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## ASSESSMENT OF INTERPERSONAL TRUST OF POLES BY THE PRINCIPAL COMPONENTS ANALYSIS AND LOG-LINEAR MODELING<sup>1</sup>

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**Summary:** Interpersonal trust in Poland is found to be at a very low level. This paper aims at the analysis of this phenomenon on the basis of European Social Survey data. Principal components analysis was applied to examine the degree of interpersonal trust in Poland in relation to other countries. Associations of three dimensions of trust, i.e. trustfulness, fairness and helpfulness, were analyzed by log-linear modeling as well as an agreement measure relevant for categorical variables. A composite indicator based on the first principal component scores confirmed the relatively poor social trust of Poles. A moderate agreement on any two of the three facets of this phenomenon was uncovered and in most cases no interactions among all three aspects of interpersonal trust were detected.

**Keywords:** interpersonal trust, principal components analysis, log-linear analysis.

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### 1. Introduction

Trust and distrust can be defined as “bets on the future uncertain actions of other people”, which can refer to various objects: persons, social roles, products, institutions, technologies or social systems [Sztompka 2002, pp. 310-312]. This paper is focused on one of those elements, namely interpersonal trust, which has an important role not only in a societal sense. Zak and Knack [2001] showed that interpersonal trust has an important impact on economic growth and can be treated as a strong economic stimulant. Various researchers found evidence of the positive associations between trust and many socio-economic aspects including willingness to trade, readiness to cooperate, facilitation of market exchange, better governance, level of subjective well-being and health [Morrone et al. 2009, pp. 24-30]. As the

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degree of interpersonal trust contributes substantially to the development of societies, the lack of it can constitute serious obstacles to further progress. Unfortunately, studies show that the level of interpersonal trust in Poland is low, which may have a negative impact on the above-mentioned issues. According to *World Value Survey* data (2005-2008 wave) Poland takes forty-first position in the ranking of 68 countries when taking into account the “share of people who think that most people can be trusted” [Morrone et al. 2009, p.12]. Six consecutive surveys carried out in Poland by CBOS demonstrate that the percentage of persons who agree with the statement “Generally speaking, most people can be trusted” varied from 19% to 26% between 2002-2012 [*Zaufanie społeczne* 2012, p. 2]. The results obtained from the *Social Diagnosis* studies in 2009-2013 indicate an even lower proportion of people who trust others – from 12% to 13% [Czapiński, Panek (eds.) 2013, p. 286].

Such an unfavorable situation inspired the in-depth analyzes of the components of interpersonal trust in Poland. This paper aims at examining this phenomenon on the basis of the *European Social Survey* data<sup>2</sup> which comprise three dimensions describing social trust: trustfulness, fairness and helpfulness. The first goal is to compare the degree of interpersonal trust in Poland and other countries by using principal components analysis both for graphical presentation and composite indicator construction. The second objective is to analyze the relations among three interpersonal trust dimensions on the basis of individual data concerning Poles only. A hypothesis is put forward that there may be differences in the perception of the three mentioned facets of trust. As the data are categorical, a log-linear analysis was applied and supported by adequate visualization methods.

## 2. Data and methods

The assessment of social trust in the *European Social Survey* is made by the means of three questions. It is worth mentioning that the same set of questions appears in all rounds of the survey, which allows a comparative analysis of this phenomenon in the period of 2002-2012. The surveyed respondents expressed their opinions about trust by answering the following questions<sup>3</sup>:

- *Would you say that most people can be trusted, or that you can't be too careful in dealing with people?*

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<sup>2</sup> This paper uses European Social Survey data: ESS Round 6: European Social Survey Round 6 Data (2012). Data file edition 1.1, ESS Round 5: European Social Survey Round 5 Data (2010). Data file edition 3.0, ESS Round 4: European Social Survey Round 4 Data (2008). Data file edition 4.1, ESS Round 3: European Social Survey Round 3 Data (2006). Data file edition 3.4., ESS Round 2: European Social Survey Round 2 Data (2004). Data file edition 3.3., ESS Round 1: European Social Survey Round 1 Data (2002). Data file edition 6.3. Norwegian Social Science Data Services, Norway – Data Archive and distributor of ESS data.

<sup>3</sup> <http://nesstar.ess.nsd.uib.no/webview/> [retrieved 2014-01-10].

- *Do you think that most people would try to take advantage of you if they got the chance, or would they try to be fair?*
- *Would you say that most of the time people try to be helpful or that they are mostly looking out for themselves?*

The answers were given on an eleven point Likert scale, with its extreme values described in words, respectively<sup>4</sup>:

- *You can't be too careful* (0) to *Most people can be trusted* (10)
- *Most people try to take advantage of me* (0) to *Most people try to be fair* (10)
- *People mostly look out for themselves* (0) to *People mostly try to be helpful* (10)

Due to the extensive response scale, aggregated data were used for the analysis. Primary data were regrouped into three categories: those that represent a rather negative approach (answers from 0 to 4), neutral attitude (answer 5) and a rather positive approach (answers 6-11). The aggregation of data was necessary due to the existence of the sparse matrices problem in the construction of contingency tables for all possible variants of answers.

Since the phenomenon of interpersonal trust is represented by several features, chosen multivariate analysis methods were used in this research. Firstly, the principal components analysis (PCA) was applied to determine the degree of social trust in Poland with respect to other countries participating in the *European Social Survey*. Secondly, the underlying structure of the answers given solely by the Poles was examined using log-linear models. The presented analyses are diverse in nature. Principal components analysis was used to conduct a comparative analysis and was based on aggregated metric data, i.e. the percentage of answers representing a positive attitude (answers 6-11). The log-linear analysis was carried out only for Poland and was conducted on categorical data taking into account all the answers (negative, neutral and positive).

Principal components analysis is applied to replace original variables by a smaller number of new, uncorrelated variables representing, as much as possible, information from the given set [Bartholomew et al. 2008, p.116]. The application of PCA in this paper was aimed at two objectives. Firstly, to find out if the set of variables can be reduced to, at most, a two-dimensional representation without a substantial loss of information which gives a possibility to present relationships among both variables and objects on the plane. Secondly, to construct, if feasible, a single index based on the first component and summarizing original variables [Bartholomew et al. 2008, p. 137] allowing to perform a linear ordering of objects. PCA was performed on the basis of correlation matrices. Hence, the importance of components can be evaluated according to eigenvalues (greater than 1) and by the proportion of explained variance [Timm 2002, pp. 450-451].

Log-linear analysis is applied to investigate the associations among categorical variables for which multi-way contingency tables are calculated. The most common

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<sup>4</sup> <http://nesstar.ess.nsd.uib.no/webview/> [retrieved 2014-01-10].

are hierarchical log-linear models in which the presence of a particular association among variables means that all lower-order interactions comprising those variables are also included [Jobson 1992, p. 57]. As three categorical variables were used to describe interpersonal trust, the log-linear analyses was carried out on the basis of three-way contingency tables. The task was to find log-linear models depicting properly the expected counts. Let us denote the considered variables as: T – attitude to trustfulness, F – attitude to fairness, H – attitude to helpfulness. A perfect fit of the model is obtained by considering all possible interactions, which in the case of the three variables means including zero-order, first-order, second-order and third-order interactions. Saturated model reflecting all possible associations is denoted [TFH] and is given by the formula (comp. [Simonoff 2003, p. 319]):

$$\ln(e_{ijk}) = \lambda + \lambda_i^T + \lambda_j^F + \lambda_k^H + \lambda_{ij}^{TF} + \lambda_{ik}^{TH} + \lambda_{jk}^{FH} + \lambda_{ijk}^{TFH}$$

where:

$\ln(e_{ijk})$  – logged expected cell counts of the three-way contingency table,  
 $\lambda, \lambda_i^T, \lambda_j^F, \lambda_k^H, \lambda_{ij}^{TF}, \lambda_{ik}^{TH}, \lambda_{jk}^{FH}, \lambda_{ijk}^{TFH}$  – parameters of the model.

Log-linear modeling aims to determine whether such a complicated structure of the saturated model can be simplified, i.e. if a more parsimonious model which does not include all interactions still can describe sufficiently the expected cell counts of the contingency table. Eight possible simpler association patterns among three variables are presented in Table 1.

**Table 1.** Non-saturated log-linear models for three categorical variables: T, F, H (models of identical structure but comprising another set of variables are not indicated)

Association pattern	Description
[-]	Constant term only
[T]	Complete independence without impact of two variables
[T], [F]	Complete independence without impact of one variable
[T], [F], [H]	Complete (mutual) independence
[TF]	Joint independence without impact of one variable
[TF], [H]	Joint independence
[TF], [TH]	Conditional independence
[TF], [TH], [FH]	Homogeneous association

Source: own elaboration based on [Gatnar & Walesiak (eds.) 2011, p. 89].

While modeling social trust, a data backward elimination procedure<sup>5</sup> was carried out to determine the best models in the sense of being parsimonious and well-

<sup>5</sup> Calculations were done with SPSS ver. 21.

-fitted. Two criteria based on the chi-squared statistics were chosen to evaluate the goodness-of-fit, i.e. Pearson chi-square statistic and likelihood ratio chi-square statistic [Jobson 1992, p. 41]. As these statistics show discrepancies between actual and expected counts, their relatively low values indicate that the proposed simplified model fitted well. For both tests the significance level was set at 0,05, which means that a model simpler than the saturated one is acceptable if the relevant chi-squared statistics has a p-value bigger than 0,05.

As underlined by Du Toit, Steyn and Stumpf [1986, p. 1], there are three main ways of statistical communication supplementing one another: words, tables and graphics. Visualization techniques play an important role in research processes and therefore the analysis presented in this study was supported by relevant graphics, including:

- biplot representations for outcomes of principal component analysis,
- panel dotplots allowing comparisons of many objects,
- charts visualizing relationships among categorical data,
- three-dimensional mosaic plots as a tool of assessment of log-linear models.

A brief explanation of particular visualization rules was given later in the text during the presentation of results. The analyses were performed using SPSS 21, STATISTICA ver. 10 and R.

### 3. Interpersonal trust in Poland in comparison with other countries

In order to compare the degree and changes of social trust in Poland and other countries, a principal components analysis was carried out for all six years for which data were available. PCA was based on variables created as the percentage of answers representing a positive attitude, i.e. claiming that people are rather trustful, helpful and fair. The eigenvalues corresponding to possible principal components and the proportion of explained variance are presented in Table 2.

**Table 2.** Key results of principal components analysis – eigenvalues corresponding to principal components (PC) and percentage of explained variance

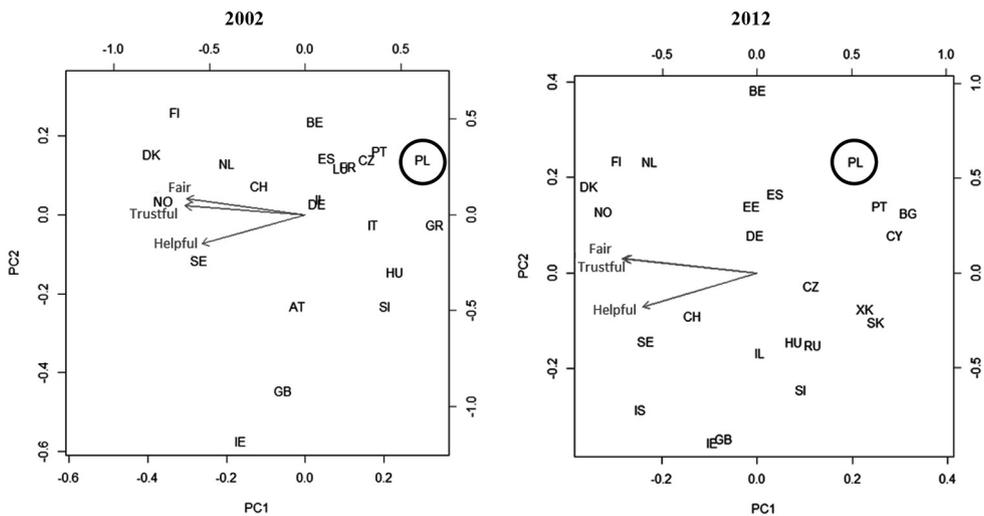
Year	Eigenvalues			Explained variance (%)		
	First PC	Second PC	Third PC	First PC	Second PC	Third PC
2002	2,86	0,10	0,04	95,37	3,17	1,46
2004	2,88	0,09	0,04	95,89	2,94	1,18
2006	2,86	0,10	0,05	95,29	3,18	1,53
2008	2,85	0,09	0,06	95,05	2,96	1,99
2010	2,85	0,10	0,05	95,08	3,19	1,73
2012	2,87	0,10	0,03	95,65	3,41	0,94

Source: own computations in STATISTICA ver.10.

In each case, the first principal component reflects over 95% of possible variance and its eigenvalue is bigger than one which means that the original variables can be summarized sufficiently by one new variable. The crucial findings from PCA can be illustrated on biplots presenting both variables and objects simultaneously [Gabriel 1971]. The most important interpretational rules can be expressed as cf. [Kroonenberg 2008, pp. 497-498]:

- objects are given as points, variables are presented as vectors (arrows),
- a small angle between variable vectors indicates a strong association of variables,
- the larger the projection of an object on a variable vector, the bigger the deviance of the object from the average value of the variable.

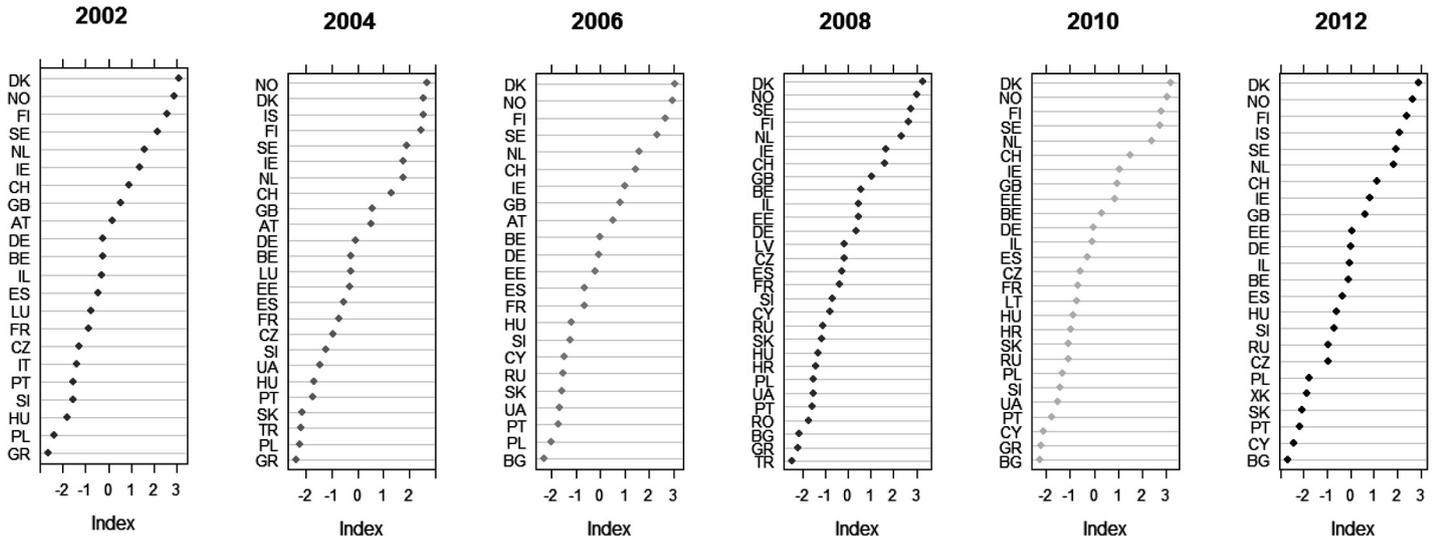
Figure 1 presents biplot representation of PCA outcomes for 2002 and 2012. The position of Poland is marked by circles. The vectors positions suggest that all the variables representing interpersonal trust are strongly associated. An exceptionally strong correlation exists between the percentage of people who declare that people are trustful and fair. This confirms the earlier observation that the first principal component reflects properly all the aspects of social trust included in the *European Social Survey* module. Projections of objects (countries) on variable vectors allow to



AT – Austria, BE – Belgium, BG – Bulgaria, CH – Switzerland, CY – Cyprus, CZ – Czech Rep., DE – Germany, DK – Denmark, EE – Estonia, ES – Spain, FI – Finland, FR – France, GB – Great Britain, GR – Greece, HU – Hungary, IE – Ireland, IL – Israel, IS – Iceland, IT – Italy, LU – Luxembourg, NL – Netherlands, NO – Norway, PL – Poland, PT – Portugal, RU – Russian Federation, SK – Slovakia, SI – Slovenia, SE – Sweden, XK – Kosovo.

**Fig. 1.** Biplots representing PCA results for 2002 and 2012

Source: own elaboration in R.



AT – Austria, BE – Belgium, BG – Bulgaria, CH – Switzerland, CY – Cyprus, CZ – Czech Rep., DE – Germany, DK – Denmark, EE – Estonia, ES – Spain, FI – Finland, FR – France, GB – Great Britain, GR – Greece, HR – Croatia HU – Hungary, IE – Ireland, IL – Israel, IS – Iceland, IT – Italy, LT – Lithuania, LV – Latvia, LU – Luxembourg,, NL – Netherlands, NO – Norway, PL – Poland, PT – Portugal, RO – Romania, RU – Russian Federation, SK – Slovakia, SI – Slovenia, SE – Sweden, TR – Turkey, UA – Ukraine, XK – Kosovo.

**Fig. 2.** Degree of interpersonal trust in 2002-2012

Source: own elaboration in R.

perceive significant differences in the attitude to people shown by citizens of different countries. The results for 2002 and 2012 indicate that the strongest interpersonal trust was presented by the residents of the Scandinavian countries and the Netherlands. The position of Poland shows a very low degree of social trust compared to other countries.

The scores on the first principal component can be treated as an overall index of social trust. The ranking of the countries according to its values are illustrated in Figure 2. The first principal component scores were multiplied by  $(-1)$  for better visualization and easier understanding.

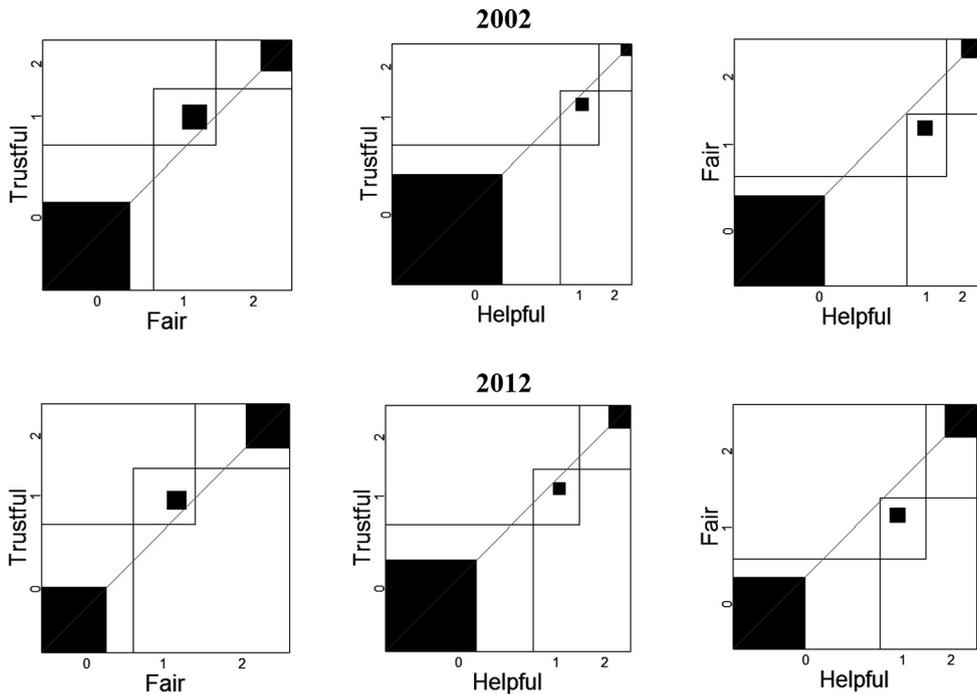
Regardless of the period analyzed, the highest degree of interpersonal trust was observed in the Scandinavian countries, the Netherlands, Ireland, Switzerland and the United Kingdom. Societies of the Mediterranean and Central-Eastern European countries turned out to be the least trustful towards people. In 2002, 2004 and 2006, Poland took the penultimate position ahead of Greece or Bulgaria. According to the results of the next three rounds of the survey (2008, 2010, 2012), social trust in Poland remained at a relatively low level, although exceeding the index for Ukraine, Portugal, Romania, Bulgaria, Greece, Turkey, Cyprus and Kosovo.

Such critical conclusions relating to interpersonal trust in Poland persuaded us to carry out a thorough analysis of responses to questions referring to this phenomenon.

#### **4. Analysis of categorical data describing interpersonal trust in Poland**

This section deals with the variables reflecting three dimensions of interpersonal trust in Poland as examined by the *European Social Survey* (trustfulness, fairness and helpfulness). As was already mentioned, raw data were reordered into three categories: persons evaluating others negatively (category marked 0), presenting a neutral attitude (category marked 1) and a positive approach (category marked 2).

One of the methods for the presentation and evaluation of association between categorical variables is Bangdiwala's observer agreement chart, mostly used for evaluation of rankings or opinions of two judges [Bangdiwala 1987 cited in Friendly 2000, pp. 94-95]. In this study this procedure was adapted to evaluate the degree of respondents agreement on considered elements of interpersonal trust. The Bangdiwala's chart is given by a square with a side equal to sample size, black squares represent observed agreement, and the white rectangles surrounding them correspond to the biggest possible agreement understood as marginal totals [Friendly 2000, p. 94]. The ratio of the area of black squares and the area of white rectangles forms the Bangdiwala measure of agreement [Friendly 2000, p. 94]. A visual representation of opinions on social trust in Poland in 2002 and 2012 are presented in Figure 3 and the values of Bangdiwala measures (B) for all years are given in Table 3.



0 – negative attitude, 1 – neutral attitude, 2 – positive attitude.

**Fig. 3.** Bangdiwala's agreement plots for three dimensions of interpersonal trust in Poland in 2002 and 2012

Source: own elaboration in R.

**Table 3.** Measures B of respondents agreement on elements of interpersonal trust

Year	Trustful and Fair	Trustful and Helpful	Helpful and Fair	Valid cases
2002	0,39	0,46	0,36	2039
2004	0,38	0,47	0,40	1664
2006	0,33	0,39	0,34	1660
2008	0,33	0,39	0,33	1584
2010	0,35	0,36	0,30	1711
2012	0,30	0,36	0,31	1844

Source: own computations in R.

The agreement charts indicate that the most consistent answers occurred in the "0" category representing the negative assessment of other people. Respondents pointed out, most of all, that people cannot be trusted and would not behave fairly. A comparison of charts for 2002 and 2012 confirms previous findings concerning the changes in social trust – the number of negative attitudes towards other

people declined in favor of consistent positive opinions. Still, negative judgments predominate. In addition, in each case there is a lack of marginal homogeneity which is shown by the position of the black squares outside the diagonal line. The values of measure B presented in Table 3 show that the biggest observed agreement concerns the opinions on trustfulness and helpfulness. The strength of agreement is moderate – the measure B range from 0,3-0,46 with the possible maximum value of 1. The accordance was not constant over time – at the end of the analyzed period it was significantly lower than in previous years. The agreement chart and B measure are very useful tools for responds assessment, but they are limited to two-way tables only. Therefore another technique, log-linear analysis, was applied to evaluate the relations among all three variables simultaneously.

The goal of log-linear analysis was to search for less complex models than the saturated ones but nevertheless reflecting substantial associations in contingency tables. In four cases (2002, 2004, 2006 and 2012) it turned out that the third-order effect may be omitted in the final solutions. It was impossible to find parsimonious models for 2008 and 2010. The elements of the eventual models and goodness-of-fit measures are given in Table 4.

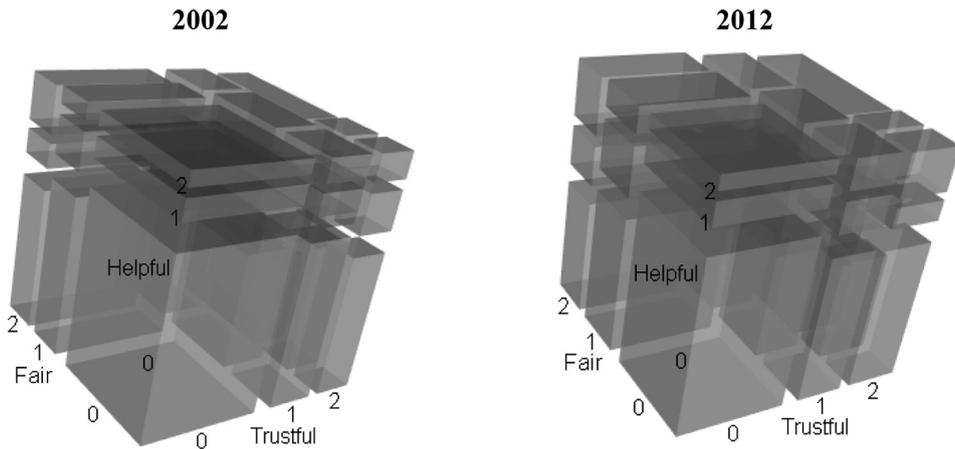
**Table 4.** Best log-linear models for variables representing interpersonal trust (T – attitude to trustfulness, F – attitude to fairness, H – attitude to helpfulness)

Year	Model	df	Pearson chi-square	p-value	Likelihood ratio chi-square	p-value
2002	[TF], [TH], [FH]	8	11,03	0,200	11,55	0,172
2004	[TF], [TH], [FH]	8	10,06	0,261	10,10	0,258
2006	[TF], [TH], [FH]	8	11,80	0,160	11,89	0,156
2008	[TFH]	0	0,00	–	0,00	–
2010	[TFH]	0	0,00	–	0,00	–
2012	[TF], [TH], [FH]	8	6,42	0,601	6,61	0,580

Source: own computations in SPSS 21.

The models for 2002, 2004, 2006 and 2012 contain all second-order interactions (and the main effects as they are hierarchical) but not the third-order effect which indicates the existence of homogeneous association, not independence conditions. This means that the association pattern between any two variables is the same for all levels of the third variable [Simonoff 2003, p. 316]. If we consider a pair of variables describing interpersonal trust (e.g. trustfulness and fairness) the association remains the same regardless of the category of the third dimension (helpfulness). Such a pattern of elements depicting the level of social trust in Poland was observed in the responses given in four rounds of the *European Social Survey*, i.e. 2002, 2006, 2008 and 2012. The results of log-linear modeling can be presented by graphical means, particularly by mosaic plots [Friendly 2000] including the three-dimensional appro-

ach developed in the *vcdExtra* R package. The contingency table cells frequencies are represented proportionally by the volume of cuboids, and large residuals, if any, are indicated by colors (blue and red for positive and negative values respectively). Figure 4 shows such three-dimensional charts corresponding to the fitted values of log-linear models for 2002 and 2012.



0 – negative attitude, 1 – neutral attitude, 2 – positive attitude.

**Fig. 4.** Three-dimensional charts corresponding to fitted values of log-linear models for 2002 and 2012

Source: own elaboration in R.

No essential residuals are marked in color on the pictures, which might be due to the proper goodness-of-fit of the models. The biggest cuboid reflects the combination of negative attitudes (0, 0, 0) to all the considered dimensions of interpersonal trust. It is worth noticing that its volume is considerably bigger than the volumes of all the other tiles. Once again the lack of social trust is immediately obvious when a considerable insight into data is applied.

In two cases (2008 and 2010) no simplification of relationships among the three social trust variables is possible. Saturated models are necessary to describe the associations included in three-way tables, what is rather non informative.

## 5. Conclusions

Interpersonal trust of Poles is at an unfavorable level compared to other European countries. According to the composite indicator built on the basis of *European Social Survey* results, a slight improvement in the positive attitudes to others has been observed since 2008. Nevertheless, Poland's position is still at the bottom end of the ranking reflecting social trust. The analysis of the attainable dimensions of interpersonal trust revealed that there is moderate agreement on any two of the three facets

describing this phenomenon: trustfulness, fairness and helpfulness. Moreover, the agreement level changed over the examined years. Log-linear modeling allowed us to formulate the conclusion that in most cases there are no interactions among all three aspects of interpersonal trust. Since homogeneous association was detected, the relationship patterns of any two variables do not differ throughout the categories of the third one. Each of the conducted analyses shows that negative attitudes to other people dominate in Polish respondents' opinions, which may have unfavorable social and economic consequences. The impact of this phenomenon needs further research, but there are many studies that evaluate and underline its role for the progress of societies. A vast overview on this topic given by Morrone et al. [2009] allows one to formulate a conclusion that many factors contributing to the development of societies are associated with interpersonal trust and therefore the low level of it in Poland can be perceived as a barrier to further progress, both in an economic and societal sense, e.g. lack of trust may lead to lower economic growth by limiting the inclination to cooperate or disrupting market trade and business relations. Additionally, a low level of trust may have a negative influence on Poles' perception of well-being and health. As this paper is focused on the analysis of the level of interpersonal trust and relationships, among its components it provides a starting point for further considerations including associations with other socio-economic aspects.

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## **OCENA ZAUFANIA INTERPERSONALNEGO POLAKÓW ZA POMOCĄ ANALIZY GŁÓWNYCH SKŁADOWYCH ORAZ MODELOWANIA LOG-LINIOWEGO**

**Streszczenie:** Zaufanie interpersonalne w Polsce odznacza się bardzo niskim poziomem. Niniejsza praca ma na celu analizę tego zjawiska na podstawie danych Europejskiego Sondażu Społecznego. Za pomocą analizy głównych składowych zbadano stopień zaufania interpersonalnego w Polsce w porównaniu z innymi krajami. Powiązania trzech wymiarów zaufania, czyli ufności, uczciwości i pomocności, były analizowane za pomocą modeli log-liniowych i miary zgodności opinii właściwej dla zmiennych niemetrycznych. Syntetyczny miernik utworzony na podstawie pierwszej głównej składowej potwierdził stosunkowo słabe zaufanie społeczne Polaków. Wykryto umiarkowaną zgodność opinii na temat dwóch z trzech aspektów tego zjawiska, a w większości przypadków nie stwierdzono interakcji między wszystkimi trzema wymiarami zaufania interpersonalnego.

**Słowa kluczowe:** zaufanie interpersonalne, analiza głównych składowych, analiza log-liniowa.