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Pension Adequacy Networks across Europe

Abstract: Europe's population is ageing. This is associated with increasing challenges for pension systems and the need to search for solutions that will allow countries to generate adequate pension benefits. The aim of the article is to present a complex network typology of adequate pension benefits in European countries. Social networks have been used as a research method. The study has taken into account the network typology resulting from pension factors such as seniority, the retirement age, the number of children, and the duration of education, separately for women and men. The correlation between networks has also been checked. The most unusual network is for the number of children among retired people. The networks for seniority and for the retirement age are the most similar to each other among all the factors examined. The obtained results show that pension systems constructed in the same way have similar patterns of the level of pension factors. Gender does not appear to differentiate connection patterns for the examined variables.

Keywords: adequacy, pension benefit, retirement age, seniority, social network analysis

JEL: C18, H55, J32

1. Introduction

Europe's population is getting older. The share of the elderly in 2020 equalled 21% of the population, as compared with 2001, when people aged 65 and over constituted 16% of the total population. It means an increase of 5 percentage points (Eurostat, 2021). This process, known as the ageing of the population, has numerous consequences. Pensioners become a very numerous, and thus strong, social group that influences the functioning of the state. As a result, the way the entire society functions changes. Also, political reasons change, and economic changes occur. One of the most important economic factors for this group of people and, at the same time, for the entire economy is the need to ensure protection against poverty for pensioners after they have finished their work and to maintain their previous standard of living (European Commission, 2012a). This, in turn, is mainly associated with the need to generate an adequately high income during retirement, and it is pensions that constitute the basic income of the elderly. Retirement benefits which enable the maintenance of an earlier standard of living are called 'adequate,' the term broadly used in reports prepared by the European Commission (2010; 2012a; 2012b; 2015; 2018), the World Bank (1994), and Holzmann, Hinz, and Dorfman (2008).

It is necessary to monitor the extent to which pension systems fulfil the function of providing adequate benefits to pensioners. An awareness of the current state of pension systems will make it possible to introduce quick changes to correct any future problems. Since it is worth learning from the best, the Open Method of Coordination (OMC), which is used between countries and allows for an exchange of experiences, is implemented to improve the quality of pension systems operation (European Commission, 2010). According to Mercer reports, current pension systems deal with the problem of adequate benefits in a variety of ways (MMGPI, 2014; 2015; 2017; 2019).

Pension benefits are influenced by a number of factors, as OECD documents Pension at a Glance have shown (OECD, 2005; 2007; 2009; 2011; 2013; 2015; 2017; 2019). These are factors directly used in the calculation of benefits, such as the retirement age and seniority. However, it is also important to remember about the factors that affect the benefits indirectly, such as the number of children or the duration of education. They have a significant impact on how long a person works, what breaks he or she has, and the level of salary he or she receives as indicated by Draxler (2009), Belloni and Fornero (2008), and Ponomarenko (2016). Therefore, it is worth conducting a study on the adequacy of retirement benefits separately for these factors.

Seniority has a direct impact on the level of benefits, as it translates into the length of time of pension capital accumulation. In many systems, we have a regulatory minimum length of seniority at which a participant of the system is eligible to receive a pension benefit. Hence, longer work is associated with a higher future pension.

The retirement age in the calculation of retirement benefits in Define Contribution schemes, which prevail in Europe, is one of the main parameters used to calculate the benefit. As a rule, its statutory level still varies significantly for women and men, which means that analyses of the adequacy of retirement benefits should be carried out separately on the grounds of gender (Belloni, Fornero, 2008; Jędrzychowska, Kwiecień, Poprawska, 2020). Systemic regulations generally allow pensioners to postpone retirement and contain a number of incentives to do so. Postponement of the ending of professional work significantly affects the future pension benefit. Each additional year of professional work means a higher pension.

The number of children does not directly affect the level of pension benefit. However, with a higher number of children, the time that a person can spend at work is shortened, which in turn means shorter seniority, and often, as a consequence, lower pension benefits. Having children is therefore a factor that is negatively correlated with the level of future benefit and its adequacy. This situation occurs from a microeconomic point of view, and it concerns a given person. However, looking at the pension system from a macroeconomic point of view, one should be aware that every pension benefit constitutes the result of the distribution of a current national income (Góra, 2003). This means that only pension systems in which many people pay contributions, i.e. systems in the countries that have a young demographic structure, are able to generate correspondingly high pension benefits.

The duration of education is a variable connected to the level of pension benefits due to the anticipated level of future wages from which pension contributions will be paid. More specifically, a longer education duration may mean achieving the level of higher education, and thus a higher future potential level of wages. At the same time, however, extending the duration of education may have an impact on shortening the length of seniority.

The following hypotheses can therefore be accepted: firstly, awareness of the consequences of extending seniority, raising the retirement age, having a small number of children, and extending the duration of education for the level of pension benefits is reflected in the actions taken by pensioners in European countries; secondly, in pension systems with the same construction, the value of pension factors is similar.

The article aims to present a network typology of adequate pensions in European countries. The typology is shown on the basis of various retirement factors. Economic networks and values of measures at the macro and micro levels as well as correlations between networks have been used as a research tool. The analysis carried out in the study can help to answer the question what economic, social and demographic behaviour of participants in the pension system most often leads to adequate retirement benefits.

Taking into account the differentiation of the shape of pension systems, it is very difficult to directly compare existing methods of calculation (Chybalski, 2016). Therefore, methods that are resistant to specific system properties are useful in such studies. Such a method is social network analysis (SNA). Therefore, the study of the adequacy of retirement benefits from the point of view of the similarity between countries in terms of level, and more specifically the schemes of retirement features, was carried out with the use of networks. Another reason for using networks is, as research has shown, the fact that the social network structure has an impact on economic innovation performance (Muller, Peres, 2019).

Network analysis has been carried out in three areas:

- the micro-level area, which refers to individual nodes and their relationships in the network; such an analysis allows you to obtain information about individual countries occurring in the network;
- the macro-level area, which concerns the entire network; such an analysis allows you to obtain information about the entire network as a whole;
- the area of connections and correlations between networks.

The application of the SNA method to the analysis of classic economic values is part of the concept of new methods of analysis or creation of new business models. We can include such an approach in the scope of Industry 4.0, which is a broad term, and different authors interpret it in many contexts (Maresova et al., 2018).

2. Materials and methods

The data used in the study come from the 7 Wave of SHARE 50+[1] called SHARELIFE (Börsch-Supan et al., 2013; Bergmann, Scherpenzeel, Börsch-Supan, 2019; Börsch-Supan, 2022). SHARELIFE focuses on people's life histories, including all important areas of respondents' lives and detailed questions on work history. Respondents from 28 European countries were interviewed. From the studied population we separated people who were retired. Subsequently, people who gave the value of their last wage and the first pension were distinguished. This allowed us to estimate an indicator called the individual rate of replacement of wage with a pension benefit *RR* (European Commission, 2018).

$$RR = \frac{\text{first pension}}{\text{lat wage}}. \quad (1)$$

1 This paper uses data from SHARE Waves 7 (https://doi.org/10.6103/SHARE.w7.700), see Börsch-Supan et al., 2013 for methodological details.

It is one of the best measures describing the level of pensions, allowing for a comparison between different countries or systems (Borella, Fornero, 2009; Chybalski, Marcinkiewicz, 2016). In the next step, we selected pensioners who receive adequate pension benefits. An adequate pension benefit provides protection against poverty and makes it possible to maintain the previous standard of living. 70% of *RR* was taken as the level ensuring adequacy (Czepulis-Rutkowska, 2000). It is regarded as a correspondingly high level of substitution.

The following factors were considered to fundamentally affect the chances of obtaining an adequate pension: seniority, the retirement age, the number of children, and the duration of education. Then, for people from each investigated country, descriptive statistics for the studied characteristics were estimated (Tables 1–2).

Table 1. Descriptive statistics for analysed factors for females

Country	Retirement Age		Seniority		Number of Children		Duration of Education		*n*
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	
Austria	56.24	4.48	36.36	7.21	1.82	1.31	12.77	4.07	302
Germany	58.19	6.14	38.19	8.77	2.02	1.28	13.89	4.62	247
Sweden	61.44	4.70	39.91	8.40	1.99	0.98	16.11	7.78	305
Netherlands	59.13	5.60	33.52	9.12	1.98	1.25	12.94	3.11	48
Spain	61.12	5.68	41.43	9.82	1.55	1.41	10.67	4.84	89
Italy	55.52	5.75	37.14	8.57	1.72	1.21	11.77	6.34	221
France	57.37	5.03	38.66	7.20	2.07	1.20	13.76	3.40	263
Denmark	58.88	7.82	37.85	9.33	2.07	1.11	15.53	5.81	178
Greece	54.13	5.78	32.45	8.24	1.72	0.88	12.98	4.72	47
Switzerland	60.56	5.03	36.00	10.00	1.82	1.28	14.53	3.52	101
Belgium	57.09	4.34	37.16	7.15	1.69	1.15	14.38	2.98	233
Czech Republic	54.87	4.71	37.57	6.40	2.12	0.91	12.95	2.58	681
Poland	53.73	5.59	33.89	7.93	2.45	1.31	12.79	3.57	212
Ireland	51.13	13.89	33.13	15.28	2.38	2.26	13.25	2.92	8
Luxembourg	57.64	4.83	35.79	8.65	1.79	1.02	13.55	4.44	33
Hungary	54.45	5.50	38.04	6.60	1.82	0.72	12.32	3.33	198
Portugal	58.55	7.17	41.06	8.39	1.72	1.33	11.47	5.80	47
Slovenia	53.78	4.18	36.74	4.26	2.00	0.65	13.62	3.35	95
Estonia	57.81	5.75	39.61	7.61	1.90	1.20	14.71	3.30	221
Croatia	55.58	6.41	36.61	6.46	1.81	0.91	13.61	3.90	31
Lithuania	56.07	5.97	38.32	7.50	2.14	1.34	13.50	4.11	117
Bulgaria	55.67	5.00	37.77	6.26	1.84	0.76	12.80	2.62	61

Country	Retirement Age		Seniority		Number of Children		Duration of Education		*n*
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	
Cyprus	61.47	3.12	41.71	7.73	2.47	1.66	10.18	5.71	17
Finland	58.19	8.04	38.22	9.82	2.07	0.96	16.56	7.27	98
Latvia	57.43	6.23	39.11	7.15	1.79	1.01	14.66	5.44	89
Malta	57.67	9.58	37.83	15.18	1.17	1.17	11.17	2.71	6
Romania	50.91	8.23	33.18	9.29	1.95	1.20	13.43	5.11	44
Slovakia	55.33	4.54	38.57	5.05	2.00	0.98	12.99	2.65	67

Source: own calculations based on SHARELIFE data

Values of variables were estimated separately for women and for men due to the difference in the principles of calculating benefits based on gender.

Table 2. Descriptive statistics for analysed factors for males

Country	Retirement Age		Seniority		Number of Children		Duration of Education		*n*
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	
Austria	57.04	4.41	42.39	5.06	2.05	1.20	12.09	3.30	337
Germany	59.09	5.41	41.07	7.06	1.90	1.17	14.75	4.54	349
Sweden	61.58	4.82	44.40	6.29	2.04	1.18	15.86	7.35	394
Netherlands	59.08	3.33	42.48	5.54	2.28	1.47	13.56	4.55	214
Spain	59.95	5.80	45.83	7.07	2.31	1.46	10.06	3.96	276
Italy	55.85	5.47	40.54	6.48	1.94	1.16	11.05	5.03	568
France	57.33	3.71	40.31	4.73	2.24	1.34	13.89	4.03	340
Denmark	59.06	7.84	39.63	8.23	2.02	1.19	16.29	4.63	156
Greece	56.44	6.39	38.58	8.04	1.87	1.16	12.49	4.31	101
Switzerland	61.58	3.55	42.57	4.94	1.93	1.27	16.21	4.08	168
Belgium	58.14	4.73	40.54	4.92	2.03	1.36	14.42	3.47	397
Czech Republic	58.16	5.72	41.06	6.86	2.00	0.99	14.28	4.38	365
Poland	55.29	7.40	38.17	7.65	2.44	1.20	13.34	3.39	197
Ireland	60.32	3.49	44.14	6.35	3.04	2.56	13.25	5.23	28
Luxembourg	57.09	2.36	40.97	6.03	2.08	1.11	13.12	4.82	86
Hungary	56.58	6.33	40.89	7.00	1.98	1.11	13.32	3.38	126
Portugal	57.48	5.88	43.79	7.89	1.94	0.99	10.04	5.20	85
Slovenia	56.80	4.87	39.48	5.00	1.84	0.78	14.03	3.67	87
Estonia	59.16	5.52	41.79	6.60	2.04	1.23	13.76	3.44	80

Country	Retirement Age		Seniority		Number of Children		Duration of Education		*n*
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	
Croatia	55.94	9.03	36.62	10.16	2.02	0.92	13.51	3.93	47
Lithuania	58.96	6.88	41.25	8.15	1.88	1.02	13.75	4.36	69
Bulgaria	55.40	8.15	37.12	8.87	1.73	0.81	14.16	4.14	67
Cyprus	61.91	4.39	45.38	7.79	2.69	1.12	12.47	5.38	32
Finland	59.51	6.01	41.92	7.47	2.10	1.32	15.59	6.51	78
Latvia	58.14	5.23	39.78	6.48	1.65	1.03	14.73	4.39	49
Malta	58.67	4.57	43.33	6.29	1.88	1.39	11.61	3.04	69
Romania	54.63	6.72	37.10	7.07	2.44	1.34	15.66	6.14	68
Slovakia	58.61	4.74	41.74	4.62	1.79	0.96	14.13	2.35	38

Source: own calculations based on SHARELIFE data

The obtained descriptive statistics for a given feature form its scheme. The scheme of the feature is therefore understood as its average level and its differentiation in a given country. Schemes for individual countries and for individual features constitute nodes of individual networks. The names of the nodes are the names of the European countries. In total, we have $N = 28$ nodes. The existence of a relationship between any two countries means the presence of a statically significant correspondence for a given pension factor. The Mann-Whitney U was used to test the significance because of extremely unequal groups. For each pair of countries i and j, and for every pension factor, we tested the following:

H_0: The distributions of two populations are identical. (2)

H_1: The two population distributions are not identical. (3)

This is how we checked whether two populations were similar or not. In the next step, we calculated the U statistic which was $\min(U_i, U_j)$:

$$U_i = n_i n_j + \frac{n_i(n_i+1)}{2} - R_i \qquad \text{and} \qquad U_j = n_j n_i + \frac{n_j(n_j+1)}{2} - R_j, \tag{4}$$

where n_i is the number of observed people in the country i, n_j is the number of observed people in the country i, and R_i and R_j is the sum of the ranks awarded i and j sample values. In the study presented in this paper, we used the statistical significance $\alpha = 0.01$. If two populations in two countries are similar, the a_{ij} coefficient achieves value 1, and $a_{ij} = 0$ indicates a lack of statistical similarity between countries in terms of a given factor. Then, using the obtained significance a_{ij} for similarity of countries, adjacency matrices A were built:

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1N} \\ \vdots & \ddots & \vdots \\ a_{N1} & \cdots & a_{NN} \end{bmatrix}. \quad (5)$$

These matrices constitute the basis for building a network of countries and links between countries due to the studied pension factors.

The networks were constructed for the four factors mentioned above: seniority, the retirement age, the number of children, and the duration of education. For gender, they were done separately. This way, we achieved eight economic networks.

Mathematically, the studied networks are defined as $G = (V, E)$, where $V = \{1, 2, \ldots, N\}$ is a set of nodes (vertices) and $E \subseteq \{i, j \mid i, j \in V\}$ is a set of links (edges). Links are simply pairs of nodes. We use symbol $a_{ij} = 1$ if nodes i and j are related to each other, and $a_{ij} = 0$ if they are not. Thus, in our case, the network is a theoretical structure represented by an undirected graph in which the nodes represent N countries, or more precisely, their mean values of the pension factor. The links constitute the relationship between countries denoting a statistical similarity a_{ij} for a given factor (Figure 1).

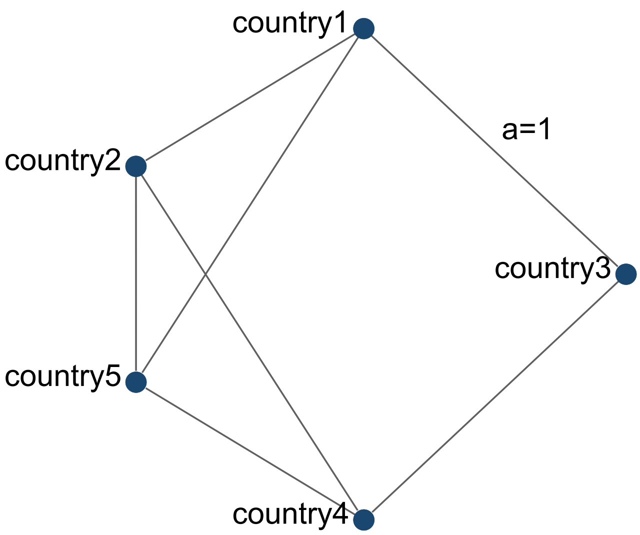


Figure 1. The network topology for pension adequacy in European countries
Source: own calculations based on SHARELIFE data

Next, networks were analysed for their characteristic properties used in economics of financial networks research (Wasserman, Faust, 2007; Emmert-Streib et al., 2017; Grund, 2018).

At the lowest analytical level – the micro level – it is possible to obtain information about individual countries occurring in the network and the relationships between them. For this purpose, we used measures oriented at individual network nodes. The ones that are most frequently used include assessment measures of centrality of individual network nodes. There are three centrality measures used in this case for node *v*: degree centrality k_v^c, closest centrality c_v^c, and betweenness centrality b_v^c. They are defined as follows:

$$k_v^c = \frac{k_v}{N-1}, \tag{6}$$

$$c_v^c = \frac{N-1}{\sum_{v \neq j} d(v,j)}, \tag{7}$$

$$b_v^c = \sum_{i \neq j} \frac{\sigma_{ij}(v)}{\sigma_{ij}}, \tag{8}$$

where k_v is the degree of node, $d(v,j)$ is the length of the shortest path between the nodes *v* and *j*, σ_{ij} is the total number of links between the nodes *i* and *j*, and $\sigma_{ij}(v)$ is the number of links between the nodes *i* and *j* that pass through the node *v*. In our study, we use the measure betweenness centrality for the analysis, which allows us to define how many shortest links go through an individual *v* node. In other words, it determines the frequency of a given node appearing in the link between two other unconnected nodes of the network. The measure betweenness centrality is used to identify structural gaps and key network links – the network core. This is how the integrity of the network is determined. It is then possible to divide the network into two subsets: the core and the periphery, i.e.: a group of countries with a typical pattern of a given retirement trait and atypical countries whose scheme of a given feature differs from the rest of the community. Such knowledge enables an improvement of the position of individual countries in the network and a reduction of gaps between countries by virtue of a given feature.

The analysis at the macro level concerns the entire network and allows us to obtain information about the network as a whole. The study was based on: density *D*, degree centralization *K* and clustering coefficient *C* (Emmert-Streib et al., 2017).

The *D* density of a network is defined as the proportion of actually observed links among the potentially observable ones:

$$D = \frac{2L}{N(N-1)}, \tag{9}$$

where *L* is the number of links:

$$L = \frac{1}{2}\sum_{i,j}^{N} a_{ij}. \tag{10}$$

For each pension feature, this indicator allows us to determine to what extent countries are similar or different from each other due to the studied variable.

Network degree centralization *K* was also calculated. The reference point here are relations between the network nodes. The degree *ki* of the node *i* is the number of links per node *i* and it is given by:

$$k_i = \sum_{j}^{N} a_{ij}. \tag{11}$$

The average degree for the entire network is:

$$K = \frac{1}{N} \sum_{i}^{N} k_i. \tag{12}$$

Degree centralization determines the degree to which the network is centralised to a maximally centralised network, the so-called star-network. The star network is a network in which only one node is connected to another node which in turn is connected to all other nodes. The highly centralised network is thus dominated by one node. A network with lower centralization is more resistant to changes. Centrality is a complementary measure to density.

Another useful network measure is the clustering coefficient *C* which for a node in an undirected network is defined by:

$$c_i = \frac{2m_i}{n_i\left(n_i - 1\right)}, \tag{13}$$

where n_i is the number of neighbours of node *i* and m_i is the number of adjacent pairs between all neighbours of *i* (Emmert-Streib et al., 2017). The clustering coefficient *C* of the entire network is averaged over all other nodes:

$$C = \frac{1}{N} \sum_{i}^{N} c_i. \tag{14}$$

It is a measure of the extent to which nodes in the network tend to cluster together. The creation of new connections, the disappearance of old ones, and the tendency to form groups of nodes with similar characteristics is called homophily. It means making similarities similar, and results from the fact that it is like the phenomena of acquaintances. As a result, in most real networks, nodes tend to form tightly related groups that have a high link density. There are several definitions of a network clustering coefficient. In the study, we use the general clustering coefficient which is measured as the average of the local clustering coefficients of all vertices.

To test the similarity between entire networks, using the correlation coefficient *r* for entire networks is necessary. It is given by:

$$r = \frac{\sum_{i=2}^{N} e_i e_{i-1}}{\sqrt{\sum_{i=2}^{N} e_i^2 \sum_{i=2}^{N} e_{i-1}^2}}, \tag{15}$$

where *ei* is a row of dyads after the transformation of an adjacency matrix into a dataset of dyads, where a dyad is a pair of nodes *i* and *j* in the network plus the relation between them. In an undirected, binary network, there are:

$$\frac{N(N-1)}{2} \tag{16}$$

Such an analysis is performed to determine the relationship between the networks for individual pension characteristics and between the networks for women and men (Grund, 2018).

At the macro level of the analysis, i.e. in relation to the typology of the network as a whole, the results of the analyses can be used, firstly, to increase the effectiveness of the mechanisms of integration and coordination of pension systems through increased possibilities of determining the standard of the level of the pension feature and, secondly, to optimise the centralization of the network based on the search for the best solution, the pension trait scheme.

In economics, the role of networks has long been studied in game theory and payment systems (Kobayashi, Masuda, 2021), in finance (Faggini, Bruno, Parziale, 2019; Baltakys, Le Viet, Kanniainen, 2021), or in economics (Rendón de la Torre et al., 2016). However, in many fields of economics, network analysis has not received much attention until recently (Nagurney, 2019; Kobayashi, Masuda, 2021). In this research network analysis is used for describing a standard economic model.

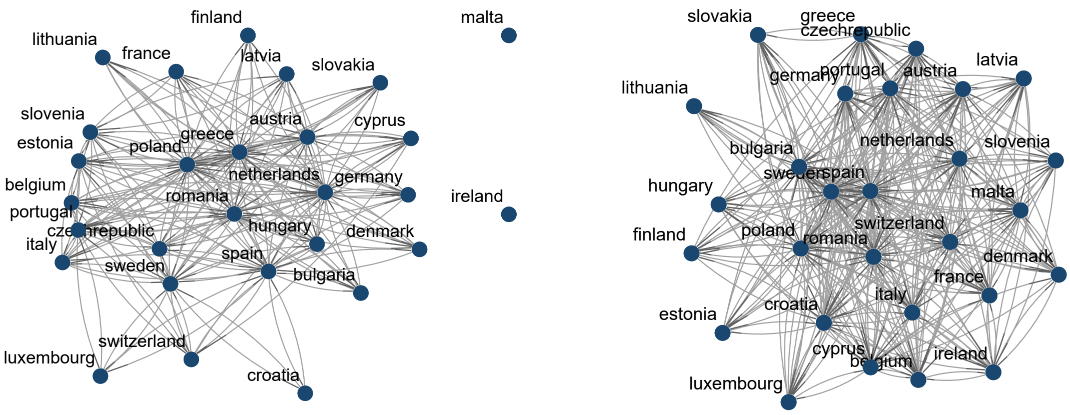
Calculations are performed using STATA 16 (Stata Corp LLC, College Station, Texas, USA).

3. Analysis of results

In this section, different networks are shown according to four factors important for the level of pension benefit, i.e. for seniority, the retirement age, the number of children, and the duration of education. Networks have been made separately for men and women. First, micro analyses are performed for each network. In the second step, networks at the macro level are discussed. Finally, correlations between the networks are considered.

3.1. Pension Adequacy Network by seniority

The first two networks presented in Figure 2 relate to seniority. They represent networks of 28 countries that are statistically similar regarding the seniority of pensioners who receive adequate pension benefits. The network shown in (a) refers to women and in (b) to men.



(a) (b)

Figure 2. Networks for pension adequacy in European countries by seniority: (a) Female, (b) Male

Source: own calculations based on SHARELIFE data

In the case of the network built for women, as we can see in Figure 2a, two countries – Malta and Ireland are isolated from the rest of the network, which in practice means that they have a completely different pattern of seniority in obtaining adequate retirement benefits. Their betweenness centrality is equal to 0 (Table 3). This is in doubt due to a small number of women receiving adequate benefits in these countries, and this fact makes it difficult to compare these countries with the other ones. Inside the network, on the other hand, are the countries that form the core, denoting the most popular solutions and patterns of seniority in these retirement systems. These countries have the highest level of betweenness centrality. These are Spain, Greece and Poland (Table 3). The other countries are therefore located on the so-called structural periphery as a result of their relatively smaller common seniority patterns. In the case of seniority network for men (Figure 2b), seniority patterns in Spain, Sweden and Poland are similar, whereas Lithuania, Slovakia and Finland have the most unusual seniority patterns. Their betweenness centrality is low (Table 3).

Table 3. Networks for seniority – betweenness centrality

Female	Betweenness	Male	Betweenness
Spain	73.85	Spain	52.90
Greece	71.43	Sweden	50.03
Poland	71.43	Poland	36.06
...	...	...	...
Croatia	0.15	Finland	1.20
Malta	0.00	Slovakia	1.20
Ireland	0.00	Lithuania	0.30

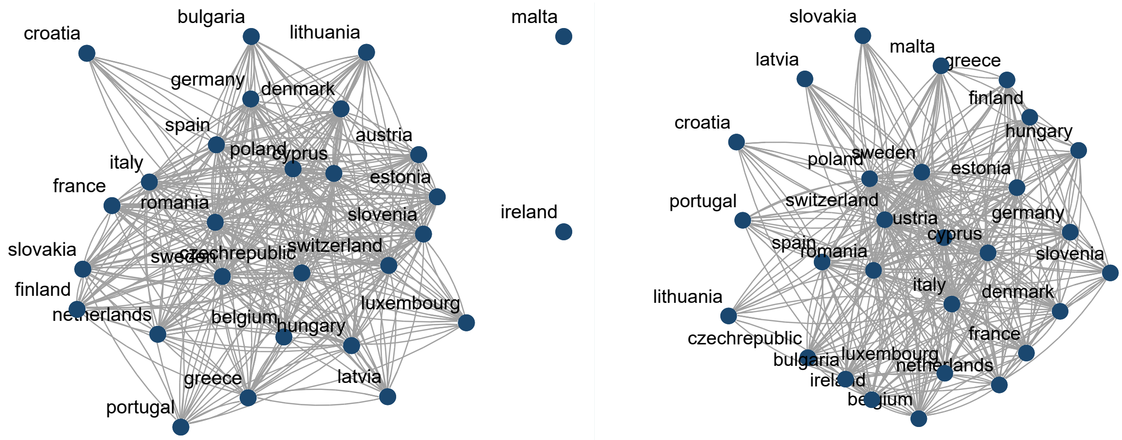
Source: own calculations based on SHARELIFE data

Poland, Greece, Sweden, and Spain have the greatest number of similarities in the pattern of seniority in comparison with other countries. They have the lowest or the highest seniority values: Greece for women – 32 years, and Spain for men – nearly 46 years. On the other hand, the countries which are isolated from other countries in seniority patterns are Ireland, Croatia, Malta, Lithuania, Slovakia, and Finland. Ireland and Malta aside, which are characterised by a small number of analysed population, the remaining countries have a mean level of seniority.

Countries located in the centre of the network, such as Spain, Sweden or Poland, are characterised by a common level of seniority for achieving adequate pension. The pension systems in these countries are very similar and consist of a mandatory state pension scheme as well as voluntary company and individual pension provision. The countries located on the edge of the network, such as Ireland and Finland, have pension systems with less common solutions. The Irish public pension is a basic scheme paying a flat rate to all who meet the contribution conditions. The Finnish pension system consists partly of national pensions, which are based on residence in Finland.

3.2. Pension Adequacy Network by retirement age

The next two networks in Figure 3 are connected with the retirement age. They represent networks of 28 countries that are statistically similar regarding the retirement age of pensioners who receive adequate pension benefits. The network shown in (a) refers to women, in (b) to men.



(a) (b)

Figure 3. Networks for pension adequacy in European countries by retirement age: (a) Female, (b) Male

Source: own calculations based on SHARELIFE data

In the case of the network built for women, just as it was in the case of the network for seniority, two countries – Malta and Ireland are isolated from the rest of the network (Figure 3). These countries have a low population of women who achieve an adequate pension compared with the other countries. The core of the network is built by Sweden, Romania, and Spain. These countries have the highest level of betweenness centrality. Sweden, Switzerland, and Cyprus (Table 4) constitute the core in the network constructed for the retirement age for men. By contrast, retirement age patterns in Croatia, Slovakia, and Latvia are atypical.

Table 4. Networks for retirement age – betweenness centrality

Female	Betweenness	Male	Betweenness
Sweden	32.52	Sweden	57.37
Romania	30.23	Switzerland	57.37
Spain	25.16	Cyprus	42.37
...	...	...	...
Croatia	0.63	Croatia	0.99
Malta	0.00	Slovakia	0.58
Ireland	0.00	Latvia	0.58

Source: own calculations based on SHARELIFE data

The countries with the highest or the lowest retirement age constitute the core of networks. They include Cyprus, with almost 62 years for men, and Romania, with about 51 years for women. Countries with a low number of links, or with a lower value of betweenness centrality, have an average level of retirement age. Here we have Croatia, for example, with about 56 years for women and for men.

The retirement age is strongly correlated with seniority. That is why the network for this variable is very similar to the network for seniority.

3.3. Pension Adequacy Network by number of children

Figure 4 illustrates how networks have been built for the 'number of children' variable.

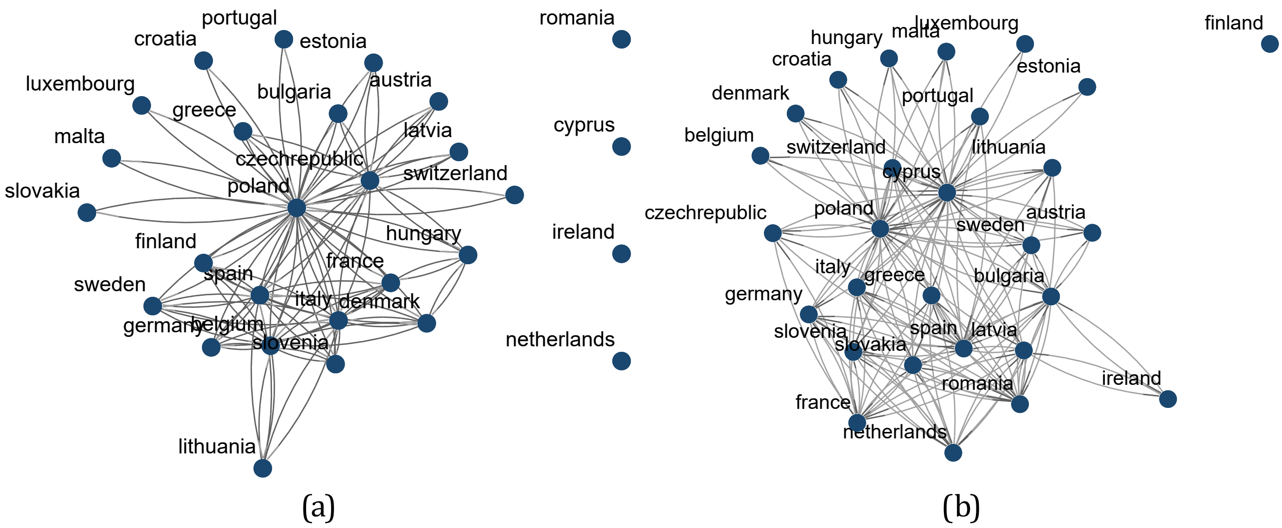


Figure 4. Networks for pension adequacy in European countries by number of children: (a) Female, (b) Male
Source: own calculations based on SHARELIFE data

In the case of the network built for women, four countries, i.e., Romania, Cyprus, Ireland, and the Netherlands, are isolated from the rest of the network. They have 0 level of betweenness centrality (Table 5). There are few countries inside the network. Poland has definitely the most common pattern. In the case of the network built for men, Finland, Estonia, and Luxembourg are isolated. The links leading through Cyprus and Poland (Table 5) are the most common.

Table 5. Networks for number of children – betweenness centrality

Female	Betweenness	Male	Betweenness
Poland	349.87	Cyprus	250.18
Czech Republic	37.67	Poland	152.18

Female	Betweenness	Male	Betweenness
Spain	23.53	Bulgaria	53.30
...	...	...	...
Ireland	0.00	Luxembourg	0.00
Cyprus	0.00	Estonia	0.00
Romania	0.00	Finland	0.00

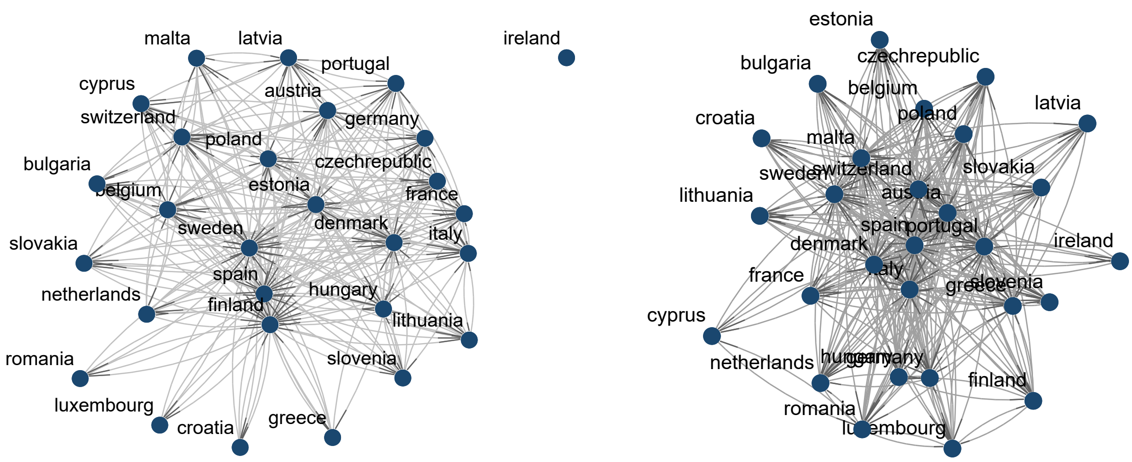
Source: own calculations based on SHARELIFE data

The most dominant scheme can be seen for Polish people who are characterised by a relatively large number of children, on average approximately 2.5, and the standard deviation of about 1.2–1.3. It is worth noting that women in Poland have ae lot of children in comparison with other European countries. However, it is connected with their relatively low retirement age associated with short seniority. The combination of these variables, however, still allowed them to achieve an adequate pension. It can be partly explained by paying state pension contributions during the time of their parental leave. This action increases the level of future pension. Another reason is associated with women's low salaries which in relation to low pension produce a sufficiently high replacement rate.

This may provide guidance for decision makers to construct fertility-friendly pension systems in which having children can be favourable for adequacy.

3.4. Pension Adequacy Network by duration of education

Figure 5 shows the last two networks which refer to the duration of education.



(a) (b)

Figure 5. Networks for pension adequacy in European countries by duration of education: (a) Female, (b) Male
Source: own calculations based on SHARELIFE data

Ireland is isolated from the rest of the network, Romania and Croatia, on the other hand, have low betweenness centrality (Table 6) for women, and Ireland, Latvia, and Croatia – for men. Spain, Sweden, and Finland have built the core in the networks for women, whereas Spain, Portugal, and Denmark have done so for men (Table 6).

Table 6. Networks for time of education – betweenness centrality

Female	Betweenness	Male	Betweenness
Sweden	89.28	Spain	55.18
Spain	82.14	Portugal	53.20
Finland	79.13	Denmark	48.47
…	…	…	…
Croatia	0.10	Latvia	0.78
Romania	0.10	Croatia	0.67
Ireland	0.00	Ireland	0.18

Source: own calculations based on SHARELIFE data

The principle for this factor is the same as for the previous ones. The core of the network is composed of the countries with the highest or the lowest duration of education. Denmark, Sweden, or Finland have around 16 years of studying, while Spain or Portugal only 10 years of studying. Countries with an average learning period of around 13.5 years have a low value of intermediation centrality and are on the periphery of the networks.

As it was in the case of network for seniority and the retirement age, countries located in the centre of the network for the duration of education, Spain and Sweden, have the most popular kind of pension system in Europe, with three parts: a national public pension from the state and an occupational pension from the employer along with any personal savings. Objects located on the edge of the network, such as Ireland, are characterised by rare pension system solutions. Their public pension is a basic scheme, paying a flat rate to all who meet the contribution conditions.

3.5. An analysis of the entire Pension Adequacy Network

Next, characteristics of the entire networks are discussed and investigated in Table 7. The retirement age networks are the densest of all the networks. The nodes in these networks have the greatest number of connections. This means that we have the largest number of similarities between countries in terms of this factor. This applies to both women and men. The high density of networks concerning seniority, the retirement age and the duration of education means that, as a result of the applied systemic pension solutions in these countries, we have similar values of these features. On the other hand, a very low network density can be seen in relation to the number of children. It indicates few similarities between countries with regard to this variable. At the same time, the network for the number of children is the most centralised. Selected countries have the greatest number of connections.

Table 7. The networks characteristics

Variable	Density		Degree Centralization		Clustering Coefficient	
	Female	Male	Female	Male	Female	Male
Seniority	0.492	0.302	0.417	0.412	0.248	0.434
Retirement Age	0.495	0.500	0.332	0.403	0.489	0.472
Number of Children	0.143	0.206	0.697	0.554	0.048	0.329
Duration of Education	0.378	0.479	0.491	0.464	0.568	0.410

Source: own calculations based on SHARELIFE data

Most of the networks obtained have a high clustering coefficient between 0.24 and 0.57. This is a typical phenomenon for economic networks. On the other hand, the clustering coefficient for the network built for women and regarding the number of children is surprisingly low. Its value equals 0.048, which means the presence of one leader. This is also confirmed by a high degree of betweenness centrality for Poland, high degree centralization, low density, and the resulting low number of links among the countries.

In the next step, the correlation between networks built for men and women for different variables has been checked. As we can see in Table 8, only networks for children vary between gender. The correlation in this case is weak. The remaining factors considered give similar networks for men and women.

Table 8. Correlation between networks for females and males

Variable	Correlation
Seniority	0.24***
Retirement Age	0.39***
Number of Children	0.22**
Time of Education	0.36***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: own calculations based on SHARELIFE data

Table 9 illustrates correlations between networks for individual variables separately for women and men.

Table 9. The Network Correlation for variables

Variable 1	Variable 2	Female	Male
Seniority	Retirement Age	0.301***	0.307***
	Number of Children	0.144**	0.178**
	Duration of Education	0.155*	0.051
Retirement Age	Seniority	0.301***	0.307***
	Number of Children	0.171**	0.144**
	Duration of Education	0.174**	0.191**
Number of Children	Retirement Age	0.171**	0.144**
	Seniority	0.144**	0.178**
	Duration of Education	0.101	0.047
Duration of Education	Retirement Age	0.174**	0.191**
	Seniority	0.155*	0.051
	Number of Children	0.101	0.047

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: own calculations based on SHARELIFE data

The networks describing the patterns relating to seniority and the retirement age are the most similar together. We have very strongly correlated networks here for both women and men. This means that the behaviour of pension system participants in individual European countries is similar with regard to these two variables. On the other hand, the educational scheme presented by the networks – the duration of education variable – is the most unusual and similar only to the scheme for the retirement age. It concerns both women and men.

4. Conclusions

The study has used Social Network Analysis (SNA) as a research method. The practical possibilities of the network have been used to study the adequacy of pension benefits in terms of the retirement age, seniority, the duration of education, and the number of children of retired people.

The SNA method has allowed us to define a network typology of pension factor links between European countries, and also in various types of pension systems. The analysis has focused on the identification of their similarities and differences. In this way, a specific structure of schemas for each of the examined retirement factor has been created. It could help to indicate which solutions are conducive to the generation of adequate retirement benefits. In this context, two basic levels of analysis have been introduced: the location of individual countries in the network and the entire network. Correlations between networks have also been checked.

First of all, the results show that networks have similar properties for variables directly affecting the level of benefits among all the examined pension factors. Networks built for seniority and the retirement age have turned out to be the densest and with the least centralization. This means that there are many similarities between the surveyed countries in terms of these two factors. The situation in the case of the duration of education variable is intermediate. In contrast, networks for the number of children are by far the least dense and have the greatest centralization.

Moreover, looking at the countries distinguished as the core and the periphery through betweenness centrality, it can be seen that countries with similar system solutions have similar patterns of pension variables (Szumlicz, Żukowski, 2004). Thus, the shape of the system affects the level of retirement factors of its participants. Therefore, it can be expected that by introducing systemic regulations conducive to certain attitudes, such as extending working time and postponing the time of retirement, it is possible to achieve a better effect for the entire population. Undoubtedly, taking such steps will help to maintain the adequacy of retirement benefits. In view of the ageing of the population, it will be necessary to introduce such solutions.

Next, it can be seen that men and women do the same in terms of the studied retirement factors. The same variable networks are similar for women and men. The correlations between gendered networks are also large and significant. This means that gender is not a factor that differentiates connection patterns for the examined factors.

The most important factor which strongly differentiates the population of pensioners in terms of the adequacy of pension benefit is the number of children. The pattern of the number of children in Poland is dominant, while other patterns of the value of this variable are much less common. Therefore, we can say that there are not many relationships between the studied countries in terms of the demographic factor of fertility. Each country has its own pattern in terms of the number of children. We can therefore conclude that there is a large space for making changes to pension systems in terms of the number of children. This is all the more important as it is a key factor in the adequacy of pay-as-you-go systems. Therefore, it is vital to seek solutions aimed at linking pensions with the number of children. The choice of such pension structures would have an impact on the future of the pension system also in the context of its stability. Individual decisions to enlarge the family could have positive implications for entire pension systems (Cigno, 2007).

The obtained results confirm that awareness of the consequences of the impact of pension factors on the level of pension benefits is reflected in the actions taken by pensioners in European countries. It can be concluded that the value of pension factors is similar in pension systems with the same construction. This means that it is worth considering changes in multi-pillar pension system countries aimed towards individual pension wealth (Chłoń-Domińczak, 2016).

In the course of further considerations on the optimal pension system and providing adequate pension benefits, it is advisable to look for solutions that also take into account different expectations in the life cycle of people belonging to pension systems (Madero-Cabib, Fasang, 2015).

The research presented in the article complements the research that uses traditional methods such as cluster analysis (Jajko-Siwek, 2020a; Krpan, Pavković, Žmuk, 2020) or sequence analysis (Jajko-Siwek, 2020b). It could be considered as a step further to aim at constructing a pension system that will provide adequate pension benefits to a wide range of pensioners.

Conflicts of Interest: The authors declare no conflict of interest.

References

Baltakys K., Le Viet H., Kanniainen J. (2021), *Structure of Investor Networks and Financial Crises*, "Entropy", vol. 23(4), p. 381.

Belloni M., Fornero E. (2008), *Gender Difference in Retirement Income and Pension Policy – Simulating the Effects of Various DB and DC Schemes*, CEPS, https://www.ceps.eu/download/publication/?id=6005&pdf=1695.pdf [accessed: 24.08.2021].

Bergmann M., Scherpenzeel A., Börsch-Supan A. (eds.) (2019), *SHARE Wave 7 Methodology: Panel innovations and life histories*, Munich Center for the Economics of Aging (MEA), https://share-eric.eu/fileadmin/user_upload/Methodology_Volumes/SHARE_Methodenband_A4_WEB_Wave7MFRB.pdf [accessed: 16.03.2023].

Borella M., Fornero E. (2009), *Adequacy of Pension Systems in Europe: An analysis based on comprehensive replacement rates*, CEPS, https://www.ceps.eu/download/publication/?id=6260&pdf=1837.pdf [accessed: 24.08.2021].

Börsch-Supan A. (2022), *Survey of Health, Ageing and Retirement in Europe (SHARE), Wave 7*, Release version: 8.0.0. SHARE-ERIC, https://share-eric.eu/data/data-documentation/waves-overview/wave-7 [accessed: 16.03.2023].

Börsch-Supan A., Brandt M., Hunkler C., Kneip T., Korbmacher J., Malter F., Schaan B., Stuck S., Zuber S. (2013), *The Survey of Health, Ageing and Retirement in Europe (SHARE)*, "International Journal of Epidemiology", vol. 42(4), pp. 992–1001.

Chłoń-Domińczak A. (2016), *Impact of changes in multi-pillar pension systems in CEE countries on individual pension wealth*, "Journal of Pension Economics and Finance", vol. 17, pp. 110–120.

Chybalski F. (2016), *The Multidimensional Efficiency of Pension System: Definition and Measurement in Cross-Country Studies*, "Social Indicators Research", no. 128(1), pp. 15–34.

Chybalski F., Marcinkiewicz E. (2016), *The Replacement Rate: An Imperfect Indicator of Pension Adequacy in Cross-Country Analysis*, "Social Indicators Research", no. 126, pp. 99–117.

Cigno A. (2007), *Low fertility in Europe: Is the pension system the victim or the culprit?*, "CESifo Forum", vol. 8(3), pp. 37–51.

Czepulis-Rutkowska Z. (2000), *Systemy emerytalne a poziom zabezpieczenia materialnego emerytów*, IPiSS, Warszawa.

Draxler J. (2009), *How to make European pensions adequate and sustainable*, CEPS, https://www.ceps.eu/download/publication/?id=6210&pdf=1811.pdf [accessed: 24.08.2021].

Emmert-Streib F., Musa A., Baltakys K., Kanniainen J., Tripathi S., Yli-Harja O., Jodlbauer H., Dehmer M. (2017), *Computational Analysis of the structural properties of Economic and Financial Networks*, https://doi.org/10.48550/arXiv.1710.04455

European Commission (2010), *Progress and key challenges in the delivery of adequate and sustainable pensions in Europe*, Brussels, https://ec.europa.eu/economy_finance/publications/occasional_paper/2010/pdf/ocp71_en.pdf [accessed: 24.08.2021].

European Commission (2012a), *Pension adequacy in the European Union 2010–2050*, Brussels, https://ec.europa.eu/social/BlobServlet?docId=7805&langId=en [accessed: 24.08.2021].

European Commission (2012b), *An Agenda for Adequate Safe and Sustainable Pensions*, "White Paper", Brussels, https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2012:0055:FIN:EN:PDF [accessed: 24.08.2021].

European Commission (2015), *The 2015 Pension Adequacy Report: current and future income adequacy in old age in the EU*, vol. I, Brussels, https://ec.europa.eu/social/BlobServlet?docId=14529&langId=en [accessed: 24.08.2021].

European Commission (2018), *The 2018 Pension Adequacy Report: current and future income adequacy in old-age in the EU*, vol. 1, Brussels, https://op.europa.eu/en/publication-detail/-/publication/f0e89c3f-7821-11e8-ac6a-01aa75ed71a1/language-en/format-PDF/source-151020563 [accessed: 24.08.2021].

Eurostat (2021), *Ageing Europe — 2021 interactive edition*, https://ec.europa.eu/eurostat/cache/digpub/ageing/ [accessed: 3.05.2023].

Faggini M., Bruno B., Parziale A. (2019), *Crises in economic complex networks: Black Swans or Dragon Kings?*, "Economic Analysis and Policy", vol. 62, pp. 105–115.

Góra M. (2003), *System emerytalny*, Wydawnictwo Naukowe PWN, Warszawa.

Grund T. (2018), *Social Network Analysis Using Stata*, https://www.stata.com/meeting/uk15/abstracts/materials/uk15_grund.pdf [accessed: 16.03.2023].

Holzmann R., Hinz R.P., Dorfman M. (2008), *The World Bank Pension Conceptual Framework*, World Bank, Washington, https://documents.worldbank.org/curated/en/716871468156888545/pdf/461750NWP0Box334081B01PUBLIC10SP00824.pdf [accessed: 24.08.2021].

Jajko-Siwek A. (2020a), *Adequate Retirement Paths in the Polish Pension System*, "The Review of Socio-Economic Perspectives", vol. 5, pp. 107–115.

Jajko-Siwek A. (2020b), *The Impact of the Flexibilization of Employment Histories on the Pension Adequacy in Poland*, "Sustainability", no. 12(19), 8260.

Jędrzychowska A., Kwiecień I., Poprawska E. (2020), *The Motherhood Pension Gap in a Defined Contribution Pension Scheme – the Case of Poland*, "Sustainability", no. 12(11), 4425.

Kobayashi T., Masuda N. (2021), *Introduction to the special issue Economics and Complex Networks*, "The Japanese Economic Review", vol. 72, pp. 1–4.

Krpan M., Pavković A., Žmuk B. (2020), *Cluster analysis of new EU member states' pension systems*, "INDECS", vol. 18(2B), pp. 180–222.

Madero-Cabib I., Fasang A.E. (2015), *Gendered Work-Family Life Courses and Financial Well-being in Retirement*, "Advances in Life Course Research", vol. 27, pp. 43–60.

Maresova P., Soukal I., Svobodova L., Hedvicakova M., Javanmardi E., Selamat A., Krejcar O. (2018), *Consequences of Industry 4.0 in Business and Economics*, "Economies", vol. 6(3), 46.

MMGPI (2014), *Melbourne Mercer Global Pension Index 2014*, https://www.mercer.com/content/dam/mercer/attachments/asia-pacific/australia/retirement/mercer-melbourne-global-pension-index/mercer-melbourne-global-pension-index-report.pdf [accessed: 24.08.2021].

MMGPI (2015), *Melbourne Mercer Global Pension Index 2015*, https://www.mercer.com/content/dam/mercer/attachments/global/Retirement/Melbourne-Mercer-Global-Pension-Index-2015/Report.pdf [accessed: 24.08.2021].

MMGPI (2017), *Melbourne Mercer Global Pension Index 2017*, https://www.mercer.com.au/content/dam/mercer/attachments/asia-pacific/australia/mmgpi-2017/au-2017-mmgpi-report.pdf [accessed: 24.08.2021].

MMGPI (2019), *Melbourne Mercer Global Pension Index 2019*, https://info.mercer.com/rs/521-DEV-513/images/MMGPI%202019%20Full%20Report.pdf [accessed: 24.08.2021].

Muller E., Peres R. (2019), *The effect of social networks structure on innovation performance: A review and directions for research*, "International Journal of Research in Marketing", vol. 36, pp. 3–19.

Nagurney A. (2019), *Networks in economics and finance in Networks and beyond: A half century retrospective*, "Networks", vol. 77(1), pp. 50–65.

OECD (2005), *Pensions at a Glance 2005: Public Policies across OECD Countries*, OECD Publishing, Paris.

OECD (2007), *Pensions at a Glance 2007: Public Policies across OECD Countries*, OECD Publishing, Paris.

OECD (2009), *Pensions at a Glance 2009: Retirement-Income Systems in OECD Countries*, OECD Publishing, Paris.

OECD (2011), *Pensions at a Glance 2011: Retirement-income Systems in OECD and G20 Countries*, OECD Publishing, Paris.

OECD (2013), *Pensions at a Glance 2013: OECD and G20 Indicators*, OECD Publishing, Paris.

OECD (2015), *Pensions at a Glance 2015: OECD and G20 indicators*, OECD Publishing, Paris.

OECD (2017), *Pensions at a Glance 2017: OECD and G20 Indicators*, OECD Publishing, Paris.

OECD (2019), *Pensions at a Glance 2019: OECD and G20 Indicators*, OECD Publishing, Paris.

Ponomarenko V . (2016), *Cumulative disadvantages of non-employment and non-standard work for career patterns and subjective well-being in retirement*, "Advances in Life Course Research", vol. 30, pp. 133–148.

Rendón de la Torre S., Kalda J., Kitt R., Engelbrecht J. (2016), *On the topologic structure of economic complex networks: Empirical evidence from large scale payment network of Estonia*, "Chaos, Solitons & Fractals", vol. 90, pp. 18–27.

Szumlicz T., Żukowski M. (2004), *Systemy emerytalne w krajach Unii Europejskiej*, Twigger, Warszawa.

Wasserman S., Faust K. (2007), *Social Networks Analysis: Methods and applications*, Cambridge University Press, Cambridge.

World Bank (1994), *Averting the Old Age Crisis*, New York, https://documents1.worldbank.org/curated/en/973571468174557899/pdf/multi-page.pdf [accessed: 24.08.2021].

Sieci adekwatności emerytalnej w Europie

Streszczenie: Proces starzenia się ludności Europy stanowi wyzwanie dla systemów emerytalnych. Oznacza to konieczność poszukiwania rozwiązań, które pozwolą poszczególnym krajom generować adekwatne świadczenia emerytalne. Celem artykułu jest przedstawienie typologii sieci adekwatnych świadczeń emerytalnych w krajach europejskich. Jako metodę badania zastosowano sieci społecznościowe. W analizie uwzględniono typologię sieci wynikającą z czynników emerytalnych, takich jak: staż pracy, wiek emerytalny, płeć, liczba dzieci oraz czas nauki. Sprawdzono również korelację między sieciami. Najbardziej nietypową sieć uzyskano dla liczby dzieci. Spośród wszystkich badanych czynników najbardziej zbliżone są do siebie sieci uzyskane dla stażu pracy i wieku emerytalnego. Otrzymane wyniki wskazują, że systemy emerytalne, które są zbudowane w ten sam sposób, charakteryzują się także podobnymi wzorcami poziomu czynników emerytalnych. Wzorce powiązań dla badanych zmiennych nie są zróżnicowane ze względu na płeć.

Słowa kluczowe: adekwatność, analiza sieci społecznych, emerytura, staż pracy, wiek emerytalny

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