QUANTITATIVE METHODS IN ECONOMICS
Vol. XIV, No. 2, 2013, pp. 191 – 199

SPATIAL DIVERSITY OF HUMAN CAPITAL IN THE EUROPEAN UNION

Iwona Skrodzka
Department of Econometrics and Statistics, University of Bialystok
e-mail: i.skrodzka@uwb.edu.pl

Abstract: The aim of this study is a comparative analysis of European Union countries in terms of human capital. Determination of the stock and prospects of human capital development is an important issue today, both in economic theory and business practice. In this study soft modeling method was used. It allows measurement of unobserved variables.

Keywords: human capital, economic development, soft modeling

INTRODUCTION

Human capital is a significant factor of economic growth [Próchniak 2006, pp. 320-323; Cichy, Malaga 2007, pp. 20-49; Florczak 2007, pp. 126-166]. Therefore, determination of the stock and prospects of human capital development is an important issue today, both in economic theory and business practice.

Human capital can be defined as a stock variable that represents the capacity of an individual, household, nation to generate a sustained flow of earned income [Dagum 2004, p. 1]. Furthermore human capital should be considered as a complex, multifaceted category with various intangible dimensions that are not directly observable and that cannot be measured with precision by a single attribute [Le, Gibson, Oxley 2005, p. 4; Łukasiewicz 2009, p. 96].

The aim of this study is to present spatial diversity of human capital in European Union countries in 2010[1]. In the article human capital is defined as an unobserved variable reflected by such components as: education, knowledge, skills, work experience and health embodied in region society [Domański 1993, p. 19; Marciniak 2000, pp. 157-158].

[1] Data availability influence the year choice.

The method which was used in this research is soft modelling[2]. Soft model enables to investigate the relationships among unobserved variables (latent variables). The values of these variables cannot be directly measured because the lack of a generally accepted definition or the absence of a clear way of measuring them. Soft model consists of two sub-models:

- the internal sub-model – a system of relationships among latent variables, which describes the relationship arising from the theory;
- the external sub-model – defines the latent variables based on observed variables, known as indicators.

Indicators allow indirect observation of latent variables. Latent variables can be define on the basis of deductive or inductive approach. Deductive approach assumes that indicators reflect latent variable. Inductive approach assumes that indicators form latent variable. The choice of approach depend on the theory or intuition of researcher [Rogowski 1990, pp. 25-26].

Thanks to soft model is possible to get synthetic measures of latent variables (as a weighted sum of indicators). One of the most important advantage of soft modelling method is that the construction of synthetic measure base not only on latent variable definition but also on relationships among other categories within model.

The parameters of soft model are estimated using partial least squares method (PLS). Statistical verification is done by Stone-Geisser test and "2s" rule[3].

In the literature description of the method can be found in Wold [1980], its generalization in Rogowski [1990] and examples of application in [Perło 2004, Skrodzka 2012]).

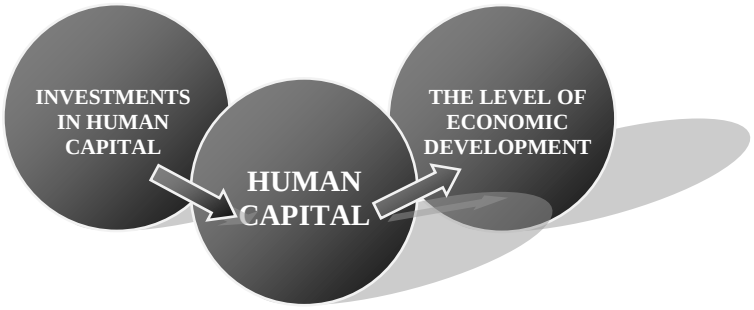
SPECIFICATION OF THE INTERNAL SUB-MODEL

Figure 1 presents the concept of internal sub-model. The concept assumes relationships among three unobserved categories: human capital, investments in human capital and the level of economic development. The first relationship assumes that human capital is a factor of economic development, the second – that human capital can be increased through investments.

[2] Soft modeling is a method proposed by Herman Wold [Wold 1980].

[3] Parameter is statistically significant when value of double error is higher than value of estimator.

Figure 1. The concept of internal sub-model



Source: own elaboration

Estimated model contains two following equations

$$HC_t = \alpha_1 IHC_{t-2} + \alpha_2 IHC_{t-1} + \alpha_3 IHC_t + \alpha_0 + \varepsilon \quad (1)$$

$$LED_t = \beta_1 HC_t + \beta_0 + \xi \quad (2)$$

where
HC – human capital,
IHC – investments in human capital,
LED – the level of economic development,
α_0, α_1, α_2, α_3, β_0, β_1 – structural parameters,
ε, ξ – error terms,
t – 2010.

SPECIFICATION OF THE EXTERNAL SUB-MODEL

Each of unobserved variables is defined by the group of indicators (see Table 1). Deductive approach is used to define above variables. Data use to specify the model were taken from World Bank[4] and Eurostat[5] and they refer to period 2008-2010. Many indicators are covered in databases. The analysis of all indicators would be unclear and difficult to interpret, hence the selection is necessary. The criteria are following:

- universality (commonly respected indicators),
- comparability (indicators as coefficients of intensity),
- variety (coefficient of variation higher than 10%).

[4] http://data.worldbank.org/
[5] http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/themes

Table 1. Indicator of latent variables

Latent variable	Indicator	Meaning	Source[6]
HC	HC01	Persons with tertiary education attainment (%).	E
	HC02	Employees with tertiary education attainment (%).	E
	HC03	Life-long learning of persons aged 25-64 (%).	E
	HC04	Human resources in science and technology (per 100 thous. people).	E
	HC05	Researchers in R&D (per million people).	WB
	HC06	Patent applications (per million people).	WB
	HC07	Percentage of people declaring their health as very good (%)	E
	HC08	Life expectancy at birth (years).	WB
	HC09	Mortality rate, neonatal (per 1000 live births).	E
IHC	IHC01	Total public expenditure on education (% of GDP).	E
	IHC02	Total public expenditure on education (PPS, per capita).	E
	IHC03	Total expenditure on health (% of GDP).	WB
	IHC04	Total expenditure on health (PPS, per capita).	WB
	IHC05	Total expenditure on R&D (% of GDP).	E
	IHC06	Total expenditure on R&D (PPS, per capita).	E
LED	LED01	Gross domestic product (PPS, per capita).	WB
	LED02	Gross value added (euro, per employee).	E
	LED03	The share of agriculture in gross value added (%).	E
	LED04	The share of services in gross value added (%).	E
	LED05	Unemployment rate (%).	WB

Source: own elaboration

Internal model of HC latent variable contains nine indicators. They reflect: education, knowledge, skills and health embodied in the society of the country. One of them (HC09) is destimulant. Internal model of INHC latent variable contains six observed variables which refer to investments in education, health and knowledge. All of them are stimulants. Internal model of LED latent variable contains five indicators. They reflect economic potential of country. Two of them (LED03, LED05) are destimulant.

ESTIMATION RESULTS

Model presented on Figure 1 was estimated using the PLS software created by J. Rogowski[7]. Table 2 contains weight and loadings estimates with regard to

[6] WB – World Bank, E – Eurostat.

[7] PLS software is available at Faculty of Economics and Management University of Bialystok.

external sub-model. All parameters are statistically significant[8]. Moreover, results are consistent with expectations. Stimulants have positive weights and loadings, destimulants have negative ones.

Table 2. Estimates of weights and loadings of the external model

Latent variable	Indicator	Loading	Weight
HC_t	HC01	0,7509	0,1370
	HC02	0,5965	0,0890
	HC03	0,8025	0,1864
	HC04	0,8428	0,1829
	HC05	0,6594	0,1342
	HC06	0,6324	0,1607
	HC07	0,4017	0,1125
	HC08	0,7016	0,2151
	HC09	-0,7811	-0,1973
IHC_t	IHC01	0,6017	0,1647
	IHC02	0,7222	0,1454
	IHC03	0,8462	0,2018
	IHC04	0,8665	0,2196
	IHC05	0,9201	0,2366
	IHC06	0,9285	0,2337
IHC_{t-1}	IHC01	0,5539	0,1570
	IHC02	0,6774	0,1394
	IHC03	0,8550	0,2060
	IHC04	0,8888	0,2248
	IHC05	0,9281	0,2408
	IHC06	0,9359	0,2342
IHC_{t-2}	IHC01	0,5005	0,1425
	IHC02	0,7290	0,1618
	IHC03	0,8686	0,2075
	IHC04	0,8803	0,2201
	IHC05	0,9229	0,2418
	IHC06	0,9274	0,2303
LED_t	LED01	0,9198	0,2241
	LED02	0,9018	0,2271
	LED03	-0,9104	-0,2411
	LED04	0,7658	0,1858
	LED05	-0,5303	-0,0909
	LED06	-0,7746	-0,2312

Source: own calculation

[8] Doubled standard deviation calculated by Tukey cut method were less than the value of the estimator.

Indicators HC04 and HC03 are the most strongly correlated with HC variable. Indicators HC09, HC01 and HC08 have strong influence on HC variable. Indicators HC07 reflects HC variable poorly. To sum up knowledge is the most significant component of human capital in UE-27 countries.

All indicators reflect IHC variable strongly. Indicators connected with R&D sector (IHC05 and IHC06) have the highest influence on IHC variable.

Equations (3) and (4) present estimations of internal relations. Standard deviations calculated basing on Tukey cut method are given in brackets.

$$\underset{}{\hat{HC}_t} = \underset{(0,0196)}{0,5612}IHC_{t-2} + \underset{(0,0317)}{0,2580}IHC_{t-1} + \underset{(0,0456)}{0,0922}IHC_t + \underset{(0,1012)}{5,0458} \tag{3}$$

$$\underset{}{\hat{LED}_t} = \underset{(0,0291)}{0,7678}HC_t - \underset{(0,3532)}{4,6541} \tag{4}$$

Signs of estimators are consistent with expectations. Moreover, all parameters are statistically significant („2s" rule). Coefficient of determination (R^2) have value 0,8 for the equation (3) and value 0,6 for the equation (4). General Stone–Geisser test is equal to 0,36[9]. The model can be verified positively.

Investments in human capital (in 2008, 2009 and 2010) influence on the stock of human capital positively. Investments in 2008 have the highest impact on the stock of human capital, investments in 2010 – the lowest. Furthermore, correlation between human capital and the level of economic development is high and positive. It is possible to claim that countries which invested more in human capital had the higher stock of human capital in 2010. Moreover countries which had the higher stock of human capital, had also the higher level of economic development in 2010.

HUMAN CAPITAL IN EUROPEAN UNION COUNTRIES

Partial Least Square method used to soft model estimation provides calculations of latent variable values. These values can be treated as synthetic measure and used for comparative analysis.

Figure 2 presents diversity of investments in human capital in European Union in 2008. Countries were divided into four groups which were constructed basing on parameters of synthetic measure (z_i): average $(\bar{z})$ and standard deviation (s_z) [Nowak, 1990, pp. 92-93]:

- I group – very high investments in human capital: $z_i \geq \bar{z} + s_z$,
- II group – high investments in human capital: $\bar{z} \leq z_i < \bar{z} + s_z$,

[9] Stone-Geisser test measures prognostic property of soft model. Its values are in the range from -∞ to 1. Positive (negative) value of this test indicates high (poor) quality of model.

- III group – medium and low investments in human capital: $\bar{z} - s_z \leq z_i < \bar{z}$,
- IV group – very low investments in human capital: $z_i < \bar{z} - s_z$.

Denmark, Sweden, Finland, Austria, Luxemburg and Netherlands were the biggest investors in human capital in 2008. The second group is composed of: Belgium, Germany, France, Ireland and United Kingdom. Slovenia, Spain, Portugal, Cyprus, Italy, Greece, Malta, Estonia, Czech Republic and Hungary were classified to third group. The rest of countries, including Poland was classified to the last group with low investments in human capital.

Figure 2. Diversity of investments in human capital in European Union in 2008

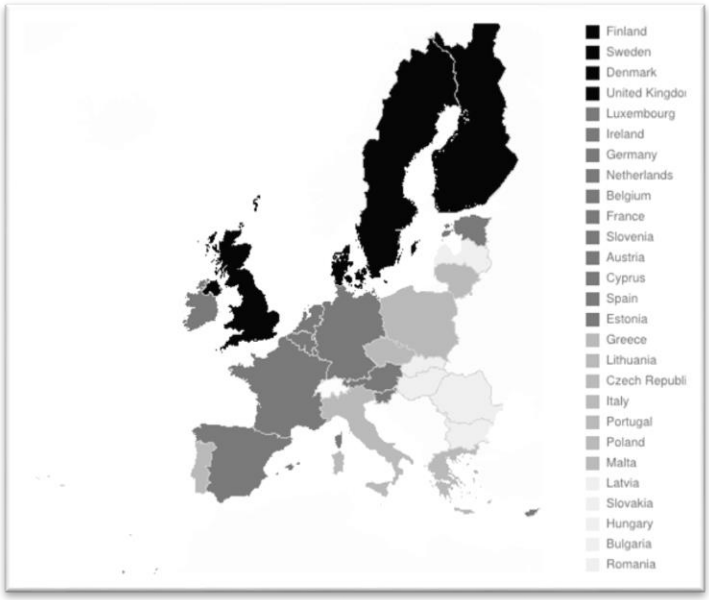
Source: own elaboration

Diversity of human capital in European Union in 2010 is shown in Figure 3. Countries were divided into four groups:

- I group – very high stock of human capital,
- II group – high stock of human capital,
- III group – medium and low stock of human capital,
- IV group – very low stock of human capital.

The highest stock of human capital was concentrated in Finland, Sweden, Denmark and United Kingdom. Luxemburg, Ireland, Germany, Netherlands, Belgium, France, Slovenia, Austria, Cyprus, Spain and Estonia were located in the second group. Greece, Lithuania, Czech Republic, Italy, Portugal, Poland and Malta build third group. The rest of countries was classified to the last group with very low stock of human capital.

Figure 3. Diversity of human capital in European Union in 2010



Source: own elaboration

SUMMARY

The presented soft model has enabled to analyze spatial diversity of human capital and investments in human capital in European Union countries. The rankings of countries were created thanks to estimated values of latent variables. Some conclusions and remarks can be formulated according to the results of this study:

- knowledge is the most significant components of human capital in UE-27,
- expenditures on R&D sector are the most significant form of investing in human capital in UE-27,
- investments in human capital influence on the human capital stock positively in UE-27,
- human capital have positive influence on the level of economic development in UE-27,
- the highest stock of human capital in 2010 was concentrated in Finland, Sweden, Denmark and United Kingdom,
- Denmark, Sweden, Finland, Austria, Luxemburg and Netherlands were the biggest investors in human capital in 2008.

REFERENCES

Cichy K., Malaga K. (2007) Kapitał ludzki w modelach i teorii wzrostu gospodarczego, [in:] M. Herbst (ed.), Kapitał ludzki i kapitał społeczny a rozwój regionalny, Wydawnictwo Naukowe „Scholar", Warszawa.

Dagum C. (2204) Human capital. Encyclopedia of Statistical Sciences, John Wiley & Sons, pp. 1-12.

Domański S. R. (1993) Kapitał ludzki i wzrost gospodarczy, PWN, Warszawa.

Florczak W. (2007) Kapitał ludzki a rozwój gospodarczy, [in]: W. Welfe (ed.) Gospodarka oparta na wiedzy, Polskie Wydawnictwo Ekonomiczne, Warszawa.

Le T., Gibson J., Oxley L. (2005) Measures of Human Capital: A Review of the Literature, Working Paper 05/10, New Zealand Treasury, New Zealand.

Łukasiewicz G. (2009) Kapitał ludzki organizacji. Pomiar i sprawozdawczość, PWN, Warszawa.

Marciniak S. (2000) Innowacje i rozwój gospodarczy, Kolegium Nauk Społecznych i Administracji Politechniki Warszawskiej, Warszawa.

Nowak E. (1990) Metody taksonomiczne w klasyfikacji obiektów społeczno-gospodarczych, PWE, Warszawa.

Perło D. (2004), Źródła finansowania rozwoju regionalnego, Wydawnictwo Wyższej Szkoły Ekonomicznej w Białymstoku, Białystok

Próchniak M. (2006) Czynniki wzrostu gospodarczego – wnioski z badań empirycznych, Ekonomista, no 3.

Rogowski J. (1990) Modele miękkie. Teoria i zastosowanie w badaniach ekonomicznych, Wydawnictwo Filii UW w Białymstoku, Białystok.

Skrodzka I. (2012) Zastosowanie modelowania miękkiego do pomiaru kapitału ludzkiego, rozprawa doktorska, Uniwersytet w Białymstoku, Białystok [maszynopis niepublikowany].

Wold H. (1980) Soft Modelling: Intermediate between Traditional Model Building and Data Analysis, Banach Centre Publication 6, Mathematical Statistics.