Benchmarking Analysis of Patent and Trademark Applications in the European Union: A Comprehensive Eu Innovation Policy Evaluation for Years 1960–2013

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This study provides benchmarking analysis of patent and trademark applications in the European Union. The objectives of benchmarking are (1) to determine what and where improvements are called for, (2) to analyze how other nations achieve their high performance levels, and (3) to use this information to improve performance in favor of the EU Internal Market.

The benchmarking study provides benchmarking results about (1) patent applications of residents and nonresidents, (2) trademark applications of residents and nonresidents, (3) total patent applications, and (4) total trademark applications. The study also provides benchmarking analyses about patent and trademark application in relation to population and gross domestic product.

The results of benchmarking cover the time period 1960–2013. The study provides some comparative statistical analyses and discusses whether there has been convergence in patent and trademark activity in the European Union. The study identifies top 10 champions in the different categories of patent and trademark activity. Key results will be reported in the forms of descriptive statistics, Pareto charts, and key statistical indicators. Some special indicators of innovation activity will be reported. The study provides some policy relevant results for the EU Internal Market development.

KEYWORDS: Patent applications, trademark applications, EU–28, benchmarking, innovation policy, innovation management, residents, nonresidents, trend analysis.

Abstract

Introduction

This article pays attention to patent activity and trademark activity. These activities will be analyzed by total numbers of patent and trademark applications and by patent and trademark applications of residents and nonresidents in the EU–28. Both these activities are very important for growth and employment policy of the European Union. These analyses are also useful when decision–makers assess strategic positions of the EU–28 innovation policy in the global setting (see e.g. Nam and Barnett 2011). Changing levels of R&D activity need continuous attention from EU policy–makers. This critical aspect of technology management has been understood for a long time in Europe. Patent claims are linked to priority and productivity claims (see e.g. Little 1981, Griliches 1990, McLeod and Radick 2013) and to IPR policy (Maresch 2016). If decision–makers of the European Union want to keep an eye on productivity and employment targets, they must understand the logic of patent and trademark claims and their systemic linkages to productivity claims. The role of open innovation paradigm is increasing internationally, but also in the European Union (Ghisetti et al. 2015). Open innovation thinking may have impacts on the future on European innovation ecosystems.

Successful innovation ecosystem depends on knowledge, which can be technological, strategic, and market related. Information and data about patents and trademarks are always results of knowledge managements processes. Existing knowledge base and stock contribute directly to the novelty or complexity of new innovations, whether they are technological innovations, business model innovations or social innovations. (Roper and Hewitt–Dundas 2015). From a knowledge management perspective it is very important to understand how patent applications and trademark applications are submitted and utilized in the EU–28. For example, we can make better knowledge investments and knowledge management strategies if we know more about the systemic dynamics of patent and trademark applications and their interlinkages with population and economic growth dynamics.

Innovativeness is always linked with the development of the economy. In the scientific literature innovativeness is often mentioned as one of the key drivers of economic growth, primarily in the sense of raising the level of education, infrastructure, health, the environment, and welfare (see Kuhlmann 2001).

Cyclical model of technological entrepreneurship and innovation links European entrepreneurship to four domains: (1) scientific exploration, (2) technological research, (3) market transitions, and (4) product creation. Between scientific exploration and technological research there is natural and life science cycle. Between scientific and market transitions there is social and behavioral science cycle. Between technological research and product creation there is integrated engineering cycle. Finally, between market transitions and product creation there is differentiated service cycle. These four cycles are important dynamic forces in the European innovation ecosystem. The natural and life science cycle creates technical capabilities. The social and behavioral science cycle creates social insights. Differentiated services cycle creates customer value. Integrated engineering cycle creates products (see Berkhout et al 2006, Troot et al 2016, 20). Typically, patents are linked to natural and life science cycle and to integrated engineering cycle. On the other hand, trademarks are linked to social and behavioral science cycle and to differentiated services cycle.

Regional innovation systems are regarded as complex systems in which components are strongly dependent on each other. Such relationships can have both linear and nonlinear character. Innovation contributes to raising the level and quality of social life and thus to leveling social inequalities. A characteristic feature of modern economy is growing awareness of the role of knowledge and innovation in generating economic progress (Popiel and Jabłońska 2014). Patents and trademarks are important elements of modern progressive economy. In European integration policy the aspect of innovation is the one of the most important policy fields.

There are always changes in innovation activity. In this article my aim is to analyze long–run changes of innovation activity of the European Union. Innovation activity is in this paper limited to two key indicators: patents and trademarks. Patents are often used to analyze technological capability (Tong and Frame 1994, Abraham and Moitra 2001, Lee et al 2015). Trademarks are often used to analyze commercial business competences of countries. A trademark is a sign capable of distinguishing the goods or services of one enterprise from those of other enter-prises (Mendonca et al. 2004, Hidalgo and Gabaly 2013). Patents and trademarks are also used as barriers to entry in markets (see e.g. Demsetz 1982). This aspect of market entry is relevant for the European Union in the global competition. Unique character of products and services is a key issue in global markets. There is also a considerable market value of R&D, patents, and trademarks (Sandler and Block 2011). In global markets trademarks are protected by intellectual property rights. In this paper key approach to analyze R&D activities of EU member countries is to perform benchmarking analyses. In this study, I shall present benchmarking results based on absolute indicator values, but also relative benchmarking analyses in relation to population size and economic growth. This article also presents a correlation matrix of key indicators of EU–28 innovation activity.

In this chapter some background analyses of patent and trademark applications are present-ed. The trend analyses are based on World Bank´s Database (World Bank 2016). Other anal-yses are also based on World Bank data. In Fig. 1 the long–run trend of patent applications and trademark applications of residents and non–residents in the EU–28 are visualized. This figure reveals that in 1960s and 1970s the volume of patent applications was higher than later. In late 1980s the volume of trademark applications started to increase. Critical Turning point was 1984.

In Fig. 2 general innovation activity based on patent and trademark applications are reported in relation to population size. This figure informs us of a dramatic change after year 1984, when the activity of trademark applications started to increase. Other turning point was in year 2000 when the volume of trademark applications turned down.

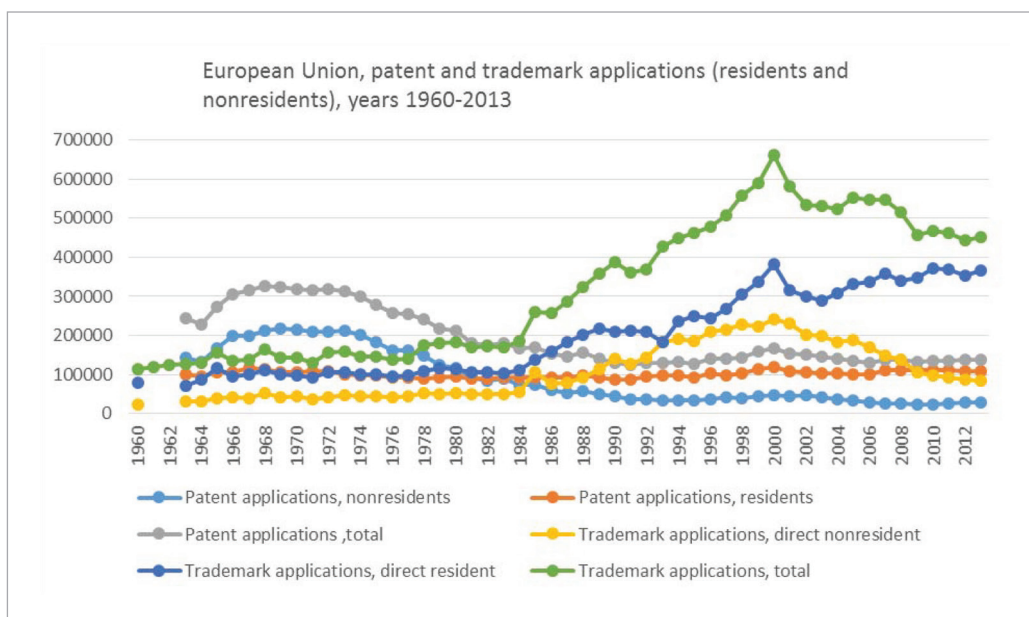## Patent applications and trademarks applications of residents and nonresidents

Figure 1
Patent applications and trademarks of residents and non–residents in the EU–28 countries.

European Union, patent and trademark applications (residents and nonresidents), years 1960-2013

If we want to measure innovation activity in the European Union (EU–28) in relation to population size, Figure 3 informs us information activity in 1963–2013. In the long run there was a downward sloping trend in 1963–1985, but in 1985 it turned to upward sloping trend in 1986–2000. In 2001–2013 we can observe downward sloping trend in European innovation activity.

In Fig. 4 patent applications/trademark applications–relationship in the EU–28 countries is figured out for years 1963–2013. This figure informs us long–run change in European innovation activity.

Figure 2

European Union (EU–28), patent applications per population and trademark applications per population, years 1960–2013.
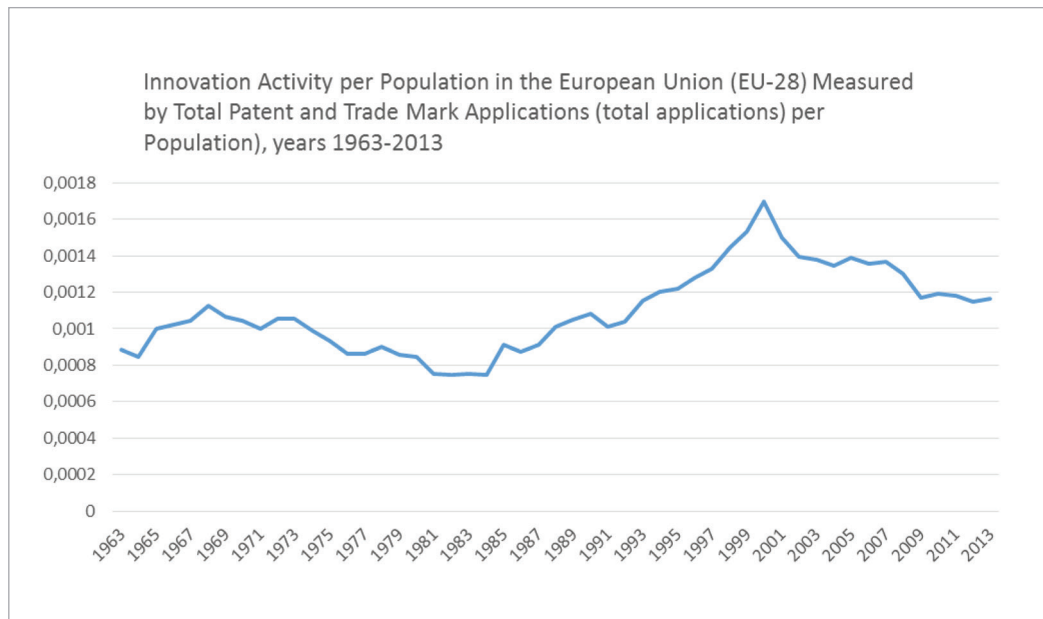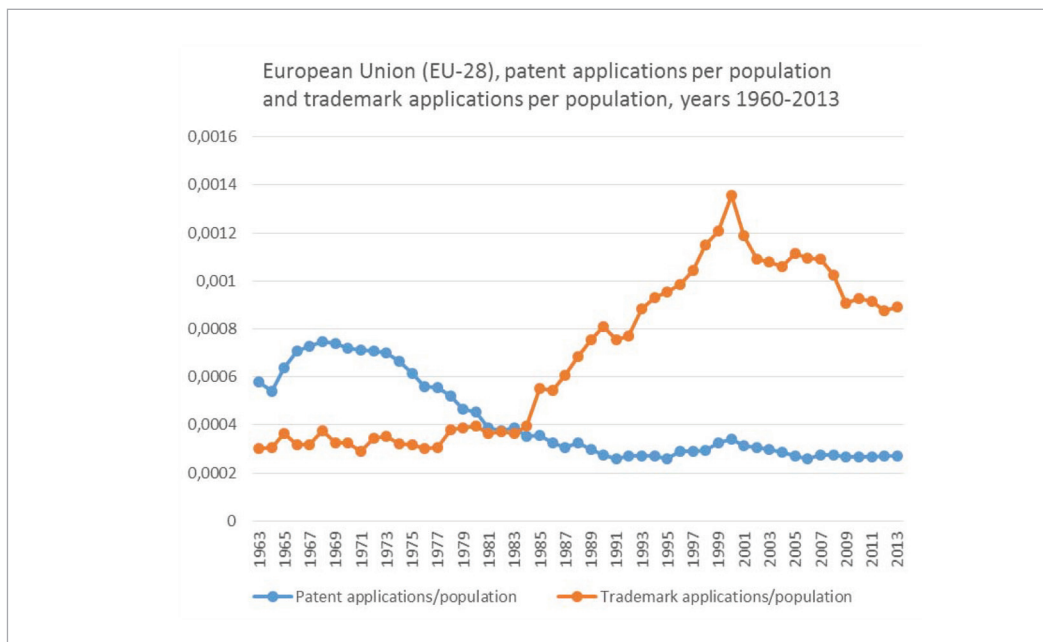

Figure 3

Innovation Activity per Population in the European Union (EU–28) Measured by Total Patent and Trade Mark Applications per Population, total applications, years 1963–2013.
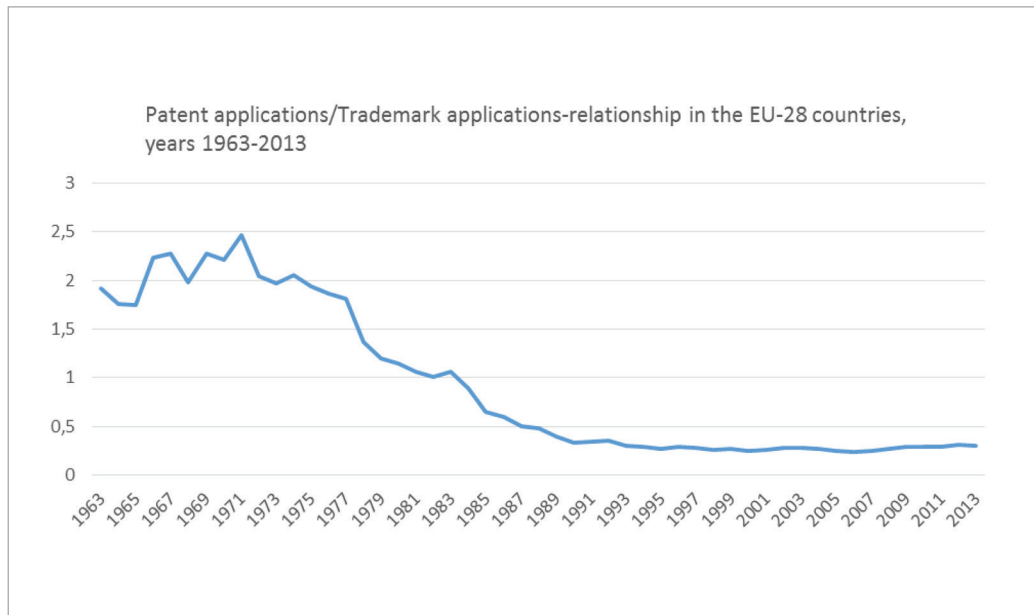
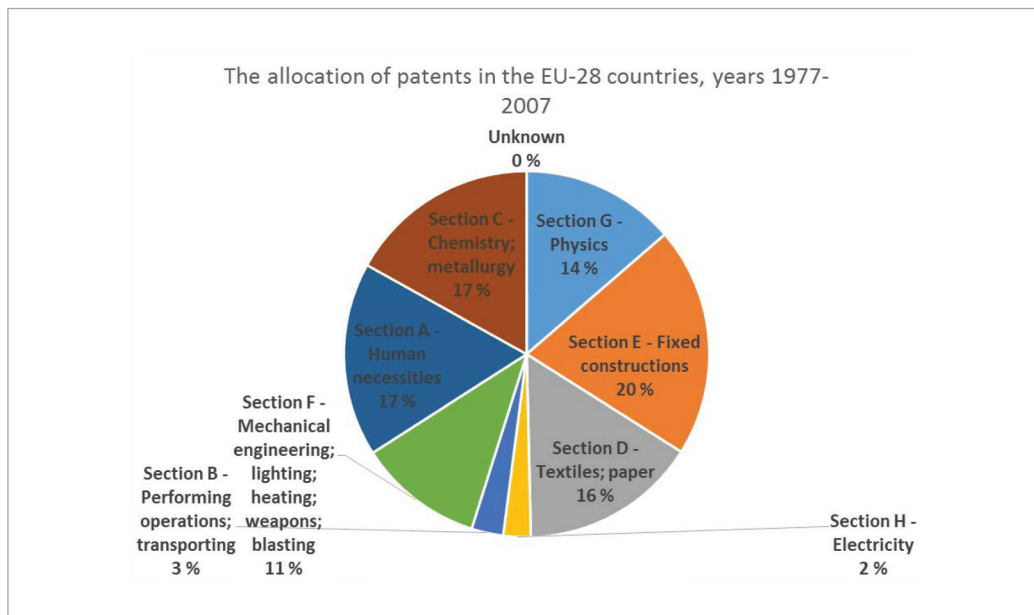Patent applications/Trademark applications-relationship in the EU-28 countries, years 1963-2013

The allocation of patents in the EU-28 countries, years 1977-2007

Unknown 0 %

Section C - Chemistry; metallurgy 17 %

Section G - Physics 14 %

Section A - Human necessities 17 %

Section E - Fixed constructions 20 %

Section F - Mechanical engineering; lighting; heating; weapons; blasting 11 %

Section B - Performing operations; transporting 3 %

Section D - Textiles; paper 16 %

Section H - Electricity 2 %

In early 1960s APA/TMA–relationship was over 2, but after 1990 it has been less than 0.5. This change indicates relative role of trademark applications has increased in the EU–28. The basic statistics of APA–/TMA–relationship indicator is reported in Table 1.

The range of APA/TMA has been 2.22 in 1963–2013 in the EU–28 and average APA/TMA has been 0.94. We can conclude the nature of innovation activity has changed quite much since early 1960s in the European Union. Figure 5 visualizes the allocation of patents in 1977–2007). Statistical data in this analysis has been obtained from Eurostat (2016).

Figure 6

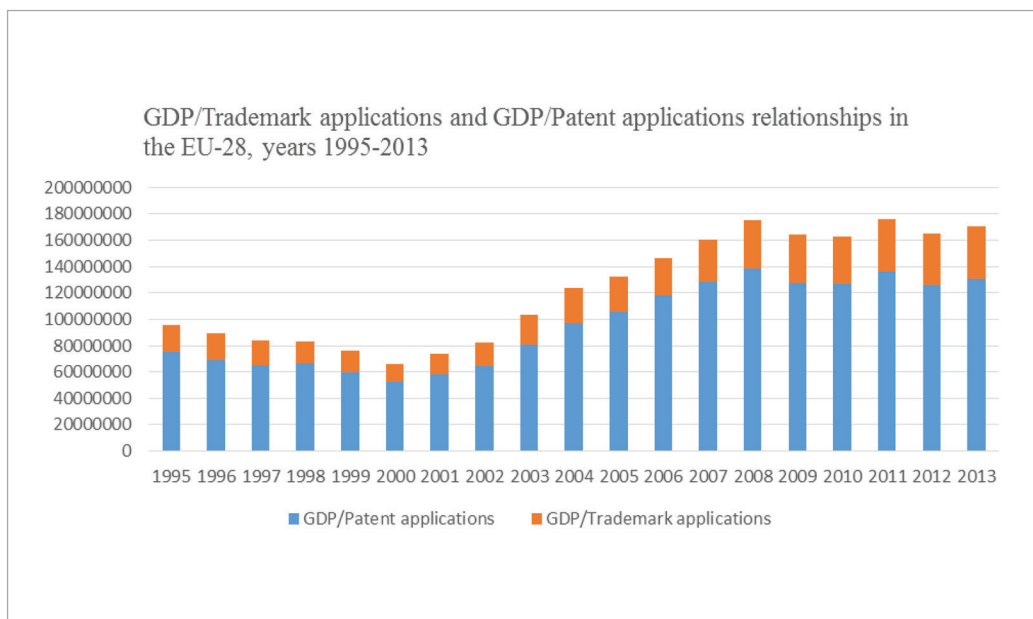GDP/Trademark applications and GDP/ Patent applications relationships in the EU–28, years 1995–2013.

GDP/Trademark applications and GDP/Patent applications relationships in the EU-28, years 1995-2013

Table 1

Summary statistics of patent applications / trademark applications– relationship in the EU–28 countries, years 1963–2013.

Average	0,936825
Median	0,477676
Variance	0,606479
Max	2,462526
Min	0,236554
Range	2,225971
Standard deviation	0,771095

As a background information GDP/Trademark applications and GDP/Patent applications relationships in the EU–28 may be useful information for readers and decision–makers. This indicator is higher for GDP/ patent applications than GDP/ trademark applications in the EU–28.

Patent applications of residents and nonresidents

In chapter 2 we focus on patent application of residents and nonresidents. Figure 7 shows the statistical development of long–term patent applications of residents in Europe. We can observe downward sloping trend in patent application of residents.

Figure 8 shows the statistical development of long–term patent applications of nonresidents in Europe. We can observe downward sloping trend in patent application of non–residents.

Figure 9 shows the activity of patent applications in different EU–member states in 2013. The results are shown in sequence. Leading countries in patenting activity are Germany, UK, France, Italy, Poland, Spain, the Netherlands, Sweden, Austria, Finland, and Denmark. The ranking of EU–member states can be seen in Fig. 9. In this article we apply old methodology of Wilfred Pareto (see .e.g. Wilkinson 2006). In this paper this method will be used to visualize relative shares of innovation activities in the European Union.

Figure 10 shows the activity of patent application of residents in different EU–member states in 2013. The results are shown in sequence. The full ranking of EU–member states in patent applications of residents can be seen in Fig. 10.
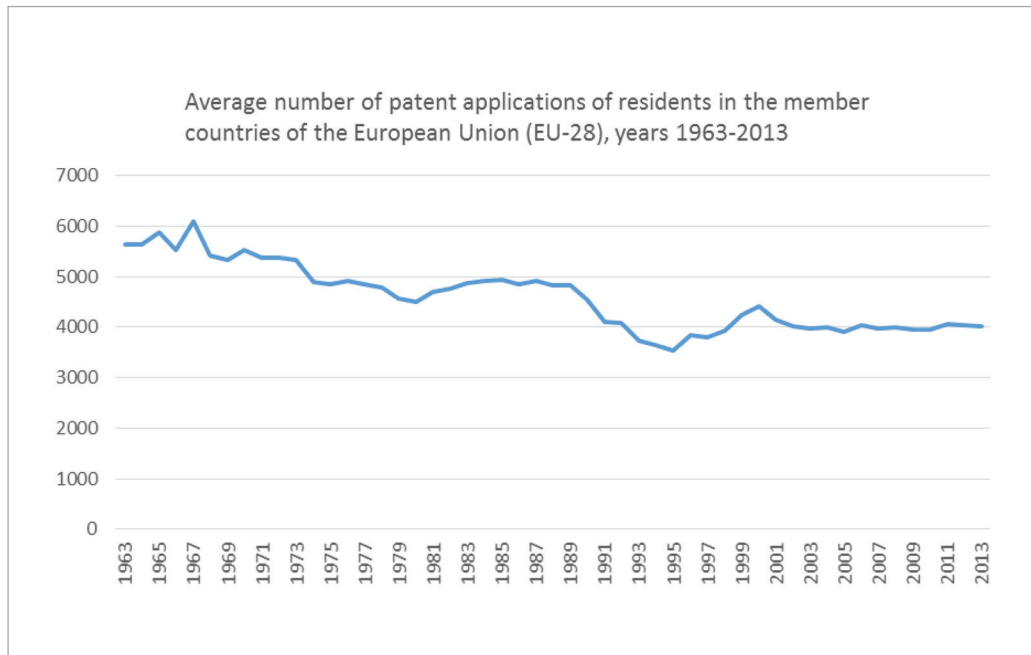
Figure 7

Average number of patent applications of residents in the member countries of the European Union (EU-28), years 1963-2013
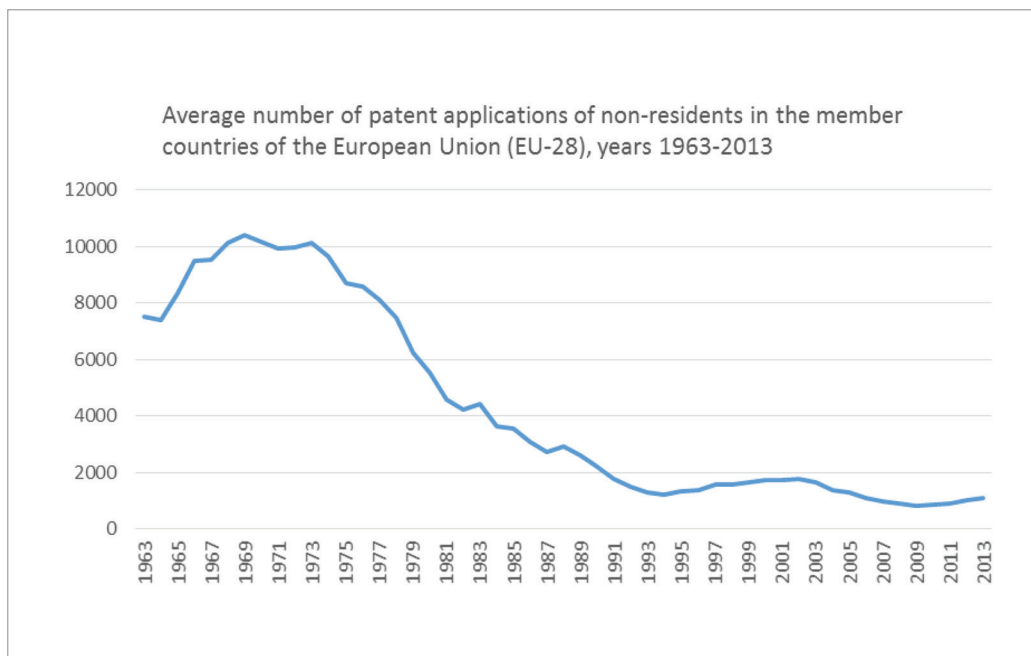

Average number of patent applications of residents in the member countries of the European Union (EU–28), years 1963–2013.

Figure 8

Average number of patent applications of non-residents in the member countries of the European Union (EU-28), years 1963-2013

Average number of patent applications of non–residents in the member countries of the European Union (EU–28), years 1963–2013.

The Figure 11 shows the activity of patent application of nonresidents in different EU–member states in 2013. The results are shown in sequence. The ranking of EU–member states can be seen in Fig. 11.

This figure reveals that in many EU member states there are no patent applications by non-residents. Germany, UK, France, and Italy dominate this specific arena of innovation activity.

Figure 9

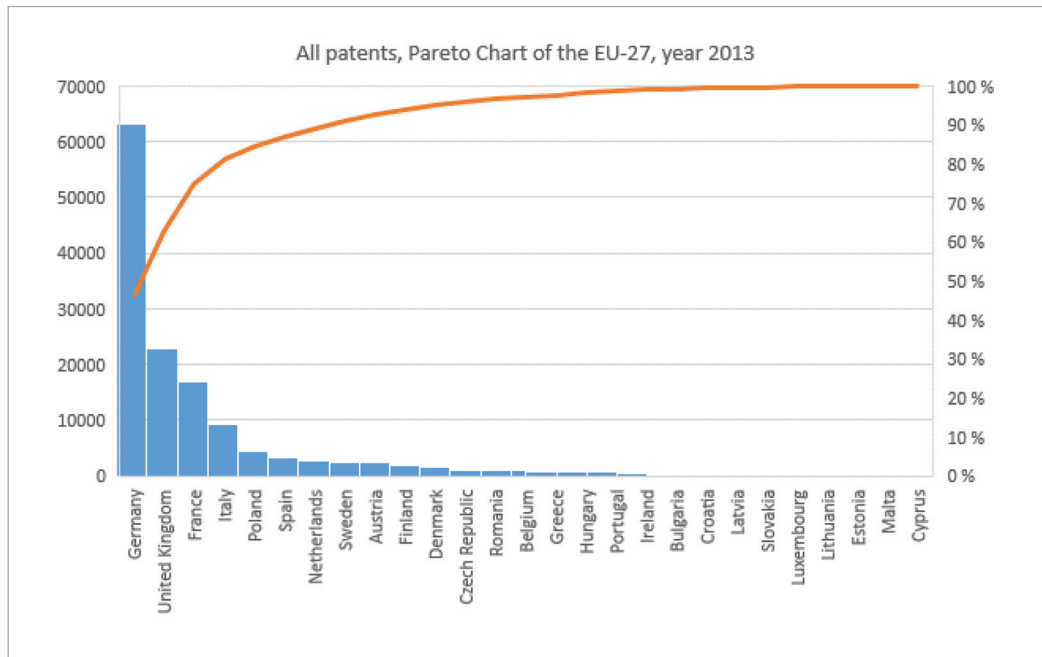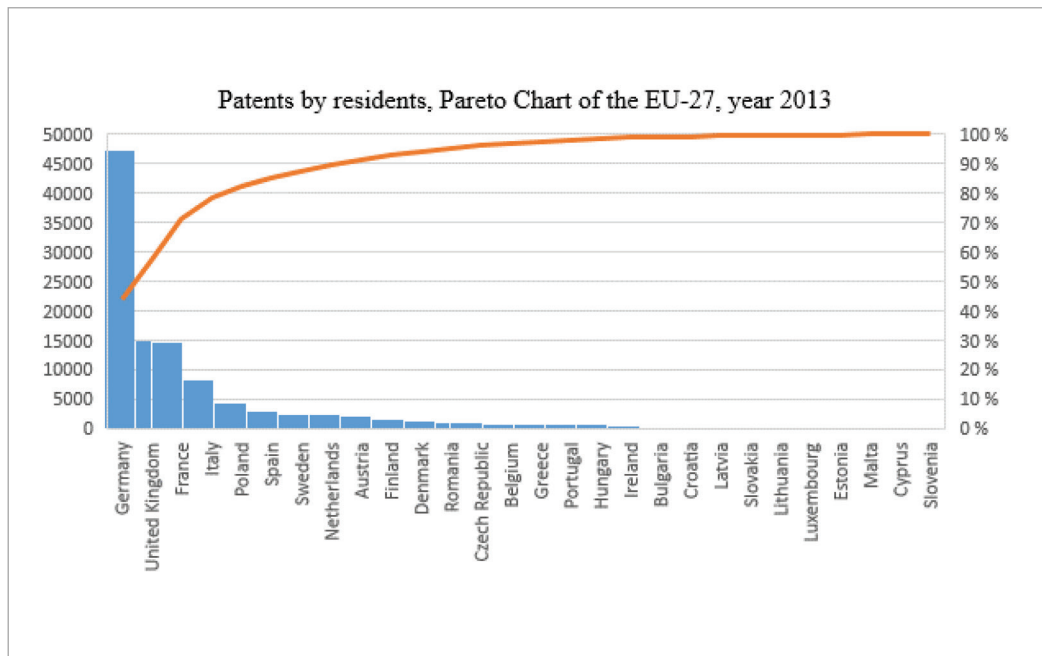All patents, Pareto Chart of the EU–27 countries, year 2013

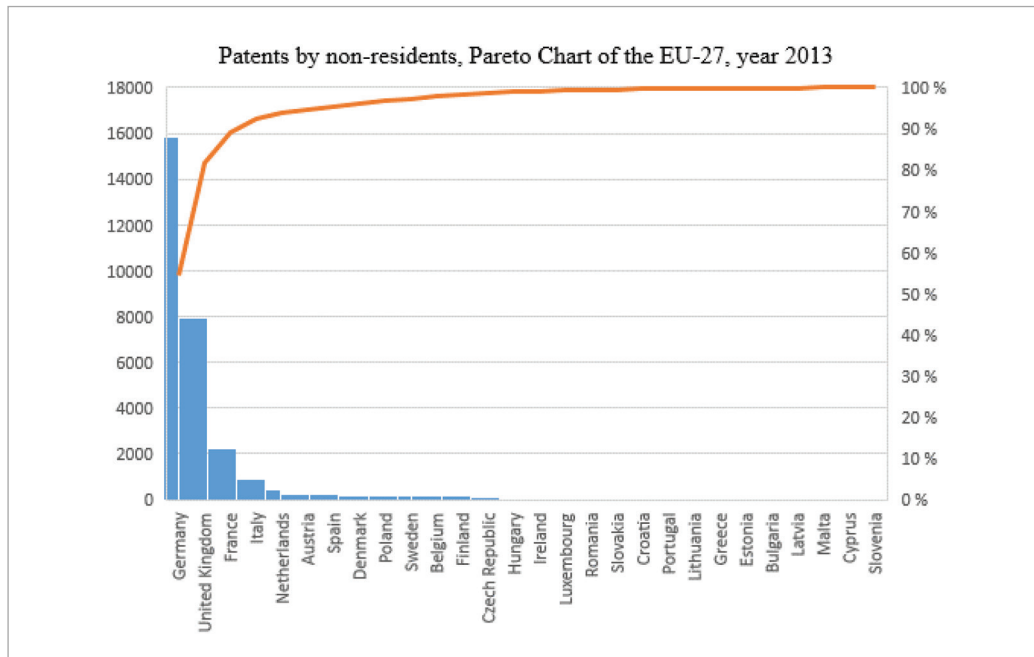## Figure 10

Patents by residents, Pareto Chart of the EU–27, year 2013

In Chapter 3 we focus on trademark applications of residents and nonresidents. Fig. 12 shows the statistical development of long–term trademark applications of residents in Europe. We can observe an upward sloping trend in trademark application of residents in the European Union.

Figure 13 shows the statistical development of long–term trademark applications of non–residents in Europe. We can observe an upward sloping trend in trademark application of non–residents in 1963–2000 and downward sloping trend in 2001–2013. Figure 14 shows the activity of all trademark applications in different EU–member states in 2013. The results are shown in sequence. Leading countries in trademark applications activity are France, Germany, UK, Spain, Italy, Belgium, Poland, Portugal, Romania, Czech Republic, Sweden, and Austria. The ranking of EU–member states can be seen in Fig. 14.

Figure 15 shows the activity of trademark application of residents in different EU–member states in 2013. The results are shown in sequence. Leading countries in trademark applications activity are France, Germany, UK, Italy, Belgium, Portugal, Poland, Romania, Czech Republic, Sweden, and Austria. The full ranking of EU–member states in trademark applications of residents can be seen in Fig. 15. Figure 16 shows the activity of trademark application of nonresidents in different EU–member states in 2013. The results are shown in sequence. Leading countries in trademark applications of non–residents are UK, Germany, France, Italy, Croatia, Spain, Belgium, Poland, Austria, Czech Republic, Romania, Slovakia, Portugal, Bulgaria, and Sweden. The full ranking of EU–member states in trademark applications of nonresidents can be seen in Fig. 16.

Trademark applications of residents and nonresidents

Figure 12

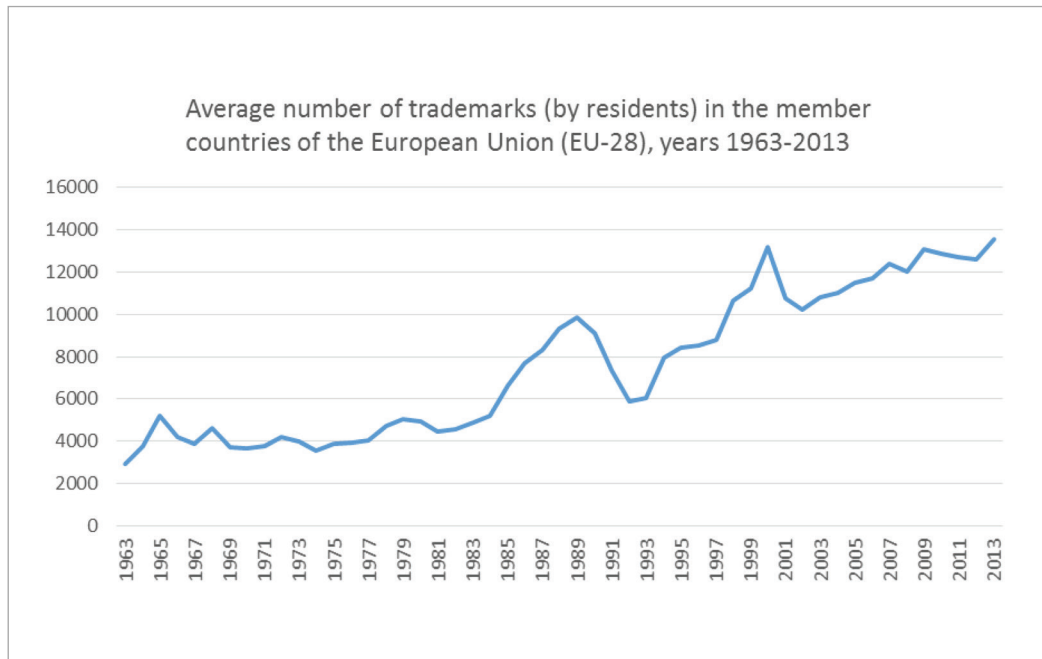Average number of trademarks (by residents) in the member countries of the European Union (EU–28), years 1963–2013

Average number of trademarks (by residents) in the member countries of the European Union (EU-28), years 1963-2013

Figure 13

Average number of trademarks (by non–residents) in the member countries of the European Union (EU–28), years 1963–2013

Average number of trademarks (by direct non-residents) in the member countries of the European Union (EU-28), years 1963-2013
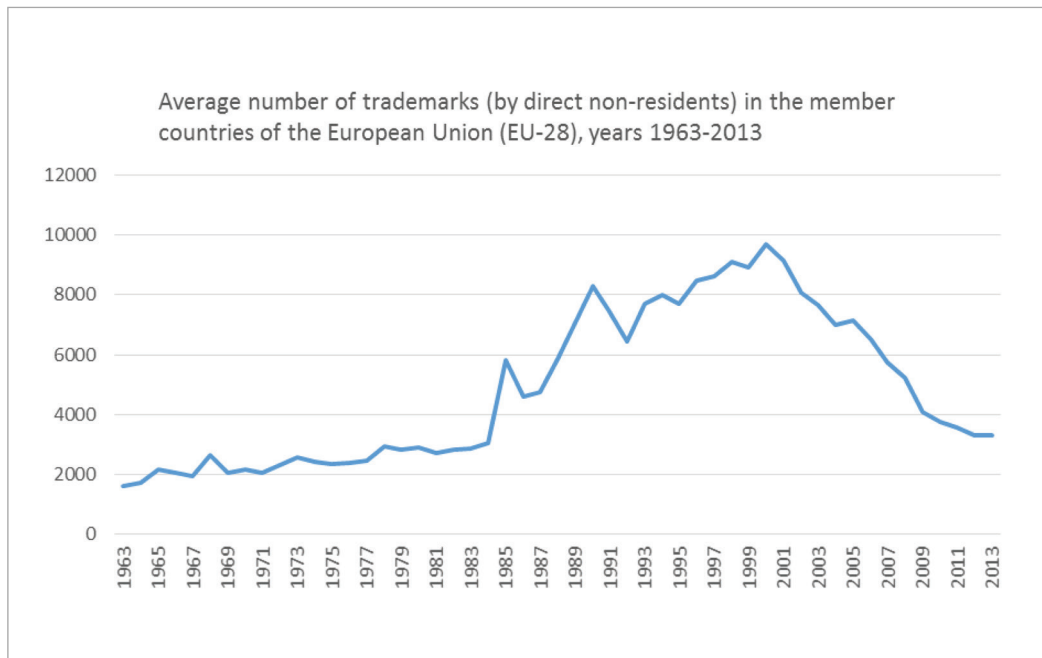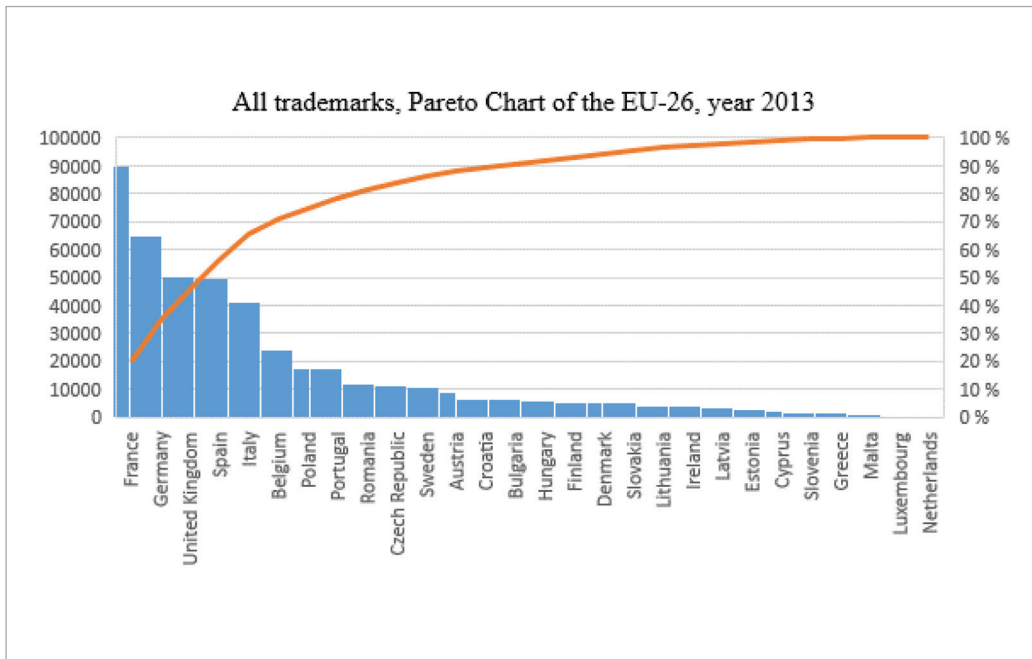
Figure 14
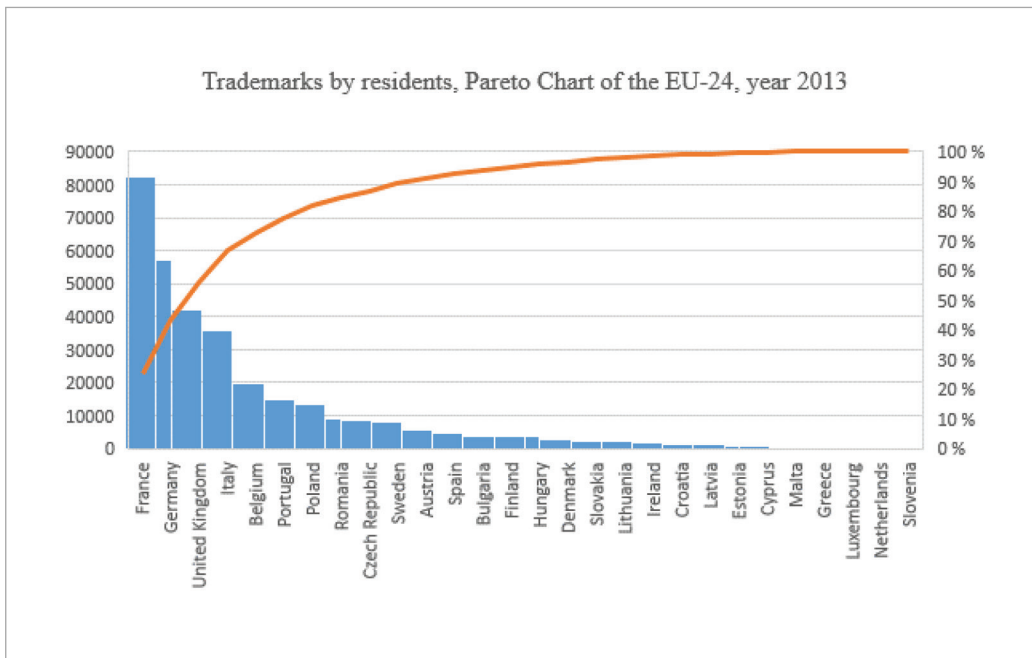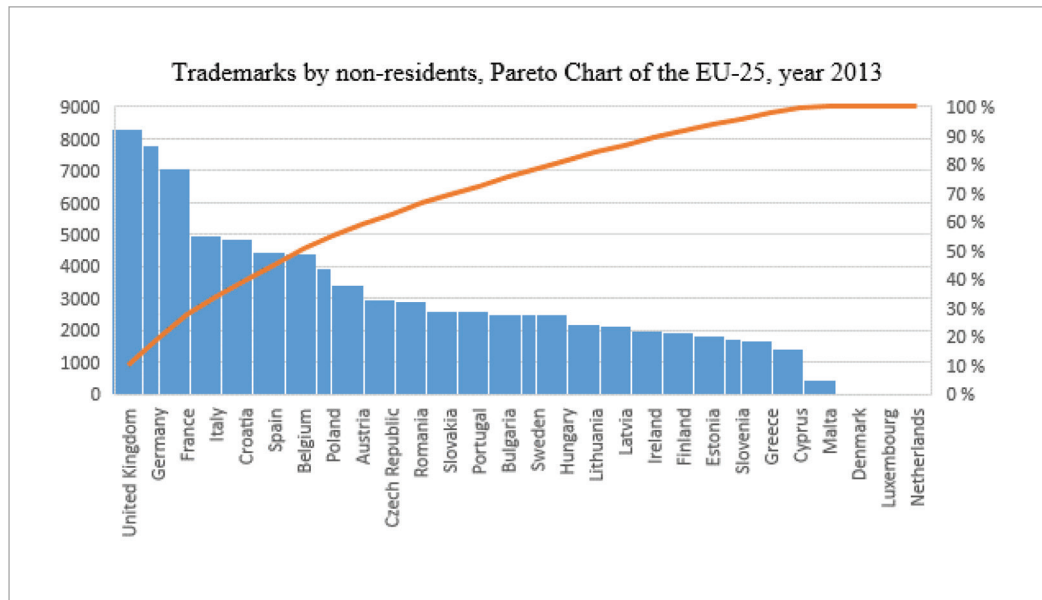All trademarks, Pareto
Chart of the EU–26
countries, year 2013

Figure 15
Trademarks by residents,
Pareto Chart of the
EU–24, year 2013

Trademarks by non-residents, Pareto Chart of the EU-25, year 2013

EU–28 innovation activity benchmarking analyses in relation to population size

In Chapter 4 some innovation activity benchmarking analyses are reported. All benchmarking analyses in this section are presented in relation to population size of EU–member states.

Fig. 17 reports the innovation champions of EU–28 using the benchmarking indicator of patents by residents per population. The benchmarking analysis is based on the observations of years 1970, 1980, 1990, 2000, and 2013. The champion of EU–28 in this category is Sweden. The full ranking of EU–member states in patent applications by residents can be seen in Fig. 17.

Fig. 18 presents EU–28 innovation champions using patents by non–residents per population as a benchmarking indicator. The benchmarking analysis is based on the observations of years 1970, 1980, 1990, 2000, and 2013. The champion of EU–28 in this category is Luxembourg. The full ranking of EU–member states in patent applications per non–residents can be seen in Fig 18.

EU-28 innovation champions, patents by residents per population benchamarking, analysis is based on the observations of years 1970, 1980, 1990, 2000 and 2013
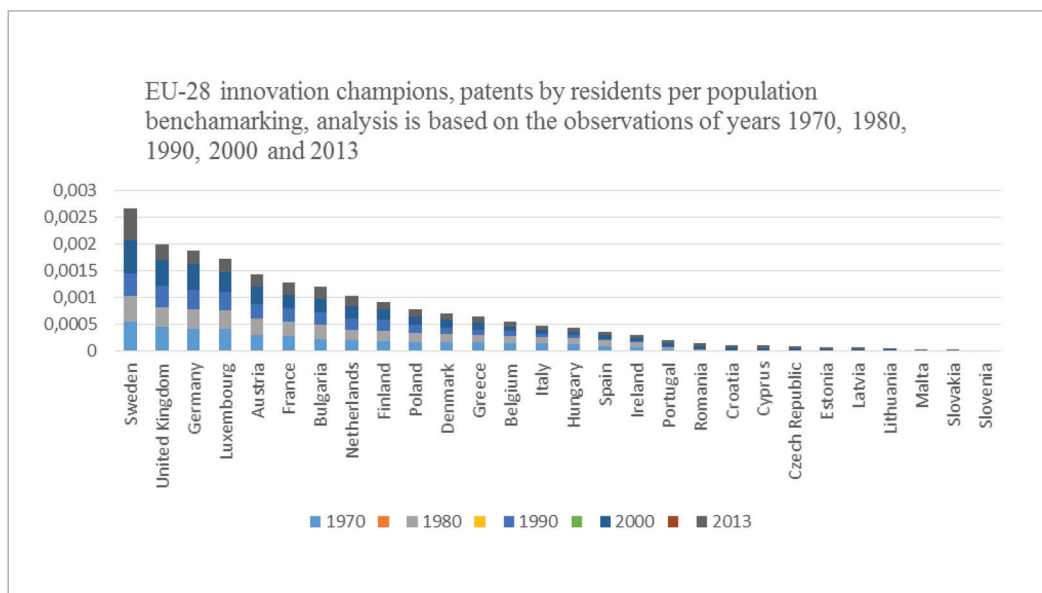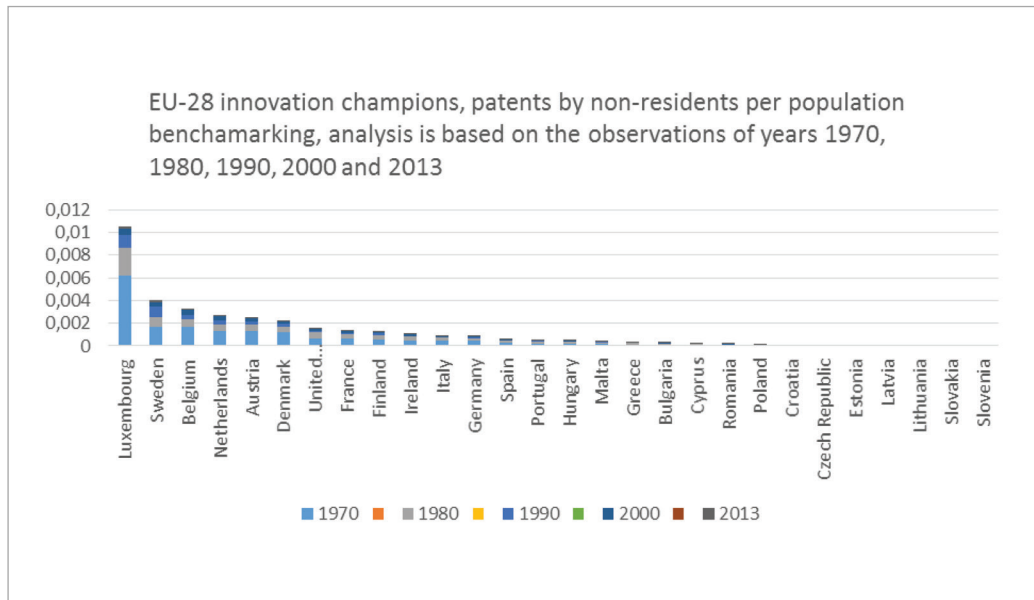
Figure 18

EU–28 innovation champions, patents by nonresidents per population. The benchmarking analysis is based on the observations of years 1970, 1980, 1990, 2000, and 2013
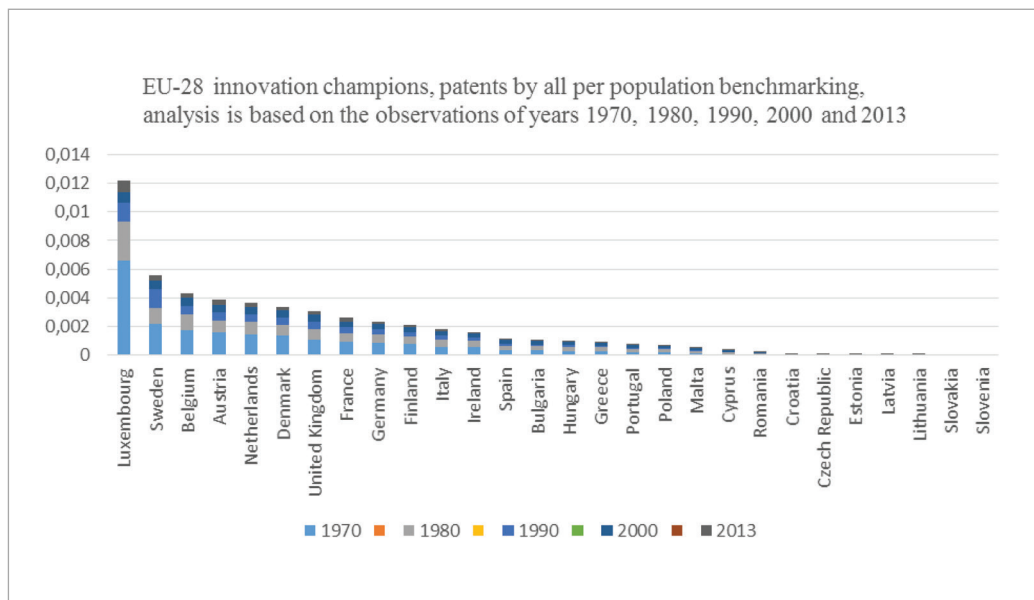

Figure 19

EU–28 innovation champions, patents by all per population. The benchmarking analysis is based on the observations of years 1970, 1980, 1990, 2000, and 2013

Fig. 19 shows EU–28 innovation champions using patents by nonresidents per population as a benchmarking indicator. The benchmarking analysis is based on the observations of years 1970, 1980, 1990, 2000, and 2013. The champion of EU–28 in this category is Luxembourg. The full ranking of EU–member states in patent applications per non–residents can be seen in Fig. 19.

Fig. 20 reports EU–28 innovation champions using trademark applications by residents per population as a benchmarking indicator. The benchmarking analysis is based on the observations of years 1970, 1980, 1990, 2000, and 2013. The champion of EU–28 in this category is Luxembourg. The full ranking of EU–member states in trademark applications by residents can be seen in Fig 19.

Figure 20

EU–28 innovation champions, trademarks by residents per population. The benchmarking analysis is based on the observations of years 1970, 1980, 1990, 2000, and 2013.

EU-28 innovation champions, trademarks by residents per population benchmarking, analysis is based on the observations of years 1970, 1980, 1990, 2000 and 2013
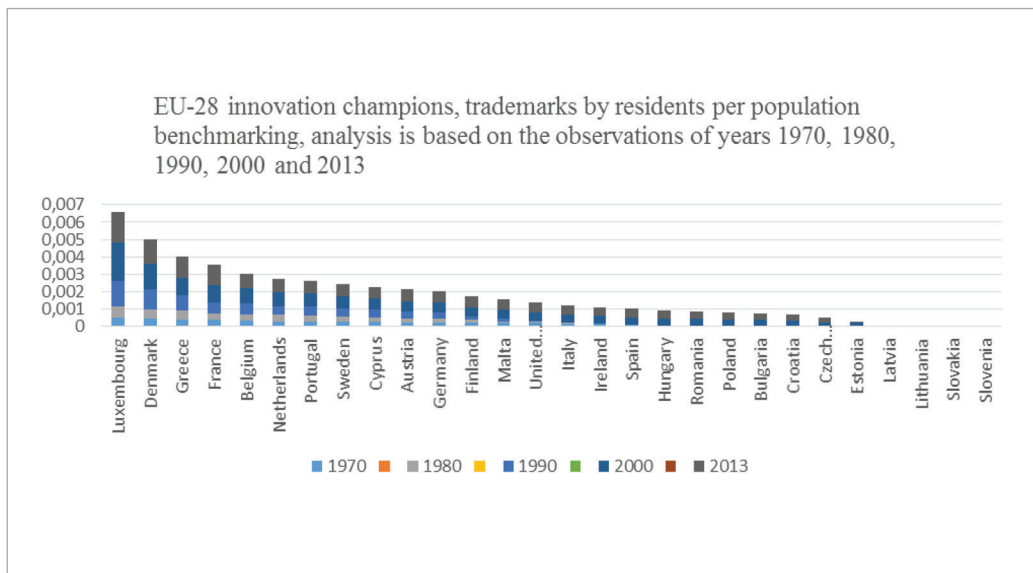
Figure 21

EU–28 innovation champions, trademarks by non–residents per population. The benchmarking analysis is based on the observations of years 1970, 1980, 1990, 2000, and 2013.

EU-28 innovation champions, trademarks by non-residents per population benchamarking, analysis is based on the observations of years 1970, 1980, 1990, 2000 and 2013
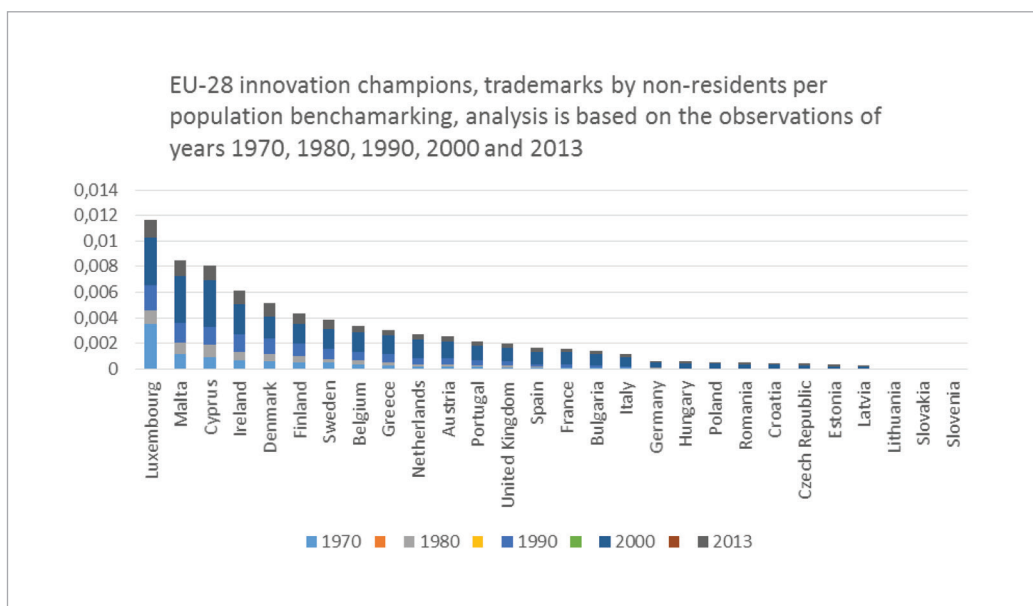
Fig. 21 reveals EU–28 innovation champions using trademark applications by non–residents per population as a benchmarking indicator. The benchmarking analysis is based on the observations of years 1970, 1980, 1990, 2000, and 2013. The champion of EU–28 in this category is Luxembourg. The full ranking of EU–member states in trademark applications by non–residents can be seen in Fig 21.

Fig. 22 reports EU–28 innovation champions using trademark applications by all per population as a benchmarking indicator. The benchmarking analysis is based on the observations of years 1970, 1980, 1990, 2000, and 2013. The champion of EU–28 in this category is Luxembourg. The full ranking of EU–member states in trademark applications by all can be seen in Fig. 22.
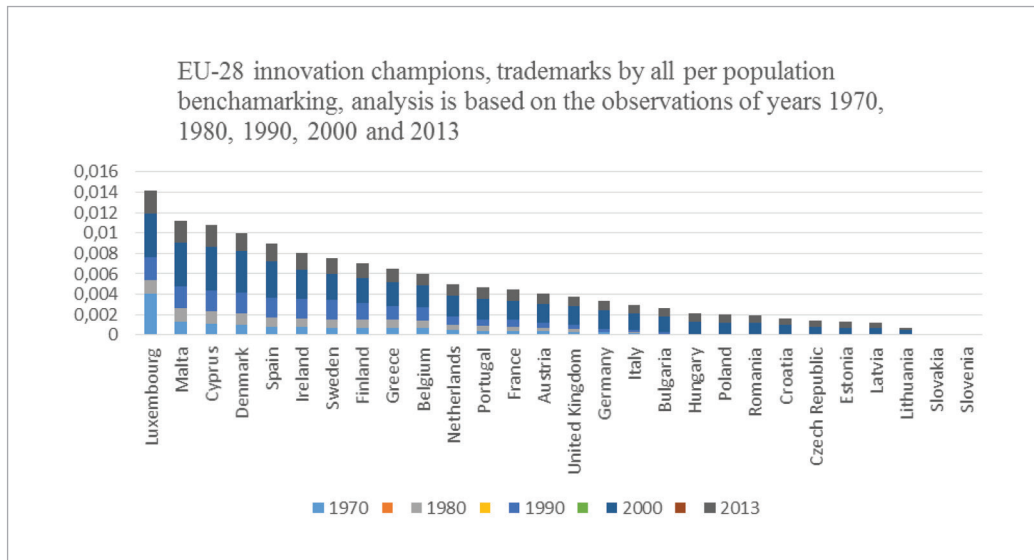
Figure 22
EU–28 innovation champions, trademarks by all per population.

Top 10 patent champions of the EU–28 are reported in Fig. 23.

In the second benchmarking analysis (Fig. 24) summary, the top 10 trademark champions of the EU–28 are reported.

In the third benchmarking analysis (Fig. 25) summary, the top 10 patent led growth champions of the EU–28 are reported.

In the fourth benchmarking analysis (Fig. 26) summary, the top 10 trademark led growth champions of the EU–28 are reported.

Top 10 patent and trademark champion analyses of the EU–28
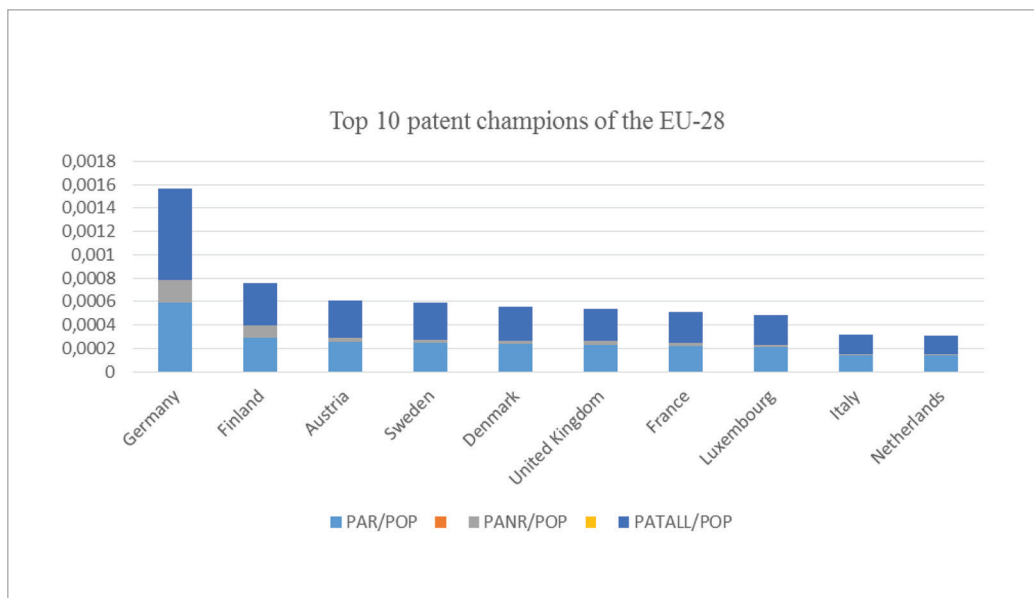

Figure 23
Top 10 patent champions of the EU–28.

Figure 24

Top 10 trademark champions of the EU–28.

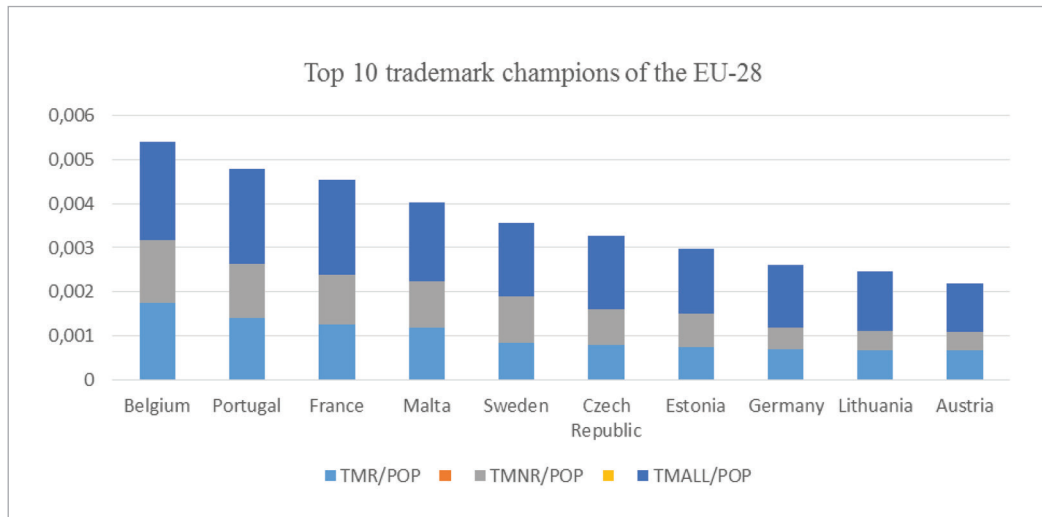

Top 10 trademark champions of the EU-28

Figure 25

Patent led growth champions of the EU–28

Patent led growth champions of the EU-28
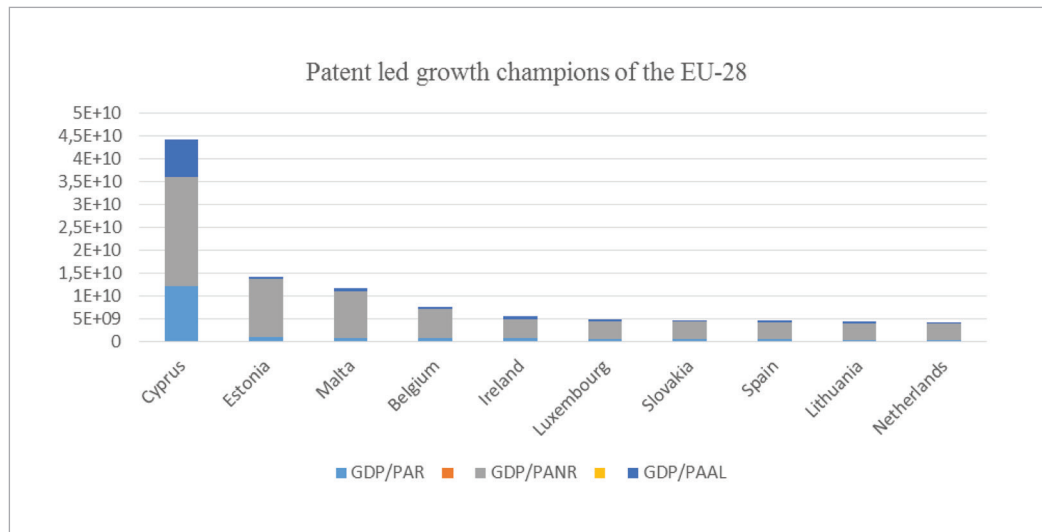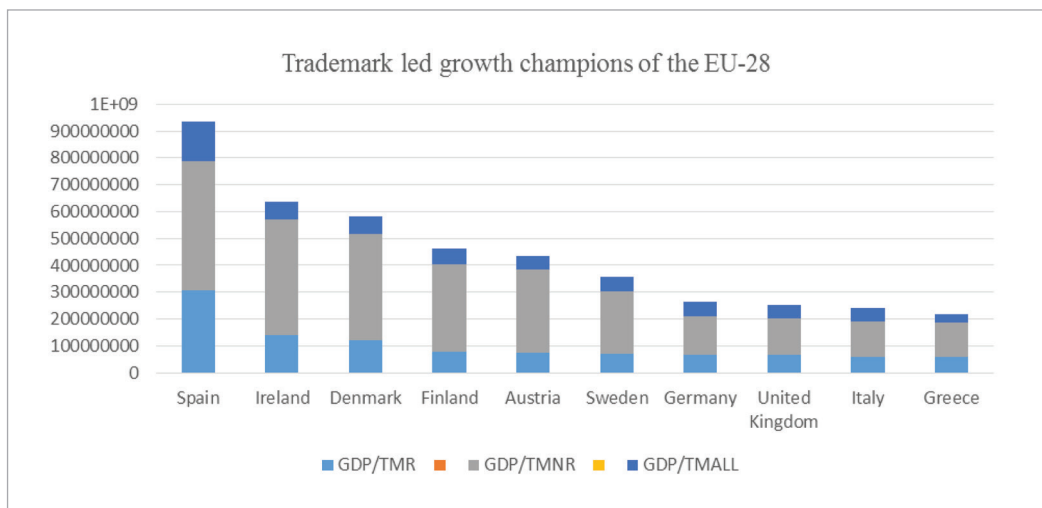
Figure 26

Trademark led growth champions of the EU–28

Trademark led growth champions of the EU-28

In Figures 27 and 28 patent application–GDP and trademark applications–GDP tradeoff analyses are visualized. These figures show that patent and trademark applications are strong drivers of economic growth in the EU–28.

In Table 2 a correlation analysis and level of significance of correlation coefficients (EU–28) for year 2013 are reported.

The statistical analyses of table 2 verifies the following correlation relationships concerning the data of EU–28 member states:

1) We found *statistically very significant correlation* between **GDP** and population, patent applications (all), patent applications by residents, patent application by non–residents, trademark applications (all), trademark applications by residents, and trademark applications by non–residents. Thus, all innovation activity data correlates with GDP.

2) We found *statistically very significant correlation* between **population** and patent applications (all), patent applications by residents, patent applications by non–residents, trademark applications (all), trademark applications by residents, and trademark applications by non–residents. Thus, all innovation activity data correlates with population development.

3) We found *statistically not significant correlation* between **patent applications (all)** and patent applications by residents, trademark applications (all), and trademark applications by non–residents.

4) We found *statistically directional correlation* between **patent applications (all)** and patents by non–residents and trademark applications by residents.

5) We found *significant correlation* between **patents by residents** and trademark applications by all.

6) We found *statistically not significant correlation* between **patents by residents** and trademarks by non–residents.

7) We found *statistically very significant correlation* between **patent applications by non–residents** and trademark applications by all.

8) We found *statistically significant correlation between* **patent applications by non–residents** and trademark applications by residents.

9) We found *statistically almost significant correlation* between **patent applications by non–residents** and trademark applications by non–residents.

10) We found *statistically almost significant correlation* between **trademark applications by all** and trademark applications by non–residents.

11) We found *no statistically significant correlation* between **trademark applications by all** and trademarks by residents.

12) We found statistically almost significant correlation between **trademark applications by residents** and trademark applications of non–residents.

In general, we can find many direct indications of complementary nature of patents and trademarks. However, because there were some correlations with statistically weak foundations, we cannot say that complementarity of patents and trademarks is extremely strong. There are some important exceptions, which are important for the functioning of the EU–28 innovation ecosystem.

Some integrative analyses of EU–28 innovation activity

Figure 27

Regression line of patent application variable and economic growth variable in 2013. EU–28 observations
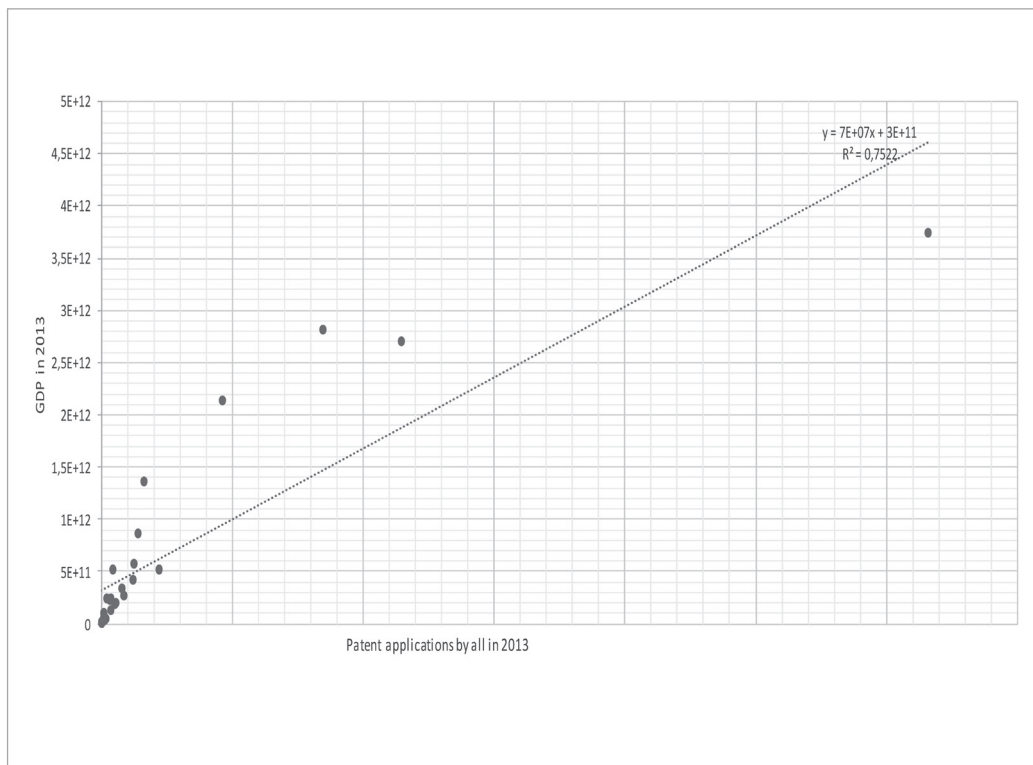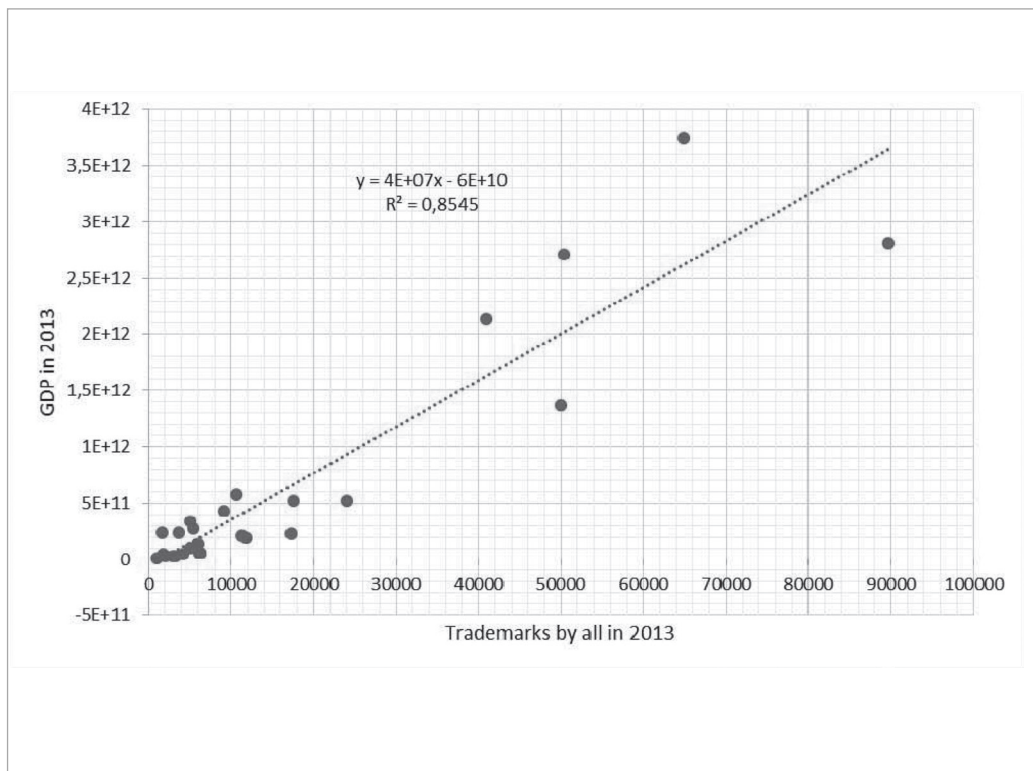

Figure 28

Regression line of trademark application variable and economic growth variable in 2013. EU–28 observations

	GDP	POP	Patent applications by all	Patents by residents	Patents by non–residents	Trade-marks by all	Trade-marks by residents
GDP	1						
POP	0,96 ****	1					
Patent applications by all	0,87 ****	0,79 ****	1				
Patents by residents	0,88 ****	0,8 ****	0,99	1			
Patents by non–residents	0,82 ****	0,72 ****	0,98 *	0,96 *	1		
Trademarks by all	0,92 ****	0,92 ****	0,69	0,72 ***	0,61 ****	1	
Trademarks by residents	0,9 ****	0,86 ****	0,72 *	0,74 **	0,64 ***	0,93	1
Trademarks by non–residents	0,89 ****	0,88 ****	0,74	0,74	0,72 **	0,87 **	0,83 **

Table 2
Correlation analysis and level of significance of correlation coefficients (EU–28), year 2013.

Level of significance: p < 0,001**** Very significant; 0,001 <= p < 0,01***Significant; 0,01 <= p < 0,05 ** Almost significant; 0.05 <= p < 0.10 ; * Directional; p>0.10 Not significant (without stars). N=28.

Referring to the theoretical discussion in the beginning of this article, it is possible to present the following conclusions:

1) Growth and employment policy: There are considerable differences in innovation activity between EU–28 countries, which implies that preconditions of growth and employment policy are not equal inside European markets.

2) IPR policy: IPR policy and associated activity is not similar inside EU–28 countries. Some countries are very good in patent activity, some are very good in trademark activity, but only few countries are good in both fields of IPR policy.

3) Open innovation paradigm: The empirical results of this study gives reason to hesitate that growing popularity of open innovation management and OI paradigm in European companies has had a negative impact on the closed innovation management paradigm. This impact of open innovation management can be seen in decreasing patent activity and increasing trademark activity.

4) Innovation and knowledge management policy: The empirical findings of this article indicate considerable change in innovation and knowledge management culture of European companies. The long run change indicates that more emphasis is today paid to commercialization of products and services instead on engineering activities and patenting. In comparative terms, this is an interesting scientific finding.

5) Cyclical model of technological entrepreneurship and innovation: The empirical findings of

this study indicate that the role of scientific exploration and technological research has de-creased, but the role of market transitions and product creation have increased in EU–28 innovation ecosystem. In relative terms, we can note that the powers of natural and life sci-ence cycle and integrated engineering cycle have decreased. On the other hand, the powers of social and behavioral science cycle and differentiated services cycle have increased.

6) Changes in innovation activity, technological capability and commercial business competen-ces: Referring to analyses of this empirical study, we can note that the technological capability does not produce so much patents in the EU–28 countries that it used to produce earlier. On the other hand, we can note that commercial business competences in European companies produce more trademarks than earlier in the EU–28 countries.

7) Barriers to entry in markets: This study informs us that in the EU–28 countries there is less ability to develop barriers to entry in markets, when we study long–run patent activity. On the other hand, there is more ability to develop barriers to entry in markets, when we study long–term trademark activity. This conclusion must be drawn with some hesitation, because we have not analyzed cumulative patent and trademark stocks. Yearly statistical observations in this empirical study, however, indicate considerable changes in ability to introduce barriers to entry to markets.

Thus, this study provides many interesting findings from theoretical viewpoints. However, there is need to make more detailed investigations in different sectors and clusters of European eco-nomies.

Conclusions

_ The empirical results of this article indicate that patent and trademark applications play an im-portant strategic role in the innovation ecosystem of the EU–28. Population changes and eco-nomic growth correlate with all analyzed patent and trademark applications indicators. When the data of year 2013 was analyzed, we found statistically very significant correlations with key indicators of innovation ecosystem of EU–28. We also found some correlations, which were not statistically significant or only directional. Some almost significant correlations were also found. In general, these results give empirical support to recent analysis of Zhou et al. (2016), who strongly emphasize complementarity of patents and trademarks in the field of venture capital funding.

_ In this article the long–run innovation activity trends of EU–28 were analyzed. Key findings of this article were: (1) In 1985 a first turning point in European innovation activity took place, (2) in 2000 there was second turning point of European innovation activity, (3) innovation activity of the EU was first patent driven (1960–1985), but in late 1980´s it turned to be more trademark driven, (4) average number of patent applications of non–residents has a downward sloping trend in the EU–28, (5) downward sloping trend in patent application of residents can be ob-served, (6) average number of trademark applications by non–residents increased until 2000, but after this turning point it started to decrease, (7) average number of trademark applications by residents in the European Union (EU–28) has an upward sloping trend curve in long–run analysis, and (8) in general innovation activity (per population) of the EU–28 there was a down-ward sloping trend in 1963–1985, but in 1985 it turned to an upward sloping trend in 1986–2000 and in 2001–2013 we can observe downward sloping trend in European innovation activity (per population).

_ In this article some key benchmarking analyses were reported. These analyses reveal the champions of innovation activity. Key finding is that in the EU–28 champions of patent activity

and trademark activity are not the same. This result indicates that there is some kind of smart specialization in the EU–28 innovation ecosystem, but many decision–makers are not aware of this kind of smart specialization pattern. This article gives new information from this strategic perspective for decision–makers in the European Union.

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