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Ewa Okoń-Horodyńska,

*Faculty of Economics and Management,
Department of Economics and
Innovation,
Jagiellonian University,
Krakow, Poland,
E-mail: ewa.okon-
horodynska@uj.edu.pl*

**Anna Zachorowska-
Mazurkiewicz,**

*Faculty of Economics and Management,
Department of Economics and
Innovation,
Jagiellonian University,
Krakow, Poland,
E-mail: anna.zachorowska@uj.edu.pl*

Rafał Wisła,

*Faculty of Economics and Management,
Department of Economics and
Innovation,
Jagiellonian University,
Krakow, Poland,
E-mail: rafal.wisla@uj.edu.pl*

Tomasz Sierotowicz,

*Faculty of Economics and Management,
Department of Economics and
Innovation,
Jagiellonian University,
Krakow, Poland,
E-mail: tomasz.sierotowicz@uj.edu.pl*

GENDER IN THE CREATION OF INTELLECTUAL PROPERTY OF THE SELECTED EUROPEAN UNION COUNTRIES

ABSTRACT. The growing importance of gender studies in many disciplines is recently presented in the literature. However, there is no research on gender as the extraordinary source of innovation development. Specifically, patent activity is among the important elements determining the involvement of men and women in the innovation process. The article presents the results of studies focused on the patent inventors' role, both women and men, in development activities of entities belonging to the business enterprise sector. The research objectives were: 1) to capture the statistical picture of inventive activity taking gender into account, and 2) to identify the directions and dynamics of change with regard to the proportion of inventors in the EU member states. The main results shows the increasing role of women rather than man as the inventors of patents in the business enterprise sector of the leading EU countries in a long term.

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Introduction

Will Europe 2020, and, in particular, the Innovation Union, which provides yet another opportunity for obtaining enormous financial and institutional support, unleash EU innovations? A comprehensive search for additional sources of the creative base supporting innovation development is becoming the necessary challenge in the conditions whose assessment varies, depending on social actors. This kind of approach brings forward gender equality. Recruiting and retaining women in scientific and technical fields is seen as a key to success for the 2020 Strategy. "Equal participation of men and women is essential for Europe to exploit the full potential of innovative strengths – not only for demographic reasons, but also in the case of innovation processes and results. There is a need to clarify what (new) cluster policy related measures can support the process to get more women involved in the innovation process of business and research" (SIT, 2011).

It needs to be considered that all economic and social activities take place within an institutional framework. The economy, like society, represents a complex of institutions, ranging from the very smallest, such as family, to the largest and most comprehensive, namely the state (Chavance, 2009). Institutional economics was chosen as a frame for research, since it offers a broad perspective, which allows to bring forward gender while analysing economic relations. Gender, on the other hand, is a fundamental organizing principle of institutions (Jacobsen, 2007), therefore it has to be taken into account while researching economic questions. In this context, introducing the role of gender into the innovation process, especially in its initial part determined by the intellectual input of individuals (intellectual property) of different gender seems an obvious and necessary issue to be studied. In this article, intellectual property included in patents was considered the determinant of this input and the number of men and women who participate in its generation was analysed and evaluated.

A number of studies and reports have stressed the acute problem of women's under-representation in science in the business enterprise sector (OECD, 2012; Hunt *et al.*, 2013). 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 enterprise sector is less than 25% in most countries (European Commission, 2010). Yet another flagship initiative under the 2020 Strategy, the New Skills and Jobs Agenda, focuses on the need to modernise labour markets, increase labour participation and match labour markets and skills. Studies show that the European labour shortage is likely to have a greater impact on female or male dominated occupations rather than on less divided sectors (European Commission, 2009). Occupations in healthcare and ICT are already affected by the shortage of professionals in Europe. For example, the rapidly growing demand for ICT specialists was one of the motivators behind the European Code of Best Practices for Women and ICT launched by the European Commission (Vinnova, 2011).

In the past decade there has been an evident growth in the number of methodological proposals of how to measure scientific and technological achievements taking the category of gender into consideration (Whittington & Smith-Doerr, 2005; Naldi *et al.*, 2005; Frietsch *et al.*, 2008). Frietsch, Haller, Vrohling and Grupp (2009) divide the studies carried out so far into the following groups of research programmes: (1) the representation of women in science and engineering using publication activity (the analysis of the number and quality of scientific and technological publications of men and women); (2) studies of the impact of an individual's own family and maternity on scientific productivity and (3) the analysis of women's scientific career paths. The results of international empirical comparative studies indicate that, in general, there is a clear statistical pattern that women are less involved than

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men in the creation of scientific and industrial knowledge (Larivière *et al.*, 2013) as well as the creation of industrial knowledge only (Whittington & Smith-Doerr, 2005; Frietsch *et al.*, 2008; Frietsch *et al.*, 2009).

When discussing the importance of the participation of women in the development of science and technology, Jaffé (2006) emphasises the inadequate level (as well as possibilities) of the quantification of this participation. The changing way of practicing science, the nature of R&D and innovative activity do not make it easier to gain insight into the nature of such phenomena as scientific and technological creativity or innovative attitudes and activity taking gender into account. The data and indicators applied so far make it possible to understand only some aspects of these phenomena, in particular the ones related to input. The lack of data and information on products/effects (output) and impact are serious limitations.

This article is a part of substantive discussion on the identification and measurement of scientific, technological and innovative activity using the criterion of gender, undertaken by the authors in the currently implemented research project entitled “Innovative Gender as a New Source of Progress”¹. In this context the major research tasks include: providing a statistical picture of innovative activity taking into account the criterion of gender and identifying the directions and dynamics of change in the number of patent inventors in the selected EU member states. Research work has been carried out in three stages: first the number of men and women as the inventors of the new technological solutions that were granted patent protection has been determined, then the focus was put on the dynamics of change of the share of male and female industrial inventors, and finally a comparative analysis of the average rate of change for the patent activity of men and women has been conducted. The study included all inventors of the patents granted by EPO in 28 countries in the period of 1999-2013.

1. Research methodology

Patent metadata and its use in economic research is not widely discussed on the international subject literature. The intellectual foundations for the sense and possibilities of using patent datasets in scientific research were laid by the following researchers (Griliches, 1990; Pavitt, 1984; Jaffe, 2006; Schmoch, 1993, 1997, 1999, 2008; Guellec & van Pottelsberghe, 2007); Cohen & Merrill, 2003; Cohen *et al.*, 2003) and in the OECD guidebooks (OECD, 2009) that harmonised the rules of 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.

One of the most important attributes of a patent description is information about the inventor of a novel solution. The standard record of a bibliographical description enables a multi-purpose analysis of patent inventors (men/women) in connection with a series of other data. The inventor(s) of the technological solution reserved in a patent description may be analysed using the following dimensions:

- 1) gender (of an individual indicated as the inventor in the patent documentation),
- 2) the composition of the team according to gender (e.g. two women, two men, etc.),
- 3) the composition of the team according to gender and the country (region) of origin (a woman from Poland, a woman from Norway, a man from Poland, a man from Germany),

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- 4) the precedence of the inventor – the order of inventors' names in a patent description is not random as it usually reflects the level of involvement of individual team members in the development of the new solution,
- 5) the heterogeneity of the team of inventors as compared with patent applications and their success (the patent was granted),
- 6) the heterogeneity of the team of inventors as compared with the frequency of citing the solution in other, subsequent patent descriptions,
- 7) the composition of the team of inventors as compared with the field of technology where new solutions are applied,
- 8) the heterogeneity and size of the team as compared with the geographic scope of protection (national, regional),
- 9) the heterogeneity of the team of inventors as compared with the economic application of the solution (by using information about the licences granted for this solution).

In the case of the countries where there is a significant proportion of private individuals applying for patent protection (e.g. Poland), the model of analysis presented above may be used for natural persons (men/women) who are not just patent inventors but also entities that apply for a patent or those entitled to a patent.

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 (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 results presented are not just patent statistics. The identification of the entity composition and the dynamics of change with regard to the share of female industrial inventors required extensive work with data, which often lacked the fundamental attributes necessary to achieve the goals as planned.

Research work was carried out in three stages. The first one aimed to determine the number of men and women as the inventors of the new technological solutions that were granted patent protection in each year in the period of 1999-2013 as European patent applications. This was executed for each of the 28 EU member states. As a result, the (evident) innovation leaders in the EU were selected.

The second stage focused on the dynamics of change of the share of male and female industrial inventors for each country selected in the first stage. The dynamics of change was determined using the average rate of change in time, as demonstrated in the equations below (Freedman, Pisani, Purves, 2007):

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

$$ASR_{cg} = (\bar{y}_{cg} - 1) \times 100 \quad (\text{Equation 2})$$

where:

\bar{y}_{cg} – stands for the geometric mean of chain indices calculated separately for men and women (as industrial inventors) from each EU member state for the entire period under analysis,

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

i – is the next observation in the time series (corresponding to the share of men and women in the number of industrial inventors in general),

c – is the next EU member state included in the study,

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

ACR_{cg} – stands for the average rate of change of the number of men and women in the population of inventors in general.

The next step was a comparative analysis of the average rate of change for the patent activity of men and women in each of the EU leaders.

2. Main results

In the period included in the study, almost 805,000 of private individuals were involved in the process of producing new technological solutions as inventors in all EU member states. *Figure 1* shows the percentage value of the number of industrial inventors from individual countries in the total number of inventors from all EU member states taking into account their population (i.e. calculated per 1 million of inhabitants).

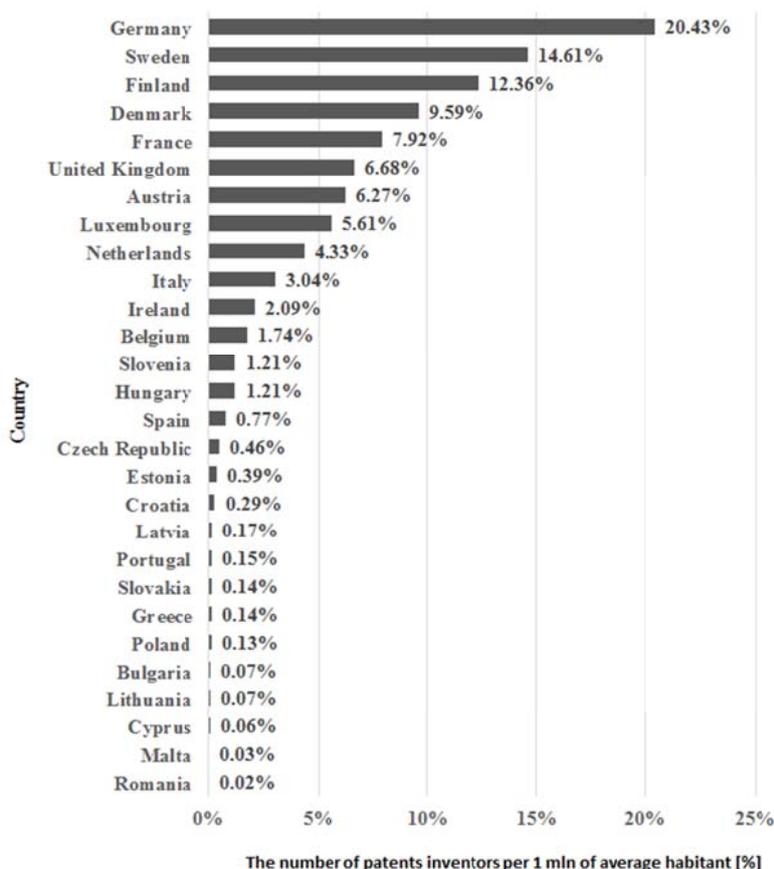


Figure 1. The percentage value of the number of national inventors of the patents granted by EPO in 1999-2013

Source: The authors' 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).

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The leader of this comparison is Germany (with the share of 20.43% in the total number of inventors in the EU). But it needs to be added that out of the entire population of 804 413 inventors almost 52% are German. Proportionally, there are also significant numbers of inventors in Sweden (14.61%), Finland (12.36%) and Denmark (9.59%).

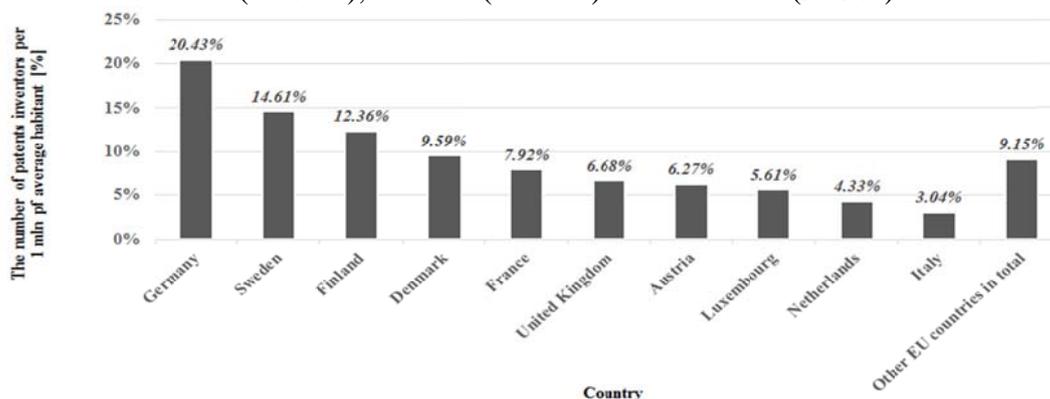


Figure 2. The percentage value of the number of inventors of the patents granted by EPO in the leading European Union countries in the 1999-2013
 Source: The authors' own work.

Figure 2 indicates that out of 28 EU countries there 10 leaders in terms of innovation. These countries include Germany, Sweden, Finland, Denmark, France, the United Kingdom, Austria, Luxembourg, the Netherlands and Italy. In total, they represent 90.85% of all EU inventors. Inventors from other EU member states account for 9.15%. Figure 3 presents the composition of inventors according to gender in each of the 28 EU member states.

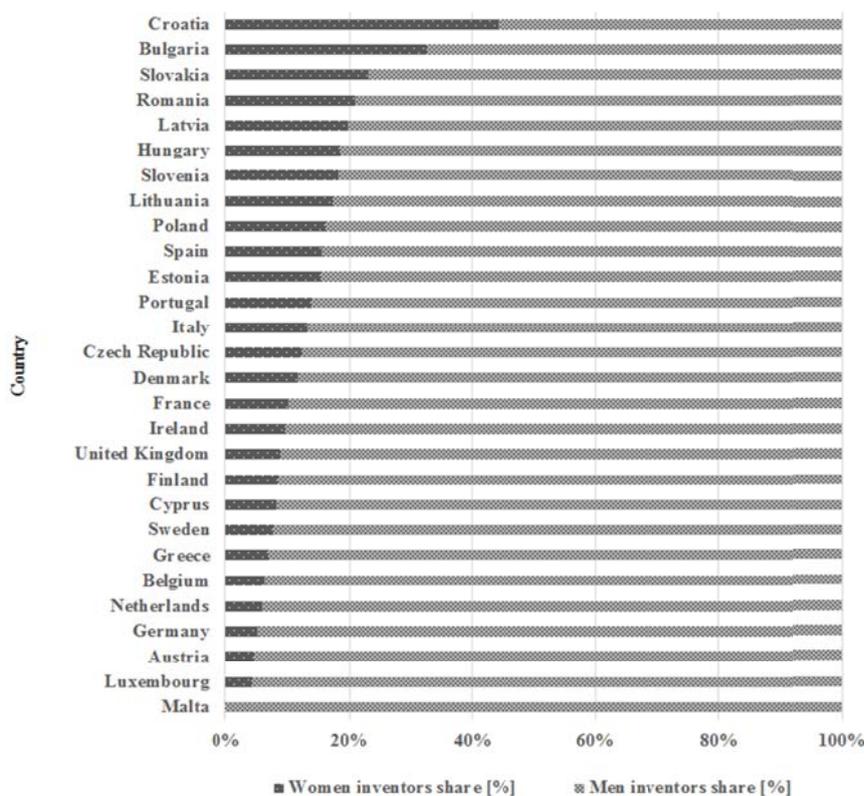


Figure 3. The percentage share of men and women who were the inventors of the patents granted by EPO in 1999-2013.
 Source: The authors' own work.

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The identification of the composition of inventors shows that Croatia is the country with, relatively, the greatest symmetry between male and female inventors (women account for 44% of inventors). The countries that come next as regards their relatively significant share of female inventors are Bulgaria (32.6%), Slovakia (23.2%) and Romania (21%).

Among the EU leaders in terms of the number of inventors, the largest proportion of female inventors was observed in Denmark (11.85%), Finland (8.57%), Sweden (7.79%) and Germany (5.24%).

3. The dynamics of change men and women participating in the invention process

The values achieved as a result of the application of equations 1 and 2 show the average rate of change with regard to the proportion of male and female inventors of the patents granted by EPO in the entire period under analysis.

Table 1. The average rate of change of the number of men and women being inventors of the patents granted by EPO in the leading EU countries in 1999-2013

| Country | Gender | Average rate of change [%] |
|----------------|--------|----------------------------|
| Germany | Women | 3.52% |
| | Men | -0.18% |
| France | Women | 1.46% |
| | Men | -0.15% |
| United Kingdom | Women | 3.43% |
| | Men | -0.28% |
| Italy | Women | 3.57% |
| | Men | -0.56% |
| Sweden | Women | 2.44% |
| | Men | -0.19% |
| Austria | Women | 1.68% |
| | Men | -0.08% |
| Denmark | Women | 5.51% |
| | Men | -0.52% |
| Luxembourg | Women | 1.49% |
| | Men | -0.07% |
| Finland | Women | 2.56% |
| | Men | -0.23% |
| Netherlands | Women | 3.03% |
| | Men | -0.17% |

Source: The authors' own work.

The largest increase in the number of women was observed in Denmark and equalled 5.51%. It means that the share of female inventors of the patents granted by EPO in Denmark was increasing during the period under analysis, on average by 5.51% per year. The smallest share of female patent inventors was observed for France and equalled 1.46%. It means that the number of female inventors of the patents granted by EPO in France was increasing during the period under analysis, on average by 1.46 % per year.

The situation of male inventors is different. The largest drop in the share of male patent inventors was identified for Italy – 0.56%. It means that the number of male inventors of the patents granted by EPO in Italy was decreasing during the period under analysis, on average by 0.56%. The smallest reduction in the number of male inventors was noted for

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Luxembourg – 0.07%. It means that the number of male inventors of the patents granted by EPO in Luxembourg was decreasing during the period under analysis, on average by 0.07%. The results achieved can be found in *Figure 4*.

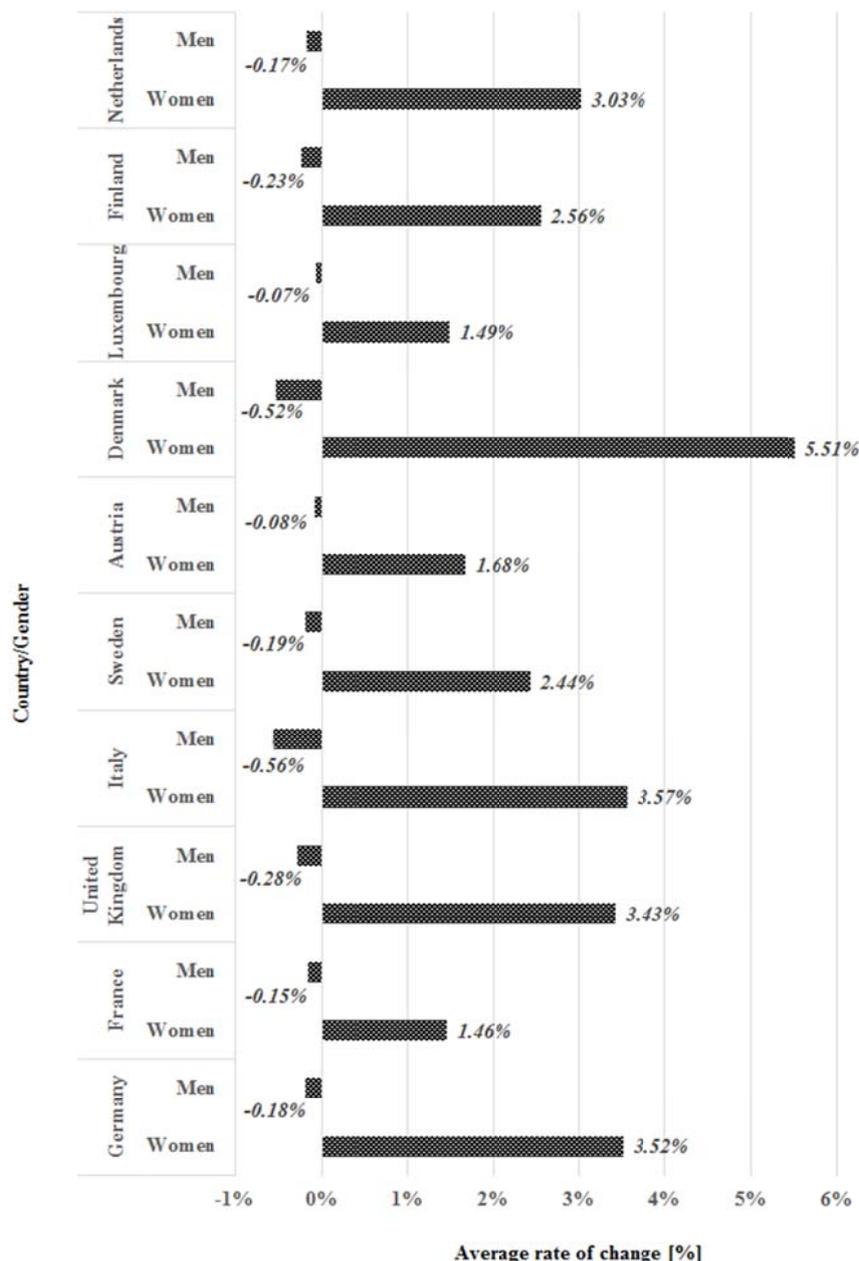


Figure 4. The average rate of change as regards the number of male and female inventors of the patents granted by EPO in the leading EU countries in 1999-2013

Source: The authors' own work.

An interesting regularity (*Figure 4*) can be discovered after the analysis of the results achieved. The patent activity of women in all the countries included in the study increased significantly while the patent activity of men decreased in all the countries included in the study throughout the same period. It means that the role of women as the inventors of patents that make an important component of the innovative potential of the leading EU countries included in the study was systematically growing in the long term. This phenomenon, which

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was observed in the field of patent activity, has a significant impact on the innovative development of the economies of the countries included in the study. Therefore, it may be concluded that the role of women in innovative development was significantly increasing in the period of 1999-2013.

Discussion & Conclusions

The numerous socio-economic objectives listed on international and national economic agendas include studies on the social identity of gender, which involves discrimination and the problems associated with it. Methodological recommendations in the area of innovation measurement accommodate the category of sex to some extent, but, in practice, they do not take into account the one of gender, i.e. the roles assigned to men and women in society which may influence the course and nature of creativity and innovation. In this context it is empirically justified to expand and continue research that would make it possible to reveal and boost the role of women in many areas of their innovative activity ignored so far. It is also necessary to continue the development of the methodology of studies in order to be able to evaluate the relationship between the effects of the innovation process and gender. The determination of the share of men and women in creating intellectual property as the fundamental source of innovation is only a starting point.

The issue explored in this paper assumes that the achievement of the ability to innovate depends on multidimensional endowments, creativity, competencies and talents inherent in people, which exemplifies patents. But, it needs to be studied with the focus on creativity and initiating the intellectual input of individuals of both genders into the development of intellectual property conditioned by equal access of men and women to the achievements of science and technology or the effectiveness of collaboration in R&D. This area is not so far explored in studies of gender, and yet patent activity, is among the important elements determining the involvement of men and women in the innovation process, which makes it an essential component of the innovative potential of the economy and should also be explored in search of extraordinary sources of innovation development. So, this article presents the results of patent studies which take gender into consideration.

The main research tasks included: capturing a statistical picture of inventive activity taking the criterion of gender into account and identifying the directions and dynamics of the changes in the share of the creators of intellectual property in the EU countries that are leaders in terms of innovation. On the basis of the observations and studies carried out, a special set of relations in the process of creating intellectual property (the source of innovation) was determined using the patent activity data available. The study included 28 EU member states in the period of 1999-2013. Out of them, there were 10 leaders in terms of patent activity in the period under analysis, which included Germany, France, the United Kingdom, Italy, Sweden, Austria, the Netherlands, Denmark and Finland. The major conclusion based on the empirical studies carried out is that the role of female patent inventors is definitely growing in all the countries included in the study. As patents may be directly applied in industry, it may also be said that the role of women in the innovative and industrial development of the countries included in the study is growing to a significant extent. The studies carried out also demonstrated that the share of men in patent activity was decreasing in all the countries under analysis. Out of 10 EU leaders in terms of innovation, the greatest dynamics of change as regards the share of women in patent activity was observed in Denmark, where this proportion was growing during the period under analysis, on average by 5.51% per year. The next country in line was Italy with an increase of 3.57% as regards the patent activity of women during the period under analysis. The knowledge acquired as a result of the studies

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carried out may be used to determine the category of gender, which may be applied to explore the role of gender in the process of innovation.

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