Women in EU as Seen by Dynamic Principal Component Analysis (PCA)

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Abstract The socio-economic activity of women in 28 European Union in 2000-2015 countries has been studied in this paper. Six variables covering the female labour market, educational and political activity, and researchers' careers have been used. They were subject to Principal Component Analysis (PCA) in two versions. One – separately for each year, and the other – jointly for the whole period. The first one was used to identify and track the positions of variables in three-component, time dependent space. Principal components were explained and some changes in loadings were discussed. For the analysis of 28 European Union countries we study their trajectories defined by factor values. The countries were clustered by Ward's agglomerative method. Four groups have been found. Two of them were easy to interpret – consisting generally of countries from the old and new European Union respectively. Linear trends were estimated for the movement of four groups in PC space. Then, differences between groups have been explained by the analysis of group trends of the original variables.

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1 Introduction

In the document adopted by the United Nations (2015a), entitled "*Transforming our World*: *The* 2030 *Agenda for Sustainable Development*", 17 sustainable development goals were defined including 169 related tasks reflecting 3 dimensions of sustainable development, i.e. economic, social and environmental. Many goals highlight an increasingly important role and position of women in both society and business life, including:

- **Goal 5**: Gender Equality
  Achieve gender equality and empower all women and girls, and within this goal implement task 5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life. Monitoring of this goal allows assessing the level of such indicators as e.g.:

  - the percentage of women in national parliaments and local self-governments or

  - the proportion of women in managerial positions as the total number of employees in managerial positions.

- **Goal 8**: Economic Growth and Decent Work
  Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all and within this goal implement task 8.5. Achieve full and productive employment and decent work for all women and men, including young people and persons with disabilities, and equal pay for work of equal value, for which the indicator referring to women's place in the country economy is the average hourly rate for employed women by occupation and age.

These priorities remain the basis of the Europe 2020 strategy (European Commission, 2010):

Smart Development	– Development of knowledge-based economy and innovation,
Sustainable Development	– Supporting a more resource efficient, more environmentally friendly and more competitive economy, as well as

Inclusive Growth   – Supporting an economy characterized by high employment
                                        level and ensuring economic, social and territorial cohe-
                                        sion.

One of the chosen goals was: Higher employment rate of population aged 20-64 from 69 % up to at least 75 %. Due to the fact that two thirds of professionally active population work in the EU, whereas in the US and Japan the respective figure is over 70 %, this goal is to be achieved e.g. by increasing the number of working women.

"*The Problem of Women*" is also addressed in long-term development strategies of the particular EU countries. For example, in Poland in the document Poland 2030. Third wave of modernity. In the long-term national development strategy it is stated that:

> "*Economic transformations result in the changing role of men in both occupational functions* (*the importance and profitability of employment in industry is decreasing, especially in the old types of industries, and the function of services is increasing, where women have more opportunities for employment*) *and the social ones* (*currently there are over* 800,000 *more tertiary education graduates in the population of women*). *Owing to cultural awakening, the women who develop their social and economic potential become the leaders of changes in many areas, and their educational aspirations are a clear proof of that.*"(Poland 2030 (2011), pg. 25)

It was also indicated that:

> "*It is obvious that along with economic growth, improvement in GDP per capita and civilization changes – opportunities emerge for constructing a more significant participation of women in development. This is how such process is actually progressing in the majority of countries worldwide. At the same time, however, it seems that its radical acceleration has a deep sense, which means that the improvement of conditions for the development of women's position, taking advantage of their potential, opens opportunities for multiplying the strength of positive development factors.*"(Poland 2030 (2011), pg. 28)

The provisions related to the role of women can be found in the area "*Combining career ambitions and life aspirations*", where the employment rate of women with the youngest child up to the age of 5 appears.

Research on women's situation of the labour market are carried with application of statistical methods, such as multivariate data analysis, classification and composite indicators used for rankings. With these methods the place of women is evaluated in many spheres, e.g.:

- Science: Access to higher education, equality in employment opportunities, scientific careers and achievements (Barnett and Sabattini (2010));

- Academic life (Britton (2017); Berheide and Walzer (2014); Bystydzienski and Bird (2006); Ecklund, Lincoln, and Tansey (2012));

- Politics (Women (2018));

- Labour market (Cipollone et al (2013); Thévenon (2013); Teow et al (2017); Pettit and Hook (2005));

- Education (Webster (2014); Dougherty (2005)).

Important fields where gender differences are studied are problems connected with unequal salaries (Cha and Weeden (2014); Meulders, O'Dorchai, Plasman, Maron, and Simeu (2010); European Union (2014); Nupo, Daza, and Ramos (2011); Organisation for Economic Co-operation and Development (OECD) (2012, 2014)), worthy work (International Labour Organization (2009b)), pensions (Council of Europe (2012)), accessibility of important professions and functions (Anker (2005)), global employment trends (International Labour Organization (2009a)), discrimination and freedom of choice in the labour market (Schieder and Gould (2016)), women place in development (Nussbaum (2000); United Nations (2016)), general tendencies in gender dependent convergence (Jacobsen et al (2015)). Comparisons are made in different reference systems, included relations between countries (Plantenga and Remery (2013)).

Data on women situation in socio-economic life have been published for many years in reports provided by such institutions as: United Nations (United Nations (2015b)), World Economic Forum (World Economic Forum (2018)), Eurostat and other offices of European Union (European Commission (2006); European Union (2013a,b)), European Institute for Gender Equality (European Commission (2017)), International Monetary Fund (Elborgh-Woytek et al (2013)), International Labour Organization (Yoon and Addati (2017)) and World Bank (World Bank Group (2017)).

2 Statistical Data and Methods

Women's situation in 28 European Union countries are characterized by the following variables:

- X_1: Unemployment rate for females
  (`http://data.worldbank.org/indicator/SL.UEM.TOTL.FE.ZS`),

- X_2: Employment to population ratio, women 15+
  (`http://data.worldbank.org/indicator/SL.EMP.TOTL.SP.FE.ZS`),

- X_3: Female members in parliament
  (`http://data.worldbank.org/indicator/SG.GEN.PARL.ZS`),

- X_4: Tertiary education female share in 30–34 age group
  (`http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=`
  `yth_educ_020&lang=en`),

- X_5: Share of female researchers in the higher education sector
  (`http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=`
  `rd_p_femres&lang=en`) and

- X_6: Share of female researchers in the enterprise sector
  (`http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=`
  `rd_p_femres&lang=en`).

All variables are expressed as percentages, and the analyzed period covers 16 years (2000-2015). Tables 1–3 present the most important statistics of variables in the years 2000-2015, along with the names of countries for which the levels of analyzed variables were the highest and the lowest in the evaluated period.

Table 1: Basic characteristics of the variables X_1–X_2. SD: Standard Deviation, VC: Coefficient of Variation. Source: author's calculations for X_1-X_3 variables based on the World Development Indicators [accessed: 2017-11-08].

Specification	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
X_1: Unemployed Females [% of Female Labour Force]																
EU 28-average	10.6	9.7	9.9	9.8	9.9	9.7	9.0	7.9	7.5	8.9	9.5	9.7	10.5	10.9	10.3	9.5
Max 1	20.3	19.9	20.6	19.9	19.7	19.1	14.9	12.9	12.9	18.1	20.2	21.8	28.2	31.3	30.1	28.8
Country	ESP	POL	POL	POL	POL	POL	POL	GRC	ESP	ESP	ESP	ESP	GRC	GRC	GRC	GRC
Max 2	18.5	18.7	18.7	17.2	19.6	17.2	14.7	12.7	11.5	14.1	16.3	21.5	25.0	26.7	25.4	23.6
Country	SVK	BGR	SVK	SVK	SVK	SVK	SVK	SVK	GRC	LVA	GRC LVA	GRC	ESP	ESP	ESP	ESP
Min 1	3.1	2.2	2.9	3.8	3.8	4.0	4.2	3.7	3.0	3.5	4.5	4.6	4.8	4.9	4.6	4.2
Country	LUX	LUX	NLD	NLD	IRL	IRL	IRL	NLD	NLD	NLD	NLD	AUT	AUT	GER	GER	GER
Min 2	3.5	2.5	3.6	4.0	4.2	4.3	4.4	3.9	3.7	5.1	4.6	5.4	5.2	5.3	5.4	5.1
Country	NLD	NLD	LUX	IRL	GBR	GBR	NLD	EST	DNK	AUT	AUT	NLD	GER	AUT	AUT	GBR
Median	8.3	7.9	8.2	9.4	8.5	8.5	7.9	6.9	6.6	8.1	9.0	8.9	9.6	10.2	8.6	7.8
SD	5.3	5.4	5.2	4.5	4.4	3.7	3.1	2.7	2.4	3.2	4.0	4.3	5.4	6.0	5.9	5.6
VC	49.6	55.8	53.1	46.1	44.1	38.5	34.3	34.3	32.4	35.9	41.7	43.7	51.7	55.3	57.7	59.3
Max 1 / Min 1	6.5	9.2	7.1	5.2	5.1	4.8	3.5	3.5	4.3	5.2	4.5	4.8	5.9	6.4	6.5	6.8
Max 2 / Min 2	5.3	7.5	5.2	4.3	4.7	4.0	3.3	3.3	3.1	2.8	3.5	4.0	4.8	5.0	4.7	4.6
X_2: Employment to Population Ratio for 15+ Females [%]																
EU 28-average	42.7	43.0	43.0	43.4	43.7	44.0	44.8	45.6	46.1	45.6	45.4	45.5	45.4	45.2	45.5	46.2
Max 1	57.0	56.9	56.9	56.1	57.0	57.3	58.4	58.3	58.8	57.7	55.9	55.7	55.7	55.5	55.5	56.4
Country	DNK	DNK	DNK	DNK	DNK	DNK	DNK	DNK	DNK	NLD	DNK	NLD	NLD	SWE	SWE	SWE
Max 2	54.9	56.0	55.9	55.5	54.9	54.8	55.2	56.0	55.9	57.4	55.5	55.2	55.5	54.8	54.6	54.3
Country	ROU SWE	SWE	SWE	SWE	SWE	SWE	SWE	SWE	SWE	DNK	NLD	DNK	SWE	NLD	DNK	DNK
Min 1	28.4	27.7	28.7	27.6	26.2	27.7	27.8	29.8	31.2	31.1	32.2	33.0	31.8	30.3	30.3	31.3
Country	MLT	MLT	MLT	MLT	MLT	MLT	MLT	MLT	MLT	MLT	MLT	MLT	GRC	GRC	GRC	GRC
Min 2	30.2	31.3	31.9	32.5	34.1	33.9	34.6	34.8	35.2	34.5	34.3	34.5	34.7	34.4	34.3	34.3
Country	ITA	ITA	ITA	ITA	ITA	ITA	ITA	ITA	ITA	ITA	ITA	ITA	ITA	ITA	ITA	ITA
Median	45.3	45.4	45.7	45.7	45.5	45.4	46.1	46.9	46.5	46.7	46.2	46.1	46.9	46.6	47.1	47.5
SD	7.4	7.6	7.3	7.1	7.0	6.8	6.9	6.8	8.2	6.4	6.1	6.2	6.2	6.4	6.4	6.1
VC	17.0	17.2	16.5	16.0	15.7	15.0	14.9	14.4	17.8	13.8	13.2	13.5	13.8	14.1	14.1	13.3
Max 1 / Min 1	2.0	2.1	2.0	2.0	2.2	2.1	2.1	2.0	2.8	1.9	1.7	1.7	1.8	1.8	1.8	1.8
Max 2 / Min 2	1.8	1.8	1.8	1.7	1.6	1.6	1.6	1.6	1.6	1.7	1.6	1.6	1.6	1.6	1.6	1.6

Table 2: Basic characteristics of the variables X_3–X_4. SD: Standard Deviation, VC: Coefficient of Variation. Source: author's calculations for X_3 variables based on the World Development Indicators [accessed: 2017-11-08] and for X_4 on the Eurostat websites [accessed: 2017-08-20].

Specification	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
X_3: Female Members of Parliament [%]																
EU 28-average	19.5	19.4	20.1	21.1	21.7	22.0	22.6	23.5	23.7	24.0	24.2	24.9	25.7	27.1	26.5	26.6
Max 1	42.7	42.7	45.0	45.3	45.3	45.3	47.3	47.0	47.0	46.4	45.0	44.7	44.7	44.7	44.7	43.6
Country	SWE	SWE	SWE	SWE	SWE	SWE	SWE	SWE	SWE	SWE	SWE	SWE	SWE	SWE	SWE	SWE
Max 2	37.5	38.0	38.0	38.0	38.0	37.5	38.0	41.5	41.5	42.0	40.7	42.5	42.5	42.5	42.5	41.5
Country	DNK	DNK	DNK	DNK	DNK	FIN	FIN	FIN	FIN	NLD	NLD	FIN	FIN	FIN	FIN	FIN
Min 1	7.1	8.3	8.7	7.7	9.1	9.1	9.2	9.2	8.7	8.7	8.7	8.7	8.7	8.8	10.1	10.1
Country	CYP	HUN	GRC	MLT	HUN	HUN	MLT	MLT	MLT	MLT	MLT	MLT	MLT	HUN	HUN	HUN
Min 2	8.3	8.7	9.1	8.7	9.2	9.2	10.4	9.4	11.1	11.1	9.1	8.8	8.8	10.7	12.5	12.5
Country	HUN	GRC	HUN	GRC	MLT	MLT	HUN	ROU	HUN	HUN	HUN	HUN	HUN	CYP	CYP	CYP
Median	15.9	17.4	17.9	19.0	19.7	20.7	20.2	20.6	20.5	20.4	21.1	22.7	23.4	24.0	24.2	26.8
SD	10.1	10.0	9.9	10.7	10.4	10.2	10.2	10.5	10.4	10.4	10.3	10.3	9.8	9.7	10.1	10.1
VC	54.3	50.9	49.6	50.8	46.2	45.9	45.1	44.9	44.6	43.9	43.6	41.6	38.7	37.1	38.0	38.0
Max 1 / Min 1	6.0	5.1	5.2	5.9	5.0	5.0	5.1	5.1	5.4	5.3	5.2	5.1	5.1	5.1	4.4	4.3
Max 2 / Min 2	4.5	4.4	4.2	4.4	4.1	4.1	3.7	4.4	3.7	3.8	4.5	4.8	4.8	4.0	3.4	3.3
X_4: Tertiary Education Female Share in 30–34 Age Group [%]																
EU 28-average	24.4	24.5	24.5	26.1	28.6	30.1	31.6	32.9	34.3	35.7	37.3	38.6	40.2	41.4	42.3	43.4
Max 1	47.9	49.6	49.3	50.2	52.1	52.1	55.3	55.4	56.6	55.5	55.5	56.0	57.9	60.8	62.7	68.4
Country	FIN LTU	FIN	FIN	FIN	FIN	FIN	FIN	FIN	FIN	FIN	IRL	IRL	IRL	LTU	LTU	LTU
Max 2	38.9	37.9	39.4	41.3	44.1	47.3	47.4	48.9	52.9	55.0	54.0	55.0	56.7	58.7	58.6	61.6
Country	EST	BEL	DNK	BEL	BEL	DNK	DNK	IRL	CYP	IRL	FIN	LTU	LTU	IRL	IRL	CYP
Min 1	8.9	9.0	8.2	8.3	10.7	12.1	12.4	13.7	15.9	18.5	19.2	20.6	22.9	24.2	27.2	27.2
Country	ROU	ROU	MLT	ROU	ROU	ROU	CZE	CZE	CZE	ROU	ROU	ROU	ROU	ROU	ROU	ROU
Min 2	10.1	10.7	9.0	10.8	12.1	13.0	13.1	14.3	17.1	18.7	22.3	24.2	26.5	27.3	29.1	30.8
Country	SVK	SVK	ROU	CZE	CZE	CZE	ROU	ROU	ROU	CZE	CZE	MLT	ITA AUT	ITA	ITA	ITA
Median	23.8	25.8	26.9	26.8	30.7	30.8	34.4	35.3	36.7	39.7	42.8	45.8	46.8	48.0	48.0	49.2
SD	10.8	9.9	10.5	10.9	11.0	11.5	12.2	11.9	12.2	11.7	11.2	11.3	11.5	11.1	10.2	10.7
VC	44.1	40.4	42.9	41.9	38.5	38.17	38.5	36.3	35.5	32.8	30.1	29.3	28.6	26.7	22.5	22.8
Max 1 / Min 1	5.4	5.5	6.0	6.1	4.9	4.3	4.5	4.0	3.6	3.0	2.9	2.7	2.5	2.5	2.3	2.5
Max 2 / Min 2	3.9	3.5	4.4	3.8	3.6	3.6	3.6	3.4	3.1	2.9	2.4	2.3	2.1	2.2	2.0	2.0

Table 3: Basic characteristics of the variables X_5-X_6 SD: Standard Deviation, VC: Coefficient of Variation. Source: author's calculations for X_5-X_6 variables from Eurostat websites [accessed: 2017-08-20].

Specification	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
X_5: Share of Female Researchers in Higher Education Sector [%]																
EU 28-average	34.6	36.0	36.7	37.6	37.8	38.4	38.9	39.5	40.1	41.0	41.4	41.8	42.3	42.8	42.9	43.2
Max 1	51.1	53.2	52.2	52.5	53.1	51.7	51.2	53.4	53.5	53.3	54.0	55.1	55.6	54.8	55.4	55.5
Country	LVA	SWE	LVA	LVA	LVA	LVA	LVA	LVA	LTU	LTU	LTU	LTU	LTU	LTU	LTU	LTU
Max 2	44.9	51.4	48.5	48.7	49.2	49.6	50.2	53.1	52.7	52.1	51.7	52.4	53.0	53.5	53.0	52.1
Country	PRT	LVA	SWE	LTU	LTU	LTU	LTU	LTU	LVA	LVA	LVA	LVA	LVA	LVA	LVA	LVA
Min 1	17.7	20.5	23.0	24.3	24.1	26.3	25.9	25.2	27.9	29.5	30.4	29.9	31.7	33.0	34.4	33.1
Country	GER	GER	GER	MLT	MLT	LUX	LUX	MLT	MLT	MLT	MLT	MLT	MLT	MLT	MLT	MLT
Min 2	21.5	22.3	23.5	25.7	26.1	26.8	26.8	26.1	33.7	34.4	32.7	33.3	33.3	33.2	34.9	35.2
Country	MLT	MLT	MLT	GER	GER	MLT	MLT	LUX	CYP	FRA	FRA	FRA	FRA	FRA	CZE	CZE
Median	36.0	36.3	36.5	37.8	37.4	37.7	37.7	38.1	39.0	40.8	41.7	41.3	42.2	42.8	42.2	42.7
SD	7.8	7.8	7.0	6.6	6.6	6.4	6.3	6.8	5.9	5.6	5.6	5.7	5.6	5.3	5.3	5.5
VC	22.5	21.8	19.2	17.6	17.5	16.6	16.3	17.2	14.8	13.7	13.4	13.7	13.3	12.4	12.4	12.7
Max 1 / Min 1	2.9	2.6	2.3	2.2	2.2	2.0	2.0	2.1	1.9	1.8	1.8	1.8	1.8	1.7	1.6	1.7
Max 2 / Min 2	2.1	2.3	2.1	1.9	1.9	1.9	1.9	2.0	1.5	1.5	1.6	1.6	1.6	1.6	1.5	1.5
X_6: Share of Female Researchers by Sectors of Performance in Business Enterprise Sector [%]																
EU 28-average	25.1	25.4	25.0	25.5	25.0	24.9	24.1	25.4	26.2	25.3	24.7	25.6	25.5	25.1	20.1	20.2
Max 1	49.4	56.1	51.0	54.0	50.5	48.8	40.7	57.3	73.4	53.4	43.7	51.3	47.5	42.8	42.2	42.2
Country	BGR	LVA	BGR	LVA	LVA	BGR	ROU	LVA	LVA	LVA	BGR	LVA	LVA	BGR	HRV	HRV
Max 2	43.3	50.7	48.2	47.5	45.1	45.7	36.7	40.1	43.2	43.4	42.0	45.0	42.9	41.7	41.2	40.6
Country	LVA	BGR	LVA	BGR	BGR	LVA	BGR	ROU	HRV	BGR	HRV	BGR	HRV	LVA	LVA	LVA
Min 1	8.5	9.3	9.0	8.7	9.4	10.0	11.6	12.2	12.5	11.4	11.4	11.4	11.0	10.5	11.4	12.3
Country	AUT	NLD	NLD	NLD	NLD	NLD	NLD	GER	GER	LUX	LUX	LUX	LUX	LUX	LUX	LUX
Min 2	9.0	9.6	10.4	11.6	11.6	11.6	11.9	13.2	13.7	11.4	13.5	14.2	14.2	14.1	13.9	12.8
Country	NLD	AUT	AUT	GER	GER	GER	GER	NLD	NLD	LUX	GER	GER	GER	GER	CZE	CZE
Median	22.1	21.7	23.6	24.1	23.9	23.4	23.4	24.0	24.0	24.0	24.3	24.0	25.0	24.0	23.2	23.3
SD	10.6	11.4	10.1	10.8	9.9	9.5	7.5	9.5	12.2	9.5	8.5	9.6	9.2	8.7	8.7	8.0
VC	42.2	44.7	40.5	42.4	39.7	38.3	31.0	37.3	46.4	37.6	34.5	37.6	36.1	34.6	43.5	39.8
Max 1 / Min 1	5.8	6.0	5.7	6.2	5.4	4.9	3.5	4.7	5.9	4.7	3.8	4.5	4.3	4.1	3.7	3.4
Max 2 / Min 2	4.8	5.3	4.6	4.1	3.9	3.9	3.1	3.0	3.2	3.8	3.1	3.2	3.0	3.0	3.0	3.2

3 The Analysis of Variables

With the data cube ($objects \times variables \times time\_units$), Principal Component Analysis (PCA) has been performed separately for each time unit while analyzing variables, and jointly for the whole period for the analysis of countries. In the new coordinate systems, variables or objects (shown as points) change their positions on consecutive time units. We propose to track its routes, and approximate them with linear trends.

With the criterion of explained variance at least 80 %, the number of principal components was 3. Three principal components create a 3D space, and having time series data we can analyze the sequence of positions of observations or variables. Since our data covers only 16 years, we decided to approximate the movement of points only by linear trends. The same type of analysis can be performed also with other approach, e.g. Procrustest Analysis (Gower (1975)), CANDECOMP/PARAFAC algorithms (Faber, Bro, and Hopke (2003)).

The position of variables in principal component space is defined by absolute values of loadings. Regularities in changes of variable loadings were approximated by linear trends. Most of them appeared to be statistically nonsignificant. In such case, loadings were represented by their averages which are given in Table 4. If a trend was significant, we gave the first (for year 2000) and the last (for 2015) theoretical value of that trend.

Table 4: Averages and trends of absolute loadings.

Variable [%]	PC1	PC2	PC3
Unemployment Rate	**0.664**	0.260	**0.614**
Employment to Population Ratio	**0.697** → **0.971**	0.457 → 0.089	0.394 → 0.130
Female Members of Parliament	**0.704** → 0.591	0.332 → 0.052	0.526
Share of Tertiary Education	**0.616**	0.333	0.320
Share of Female Researchers in Higher Education	0.329 → 0.038	**0.875**	0.172
Share of Female Researchers in Enterprises	0.469	**0.630** → **0.840**	0.173

From Table 4 we can see that employment rate, percentage of female parliamentary members and share of tertiary educated women in 30–34 age group definitely "belong" to the first principal component. Share of female researchers,

both in higher education and enterprise sector create PC2. Unemployment rate contributes almost equally to PC1 and PC2. Absolute loadings bigger than 0.6 are given in bold.
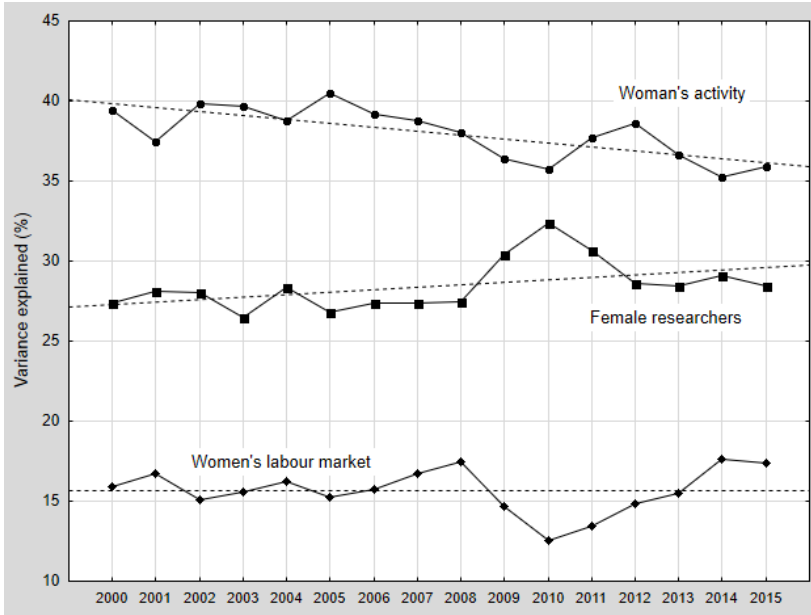

Figure 1: Percentage of variance explained for 3 principal components.

With the results shown in Table 4 we can assign the following names to 3 principal components: PC1 – *Women's activity*, PC2 – *Female researchers*, PC3 – *Women's labour market* (see also Figure 1). The importance of women's labour market was stable in 2000–2015 with the average 15.7 % of variance explained. Trends for the first two principal components were statistically significant with slope −0.246 ($p = 0.0017$) for women's activity in politics, employment and education and +0.155 ($p = 0.0616$) for the share of female researchers. These trends are illustrated in Figure 1.

4 The Analysis of Countries

For the analysis of countries, the results of PCA performed for all analysed years together, were used. The loadings without and with Varimax rotation is given in Table 4. The total variance explained is 82.1 %. Factor values of 3 principal components have been used as coordinates for the "movement" of countries in 3D space. PCA has been performed jointly for the whole analyzed period. Trajectories of countries can be approximated by trends but for the sake of clarity we decided to cluster countries first, to avoid an interpretation of 28 different trends. On the other hand it seems reasonable to assume that changes of "positions" in 3D PC classification space can be more or less similar for some countries. Countries trajectories have been clustered by Ward's method (Ward Jr., 1963). The dendrogram (see Figure 2) reveals the partition of EU countries into four groups:

A – Austria, Luxembourg, Germany, Belgium, France, Cyprus, Slovenia, Great Britain, Ireland, Denmark, Netherlands, Finland, Sweden,

B – Bulgaria, Croatia, Poland, Slovakia, Estonia, Lithuania, Portugal, Latvia, Romania,

C – Czechia, Hungary, Italy, Malta, and

D – Spain, Greece.
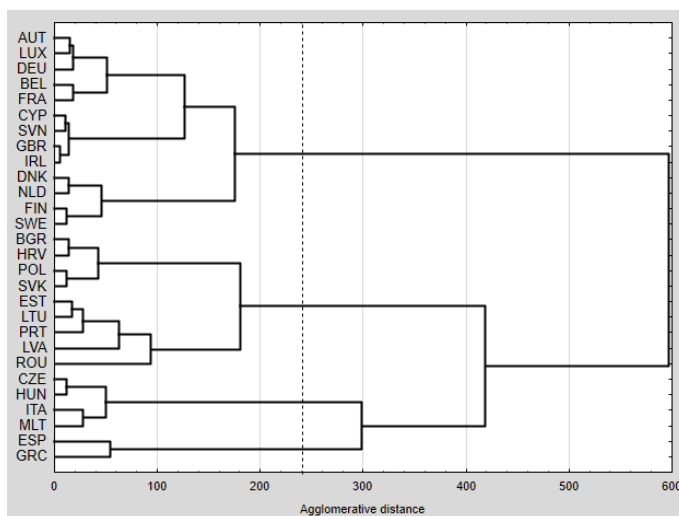
Figure 2: Ward's dendrogram in clustering EU countries in dynamic PC space.
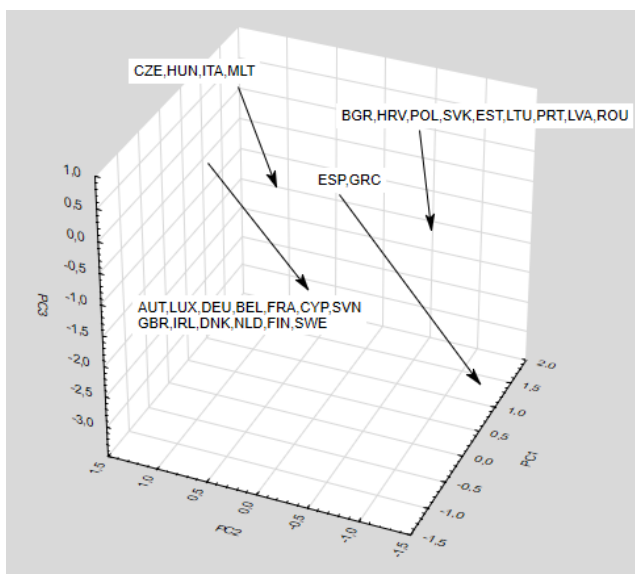
Figure 3: Trajectories of groups as approximated by linear trends.

The dynamic movement of group averages in illustrated on Figure 3. Arrows indicate the direction of movement. The directions of movement are generally similar, but the starting points were different. Group A consists mainly of "old" EU countries, while Group B gathers former socialist countries plus Portugal. Group C has rather strange composition of two post-socialist countries and two Mediterraneans. In Group D we have countries mostly touched by the economic crisis.

Table 5: Comparable levels of variables in groups of countries.

Variable [%]	Group A	Group B	Group C	Group D
	AUT, LUX, GER, BEL, FRA, CYP, SVN, GBR, IRL, DNK, NLD, FIN, SWE	BGR, HRV, POL, SVK, EST, LTU, PRT, LVA, ROU	CZE, HUN, ITA, MLT	ESP, GRC
Unemployment rate	low	medium	low	high
Employment	high	medium	low	low
Parliament	high	medium	low	high
Tertiary education	high	medium	low	medium
Researchers in HE	medium	high	low	medium
Researchers in Ent.	low	high	low	medium

The group order of time series is generally preserved in the analyzed period so it is possible to formulate a simplified characteristic of the group of countries (see Table 5).

5 Conclusions

With the Principal Component Analysis approach it is possible to identify and estimate the general trends in spatio-temporal data. One can analyze changes in variance explained, loadings and positions of objects in PC space. Some interesting findings have been identified in the analyzed problem. The best situation of women from the point of view of the variables included in the research is in the West-European countries. Lower female share among researchers in enterprises is some kind of a surprise. The opposite situation is observed in post-socialist countries where the share of female researchers in the higher education sector and in enterprises is very high. Group C has all variables at comparatively low level which is good as far as unemployment is concerned, but not good for other variables. A very high unemployment rate and low economic activity of women is the main problem in Spain and Greece.

Appendix – Acronyms of Countries

AUT	Austria	**GBR**	United Kingdom	**MLT**	Malta
BEL	Belgium	**GER**	Germany	**NLD**	Netherlands
BGR	Bulgaria	**GRC**	Greece	**POL**	Poland
CYP	Cyprus	**HRV**	Croatia	**PRT**	Portugal
CZE	Czech Republic	**HUN**	Hungary	**ROU**	Romania
DNK	Denmark	**IRL**	Ireland	**SVK**	Slovak Republic
ESP	Spain	**ITA**	Italy	**SVN**	Slovenia
EST	Estonia	**LTU**	Lithuania	**SWE**	Sweden
FIN	Finland	**LUX**	Luxembourg		
FRA	France	**LVA**	Latvia		

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