment in human capital. This means that the dominating channel for building human capital by public expenditure on healthcare and education is not subject to the regime of technical efficiency in order to obtain high economic development expressed by GDP per inhabitant. This somewhat surprising research result requires further investigation to confirm its veracity.

To this end, it would be necessary to recalculate models taking into account, among others, a different set of DEA output indicators or a different sample of countries, for example on a more even level of their development. It would also be advantageous to use alternative quantitative methods. If in-depth studies confirm that the technical efficiency of public spending does not affect a country's economic development, then perhaps the widely accepted imperative of striving for technical efficiency in the public sector performance should be reconsidered, especially from the viewpoint of the so-called Aristotelian (substantive) approach to efficiency.

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CZY EFEKTYWNOŚĆ INWESTYCJI PUBLICZNYCH W KAPITAŁ LUDZKI WPŁYWA NA ROZWÓJ GOSPODARCZY KRAJU?

Streszczenie: Współczesne teorie wzrostu gospodarczego podkreślają znaczenie inwestycji w kapitał ludzki jako najbardziej opłacalnych. Chociaż pozytywny związek między inwestycjami publicznymi w kapitał ludzki a rozwojem gospodarczym kraju jest powszechnie akceptowany, to odpowiedź na pytanie, czy efektywność tych inwestycji jest kluczowa dla dobrobytu, nie jest już tak oczywista. Celem pracy jest poznanie zależności między efektywnością techniczną wydatków publicznych na kapitał ludzki a rozwojem gospodarczym na próbie 28 krajów UE. Zastosowano metodę DEA do oceny efektywności wydatków publicznych na ochronę zdrowia i edukację w celu budowy kapitału ludzkiego. Następnie wyniki DEA skorelowano ze wskaźnikami rozwoju gospodarczego krajów wyrażonymi jako PKB na mieszkańca. Badanie dowodzi, że powszechnie akceptowana zależność między potencjałem kapitału ludzkiego a dobrobytem krajów nie znajduje odzwierciedlenia w korelacji między PKB na mieszkańca a DEA – efektywnością inwestycji publicznych w kapitał ludzki.

Słowa kluczowe: kapitał ludzki, efektywność, DEA, rozwój gospodarczy.