A C T A U N I V E R S I T A T I S L O D Z I E N S I S
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STATISTICAL ANALYSIS OF EFFICIENCY OF THE PENSION SYSTEMS IN EU AND EFTA COUNTRIES

Abstract. In the paper we present the results of the empirical analysis of the level of pension systems' efficiency and a classification of pension systems' efficiency of the EU and EFTA countries in the years 2005–2007. In the mentioned analysis we use the linear ordering methods, the cluster analysis and the statistical data on adequacy, sustainability and modernization of pension systems from the EUROSTAT and OECD database. We discuss the position of the Polish pension system in comparison with other countries and the group of similar pension systems.

Key words: adequacy, sustainability and modernization of pension systems; pension systems' efficiency; linear ordering methods; synthetic measure; cluster analysis; EU and EFTA countries.

I. ANALYSIS OF PENSION SYSTEMS' EFFICIENCY

The analysis of pension systems' efficiency and their classification from the point of view of efficiency is a relatively new problem in the literature of the subject. The aim of the paper is to present the results of both theoretical considerations and empirical research on the level of pension systems' efficiency in the EU and EFTA countries. The paper presents results of linear ordering and clustering of pension systems (taking efficiency into account), as well as results of maps for the objects. The analysis carried out in the years 2005–2007 encompassed 25 EU and 2 EFTA countries (Iceland and Norway).

An attempt to define and measure the level of efficiency of pension systems in the EU and EFTA countries requires considering aims, functions, effects and conditions of pension systems. A pension system is said to be effective when, thanks to pensions, it performs the basic and desired socio-economic functions. So the initial aims for which it was founded, which are defined as adequacy, sustainability and modernization, are fulfilled. Moreover, an effective pension system should: exert a neutral influence on other sectors of economy, when it comes

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to some additional effects it produces, and minimize the (possible) negative aspects of its influence on the remaining spheres of economy.

Table 1. Diagnostic features in the area of pension systems' efficiency

NO.	Sign	Variable type	Aims of pension system / variable
Adequate pensions			
1	A13	S	Aggregate rate of replacing income with pensions (65–74/50–59)
2	A16	D	The average, unit cost of poverty reduction among people aged 65+ through pensions (according to *PPS*) – measure proposed by the author
3	A24	D	Inequality of income distribution S80/S20
Sustainable pension system			
4	W11	S	Employment rate of people aged 55–64 (w %)
5	W21	D	Indicator of administrative costs of pension system
6	W31	D	Partial coefficient of demographic burden (65+/15–64)
Suitable for modernization pension system			
7	M11	D	Difference in poverty rate of elderly people aged 65+ after "pension transfers", by sex *(at 60% of median national equivalent income)* – measure proposed by the author
8	M12	D	Difference in median of relative income (65+/02–64) by sex
9	M13	D	Difference in aggregate rate of replacing income with pension by sex (65–74/50–59).

a Variable type: S – stimulant, D – destimulant.
Source: Own elaboration.

On the basis of the literature e.g. the economics of pension systems, Barr (2004); documents and reports in the area of Open Method of Coordination (OMC) of pension systems, *Quality and viability of pensions…* (2001), *Portfolio of overarching indicators…* (2008); the World Bank and OECD reports focusing on problems of pension systems, Holzmann *et al.* (2005, 2008) and other papers, we constructed a database of ca 30 potential indicators with the aim of analyzing 27 countries (EU and EFTA). The data collected within the framework of the European research on: Income, Social Inclusion and Living Conditions (EU-SILC) were of prime importance to the analysis. A set of 21 variables in the area of adequacy, sustainability and modernization of pension systems was adopted as a set of admissible variables. However, as a result of initial data analysis – evaluation of variability and correlation of characteristics – the number of variables was limited from 21 to 9 diagnostic features (Table 1).

II. LINEAR ORDERING OF PENSION SYSTEMS

The analysis included 10 results of linear ordering of pension systems with respect to efficiency (Table 2). They come from taking into consideration equal and correlative measures for variables and use of different methods of characteristics' normalization, Domański *et al*. (1998). The sum of values of characteristics, Grabiński *et al.* (1989), was adopted as a formula of variables' aggregation needed for construction of synthetic measure. The quality of result of systems' ordering was assessed with the use of direction variance of synthetic variable which evaluates the result of linear ordering on the basis of orthogonal projection of points (systems) onto the straight line, Kolenda (2006), Mikulec (2008).

Table 2. Quality of results assessment of pension systems' linear ordering

SPECIFICATION	System of weights	Normalization	Assessment criterion – direction variance of measure M^*		
			2005	2006	28007
Variant 1	equal	zero unitarization $\langle 0;1\rangle$	0,0390	0,0376	0,0501
Variant 2	equal	unitarization by range $\langle -1;0\rangle$	0,0390	0,0376	0,0501
Variant 3	equal	unitarization: $a_j = 0$, $b_j = \max_i x_{ij} - \min_i x_{ij}$	0,0390	0,0376	0,0501
Variant 4	**equal**	standardization: $a_j = \bar{x}_j$, $b_j = s_j$	**0,5810**	**0,6045**	**0,7884**
Variant 5	**equal**	standardization: $a_j = 0$, $b_j = s_j$	**0,5810**	**0,6045**	**0,7884**
Variant 6	correlational	zero unitarization $\langle 0;1\rangle$	0,0334	0,0321	0,0467
Variant 7	correlational	unitarization by range $\langle -1;0\rangle$	0,0334	0,0321	0,0467
Variant 8	correlational	unitarization: $a_j = 0$, $b_j = \max_i x_{ij} - \min_i x_{ij}$	0,0334	0,0321	0,0467
Variant 9	correlational	standardization: $a_j = \bar{x}_j$, $b_j = s_j$	0,4942	0,5180	0,7022
Variant 10	correlational	standardization: $a_j = 0$, $b_j = s_j$	0,4942	0,5180	0,7022

Source: Own elaboration.

The best ordering of pension systems' efficiency and assessment of results' quality, were obtained for variants 4 and 5. The system of equal weights for diagnostic characteristics and standardization of diagnostic variables was adopted for them. Table 3 presents detailed results of linear ordering of pension systems (variant 5) in the years 2005–2007.

Table 3. Detailed results of pension systems' ordering in the years 2005–2007

PENSION SYSTEM	Synthetic variable M	Position	Synthetic variable M^*	Direction variance of measure M^*	PENSION SYSTEM	Synthetic variable M	Position	Synthetic variable M^*	Direction variance of measure M^*
1	2	3	4	5	6	7	8	9	10
THE YEAR 2005									
Slovakia	3,766	1	1,807	3,2667	Germany	3,110	15	–0,160	0,0257
Iceland	3,699	2	1,607	2,5813	Portugal	3,077	16	–0,260	0,0677
Luxembourg	3,476	3	0,937	0,8788	Norway	3,070	17	–0,280	0,0786
Sweden	3,475	4	0,937	0,8770	Austria	3,045	18	–0,355	0,1257
Hungary	3,420	5	0,769	0,5918	Estonia	3,043	19	–0,360	0,1299
Czech Republic	3,377	6	0,641	0,4105	Denmark	3,038	20	–0,376	0,1415
Finland	3,303	7	0,420	0,1766	Lithuania	2,979	21	–0,553	0,3056
Spain	3,258	8	0,284	0,0809	Latvia	2,925	22	–0,715	0,5109
Malta	3,254	9	0,271	0,0734	Greece	2,895	23	–0,805	0,6474
Holland	3,233	10	0,209	0,0436	France	2,876	24	–0,863	0,7450
United Kingdom	3,214	11	0,152	0,0230	Ireland	2,835	25	–0,985	0,9705
Cyprus	3,193	12	0,089	0,0079	Italy	2,761	26	–1,207	1,4578
Belgium	3,179	13	0,048	0,0023	Slovenia	2,760	27	–1,210	1,4646
Poland	**3,150**	**14**	**–0,041**	**0,0017**	**SUM**	*x*	*x*	*x*	**0,5810**
THE YEAR 2006									
Luxembourg	3,491	1	1,901	3,6154	Malta	2,853	15	–0,011	0,0001
Slovakia	3,281	2	1,272	1,6178	Lithuania	2,825	16	–0,096	0,0093
Iceland	3,241	3	1,153	1,3292	**Poland**	**2,797**	**17**	**–0,180**	**0,0326**
Sweden	3,106	4	0,747	0,5581	Holland	2,748	18	–0,327	0,1071
Finland	3,09	5	0,700	0,4901	France	2,741	19	–0,346	0,1200
Cyprus	3,055	6	0,594	0,3527	Belgium	2,724	20	–0,399	0,1592
Spain	3,031	7	0,523	0,2733	Austria	2,721	21	–0,409	0,1670
United Kingdom	3,016	8	0,478	0,2285	Portugal	2,686	22	–0,513	0,2634
Czech Republic	2,947	9	0,269	0,0724	Greece	2,653	23	–0,610	0,3724
Norway	2,896	10	0,118	0,0139	Slovenia	2,546	24	–0,933	0,8699
Hungary	2,883	11	0,078	0,0062	Latvia	2,416	25	–1,324	1,7519
Germany	2,873	12	0,049	0,0024	Italy	2,405	26	–1,356	1,8394
Denmark	2,867	13	0,032	0,0010	Ireland	2,378	27	–1,438	2,0665
Estonia	2,866	14	0,029	0,0008	**SUM**	*x*	*x*	*x*	**0,6045**
THE YEAR 2007									
Iceland	3,628	1	2,100	4,4095	Holland	2,902	15	–0,078	0,0060
Luxembourg	3,343	2	1,246	1,5526	Malta	2,884	16	–0,133	0,0177
Norway	3,336	3	1,224	1,4977	Portugal	2,880	17	–0,144	0,0207
Slovakia	3,241	4	0,938	0,8801	Germany	2,848	18	–0,240	0,0577
Czech Republic	3,197	5	0,805	0,6487	Austria	2,844	19	–0,253	0,0638
Hungary	3,125	6	0,590	0,3479	Belgium	2,842	20	–0,258	0,0665

Table 3 (cont.)

1	2	3	4	5	6	7	8	9	10
Finland	3,116	7	0,563	0,3173	Cyprus	2,794	21	–0,401	0,1608
Poland	**3,110**	**8**	**0,546**	**0,2983**	Greece	2,716	22	–0,635	0,4038
Sweden	3,081	9	0,459	0,2109	Lithuania	2,684	23	–0,733	0,5372
Spain	3,030	10	0,305	0,0928	Latvia	2,587	24	–1,023	1,0456
France	2,963	11	0,103	0,0107	Ireland	2,477	25	–1,354	1,8331
Denmark	2,935	12	0,021	0,0004	Slovenia	2,451	26	–1,433	2,0528
Estonia	2,934	13	0,017	0,0003	Italy	2,202	27	–2,180	4,7515
United Kingdom	2,910	14	–0,054	0,0029	**SUM**	*x*	*x*	*x*	**0,7884**

Source: Own elaboration.

The obtained results show that the position of Polish pension system, with respect to the general social efficiency of the system's functioning, has improved. However, the fact that in the years 2006–2007 Polish pension system moved from the 17 to the 8 position in the list can be mainly attributed to deterioration and/or lack of improvement in values of diagnostic features of the remaining pension systems.

When we analyze changes in values of characteristics of pension systems in respective countries in the ranking list for the years 2006–2007 we can see that:

- Polish pension system recorded: a fall in the value of 3 diagnostic features, a rise in the value of 4 variables and no change in the value of 2 diagnostic features.
- Simultaneously, the overall structure of changes in values of characteristics for all analyzed pension systems was as follows: in 43% of cases an improvement in the value of the examined characteristic was observed; in 48% of cases a deterioration of value of characteristics occurred, and in 9% of cases the value remained on the same level.

When we examine changes in positions of particular countries' pension systems in the ranking list for the years 2006–2007 we can observe the following:

- Polish pension system recorded a lower position in the ranking list with respect to just 1 variable, a higher position in the ranking list in case of 6 variables, and no change in position for 2 diagnostic variables.
- Simultaneously, the general level of change of position in the ranking list for all the examined pension systems (27 countries and 9 variables) looks as follows: in 36% cases both an increase and a decrease in the position were observed, and in 28% cases no change in the position in the ranking list was noted.

III. CLASSIFICATION OF PENSION SYSTEMS

The analysis of clusters of pension systems in 27 EU and EFTA countries, which was carried out with the use of agglomerative methods for the year 2005 enabled to distinguish 3 groups of countries with similar systems' efficiency. For the following year a few variants of very similar systems' classifications, which consisted of either 4 or 6 clusters, were obtained. For 2007 we distinguished 7 groups of countries, whose pension systems were characterized by a similar efficiency.

Taking into consideration the quality of classification, results of replication analysis, properties of particular methods and theoretical division of pension system it was decided to accept the Ward's method with squared Euclidean distance as the final result of systems' clustering for the year 2005[1]:

- Cluster 1: Belgium, Malta, Spain, Portugal, Iceland, Ireland, Finland, Germany, Slovenia and Greece.
- Cluster 2: Denmark, Cyprus, United Kingdom, Luxembourg, Austria, Norway, France, Italy, Holland and Sweden.
- Cluster 3: Czech Republic, Hungary, Slovakia, Estonia, Lithuania, Latvia and Poland.

For 2006 a division into 6 clusters of systems obtained with the use the complete link method with general distance measure (GDM) was adopted as the final result of cluster analysis:

- Cluster 1: Belgium, Iceland, Spain, Portugal and Finland.
- Cluster 2: Denmark, Cyprus and United Kingdom.
- Cluster 3: Ireland, France and Sweden.
- Cluster 4: Italy, Luxembourg, Holland, Austria and Norway.
- Cluster 5: Czech Republic, Estonia, Lithuania, Latvia, Hungary, Slovakia and Poland.
- Cluster 6: Germany, Greece, Malta and Slovenia.

And finally, for 2007 the division into 7 clusters obtained with the use of the group average method with squared Euclidean distance turned out to be the best, when quality (silhouette index) and stability of result of clustering (replication analysis) are taken into account:

- Cluster 1: Belgium, Finland and Iceland.
- Cluster 2: France, Italy, Sweden, Luxembourg, Holland and Austria.
- Cluster 3: Denmark, Ireland and Cyprus.
- Cluster 4: United Kingdom.
- Cluster 5: Czech Republic, Slovenia and Greece.
- Cluster 6: Germany, Spain, Malta, Portugal and Norway.
- Cluster 7: Estonia, Poland, Hungary, Latvia, Lithuania and Slovakia.

[1] Underlining denotes a pension system whose values of diagnostic features are close to average values of features in a given cluster.

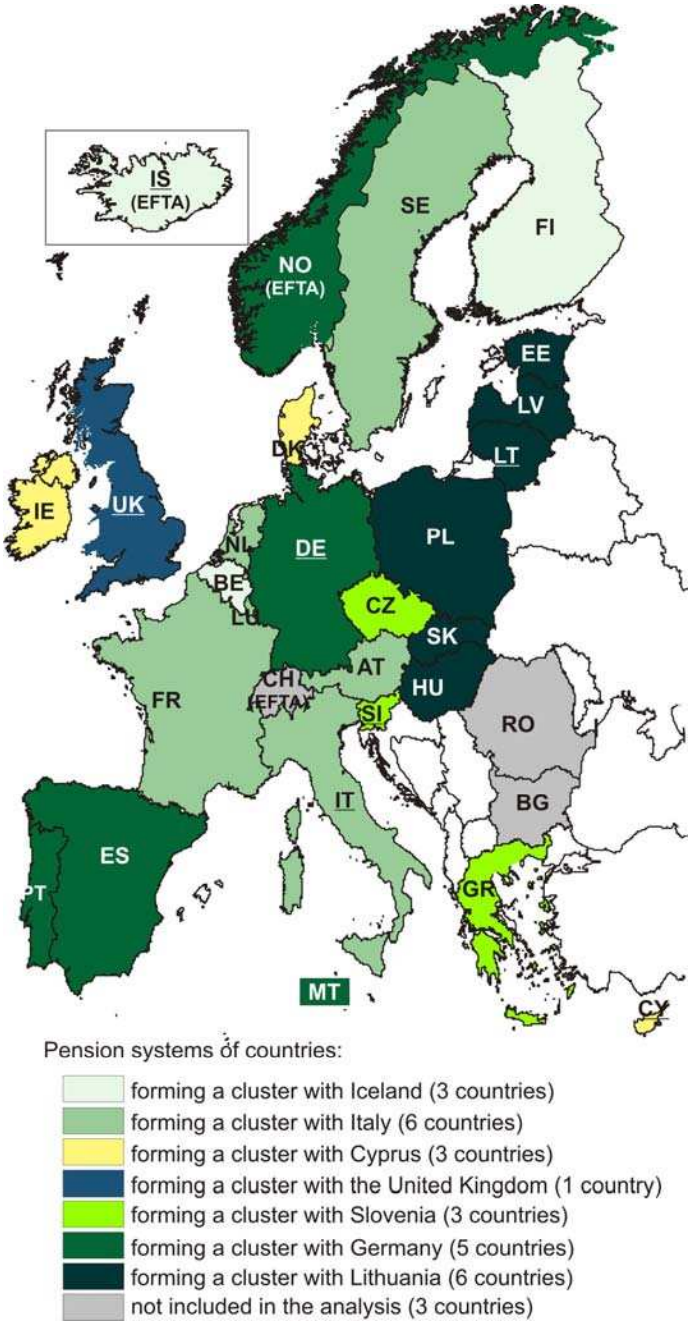

Figure 1. Results of cluster analysis of pension systems in 27 EU and EFTA countries for 2007

Source: Own elaboration.

The results of clustering carried out between 2005 and 2007 show that the countries of Central and Eastern Europe which form the following cluster: Estonia, Lithuania, Latvia, Poland, Slovakia, Hungary, (Czech Republic) show one common characteristic i.e. similar pension systems' efficiency.

IV. MAP OF PENSION SYSTEMS

The problem which arises when we conduct comparative analysis of results of systems' linear ordering is reduced to two issues. Firstly, even for systems which are close to each other in the ranking it is difficult to assess significance of differences between their positions. Secondly, the systems which are close to each other are not necessarily similar. An extended analysis of systems is enabled by a map of objects, Kolenda (2006), or a diagram which combines the results of objects' ordering based on a proper synthetic measure and squared Euclidean distance between systems (Figure 2, the only criterion for analysis is similarity to Polish pension system).

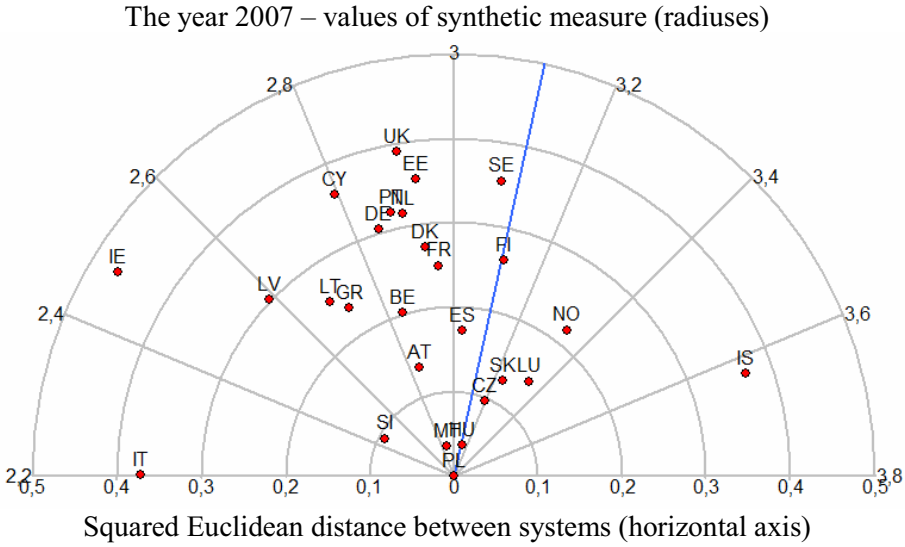

Figure 2. Efficiency of Polish pension system in comparison with EU and EFTA countries
Source: Own elaboration – programme Numerical Taxonomy 2006, Kolenda (2006).

When the analysed efficiency is taken into consideration then in the years 2005–2007 Polish pension system showed the greatest similarity to the system of Hungary (HU), and then to the system of the Czech Republic (CZ), or Slovakia

(SK) – excluding Malta (MT) and Luxembourg (LU). Interestingly, the system most similar to Polish, with respect to efficiency, was the system of Slovenia (SI), the country which occupies lower position in the ranking list.

V. CONCLUSIONS

When we sum up the results of analysis in the area of linear ordering and pension systems' clustering with respect to their efficiency in the period of 2005–2007 it is worth noting the level of significance of changes which occurred. In order to analyse similarities of rankings Walesiak W^2 measure was used, Gatnar, Walesiak (2004), and the τ-Kendall correlation coefficient (sequence) of ranks, Ferguson, Takane (2007), was applied. In order to assess similarity of clustering results the adjusted Rand's index, Rand (1971) was used.

The Walesiak measure, calculated on the basis of value of synthetic measure for the years 2005 and 2007, $W^2_{05/07} = 0{,}085$ and for the years 2006 and 2007, $W^2_{06/07} = 0{,}034$ was close to zero, which shows insignificant differences (great similarity) between rankings. On the other hand, the average deviation in value of synthetic variable for pension systems in the years under investigation amounted to $\sqrt{W^2_{05/07}} = 29{,}1\%$, and $\sqrt{W^2_{06/07}} = 18{,}6\%$. The τ-Kendall correlation coefficient determined on the basis of positions of pension systems in the rankings confirmed similarity between rankings at the level $\tau_{05/07} = 59{,}5\%$ and $\tau_{06/07} = 62{,}4\%$. However, the adjusted Rand's index, which assesses similarity of results of analysis of pension systems clusters, pointed at „average " consistency of clustering results which achieved $ARI_{05/07} = 44{,}8\%$ and $ARI_{06/07} = 50{,}7\%$, respectively.

When we consider both the obtained results and development of theoretical models of social policy after the year 2000, which indicate the necessity of distinguishing 6 or more models of similar systems, we need to accept the result of linear ordering and cluster analysis for the years 2006 and 2007 as the final result of analysis of pension systems' efficiency.

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STATYSTYCZNA ANALIZA EFEKTYWNOŚCI SYSTEMÓW EMERYTALNYCH W KRAJACH UE I EFTA

W artykule przedstawione zostały wyniki empirycznej analizy stopnia efektywności i klasyfikacji systemów emerytalnych krajów UE i EFTA w latach 2005–2007. W przedmiotowej analizie wykorzystano metody porządkowania liniowego i klasyfikacji (analizy skupień) oraz dane statystyczne z zakresu adekwatności, stabilności i modernizacji systemów emerytalnych poszczególnych krajów, pochodzące z bazy danych EUROSTAT i OECD. Omówiona została pozycja polskiego systemu emerytalnego na tle systemów analizowanych krajów oraz grupy systemów podobnych.