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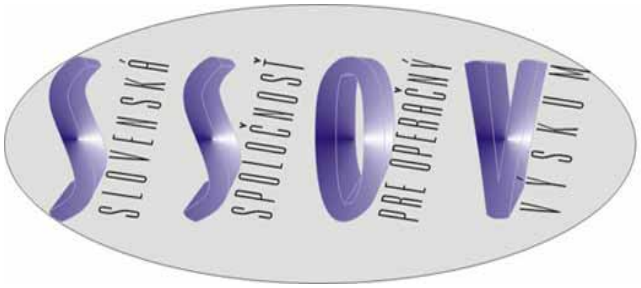

Proceedings of the International Scientific Conference

QUANTITATIVE METHODS IN ECONOMICS
Multiple Criteria Decision Making XVIII

25th May - 27th May 2016
Vrátna, Slovakia

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Vrátna, Slovakia

Technical Editor: Marian Reiff, Pavel Gežík, University of Economics, Bratislava
Web Editor: Martin Lukáčik, University of Economics, Bratislava
Web: http://www.fhi.sk/en/katedry-fakulty/kove/ssov/papers//

Publisher: Letra Interactive, s. r. o.
ISBN 978-80-972328-0-1
Number of copies: 90

QUALITY OF HUMAN CAPITAL IN THE EUROPEAN UNION IN THE YEARS 2004-2013. APPLICATION OF STRUCTURAL EQUATION MODELING

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Abstract
EU policy guidelines point out that improvement of quality of human capital (QHC) should be treated as an important factor supporting convergence process. Thus, the aim of the research is the identification of the variables that determine changes in QHC. It is assumed that QHC should be considered as a latent variable, which can be measured with application of Structural Equation Modeling (SEM). SEM includes confirmatory factor analysis and path analysis used in econometrics. In the research, the hypothetic SEM model was proposed for the years 2004-2013. Four subsets of observable variables were used: a) macroeconomic and labour market effectiveness, b) quality of education, c) national innovation system, d) health and social cohesion. The research confirmed significant influence of the proposed variables on the level of QHC and positive tendencies in changes of QHS in the EU countries.

Keywords: *Structural Equation Model (SEM), quality of human capital, European Union*

JEL Classification: C30, C38
AMS Classification: 62P20

1 INTRODUCTION

Quality of human capital (QHC) is currently considered as one of the most important development factors in the case of highly developed countries that compete in the reality of global knowledge-based economy. The fundamental role of this factor was pointed out in many European Union policy guidelines, such as Lisbon Strategy or Europe 2020 plan (see: Balcerzak, 2015; Baležentis *et al*., 2011; European Commission, 2010). Thus, the aim of the research is the identification of variables that determine changes in QHC at macroeconomic level. Structural Equation Modeling (SEM) methodology was applied here. The research was conducted for the European Union countries in the year 2004-2013. QHC is analyzed as an economic factor that is crucial for utilizing the potential of global knowledge-based economy (Balcerzak, 2009). This perspective was a prerequisite to the selection of potential diagnostic variables for the model.

2 SEM METHODOLOGY

Quality of human capital should be considered as a multivariate phenomenon (Balcerzak, 2016; Balcerzak and Pietrzak, 2016a, 2016c; Pietrzak and Balcerzak, 2016a) that can be also considered as a latent variable. Thus, it can be measured with application of SEM methodology. This analytical approach includes confirmatory factor analysis and path analysis used in econometrics. SEM models are more elastic than regression models, as they enable to analyse the interrelations between latent variables that are the result of influence of many factors (Loehlin, 1987; Bollen, 1989; Kaplan, 2000; Pearl, 2000; Brown, 2006; Byrne, 2010).

The SEM model consists of an external model and an internal model. The external model, which is also called a measurement model, is given as:

$$\mathbf{y} = \mathbf{C}_{\mathbf{y}}\boldsymbol{\eta} + \boldsymbol{\varepsilon}, \tag{1}$$

$$\mathbf{x} = \mathbf{C}_{\mathbf{x}}\boldsymbol{\xi} + \boldsymbol{\delta}, \tag{2}$$

where: $\mathbf{y}_{p\times 1}$ - the vector of observed endogenous variables, $\mathbf{x}_{q\times 1}$ - the vector of observed exogenous variables, $\mathbf{C}_{\mathbf{y}}, \mathbf{C}_{\mathbf{x}}$ - matrices of factor loadings, $\boldsymbol{\varepsilon}_{p\times 1}, \boldsymbol{\delta}_{q\times 1}$ - vectors of measurement errors.

The internal model, which is called a structural model, can be described as:

$$\boldsymbol{\eta} = \mathbf{A}\boldsymbol{\eta} + \mathbf{B}\boldsymbol{\xi} + \boldsymbol{\zeta}, \tag{3}$$

where: $\boldsymbol{\eta}_{m\times 1}$ - vector of endogenous latent variables, $\xi_{k\times 1}$ - vector of exogenous latent variables, $\mathbf{A}_{m\times m}$ - matrix of regression coefficients at endogenous variables, $\mathbf{B}_{m\times k}$ - matrix of coefficients at exogenous variables, $\zeta_{m\times 1}$ - vector of disturbances.

3 THE MEASUREMENT OF QUALITY OF HUMAN CAPITAL WITH APPLICATION OF SEM MODEL

Quality of human capital is analysed at the macroeconomic level from the perspective of its influence on the abilities of countries to compete in the reality of global knowledge-based economy. The research is conducted for 24 EU economies in the years 2004-2013 basing on Eurostat data.

Table 1. The factors influencing quality of human capital

Aspect 1 (A_1) - Macroeconomic and labour market effectiveness
x_1 – Employment rate (20 to 65)
x_2 – Labour productivity (percentage of EU28 total based on PPS per employed person)
x_3 – Unemployment rate (total - annual average, %)
Aspect 2 (A_2) - Quality of education
x_4 – Lifelong learning - participation rate in education and training (last 4 weeks) (% of population 25 to 64)
x_5 – Science and technology graduates (tertiary graduates in science and technology per 1 000 inhabitants aged 20-29 years)
Aspect 3 (A_3) - National innovation system
x_6 – Exports of high technology products as a share of total exports
x_7 – Total intramural R&D expenditure (GERD) Percentage of gross domestic product (GDP)
Aspekt 4 (A_4) Health and social cohesion
x_8 – People at risk of poverty or social exclusion (Percentage of total population)
x_9 – Life expectancy at birth
x_{10} – Material deprivation rate

Source: own work based on: Balcerzak and Pietrzak (2016b); Jantoń-Drozdowska and Majewska (2015); Madrak-Grochowska (2015); Pietrzak and Balcerzak (2016b); Rószkiewicz (2014); Zielenkiewicz (2014).

It is assumed that QHC is a latent variable. In order to measure and describe QHC, an external model was built basing on SEM methodology. It is assumed that an internal model does not occur. It means that only the confirmatory factor analysis, which enables to measure the latent variable in the form of QHC, was conducted here. The analysis was conducted basing on the observed variables presented in Table 1. The variables belong to four socio-economic aspects related to QHC: a) macroeconomic and labour market effectiveness, b) quality of education, c) national innovation system, d) health and social cohesion. Basing on the literature review of previous research, it can be said that these aspects influence the abilities of countries to compete in the reality of knowledge-based economy.
The assumed that the hypothetic SEM model was estimated in AMOS v. 16 packet with application of maximum likelihood method. The results are presented in Table 2. All the parameters of external model are statistically significant, which confirms that all the observable variables for QHC were properly identified. The standardized evaluations of parameters given in Table 2 can be used to evaluate the strengths of the influence of the given variable for QHC. The variables with the strongest influence can be ordered as follow: X_7 (total intramural R&D expenditure, GERD), X_{10} (material deprivation rate), X_8 (people at risk of poverty or social exclusion) and X_4 (lifelong learning - participation rate in education and training). The variables with average influence: X_1 (employment rate), X_2 (labour productivity) i X_9 (life expectancy at birth). Finally, the variables with the weakest influence: X_6 (exports of high technology products as a share of total exports), X_3 (unemployment rate) i X_5 (science and technology graduates)[1]. The results do not allow to point the dominant aspect in the context of evaluation of QHC at macroeconomic level.

Table 2. The estimations of parameters of SEM model based on the confirmatory factor analysis

Variable	Parameter	Estimate	Standardized	p-value
x_1	α_1	1	0,753	-
x_2	α_2	4,494	0,702	~0,00
x_3	α_3	0,543	0,468	~0,00
x_4	α_4	1,507	0,818	~0,00
x_5	α_5	0,234	0,219	~0,00
x_6	α_6	0,701	0,470	~0,00
x_7	α_7	0,188	0,878	~0,00
x_8	α_8	0,276	0,864	~0,00
x_9	α_9	0,488	0,649	~0,00
x_{10}	α_{10}	3,156	0,870	~0,00

Source: own estimation based on Eurostat data.

In order to asses an adjustment of the model to the input data, the Incremental Fit Index (IFI) and Root Mean Square Error of Approximation (RMSEA) coefficients were used. The value of the IFI coefficient for the estimated SEM model equals 0,722, and the value of the RMSEA coefficient equals 0,2339. These values are higher than the suggested values of 0,9 for IFI and 0,1 for RMSEA. However, due to the macro-economic data used in the research, the value of these indices can be assessed as acceptable. It means that the adjustment of the model to the input data is proper.

[1] The strengths of impact of variables and their classification to the three subsets was done arbitrarily by the authors.

The level of QHC in the years 2004 and 2013 was assessed basing on the sum of product of values of Factor Score Weights and the values of given variables. The countries were ordered starting with the highest value of the obtained indicator for QHC to the ones with its lowest value. This enabled to propose two ratings of countries for the years 2004 and 2013. Then, the comparison of the values of indicator for QHC in the first and last year of analysis enabled to assed the percentage changes of the values of the indicator for the analyzed countries. The results are presented in Table 3.

Table 3. The level of quality of human capital in EU countries and its changes in the years 2004-2013

2004			2013			2004-2013		
Country	**QHC**	**Rating**	**Country**	**QHC**	**Rating**	**Country**	**% Change**	**Rating**
Sweden	27,44	1	Sweden	30,89	1	Poland	19,98%	1
Denmark	26,99	2	Finland	28,03	2	Slovak Rep	16,63%	2
Finland	26,71	3	Denmark	27,33	3	Estonia	16,61%	3
Netherlands	25,70	4	Netherlands	26,36	4	Czech Rep.	15,90%	4
Austria	24,30	5	Austria	25,62	5	Sweden	12,57%	5
United Kingdom	24,26	6	France	24,74	6	Bulgaria	9,47%	6
Germany	23,40	7	Germany	24,49	7	Lithuania	9,27%	7
France	22,92	8	Czech Rep.	23,46	8	Latvia	9,06%	8
Ireland	22,32	9	Belgium	22,95	9	France	7,93%	9
Slovenia	22,13	10	Slovenia	22,72	10	Romania	6,68%	10
Belgium	22,12	11	United Kingdom	22,52	11	Austria	5,40%	11
Czech Rep.	20,24	12	Estonia	21,56	12	Finland	4,94%	12
Spain	20,12	13	Ireland	20,82	13	Germany	4,65%	13
Italy	19,74	14	Spain	20,07	14	Belgium	3,78%	14
Portugal	18,90	15	Portugal	19,53	15	Portugal	3,36%	15
Estonia	18,49	16	Italy	19,28	16	Slovenia	2,67%	16
Greece	17,69	17	Slovak Rep	19,26	17	Netherlands	2,58%	17
Hungary	17,41	18	Poland	18,48	18	Hungary	2,42%	18
Lithuania	16,68	19	Lithuania	18,22	19	Denmark	1,27%	19
Slovak Rep	16,51	20	Hungary	17,83	20	Spain	-0,24%	20
Latvia	15,91	21	Latvia	17,35	21	Italy	-2,31%	21
Poland	15,41	22	Greece	16,65	22	Greece	-5,85%	22
Romania	15,16	23	Romania	16,17	23	Ireland	-6,73%	23
Bulgaria	14,30	24	Bulgaria	15,66	24	United Kingdom	-7,17%	24

Source: own estimation based on Eurostat data.

4 CONCLUSIONS

The conducted research concentrated on the problem of measurement of QHC at the macroeconomic level in the context of knowledge-based economy requirements. It was assumed that the QHC should be considered as a latent variable, thus SEM methodology was applied in the analysis. The aim of the research was the identification of variables that determine changes in QHC.

The hypothetic SEM model confirmed a significant influence of the proposed ten variables on the level of QHC. The analysis shows significant differences in the sphere of QHC between

"old" and "new" members of European Union. However, in the years 2004-2013 the new member states made significant progress, which could be seen especially in the case of Poland, the Slovak Republic, Estonia and the Czech Republic.

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