Journal of Research in Business, Economics and Management (JRBEM)
ISSN: 2395-2210

SCITECH
RESEARCH ORGANISATION

Volume 5, Issue 3
February 29, 2016

Journal of Research in Business, Economics and Management
www.scitecresearch.com

Women, Men and Creativity in Business Sector – Comparative Studies of Leading EU and ECE Countries

Anna Zachorowska-Mazurkiewicz[1], Tomasz Sierotowicz[2]
Institute of Economics, Finance and Management, Jagiellonian University, Lojasiewicza 4, 30-348 Krakow

Abstract

The main focus of the paper is innovativeness and creativity in gender perspective. The question asked is about the relation between gender, research and innovation. The paper is based on the data from European Patent Office (EPO) for years 1999-2013 concerning creative activities by women and men in business sector. For the purpose of the analysis, leading countries have been selected in terms of patent activities, which were then divided into two groups – 10 leading countries from the EU, and three leading countries from the transition economies. The main objective of the paper is to compare the dynamics of three variables: R&D expenditures, number of women and men employed as R&D personnel or researchers in business enterprise sector, number of women and men recognized in EPO database as inventors of patents that are employed in business sector.

Keywords: R&D, Patent, Gender, European Union, CEE Countries.

JEL Classification: O31, O39, O 52, O57.

Introduction

The main focus of the article is innovativeness and creativity in gender perspective. The question asked is about the relation between gender, research and innovativeness. The paper is based on the data from European Patent Office (EPO) for years 1999-2013 concerning creative activities by women and men in business sector. The sense and possibilities of using patent datasets in scientific research were laid by the following researchers: Cohen, Nelson, Walsh, (2002, 2003); Griliches (1990), Pavitt (1989); Guellec, Pottelsberghe, (2000, 2001); Jaffe, Trajtenberg, Henderson, (1993); Schmoch (1997, 2008). These authors point at the information gathered in patent statistics as one of the components of the system measuring technological change, scientific and innovative activity as well as general structural changes in the economic environment. Patent statistics, an important source of information about the current level of development of economies, is still insufficiently applied, primarily because of the limitations of the methods of using patent statistics, which are far from the holistic approach.

In the paper two groups of countries are distinguished in terms of patent activity: 10 leading EU economies and three leading transition countries that are currently members of the European Union. In the following section of the article the number of women and men researchers and R & D personnel are analysed in two distinguished groups, and the analysis of the number of women and men innovators follows. Methods used in the presented research allowed for defining and comparing the dynamics of changes in expenditures on research and development (R&D) in business sector with the dynamics of changes in employment of women and men as R&D personnel and researchers, as well as with the women's and men's creativity expressed as a number of inventors of industrial property in this sector. The undertaken research allowed for defining specificity of observed changes which made it possible to answer the main research question: is (and to what extent) an increase in expenditures on R & D in business sector promoting employment of women and men as R&D personnel and researchers, and an increase in women's and men' creativity expressed in the number of inventors of industrial property? The results of the analysis serve as a base for some policy recommendations formulated at the end of the paper.

1. Background – Review of Literature

Innovation is perceived as an equivalent to something new or modified OECD (2005). As Alsos *et al.* (2013) notice, innovation is increasingly seen as one of the main ways to enhance economic growth, and thus create prosperous nations, and is considered crucial for technological development. As Okoń-Horodyńska and Zachorowska-Mazurkiewicz (2015) write, the special role in economic development assigned to innovation triggered the discussion emphasized in current EU policy (Europe 2020). Hunt et al. (2013) state that innovation is a driver of economic growth and a key to a future prosperity[1]. As Scott Shane (2009, p. 146) states, the aim of innovation policy is among other things to take people out of poverty, reduce unemployment, create jobs, and enhance growth[2]. Growth will be highest if the innovative capacity of the whole workforce is exploited.

Science and society are highly interdependent, each constantly affecting the other. Technological innovation, like scientific research, are not gender-neutral activities. The gender dimension is deeply embedded in the way we do science and develop new technologies, influencing the entire process of technological innovation Abels (2012, p. 187). The European Commission (2001, p. 12) notices, however, that the perception of technology and science is gender-blind. Science through its search for objectivity tends to dismiss gender dimension.

Integrating gender in research requires deep transformation of research design, as well as paradigms and concepts underlying the research design. This could be the reason why research on gender and innovation has not been extensive. There are, however, some studies in this research area that have quite interdisciplinary nature. In social sciences they include business, management and economics literature, but some topics seem to be studied more than others. These include the influence of gender on university scientists' involvement in innovation related activities, the influence of gender on innovation activity, social innovation and public sector innovation, and gender differences in the adaptation of innovation. A number of studies and reports have stressed the acute problem of women's under-representation in science in the business sector (OECD, 2012; Hunt *et al.*, 2013). The results of international empirical comparative studies indicate that, in general, there is a clear statistical pattern that women are less involved than men in the creation of scientific and industrial knowledge (Larivière *et al.*, 2013; Whittington & Smith-Doerr, 2005; Frietsch *et al.*, 2008; Frietsch *et al.*, 2009; Okoń-Horodyńska *et al.* 2015). Whilst women represent over 35% of all researchers in the higher education and government sectors of most European countries, this is not the case for the corporate sector. The percentage of female researchers in the business sector is less than 25% in most countries (European Commission 2010). Hunt et al. (2013) investigated women's underrepresentation among the holders of commercial patents. They concluded that the magnitude of the gender gap in patenting raises the concern that, rather than reflecting comparative advantage or different tastes by gender, the gap reflects gender inequality and an inefficient use of female innovative capacity (p. 831). Research on the role of gender in innovation within private firms seems to be scarce. There is also limited research with a gender perspective on innovation policy, innovation systems and innovation support schemes (Alsos *et al.* 2013, p. 240).

According to Alsos *et.al.* (2013, p. 237) one of the reasons for the lack of studies taking a gender perspective to innovation is the apparent invisibility of people in innovation. When people are not visible in the discourse, gender easily becomes invisible. Gender in innovation has remained invisible due to the fact that most studies on innovation are about products, processes or organizations, and not about people. It is not to say that gender is irrelevant to studies of innovation. As Thorslund and Göransson (2006) highlighted, individuals – men and women – are smallest parts of innovation systems, and all the systems are results of their parts (cited in Alsos *et.al.* 2013, p. 238). The invisibility of actors does not mean there are no actors in innovation. Processes, organizations and systems consist of actors. Identifying these actors is one way of examining gender in innovation.

The next question concerns the way, in which gender should be included in research. Formal modelling can fulfil two useful functions. First, it can help to organize our body of knowledge and state of the arguments with theoretical precision. In this way it is possible to identify and isolate key variables, specifying the nature of interaction between these variables. Second, formal modelling is a crucial step in policy making. Simple models can be used to demonstrate the potential effectiveness of gender-aware policies to policy-makers (Cagatay 2003, p. 30). The contribution of adopting the perspectives of gender as a variable and innovation as a result is a dominant approach in empirical research on gender and innovation. The literature on gender differences on patenting, commercialization, etc. in university context is often quantitative, comparing the tendencies of women and men contribution to innovation. Examples of such studies presented by Alsos *et al. (*2013) include Bozeman and Gaughan (2007) studies that show that male researchers are more likely than female researchers to engage in industry cooperation, or Foss *et al.* (2013) study showing that even though

[1] More than a half of US economic growth since the Second World War is attributable to technological progress (Boskin and Lau 2000, cited by Hunt et al. 2013, s. 831).

[2] Innovation is therefore important macroeconomic factor that needs to be considered.

women are equally innovative in generating new ideas, their ideas are more seldom implemented in organization compared to men. Taking a "gender as variable" perspective may allow exploration of policy measures targeting women and men. It may help to search for the built-in gender bias embedded in policy and research on innovation.

Looking into the policy, there are some gender issues that are quite apparent. One is that in the EU women and science activities are funded under the science/society programme – the smallest component amount in the research budget, while most money goes into the male-dominated science and engineering programmes. Most policy recommendations follow an equal treatment or positive action approach, focusing on women, not on gender. They rather focus on increasing the share of women scientists in industrial research, still missing a comprehensive approach gendering the foundations of EU research policy (Abels 2012, p. 202). And the result is the underrepresentation of women in science and among holders of commercial patents.

Taking this into account, the paper looks into the dynamics of changes in terms of the number of women and men researchers, R & D personnel and inventors, and combines them with the changes in R & D expenditures in business sector. This simple exercise is based on the disaggregation of data by gender. The analysis is conducted for the EU countries. Two groups of leading countries have been distinguished in terms of creative patent activities – 10 EU leading countries and three leading transition economies. The objective of this exercise is to present the correlation between R & D expenditures and employment of women and men in R & D sector, and to compare the two distinguished groups of the countries. Such information should then be used to design new gender-aware set of policies.

2. Research Method

There are various sources of patent information. This article uses the full patent database (for European patent applications) of *Thomson Innovation* developed by Thomson Reuters for the period of 1999-2013. In order to work with such an extensive metadata set of bibliographical descriptions, it is necessary to apply automated techniques of grouping items using dictionaries of female and male names, as well as typology of other agents (separately for inventors and entities applying for a patent) and postal codes (indicated separately as a standard as part of the addresses of patent inventors and seats/addresses of entities applying for a patent). The research period – 1999 – 2013 – was chosen due to the integrity of primary data obtained from EPO database. From patent statistics the data chosen concern time series of annual numbers of female and male inventors of novelties that received patent protection in years 1999-2013 under European patent application including their association with agents belonging to business sector. Additionally, Eurostat data have been used regarding indicators, such as: "Population by age and sex", "Total female R&D personnel and researchers business enterprise sector", "Total intramural R&D expenditure (GERD) of business enterprise sector".

The research was carried out in four stages. The first one aimed to determine two groups of leading countries in terms of the number of women and men inventors from 19 EU countries and from 9 transition states that are currently members of the EU: Bulgaria, Czech Republic, Estonia, Lithuania, Latvia, Poland, Romania, Slovakia and Hungary. At this stage of the research all EU countries were taken into consideration. The division into two separate groups was due to the fact that patent activity of 9 transition states measured by the number of patents awarded by the EPO in the whole period reached 0.78 %, while 99.22 % was awarded to 19 EU member states. And since the goal was to determine the trends that would describe women and men creative patent activity both in the EU countries, and in the group of transition economies, such a division appeared to be necessary. Identified leading countries from the two groups were then used to obtain time series that are presented in table 1.

Table 1: Time Series Obtained During the Preparation of Entry Data for All Leading EU Countries in the Period 1999-2013

Variables	Description
x_c	Time series of the total intramural R&D expenditure (GERD) of business sector.
y_{cwr}	Time series of the women R+D personnel and researchers in business sector.
y_{cmr}	Time series of the men R+D personnel and researchers in business sector.
y_{cwp}	Time series of the women inventors of industrial property in the business sector.
y_{cmp}	Time series of the men inventors of industrial property in the business sector.

Source: authors' own work

The presented time series allowed, in the second stage of research, to verify statistically significant correlation between R & D expenditures in the business sector, and the number of women inventors, number of men inventors in business sector in each of the leading EU countries. Pearson correlation coefficient[3] was used in this stage (Triola, 2014; Doane & Seward, 2012):

$$r_{cz} = \frac{\sum_{i=1}^{n}(x_{ci} - \bar{x}_c) \times (y_{cpi} - \bar{y}_{cp})}{\sqrt{\sum_{i=1}^{n}(x_{ci} - \bar{x}_c)^2 \sum_{i=1}^{n}(y_{cpi} - \bar{y}_{cp})^2}} \qquad \text{(Equation 1)}$$

where:

r_{cz} – Pearson's correlation coefficient, calculated for each country covered by the research and pair of time series being verified for the presence of statistical correlation,

n – number of observations,

c – another country covered by the research,

z – pair of time series (corresponding to the variables), being verified for the presence of statistical correlation,

p – another time series of variable subjected to verification of the presence of statistical correlation with the annual value of the intramural expenditure on R&D activity of the business enterprise sector: y_{cwr}, y_{cmr}, y_{cwp}, y_{cmp}, respectively (table 1),

i – another pair of two time series observations (corresponding to the number of years in the calculated series),

x_{ci} – another observation of the annual value of the intramural expenditure on R&D activity of the business enterprise sector (table 1),

y_{cpi} – another observation of the annual number of variable subjected to verification of the presence of statistical correlation: y_{cwr}, y_{cmr}, y_{cwp}, y_{cmp}, respectively (table 1),

$\bar{x}_c$– arithmetic mean of expenditure on R&D activities throughout the research period,

$\bar{y}_{cp}$– arithmetic mean of the annual number of variable subjected to verification of the presence of statistical correlation: y_{cwr}, y_{cmr}, y_{cwp}, y_{cmp}, respectively (table 1), throughout the research period.

Table 2 presents pairs of variables that were verified using Pearson correlation coefficient.

Table 2: Variables Verified for the Existence Of Correlation for Each Country in 1999-2013

Correlation Coefficient	Variable X_c	Variable Y_{cp}
r_{c1}	x_c	y_{cwr}
r_{c2}	x_c	y_{cmr}
r_{c3}	x_c	y_{cwp}
r_{c4}	x_c	y_{cmp}

Source: authors' own work

The third stage of research focused on the annual values of the ratio of the number of women to the number of men calculated using time series from table 1. In order to calculate the ratio the following equation has been used:

$$Wm_{acr} = \frac{y_{capw}}{y_{capm}} \qquad \text{(Equation 2)}$$

where:

Wm_{acr} – annual value of women to men ratio for each country studied

[3] Other two correlation coefficients Rho Spearmana and Kedalla Tau were calculated for a sample of countries, and they gave similar results.

y_{capw} – annual value of the time series, presented in table 1, of variable representing women: y_{cwr}, y_{cwp}, respectively for each country covered by the research,

y_{capm} – annual value of the time series, presented in table 1, of variable representing men: y_{cmr}, y_{cmp}, respectively for each country covered by the research,

c – following country researched,

r – number of the following variable comprising time series, calculated as the women to men ratio,

a – following year in the time series.

Table 3 presents variables obtained using equation 2.

Table 3: Time Series of the Annual Values of the Women to Men Ratio for Each Country Examined in 1999-2013	
Variables	**Description**
Wm_{ac1}	Time series of the women to men ratio, being R+D personnel and researchers of business sector.
Wm_{ac2}	Time series of the women to men ratio, being inventors of industrial property of the business sector.
Source: authors' own work.	

The last, forth, stage focused on dynamics of change, using time series of variables presented in tables 1 and 3. The dynamics of change was determined using the average rate of change in time, as demonstrated in the equations below (Freedman *et.al.* 2007, Sobczyk, 2007, Hughes-Hallett, et al., 2014):

$$log\bar{y}_{Cg} = \frac{1}{n-1}\sum_{i=2}^{n} log\frac{y_{cgi}}{y_{cgi-1}} \qquad \text{(Equation 3)}$$

$$Acr_{Cg} = \left(\bar{y}_{Cg} - 1\right) \times 100 \qquad \text{(Equation 4)}$$

where:

$\bar{y}_{cg}$ – stands for the geometric mean of chain indices calculated separately, specified variables (in tables 1 and 3) for each EU member state for the entire period under analysis,

g – following variable (in table 1 or 3), for which the calculation has been done in each country under analysis,

n – number of observations in a time series (corresponding to the number of years of the period under analysis),

i – following observation in the time series,

c – next EU country included in the study,

$\frac{y_{cgi}}{y_{cgi-1}}$ – value of the next chain index,

Acr_{cg} – average rate of change of the value of the following variable (in table 1 or 3), in each country under analysis.

Using equations 3 and 4 the values have been obtained for the each country under analysis in the entire period 1999-2013. The results have been presented in table 4.

Table 4: Variables Calculated in the Third Stage of the Research	
Symbol	**Description**
Acr_{C1}	Average rate of change of the total intramural R&D expenditure (GERD) of business sector.
Acr_{C2}	Average rate of change of women being R+D personnel and researchers of business sector.
Acr_{C3}	Average rate of change of men being R+D personnel and researchers of business sector.

Acr_{C4}	Average rate of change of women being inventors of industrial property of the business sector.
Acr_{C5}	Average rate of change of men being inventors of industrial property of the business sector.
Acr_{C6}	Average rate of change of the women to men ratio, being R+D personnel and researchers of business sector.
Acr_{C7}	Average rate of change of the women to men ratio, being inventors of industrial property of the business sector.
Source: author's own work	

The results allowed to conduct the comparison, and to phrase conclusions and recommendations.

3. Research Results

3.1 Identification of the Leading Countries in Terms of Creative Patent Activity

The first stage of research work was executed for each of the 28 EU member states. It consisted of selecting two groups of leading countries in terms of the number of women and men inventors from 19 EU countries and from 9 transition countries that are currently members of the EU: Bulgaria, Czech Republic, Estonia, Lithuania, Latvia, Poland, Romania, Slovakia and Hungary. The identification of these groups was conducted in two steps. In the first one, the criterion was the share of women, men and women and men inventors in the total number of women, men and women and men in 19 EU countries and 9 transition EU countries. In the second step, the criterion was the share of women, men, and women and men inventors of industrial property per 1 m citizens, women, men, and women and men.

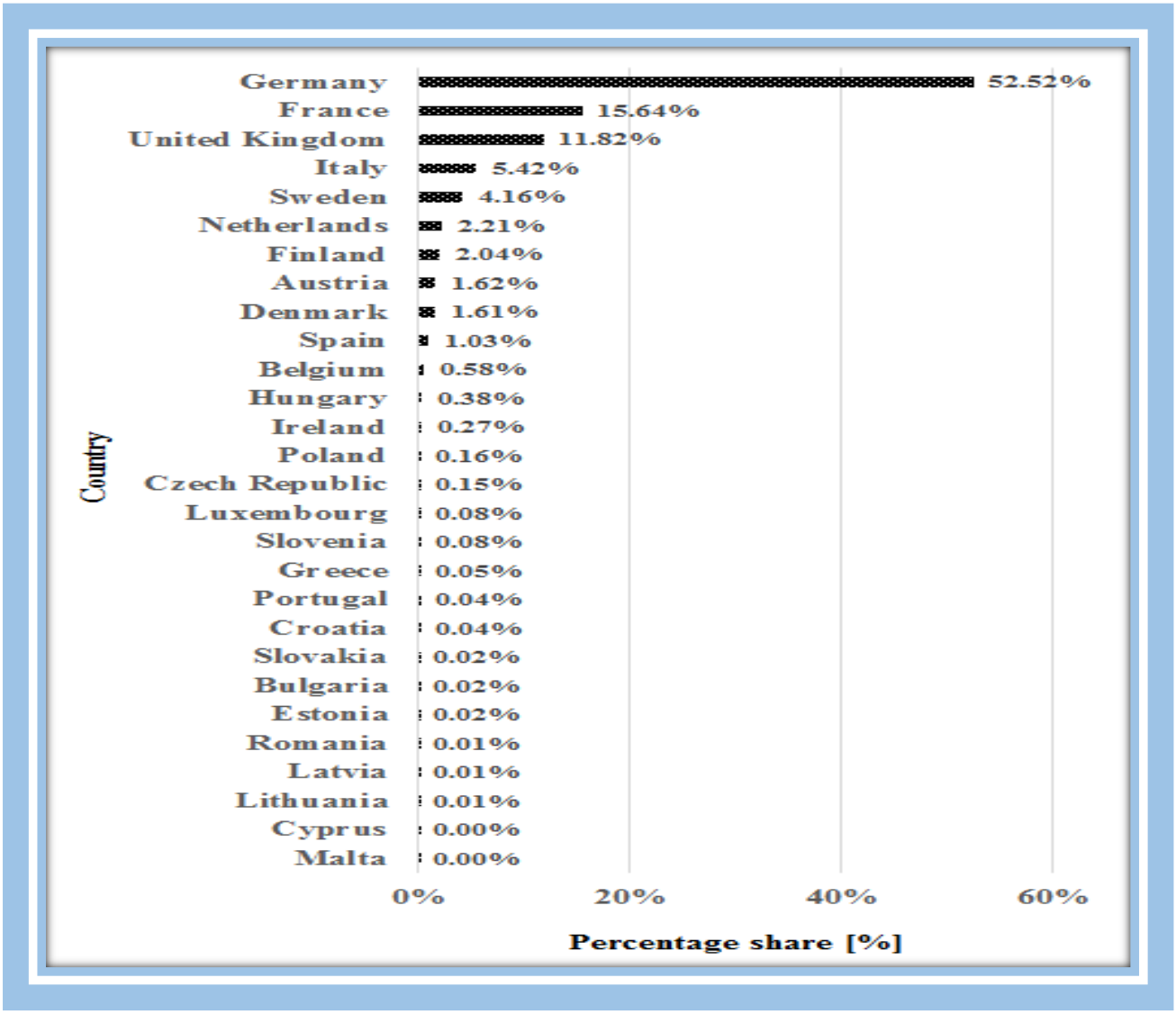
In the period under analysis, in all EU member states 58 678 women and 733 281 men were regarded as inventors of the industrial property. The total number of women and men inventors was 791 959. In table 5 the proportions of women and men as inventors of industrial property are presented.

Table 5: Share of Women and Men Inventors of the Industrial Property in 1999-2013						
Country	**Share of women inventors in a total number of women inventors in the EU in the whole period analysed badawczym**	**Share of men inventors in a total number of men inventors in the EU in the whole period analysed**	**Share of inventors in a total number of inventors in the EU in the whole period analysed**	**Share of women being inventors per 1 m female inhabitants [%]**	**Share of men being inventors per 1 m of male inhabitants [%]**	**Share of women and men being inventors per 1 m of inhabitants [%]**
Austria	1.02%	1.67%	1.62%	3.54%	6.66%	6.35%
Belgium	0.49%	0.58%	0.58%	1.35%	1.79%	1.75%
Bulgaria	0.08%	0.01%	0.02%	0.29%	0.06%	0.07%
Croatia	0.23%	0.02%	0.04%	1.53%	0.18%	0.29%
Cyprus	0.00%	0.00%	0.00%	0.06%	0.06%	0.06%
Czech Republic	0.25%	0.14%	0.15%	0.70%	0.45%	0.47%
Denmark	2.58%	1.54%	1.61%	13.81%	9.09%	9.54%
Estonia	0.03%	0.02%	0.02%	0.69%	0.38%	0.39%
Finland	2.36%	2.02%	2.04%	12.91%	12.45%	12.47%
France	21.49%	15.17%	15.64%	9.73%	7.92%	7.99%
Germany	37.16%	53.75%	52.52%	13.03%	21.30%	20.57%
Greece	0.04%	0.05%	0.05%	0.12%	0.14%	0.14%
Hungary	0.95%	0.34%	0.38%	2.64%	1.12%	1.22%
Ireland	0.36%	0.27%	0.27%	2.49%	2.03%	2.09%
Italy	9.76%	5.08%	5.42%	4.79%	2.88%	3.00%
Latvia	0.03%	0.01%	0.01%	0.38%	0.16%	0.17%
Lithuania	0.02%	0.01%	0.01%	0.14%	0.07%	0.07%
Luxembourg	0.05%	0.09%	0.08%	2.94%	5.83%	5.64%
Malta	0.00%	0.00%	0.00%	0.00%	0.03%	0.03%
Netherlands	1.79%	2.25%	2.21%	3.19%	4.44%	4.37%
Poland	0.35%	0.14%	0.16%	0.26%	0.12%	0.13%
Portugal	0.08%	0.04%	0.04%	0.22%	0.13%	0.14%
Romania	0.04%	0.01%	0.01%	0.05%	0.02%	0.02%
Slovakia	0.07%	0.02%	0.02%	0.40%	0.12%	0.14%
Slovenia	0.19%	0.07%	0.08%	2.67%	1.07%	1.21%
Spain	2.18%	0.94%	1.03%	1.44%	0.69%	0.76%
Sweden	4.37%	4.14%	4.16%	14.01%	14.58%	14.67%
United Kingdom	14.03%	11.65%	11.82%	6.64%	6.23%	6.25%
Total	***100%***	***100%***	***100%***	***100%***	***100%***	***100%***

Source: author's own work based on: EPO patent statistics (2014), available at Thomson Innovation: http://www.thomsoninnov-ation.com/ti/conte-ntsets/patents/, (Accessed: 08.12.14).

Columns 2, 3 and 4 (table 5) present the percentage shares of respectively women, men, and women and men in the total number of respectively women, men, and women and men that are inventors of industrial property, coming from the EU countries in years 1999-2013 presented. Columns 5, 6 and 7 present the shares of respectively women, men, and women and men that were inventors of industrial property in 1999-2013 per 1 m inhabitants of the EU countries, respectively women, men, and women and men presented. The share of women and men from a given country in the total number of women and men from all EU countries that are inventors of industrial property is shown in figure 1.

Fig. 1. Share of Women and Men Inventors in the Total Number of Inventors (Women and Men) in the EU Countries in Analysed Period



Source: author's own work

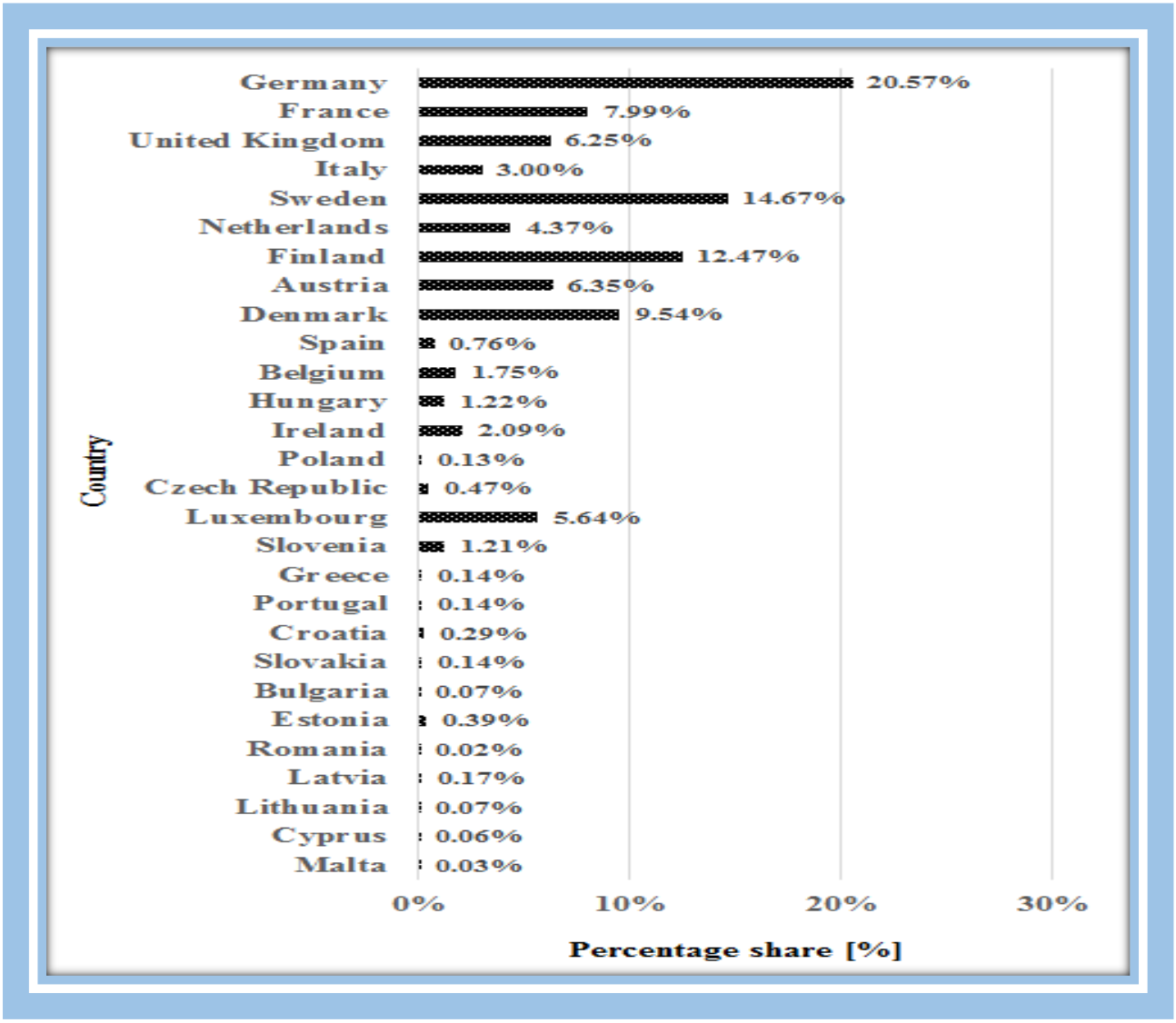
As it is presented in the table 5 and figure 1, the share of inventors (women and men) coming from Germany, France, UK, Italy, Sweden, the Netherlands, Finland, Austria, Denmark and Spain comprise 98.07% of total inventors (women and men) from all EU member states in the period under study. The shares of inventors coming from 9 transition states comprise 0.78% of a total number of inventors. The share of inventors coming from Poland, Hungary and Czech Republic comprise 88.46% of total inventors (women and men) coming from all post-socialist states under study in the analysed period.

The presented results from the first step of the identification of the leading groups point at the following countries as leaders from the EU countries in terms of creative activity in industrial property in years 1999-2013: Germany, France,

UK, Italy, Sweden, the Netherlands, Finland, Austria, Denmark and Spain. Among the 9 transition countries Poland, Hungary and Czech Republic may be considered leaders in term of creative patent activity in 1999 – 2013.

The second step of the identification of groups of the leading countries, the criterion of the share of women, men, and women and men inventors of industrial property per 1 m inhabitants, women, men, and women and men in analysed period was adopted. The results are presented in figure 2.

Fig. 2. Share of Women and Men Inventors Per 1 M EU Inhabitants in the Analysed Period



Source: author's own work

The data presented above show that shares of inventors (women and men) coming from Germany, Sweden, Finland, Denmark, France, UK, Luxemburg, the Netherlands and Italy comprise 90.85% of total number of inventors (women and men) per 1 m EU inhabitants in the analysed period. Shares of 9 transition states comprise 2.69% of total number of women and men inventors of industrial property per 1 m EU inhabitants. Share of inventors (women and men) coming from Poland, Hungary, Czech Republic, Latvia and Estonia comprise 88.49% of total number of inventors (women and men) coming from the transition economies in the analysed period.

As a result of the second step of the identification of leading countries in terms of creative activity per 1 m inhabitants, both women and men, and women and men together, it could be stated that for the EU the leading countries are as follows: Germany, France, UK, Italy, Sweden, the Netherlands, Finland, Austria, Denmark and Luxemburg. While comparing the results of the first and the second steps of the identification, it could be noticed that nine countries are the same. There are, however, differences in both steps – there is Spain identified as a leading country in the first step, and

Luxemburg in the second. Taking into consideration the number of inhabitants, Spain makes up more than 22% of all EU inhabitants, while Luxemburg only 0.5%. Due to this, Spain is more significant state in terms of the number of citizens. Additionally, there were 8 146 inventors of industrial property in Spain, while in Luxemburg only 657 for the whole period under study, which makes Spanish inventors a cohort 12 times bigger. Thus, for further research Spain was chosen for the group of leading EU countries. The first identified group of the leading EU countries in terms of the creative activities consists of: Germany, France, UK, Italy, Sweden, the Netherlands, Finland, Austria, Denmark and Spain. There is quite a different situation in the 9 transition EU states. None of these countries could be considered a leading country in terms of creative activity, therefore none is enlisted in the first group.

In the second step of identification, Latvia and Estonia, along with Czech Republic, Hungary and Poland, were identified. The reason for it is probably the low number of inhabitants, since creative activity in these two countries is one of the lowest among post-socialist EU states. In the analysed period, there were 18 women and 73 men inventors of industrial property in Latvia, and respectively 20 and 110 in Estonia. Due to this, and taking into consideration main research questions, the second group of the leading countries in terms of creative activity consists only of Czech Republic, Poland and Hungary.

These two groups of countries were used in further stages of the study.

3.2 Correlation of R & D Expenditures with the Creative Patent Activity of Women and Men

Using equation 1, the statistical correlation between time series of variables listed in Table 2 was calculated. Results for 10 EU leading countries are presented in table 6.

Table 6: Correlation Coefficient for the Group of 10 Leading EU Countries for Years 1999-2013

Country/Pearson Coefficient	r_{c1}	r_{c2}	r_{c3}	r_{c4}
Austria	0.99	0.99	0.64	0.73
Denmark	0.92	0.94	0.76	0.76
Finland	-0.28	0.72	0.02	0.20
France	0.98	0.98	0.84	0.72
Germany	0.94	0.97	0.63	0.33
Italy	0.99	0.98	0.76	0.67
Netherlands	0.94	0.94	0.45	0.29
Spain	0.99	0.99	0.87	0.85
Sweden	0.43	0.34	0.53	0.42
United Kingdom	0.52	0.47	0.37	0.17

Source: author's own work

The results presented in table 6 show that there is a strong positive correlation between R & D expenditures in business sector and each of the four variables used in the analysis in Austria, Denmark, France, Italy, and Spain. For the rest of the countries, there were strong positive correlations between R & D expenditures in business sector and the number of women and men inventors and R & D personnel in Germany 0.94, the Netherlands 0.94 and the United Kingdom 0.52; there are weak correlations for the same variables in Sweden 0.43; there is one weak negative correlation in Finland -0.28, and this is the only case of such kind in the group of 10 leading countries. There are strong positive correlations between R & D expenditures in business sector and numbers of men inventors and R & D personnel in Finland 0.72, Germany 0.97 and the Netherlands 0.94; there is a weak positive correlation in Sweden 0.34 and the United Kingdom 0.47. There are strong positive correlations between R & D expenditures and the numbers of women inventors and R & D personnel in the same sector in Germany 0.63 and Sweden 0.53; and there are weak correlations in Finland 0.02, the Netherlands 0.45 and the United Kingdom 0.37. And for R & D expenditures in business sector and the number of men inventors of industrial property there are weak correlations in Finland 0.2, Germany 0.33, the Netherlands 0.29, Sweden 0.42 and the United Kingdom 0.17.

Using equation 1, statistical correlations were calculated between time series described in table 2 for three leading post-socialist countries. The results are presented in table 7.

Table 7: Correlation Coefficient for the Leading Transition Countries in Years 1999-2013				
Country/Pearson Coefficient	r_{c1}	r_{c2}	r_{c3}	r_{c4}
Czech Republic	0.95	0.99	0.19	0.81
Hungary	0.97	0.98	-0.05	-0.08
Poland	0.49	0.91	0.38	0.89

Source: author's own work

Results presented in table 7 concerning the R & D expenditures in business sector and the number of women inventors and R & D personnel in the same sector show: strong positive correlation for Czech Republic 0.95 and Hungary 0.97, and weak positive correlation for Poland 0.49. There were strong positive correlations between R & D expenditure in business sector and a number of men inventors and R & D personnel in all analysed transition countries. In the case of R & D expenditures in business sector and the number of women inventors of industrial property in the same sector: there were weak positive statistical correlations in Czech Republic 0.19 and Poland 0.38, and weak negative correlation in Hungary -0.05. Between R & D expenditures and the number of men inventors of industrial property in the same sector there were strong positive statistical correlations in Czech Republic 0.81 and Poland 0.89, and weak negative correlation in Hungary -0.08.

3.3 The Dynamics of Changes in Patent Activity of Women and Men in Business Sector

New solutions are outcomes of research and development activities. Financial expenditure, as well as women's and men's involvement in R & D are inputs. Those variables are important for the measurement of creative patent activities of women and men, who are directly engaged in research and development which lead to the creation of new solutions that could be implemented in an industry. Using equation 2, it was possible to calculate time series presented in table 3. Then using equation 3 and 4 the dynamics of changes in specified variables presented in table 4 was calculated for each country under study. The results of these calculations are presented in the following sections of the paper for the EU leading countries and transition leading countries.

3.3.1. The Dynamics of Changes in Patent Activity in EU Leading Countries

The average rate of changes of variables described in table 4 for EU leading countries are presented in table 8.

Table 8: Average Rate of Change of Variables Describing Patent Activity of the Leading EU Countries in 1999-2013							
Country\Variable	Acr_{C1}	Acr_{C2}	Acr_{C3}	Acr_{C4}	Acr_{C5}	Acr_{C6}	Acr_{C7}
Austria	5.05%	5.91%	3.34%	7.03%	4.34%	2.48%	2.58%
Denmark	5.77%	5.73%	4.12%	9.85%	6.00%	1.54%	3.64%
Finland	4.04%	-0.24%	0.09%	3.09%	1.68%	-0.33%	1.39%
France	3.58%	4.46%	5.32%	4.42%	3.14%	-0.82%	1.24%
Germany	3.70%	1.72%	1.47%	6.65%	3.01%	0.24%	3.54%
Italy	4.76%	7.38%	5.26%	8.94%	4.74%	2.02%	4.01%
Netherlands	3.95%	8.02%	6.17%	5.88%	2.68%	1.74%	3.11%
Spain	7.28%	10.54%	7.21%	15.82%	9.33%	3.11%	5.94%
Sweden	2.82%	1.13%	0.86%	8.04%	5.21%	0.28%	2.69%
United Kingdom	1.51%	1.68%	2.06%	5.42%	1.33%	-0.37%	4.04%

Source: author's own work

The results in table 8 show that in all EU leading countries R & D expenditures increased in business sector (variable Acr_{C1}). The highest growth was noted for Spain, where the expenditures increased in the whole analysed period, from year to year on average by 7.28 %. The smallest increase was noted in the United Kingdom, where average annual growth of R & D expenditures in business sector in the whole analysed period was 1.51 %.

Acr_{C2} variable shows the dynamics of changes concerning the number of women researchers and R & D personnel in business sector in EU leading countries. The results presented in the table show that in all EU leading countries, besides Finland, the number of women researchers in business sector has increased. The highest growth was noticed in Spain, where the number of women has increased in the period under study from year to year on average by 10.54 %. This increase is higher than in the case of R & D expenditures in business sector, which in Spain reached 7.28 %. A situation similar to Spanish could be observed in Austria, France, Italy, the Netherlands, and the UK, where the annual average growth of R & D expenditures in business sector is lower than the annual average growth of the number of women researchers in the same sector. It could be concluded that the increase in R & D expenditures in business sector advantages the employment of women researchers in this sector.

Variable Acr_{C3} represents the dynamics of changes in the number of men researchers and R & D personnel in business sector in EU leading countries. Calculations show that in all EU leading countries the number of men researchers and R & D personnel has increased in business sector. The highest growth was noted for Spain, where the number of men in the period under study has increased annually by 7.21 % on average. The lowest increase was noticed in Finland, where the annual average growth in the number of men researchers and R & D personnel has reached 0.09 %.

The dynamics of changes in the number of women inventors of industrial property in business sector in EU leading countries is represented by a variable Acr_{C4}. The results presented in table 8 show that in all EU leading countries the number of women inventors of industrial property has increased in business sector. The highest growth in business sector was noted in Spain, where the number of women inventors of industrial property has increased from year to year by 15.82 % on average. It is much higher than average annual growth of R & D expenditures and of the number of women researchers and R & D personnel that reached in Spain respectively 7.28 % and 10.54 %. Similar situation could also be observed in Austria, Denmark, Germany, Italy, Sweden and the United Kingdom. Additionally, there was a higher growth of women inventors of industrial property than the number of women inventors and R & D personnel in Austria, Denmark, Germany, Italy, Spain, Sweden and the UK. It could be concluded that the growth of the number of women researchers and R & D personnel in business sector entails a greater growth of the number of women engaged in the cooperation in creative patent activities. It could be recognized as a synergy in women's cooperation in creation of new solutions for industry. The lowest growth was noted for Finland, where the number of women inventors of industrial property increased in analysed period from year to year by 3.09 % on average.

The dynamics of changes of the number of men inventors of industrial property in business sector in EU leading countries is represented by the variable Acr_{C5}. Results presented in table 8 show that in all EU leading countries the number of men inventors of industrial property in business sector increased in the period under study. The highest growth in business sector was noticed in Spain, where the number of men inventors of industrial property increased in the analysed period annually by 9.33 % on average. This growth is higher than average annual increases in R & D expenditures and the number of men researchers and R & D personnel, which were respectively 7.28 % and 7.21 %. Apart from Spain, similar situation could be observed in Denmark and Sweden. It could be concluded that in these three countries the increase in the number of men researchers and R & D personnel in business sector is linked to the greater increase in the number of men engaged in the cooperation in creative patent activity. Just as in the case of women, it could be treated as a synergy phenomenon in cooperation between men in creating new solutions for industry. However the scale of the phenomenon is 2.5 times greater in the case of women than in the case of men, because the synergy effect could be noticed in seven countries examined.

The dynamics of changes in the ratio of the number of women to men researchers and R & D personnel in business sector in EU leading countries represents the variable Acr_{C6}. Results show that the number of women in relation to men increased in the whole period under study in Austria, Denmark, Germany, Italy, the Netherlands, Spain and Sweden. The biggest change took place in Spain 3.11%. However, the opposite trend was observed in the rest of the countries. But it may be concluded that in most of the EU leading countries, in terms of patent activity, the ratio of the number of women to men researchers and R&D personnel was growing in years 1999-2013.

The dynamics of changes in the ratio of women to men inventors of the industrial property in business sector in EU leading countries represents variable Acr_{C7}. The results show that the ratio of women to men inventors was growing in all EU leading countries in 1999-2013. The fastest growth was noted in Spain 5.94 %. It can be concluded that the women's role in creative patent activity is growing in the period under study in EU leading countries.

3.3.2 The dynamics of changes in patent activity in leading transition countries

The results of calculations of the average changes described in table 4 for the group of leading post-socialist countries are presented in table 9.

Table 9: Average Rate of Change of Variables Describe Patent Activity of the Leading Transition Countries in 1999-2013							
Country\Variable	**Acr_{C1}**	**Acr_{C2}**	**Acr_{C3}**	**Acr_{C4}**	**Acr_{C5}**	**Acr_{C6}**	**Acr_{C7}**
Czech Republic	10.46%	2.61%	5.32%	0.00%	15.88%	-2.57%	-13.71%
Hungary	15.90%	5.62%	10.10%	4.65%	0.47%	-4.07%	4.16%
Poland	8.99%	-0.39%	2.87%	9.36%	26.12%	-3.17%	-13.29%

Source: author's own work

Based on calculations, it was observed that the dynamics of changes in R & D expenditures in business sector (variable Acr_{C1}) was positive. The biggest change was noticed in Hungary, where the expenditures increased throughout the whole period annually by 15.90 % on average. The smallest change could be observed in Poland, where the annual average increase in R & D expenditures reached 8.99 %.

The dynamics of changes concerning the number of women researchers and R & D personnel in business sector in leading transition countries is represented by Acr_{C2}. The results in table 9 show that in Czech Republic and Hungary the number of women researchers and R & D personnel in business sector in the whole analysed period increased from year to year on average by 2.61 % and 5.62 %. The dynamics of change is significantly lower than the change in R & D expenditures in business sector. The opposite situation could be observed in Poland, where despite the positive change in terms of the R & D expenditures, the dynamics of changes in the number of women researchers and R & D personnel in the whole period under study decreased from year to year by 0.39 % on average.

The dynamics of changes in the number of men researchers and R & D personnel in the business sector in leading transition countries represents the variable Acr_{C3}. The results of calculations show that in all the countries the number of men researchers and R & D personnel in business sector increased, in Hungary in the highest degree annually by 10.10% on average.

The dynamics of change in the number of women inventors of industrial property in business sector in leading transition countries is represented by the variable Acr_{C4}. The results show that the greatest change in the number of women inventors of industrial property happened in Poland – annually by 9.36% on average. Simultaneously, in Poland the number of women researchers and R & D personnel decreased in the same period annually by 0.39% on average. It could be concluded that the patent activity of women in Poland in business sector is not linked to the employment in R & D divisions. This activity may also apply to small and medium enterprises, where such an activity is not conducted in a continuous way.

The dynamics of changes in the number of men inventors of industrial property in business sector in leading transition countries represents Acr_{C5}. The results presented in table 9 show that in all analysed countries there was an increase in the number of men inventors, and the highest one was observed in Poland, annually by 26.12 % on average. It is a much greater increase than in the case of women inventors of industrial property in Poland.

The dynamics of change of the ratio of the number of women to the number of men researchers and R & D personnel in business sector in the leading transition states is represented by Acr_{C6}. The results show that in all leading transition states there was a decrease in the ratio of women to men researchers and R & D personnel in business sector. This is a trend opposite to the one noticed in 7 EU leading countries, where the ratio of the number of women to men researchers and R & D personnel was increasing throughout the whole period under study.

The dynamics of the change of the ratio of the number of women to men inventors of industrial property in business sector in leading post-socialist countries represents the variable Acr_{C7}. The results show that in Czech Republic and Poland the ratio of the number of women to men inventors of industrial property decreased annually by 13.71% and 13.29% on average respectively. This is also an opposite trend to the leading EU countries, where the ratio of the number of women to men inventors of industrial property was increasing in the same period.

4. Conclusions and Policy Recommendations

The following countries were included in the group of the EU leading countries in terms of patent activity: Germany, France, UK, Italy, Sweden, the Netherlands, Finland, Austria, Denmark and Spain. And the following countries were included in the group of leading transition countries that are currently members of the EU: Poland, Czech Republic and Hungary. This division was necessary because none of the transition EU member states is among the EU leaders in terms of creative patent activity. Nevertheless, this activity is an important factor of economic growth, which in turn leads to economic development and to the reduction of unemployment and poverty. The EU leading countries could be used as models for the transition states of how to increase the creativity and innovativeness of the economy.

In all EU leading countries the number of women inventors of industrial property in business sector was increasing in the whole period under study. Results of the conducted study show that in Austria, Denmark, Germany, Italy, Spain, Sweden and the United Kingdom the dynamics of growth of the number of women inventors of industrial property was higher than the dynamics of growth of the number of women researchers and R & D personnel. It could be concluded that the increase in the number of researchers and R & D personnel activates the higher increase in the number of women engaged in cooperation in creative patent activity. This relation could be defined as a synergy in the women's cooperation in the creation of new solutions for industry. In Spain, Denmark and Sweden there was higher dynamics of growth in the number of men engaged in the cooperation in creative patent activity than in the number of men researchers and R & D personnel in business sector. As in the case of women, this could be defined as a synergy phenomenon describing the cooperation of men in the creation of new solutions for industry. However, synergy phenomenon is much stronger in the case of women than men (2.5 times stronger), since the phenomenon appears in seven countries under study. It could also be concluded that since, in the majority of the countries, the number of women researchers and R&D personnel increased more rapidly than the number of men, and in all the countries the increase in the number of women inventors was higher than men, the success in terms of the number of patents awarded is the outcome of the changes in the structure by gender.

The study conducted in the group of leading transition countries show that the dynamics of growth in the number of men inventors of industrial property is higher than in the case of women inventors in the same period under study. It is a different situation than in the EU leading countries, where the number of women inventors of industrial property was increasing at the higher pace than the number of men. At the same time, the dynamics of the growth of the number of men inventors of industrial property in Poland and Czech Republic was higher than in Spain, where the dynamics was the highest among EU leading countries. In Poland and in Czech Republic there was a drop in the ratio of the number of women to the number of men inventors of industrial property in business sector. It is a situation opposite to the one describing EU leading countries, where the ratio was increasing throughout the analysed period. It could be concluded that the role of women in the process of innovation is limited in business sector in transition countries. This limitation leads to the decreasing role of women inventors of industrial property in business sector. That could also be a factor explaining poor performance of these countries in terms of patent obtained.

The results of the study conducted leads to certain policy conclusions. For the post-socialist countries, there is a need to further increase R & D expenditures in business sector. Additionally, the employment of R & D personnel and researchers should be monitored in order to promote hiring of women. In this context a new question should be posed – how to attract women to this sector? In order to answer this question, further research needs to be conducted that would focus on the reasons why women in post-socialist countries are not employed as researchers and R & D personnel.

Acknowledgements

This work is supported by the National Centre for Research and Development (NCBiR) under Grant No Pol-Nor/200588/60/2013 „Innovative Gender as a New Source of Progress" by the Polish-Norwegian Research Programme.

References

[1] Abels, G. (2012). Research by, for, and about Women: Gendering Science and Research Policy. In G. Ables, J.M. Mushaben (Ed.). Gendering the European Union. New Approaches to Old Democratic Deficits. (pp. 187 – 207). Basingstoke: Palgrave Macmillan.

[2] Alsos, G.A., Ljunggren, E. and Hytti, U. (2013). Gender and innovation: state of the art and a research agenda. International Journal of Gender and Entrepreneurship, 5 (3), 2013, 236-256.

[3] Bozeman, B. and Gaughan, M. (2007). Impacts of grants and contracts on academic researchers' interactions with industry. Research Policy, 36 (5), 694-707.

[4] Boskin, M.J., Lay, L.J. (2000). Generalized Solow neutral technical progress and postwar economic growth. NBER Working Paper 8023.

[5] Cagatay, N. (2003). Engendering Economics. In M. Gutierrez (Ed.), Macro-economics: Making Gender Matter; Concepts, policies and institutional change in developing countries (pp. 22-41), London, New York: Zed Books.

[6] Cohen W.M., Merrill, S.A. (2003). Patents in the Knowledge-Based Economy. Washington: The National Academies Press.

[7] Cohen W.M., Nelson, R.R. and Walsh, J.P. (January 2002). Links and Impacts: The Influence of Public Research on Industrial R&D. Management Science, 48 (1), 1-23.

[8] Doane, D., Seward, L. (2015). Applied Statistics in Business and Economics. New York: McGraw-Hill.

[9] European Commission (2001). Regular Reports from the Commission on Hungary's Progress towards Accession. http://ec.europa.eu/enlargement/archives/key_documents/reports_2001_en.htm (accessed 2014).

[10] European Commission (2010). Europe 2020. A Strategy for Smart, Sustainable and Inclusive Growth.

Luxembourg: Publications Office of the European Union.

[11] Frietsch, R., Haller, I., Funken-Vrohlings, M. and Grupp, H. (2009). Gender-specific patterns in patenting and publishing. Research Policy, 38, 590-599.
[12] Frietsch, R., Haller, I., Vrohlings, M., Grupp, H. Gender-specific patterns in patenting and publishing. Karlsruhe, DE: Fraunhofer ISI discussion papers innovation systems and policy analysis, 2008, No. 16.
[13] Foss, L., Woll, K. and Moilanen, M. (2013). Creativity and implementations of new ideas: do organizational structure, work environment and gender matter? International Journal of Gender and Entrepreneurship, 5 (3), 298-322.
[14] Freedman, D., Pisani, R., and Purves, R. (2007). Statistics. New York: W. W. Norton & Company.
[15] Griliches Z. (1990). Patent Statistics as Economic Indicators: A Survey. Journal of Economic Literature, 28, 1661-1707.
[16] Guellec D. and Pottelsberghe van, B. (2000). Applications, Grants and the Value of Patents. Economic Letters, 69 (1), 109-114.
[17] Guellec D. and Pottelsberghe van, B. (2001). The Internationalisation of Technology Analysed with Patent Data. Research Policy, 30 (8), 1256-1266.
[18] Guellec D., Pottelsberghe van, B. (2007). The Economics of the European Patent System. Oxford: Oxford University Press.
[19] Hughes-Hallett, D., Lock, P. F., Gleason, A. M., Flath, D. E., Lovelock, D., Quinney, D., Connally, E., Lonzano, G. I., Rhea, K. R., Kalaycý, S., McCallum, W. G., Speigler, A. H., Lahme, B., Osgood, B., G. (2014). Applied Calculus. New York: Willey.
[20] Hunt, J., G.J.-P., Herman, H. and Munroe, D.J. (2013). Why are women underrepresented amongst patentees? Research Policy 42, 831-843.
[21] Jaffe A.B., Trajtenberg, M. and Henderson, R. (1993). Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations. Quarterly Journal of Economics, 108, 577-598.
[22] Larivière, V., Ni, Ch., Gingras, Y., Cronin, B. and Sugimoto, C.R. (2013). Bibliometrics: Global gender disparities in science. Nature, 504, 211-213.
[23] OECD (2005). Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data. Paris: OECD.
[24] Okoń-Horodyńska, E. and Zachorowska-Mazurkiewicz, A. (2015). Innovation, Innovativeness and Gender – Approaching Innovative Gender. Scientific Annals of the "Alexandru Ioan Cuza" University of Iasi Economic Sciences, 62 (1), 1-22.
[25] Okoń-Horodyńska, E., Zachorowska-Mazurkiewicz, A., Sierotowicz, T. and Wisła, R. (2015). Gender in the creation of intellectual property of the selected European union countries. Economics & Sociology, 8 (2), 11 – 25.
[26] Pavitt, K., Robson, M. and Townsend, J. (1989). Technological Accumulation, Diversification and Organisation in UK Companies 1945-1983. Management Science, 35 (1), 81-99.
[27] Schmoch, U. (1997). Indicators and the Relations between Science and Technology. Scientometrics, 38 (1), 103-116.
[28] Schmoch, U. (2008). Concept of a Technology Classification for Country Comparisons. Final Report to the World Intellectual Property Organisation. Karlsruhe: Fraunhofer Institute for Systems and Innovation Research.
[29] Shane, S. (2009). Why Encouraging More People to Become Entrepreneurs Is Bad Public Policy. Small Business Economics, 33 (2), 141-149.
[30] Sobczyk, M. (2007), Statistics, Warsaw: PWN.
[31] Thorslund, J.G., Göransson, U. (2006). Könsblinda innovationssystem – genusanalys av några central begrepp I VINNOVAs verksamhet. Arbetsrapport I FoU-projektet Jämställdhet och Genusvetenskap, Stockholm: VINNOVA.
[32] Triola, M.F. (2014). Essentials of Statistics. New York: Pearson.
[33] Whittington, K. B. and Smith-Doerr, L. (2005). Gender and Commercial Science: Women's Patenting in the Life Sciences. Journal of Technology Transfer, 30 (4), 355-370.

Authors' information

Anna Zachorowska-Mazurkiewicz, Ph.D.

Anna Zachorowska-Mazurkiewicz, Ph.D. is an assistant professor in the Institute of Economics, Finance and Management, Faculty of Management and Social Communication at Jagiellonian University in Krakow, Poland. She holds a Ph.D. in economics. In 2005 she was a fellow in *Program on Knowledge Networking and Capacity Building on Gender, Macroeconomics and International Economics*, University of Utah, Salt Lake City, Utah, US. In 2010 she was a Marie Curie fellow in School of Social Justice at University College Dublin. Selected publications: Macroeconomics and trade. [In:] Gender Mainstreaming. Poland 2007. UNDP Raport. Warsaw 2007, s. 13-23, ISBN 978-83-917047-8-3. (co-author E. Lisowska); Role of Economic Policy in Reinforcing Gender Inequality – A Case Study of Poland in the European Union. [w:] *Journal of Economic* Issues, Vol. XLIII, no. 2, June 2009, s. 503-511. ISSN: 0021-3624.

Tomasz Sierotowicz

Tomasz Sierotowicz, Ph.D., Eng., is employed at the Department of Economics and Innovation, Institute of Economics, Finance and Management, Jagiellonian University in Krakow (Poland). Participation in research projects e.g.: „Trends of chosen technologies of the information society to 2025", „Establishment of the universal, open, hosting and communication, repository platform for network resources of knowledge to be used by science, education and open knowledge society". Selected international experience: ICS–Scranton, PA, (USA); Cleveland Institute of Electronics, Cleveland, OH, (USA); ESL, Princeton, NJ, (USA). The areas of interests include strategies and innovation development, strategic management, theory and practice of innovation development in macro and micro perspective, economics of ICT change.