

# Trends and characteristics of patenting activity in Poland in 1990–2018

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**Abstract.** Patenting activity is broadly analysed in the literature at the micro, mezzo, and macroeconomic levels. Yet, not much attention regarding this issue is devoted to European countries in transition. The main aim of the study is a quantitative analysis of all patent applications filed with and grants issued by the Polish Patent Office throughout the period of 1990–2018 at the aggregate and regional level. We investigate trends and factors determining the patenting activity in Poland – the country at an advanced level of the economic and social transition. The empirical analysis leads to several findings. First of all, we identify changes in the field of patenting related to Poland’s accession to the EU in 2004, which resulted in the increase of residents’ patenting activity and decrease of that of non-residents (in terms of the number of filed applications and granted patents at a national and regional level). This holds for absolute numbers as well as for a *per capita* perspective. Additionally, we demonstrate that the increase in R&D expenditure is not followed by a proportional increase in patenting, as the patent-to-R&D ratio is systematically shrinking. Finally, the study compares trends in patenting activity in Poland with those in different groups of countries, proving that the dynamic of change in Poland is much slower than could be expected.

**Keywords:** patents, Central and Eastern Europe, Polish Patent Office, innovations

**JEL:** O31, O34

## 1. Introduction

The history of patents goes back to 15th-century Italy, but its modern understanding originated in the 18th century in Great Britain and the United States (Hall & Harhoff, 2012). Since then, governments worldwide have been granting inventors the right to exclude other agents from exploiting the innovation for some time. In exchange for that, inventors agree to share their intellectual property with society as the patent expires, thus increasing social welfare. This demonstrates that patents are an important element of the economy in all its three dimensions, i.e. the micro-economic dimension (generating profits for individual companies), the mezzo-economic dimension (giving a strategic advantage over competitors), and the macroeconomic one (providing valuable knowledge on the economy).

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This study aims to investigate recent trends in the patenting activity in Poland – the country in transition for the past 30 years, which started upon the introduction of the market economy. We analyse the database of intellectual property rights granted over the period of 1990–2018 and compare the findings with the most important trends worldwide. It should be underlined that our study is most of all quantitative-based, which restricts the complexity of the final conclusions.

The article contributes to the literature in several ways. First of all, to the best of the authors' knowledge, it is the first study that analyses trends in patenting in Poland over a long period (21–25 years). Additionally, the study investigates regional variation within the country. Finally, different measures of patenting activity are utilized.

The remaining part of the article consists of four sections. Section 2 provides a review of the literature on trends and characteristics of patent activity in the world, Section 3 presents the history of patenting in Poland and the relevant literature, Section 4 introduces the dataset and empirical results, and Section 5 features the conclusions of the paper.

## **2. Literature review**

Patenting has been widely discussed in the literature since the unexpected boom in this kind of activity in the early 1980s, which occurred in connection to the revolution in intellectual property rights in the U.S. In 1980 the Bayh-Dole Act was adopted, aiming at strengthening the protection of intellectual property, simplifying the process of resolving disputes, and extending the maximum time a patent is protected (Gallini, 2002). Kortum and Lerner (1999) argue that the increase in patenting activity is related not only to changes in regulations, but also results from the way innovations are dealt with in the U.S., which, in general terms, stimulates innovativeness. Bessen and Hunt (2007) suggest that this trend may be partially caused by the improvement in cost efficiency of patenting over time. Similarly, Posner (2005) finds the intensification of the worldwide patenting activity to be the effect of lower costs and the comparative ease in intellectual property copying, which, as observed by Lee and Lim (2019), has so far found a continuous reflection in the relevant data. The U.S. companies continue to dedicate increasing amounts to gaining new patents. On the other hand, though, this activity entails a decline in the average quality of patents (Caillaud & Duchêne, 2011).

Over the last four decades, characteristics of and trends in patenting activity have been investigated in literature at three different levels. First of all, patents are considered as a measure of innovative activity at the macro-level (Acs & Audretsch, 1989; Pakes & Griliches, 1980; Scherer, 1983), allowing cross-country and cross-industry

comparisons, as the propensity to patent varies between sectors as well as between countries. In that latter case, the differences are especially noticeable when comparing developed and developing countries (Chandran Govindaraju & Wong, 2011; Penrose, 1973). Research indicates that the quality of regulations on the protection of intellectual property rights affects the propensity to patent to a large extent. More efficient protection, as well as the introduction of international agreements on cooperation in the sphere of intellectual property (for example the Trade-Related Aspects of Intellectual Property Rights – TRIPS) means more patent applications are filed, whereas less efficient systems promote treating inventions as ‘company secrets’ (Dass et al., 2015).

On the other hand, more recent literature suggests that due to the fragmentation of research and development (R&D) activity within multinational enterprises, cross-country comparisons may be blurred, for example in terms of patent valuation (Grupp & Schmoch, 1999). Hall and Harhoff (2012) indicate that only in a few industries (e.g. pharmaceuticals) patents stimulate innovative activity, but in general, they are the result of competition between firms (‘if your competitors have them, you need them too’) and do not enhance social well-being to a large extent. This conclusion leads to the second level of analysis, which is the industry level.

Hall and Ziedonis (2001) argue that companies in the semiconductor industry tend to perform ‘patent portfolio races’ to gain a strategic advantage over their competitors. Similarly, Cohen et al. (2000) investigate the reasons for which companies engage in patenting. Their findings show that except for the standard prevention of invention copying, companies’ main motivation is to prevent their competitors from patenting similar solutions (called ‘patent blocking’), thus gaining an advantage in negotiations and avoiding lawsuits.

The last level of the analysis (micro) involves examining financial aspects of patenting at firm level. For example, in his classical paper, Griliches (1981) finds a positive relationship between the intangible value of companies based in the U.S. (measured by the number of held patents and other similar indications) and their market value. Austin (1993) observes that a public announcement of a company about having received a patent may have a positive influence on its market value. Additionally, the author points out the possibility of the occurrence of a positive spill-over effect, meaning that the market’s positive reaction to one company gaining a patent results in the increase in the market value of other companies operating within the same industry.

Hsu and Ziedonis (2008) suggest that the number of patents in a company’s portfolio can increase the likelihood that a company will receive Venture Capital financing. In contrast, Munari and Toschi (2008) show that generally in the case of Venture Capital financing in nanotechnology start-ups, the number of all patents obtained by a company is not related to the amount of financing received. On the

other hand, patents concerning the main activity of a company (nanotechnology) significantly affect financing by the Venture Capital.

Useche (2014) investigates the relationship between the number of patents and the Initial Public Offering (IPO) success in the EU and the US and finds a positive relation – each patent application filed prior to the IPO increases the revenue by 0.5% and 1.1%, respectively.

On the other hand, Lee and Lim (2019) argue that the market values primarily the ratio of patent count to R&D expenditure, while citations play a secondary role. Additionally, the authors suggest that the market appreciates patents of younger companies more than those of well-established firms.

Gambardella et al. (2008) analyse the value of patents granted by the European Patent Office (EPO). The authors estimate the average value of patents at EUR 3 million, their median at about EUR 300,000, and the mode between EUR 6,000 and EUR 7,000, which confirms the right-skewed distribution of the patent value. Interestingly, the value of a patent is correlated with patent citations, references, claims, and country of origin, although these do not fully explain the variability of this value.

Bessen (2008) estimates the value of patents in the US and finds out that the average value of a patent granted by the United States Patent and Trademark Office (USPTO) is substantially higher than that granted by its European counterpart. The author also asserts that the value of a patent is positively correlated to the company's size, and estimates the influence of patent citations on its value. He finds out that additional citation increases the value of a patent by 4–7%. It should be noted, however, that patent citations explain the variability of a patent's value only to a limited extent.

A detailed analysis of the inventor's profile is performed by Akcigit et al. (2017), who examine the combination of US patent and census data for the period of 1880–1940. According to the study, inventors then were highly-educated, made delayed marriage decisions and migrated to regions with a higher propensity to innovate. As a result, inventors had larger incomes than non-inventors. Additionally, the authors discover a relation between patenting activity and long-run economic growth, observable also at a regional level.

It should be underlined that the accuracy of patent count as the measure of innovative activity at firm level is widely discussed in the literature. For example, Trajtenberg (1990) suggests that patent count is a better measure of innovative activity than R&D expenditure, but on the other hand, the idea can be criticised as it fails to take into account the quality of a patent. Including patent citations in the analysis may solve this problem. Narin et al. (1987) have similar observations – they suggest that in the case of the pharmaceutical industry, the counts and citations of patents correctly predict the 'technological strength' of a company. The authors distinguish between patent count, which is considered as a measure of research input correlated

with the R&D budget, and citations considered as a measure of research output and quality correlated with the financial performance of a company. Thus, citations may constitute an element of the financial analysis of a company.

### 3. Brief history of patenting in Poland

Surprisingly, little attention has been paid in the literature to trends and characteristics of patent activities in transition economies, especially in the ‘emerging Europe’. Countries of Eastern, Central, and Southern Europe are certainly on a different trajectory of patenting activity than developed countries. There are several reasons behind this situation, including history-based ones, such as, at least for some of them, the operating in an innovation-discouraging, centrally-planned economy for nearly half a century. In result, the majority of these countries are considered as modest or moderate innovators (European Commission, 2020), lacking an ‘innovation culture’. They are characterised by a lower propensity to patent, which, in turn, results in firms’ low awareness and lack of expertise in protecting intellectual property (Turczak, 2010).

On the other hand, the accession to the EU, growing R&D expenditure and steady economic growth observed in the region over recent years seem to have changed those patterns to some extent. From this perspective, patenting activity in Poland – the largest market within the ‘emerging Europe’ group – is particularly interesting.

The Polish Patent Office (PPO; Urząd Patentowy Rzeczypospolitej Polskiej) was originally established on the basis of a Temporary Decree of the Head of State in 1918, and in 1919 the law on the protection of patents was introduced. Later Poland joined the Paris Convention on the protection of intellectual property (see Zaremba, 1993). The same year the first trademark was registered, and the first invention five years later, in 1924 (a bakery shovel – see Krzemień & Ogurek, 2017). The activity of the PPO was interrupted by the outbreak of the Second World War, and resumed in 1945. Poland joined the World Intellectual Property Organization (WIPO) in 1975 and signed the Patent Cooperation Treaty in 1990. Currently, intellectual property rights in Poland are primarily regulated by the Industrial Property Act of 2000.

As mentioned above, the literature on patent activity in Poland seen from the macroeconomic perspective is scarce. The majority of articles analyse the issue of patenting at a micro level – as a part of knowledge management (Klincewicz, 2011), as a proxy for innovations (Niedbalska, 2001), or in analyses of groups of countries, without a particular focus on Poland (Okoń-Horodyńska et al., 2015).

As far as the existing body of literature focusing on the macroeconomic aspects of patenting activity is concerned, there are a few publications that should be mentioned here. Weresa (2010) analyses patenting activity in Poland from 1995 to 2008 and concludes that after a period of stagnation in the 1990s, a slight increase in this

kind of activity has been observed after the country's accession to the EU in 2004. Polish inventors have become relatively successful in gaining patents in the fields of mechanical engineering, lighting, heating, weapons and blasting.

Turczak (2010) identifies the barriers to patenting in Poland, which include the lack of firms' expertise relating to the subject, high costs of patenting inventions, and complex (as well as time-consuming) administrative procedures. Furthermore, Polish inventors are discouraged by lengthy processes of resolving disputes. Finally, the author points out that the PPO does not grant patents for computer software, which results in a lower propensity to patent in the high-tech industry.

Wachowska and Niklewicz-Pijaczyńska (2015) analyse nearly 2000 patents granted to Poland's top eight universities and 20 companies in terms of the number of patents obtained in the period of 2005–2011. The authors assess the quality of patenting by selecting 'dead patents' – inventions whose protection was not extended after the expiry of the initial protection period, which undermines the success of their commercialisation. Interestingly, almost half of all university patents were considered 'dead', whereas in the case of business-obtained patents, it was only 18%. On the other hand, the amount of 'dead' patents was correlated to the overall number of the gained patents – the larger the patent portfolio owned by the company, the more 'dead' patents there.

#### 4. Dataset and empirical results

In order to achieve the broadest possible perspective in analysing patenting trends in Poland, we utilised a dataset comprising 3 different sources of data.

Firstly, we merged the data on patent applications and patents granted from the annual reports of the PPO from 2003 to 2018 and surveys conducted by Statistics Poland (Główny Urząd Statystyczny) from the *Science and technology* reports published from 2004 to 2019. In addition to the classic industrial property rights measures, such as the number of patent applications (filed by domestic and foreign entities) and patents granted (to domestic and foreign entities), we examined the structure of the patenting activity for both domestic and foreign entities within the total number of patent applications and grants from 1990 to 2018. Moreover, we analysed the trends and the structure of patenting in Poland by type of activity according to the International Patent Classification (IPC), covering the period of 1990–2018. There are the following sections of activity:

- Chemistry & metallurgy;
- Human necessities;
- Performing operations & transporting;
- Mechanical engineering, lighting, heating, weapons & blasting;
- Physics;

- Fixed constructions;
- Electricity;
- Textiles & paper.

Secondly, the data were supplemented with figures provided by the Local Data Bank – the largest database of regional statistics on Poland, run by Statistics Poland. Data obtained in the above-described way enabled us to analyse regional trends in patenting activity in 16 Polish voivodships from 2004 to 2018 and to enumerate patent applications per 1 million inhabitants at the aggregate and regional level. Furthermore, we investigated the effectiveness of R&D expenditure in terms of patenting (number of patents per 1 billion PLN GERD – *Gross Domestic Expenditure on Research and Development*).

Lastly, we extracted the World Bank data on patent applications and population in groups of countries (World, Europe, and Central Asia; high income, middle income) over the period of 1990–2018 to compute long-term trends in patenting per 1 million inhabitants worldwide, and to compare them to the results for Poland.

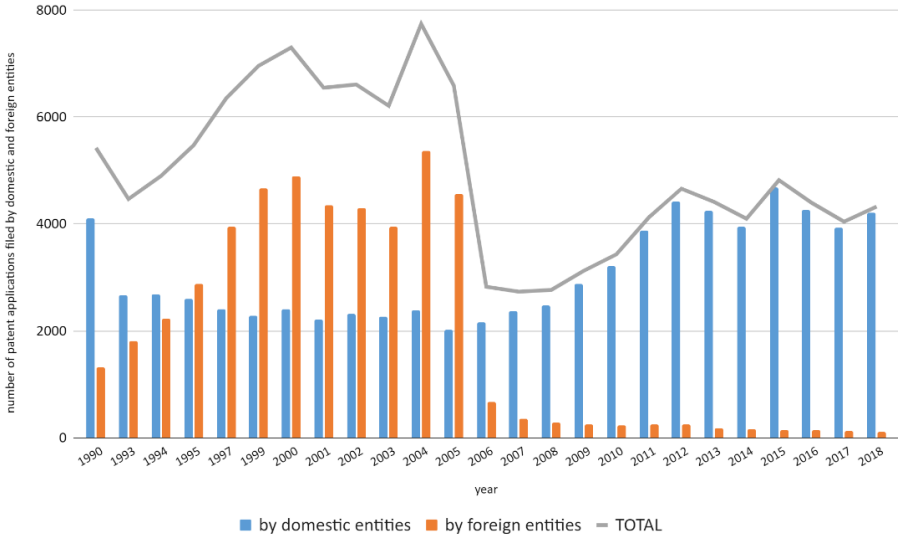
The main features of this collection of data are: its focus on relatively long periods of time and the capacity of the patents to be disaggregated into more specific divisions, e.g. according to the type of activity and place of residence of the main applicant. All of this makes it possible to provide a very detailed and unique description of patent activity in particular transition economies.

In the study, we mainly focused on analysing the patenting activity of domestic (Polish) entities recorded by the PPO, for two reasons. First is the lack of sufficient data on domestic entities which applied for patents in the period of 1990–1999 and the lack of data on patents granted to them by the EPO in the period of 1990–2006. Secondly, relatively low numbers are recorded during the available period at the EPO. According to the statistics provided by Statistics Poland and by the PPO, patent applications filed by domestic entities with the EPO accounted for only 13 percent of the total number of domestic patent applications filed in 2018 (538 patent applications were filed with the EPO that year, compared to 4,207 applications filed with the PPO). Likewise, the amount of patents granted by the EPO to Polish entities in 2017 accounted for only 10 percent of all patents granted to these entities in this period (216 granted by the EPO and 2,795 by the PPO). Basically, it could be said that the patenting activity of Polish entities in the EPO is on an upward trend, but the numbers are still relatively low.

We start with trends in aggregated patent applications and patents granted. As Figure 1 indicates, the aggregated highest number of patent applications received by the PPO equalled 7,740, and it was in 2004. The total number of patent applications filed with the PPO plunged to the lowest level of 2,732 entries in 2007 (marking a decrease of 65% compared to 2004). Moreover, looking closer at the structure of applications distinguishing between domestic and foreign entities, one can observe

a drop of 93% for foreign entities and only a 1% decrease for domestic entities over the period of 2004–2007, which is due to Poland’s notifying the Convention on the Grant of European Patents and the country’s accession to the EPO in 2004. This institution was established to grant European Patents which guarantee the protection of an invention in all states being parties to the European Patent Convention. Consequently, since then the outflow of patent applications filed by foreign entities with the PPO has been substantial, and in the last decade foreign enterprises were more likely to file patent applications with the EPO than the PPO (in 2018, the number of patent applications filed with the PPO by foreign entities equalled 115). However, a reverse trend could have been observed for domestic entities. A gradual increase in the number of their patent applications occurred in the period of 2005–2015. In 2005, domestic entities filed 2,024 patent applications with the PPO (which is the lowest recorded number), whereas in 2015 this number rose to 4,818 – a more than twofold increase, and fluctuating at around 4,000 applications until 2018, when it stabilised at about 4,300 applications.

**Figure 1.** Trends in patent applications of domestic and foreign entities



Source: Urząd Patentowy Rzeczypospolitej Polskiej (2003–2018).

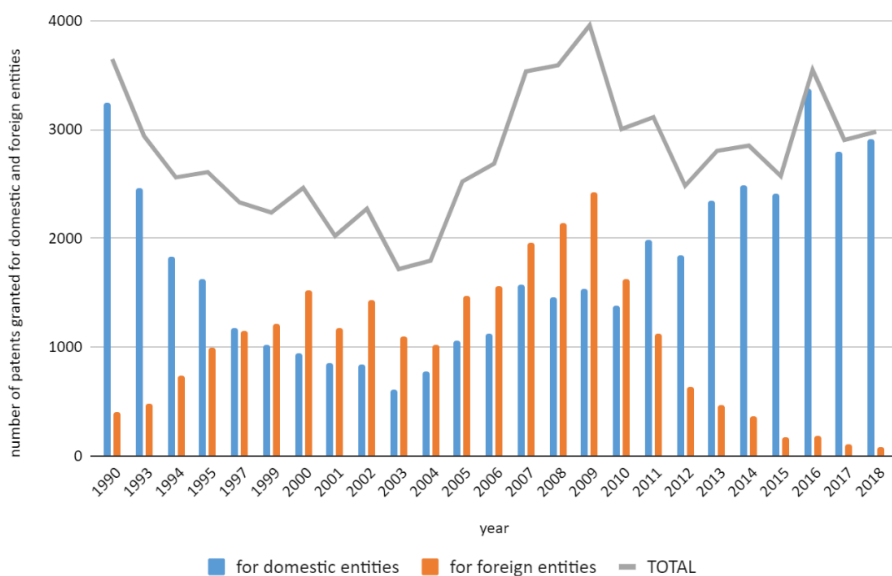
Figure 2 shows statistics relating to patents granted to domestic and foreign entities. As previously mentioned, during the transformation of the Polish economy, the number of issued patents reached the level of 3,647. From 1990 to 2003, a decline in patenting activity was observed, and the structure of patents granted changed



significantly. At the beginning of the 1990s, 89% of all patents were granted to domestic entities, while in 2003 it was only 36%, and 64% were granted to foreign enterprises. A record low number of patents granted in Poland occurred in 2003, when it plummeted to 1,716. In the next 6 years, this figure was on the rise, reaching a record-high of 3,958 patents granted in 2009, which mainly resulted from the intensification of innovative activity undertaken by both foreign and domestic entities. After 2009, the structure of patents granted changed back to that from the 1990s, with a decreasing number of foreign entities involved in the patenting activity, and domestic companies showing an upward trend. The year 2018 only confirms the above-described tendency, as 2,906 patents were granted to domestic entities (98% of the total number), and only 74 to foreign entities (2%). The total amount of patents issued for domestic and foreign entities that year reached 2,980.

Two factors determined the increase in the number of filed patent applications and patents granted. The first is Poland's accession to the EU, and the second – the worldwide trend of intensified patenting, described by Posner (2005) as resulting from decreasing costs of technology transfer. Finally, it can be argued that along with Poland's transition to the market economy and dynamic economic growth, the innovation management within firms significantly improved, as described in Kortum and Lerner (1999).

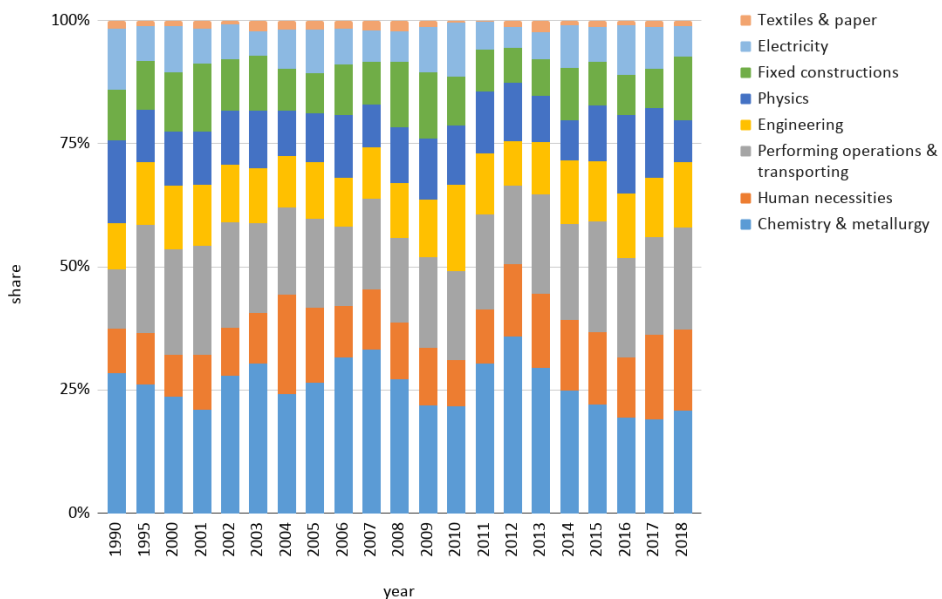
**Figure 2.** Trends in number of patents granted for domestic and foreign entities



Source: Urząd Patentowy Rzeczypospolitej Polskiej (2003–2018).

When disaggregating data to specific sectors, slight changes in the structure of the domestic patenting activity could be observed. Figure 3 shows the structure of patents granted over the period of 1990–2018. In general, a fluctuation of trends is visible across all the sectors. Most patents were granted to the Chemistry and metallurgy and the Performing operations and transporting sectors, with their share approximating 21% in 2018. After these came the Human necessities industry, following a gradual upward trend, having almost doubled its share, to 16% of all patents granted. Examining the consecutive sectors, it can be noticed that Engineering and Fixed constructions have had quite stable shares that amounted to 13% in 2018. A comparatively small number of domestic entities received patents in the Physics, Electricity, and Textiles and paper sectors, obtaining only one-digit shares in 2018. Interestingly, the graph shows the Physics industry’s gradual decrease in the number of patents granted, from a 17% share in the transformation period (the second-largest amount of patents granted in 1990) to only 8% in 2018, thus illustrating a change in the behaviour of domestic entities. This change involved shifting the number of issued patents to the Human necessities sector. The above results are in line with Weresa (2010), taking into account trends at the country and sectoral levels.

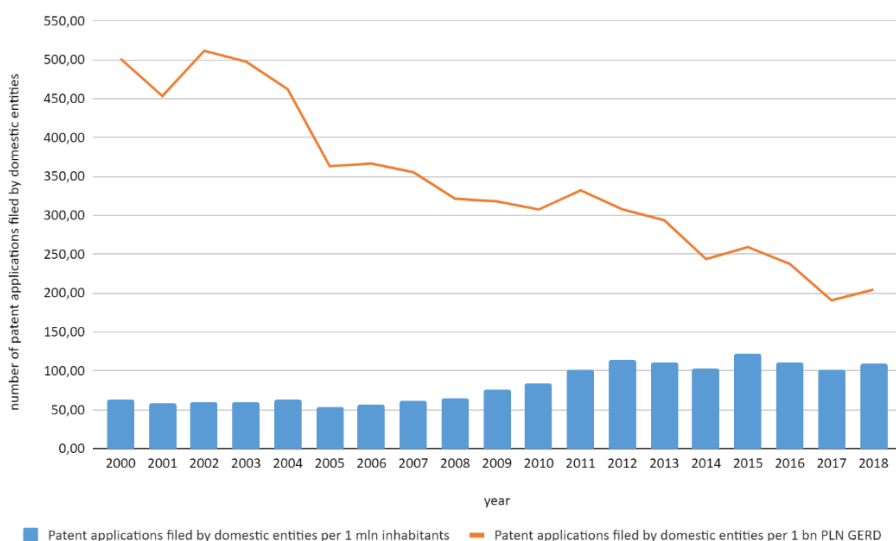
**Figure 3.** Structure of patents granted to domestic entities according to the type of activity



Source: Urząd Patentowy Rzeczypospolitej Polskiej (2003–2018).

When we analyse the patenting activity of residents, it is crucial to present the indicators per 1 million inhabitants and per 1 billion PLN GERD. This also proves helpful when analysing the outcomes in relation to the whole country, specific regions, and comparing the results of Polish residents with those of other countries. As shown in Figure 4, the patent-to-R&D ratio was systematically decreasing over the period of 2000–2018 and dropped from 501 patents per 1 billion PLN spent on research and development in Poland to 191 patents in 2017, and 204 patents in 2018. This trend can be related to the significant increase in research and development expenditure following the EU accession in 2004 and the support from the European Funds. The above result is in line with a study conducted by Lee and Lim (2019) for the United States. Moreover, the trends in patent applications filed by domestic entities per 1 million inhabitants in Poland over the period 2000–2018 should be taken into account. The data show relatively low dynamics of the indicator until 2005, when it reached its lowest point of 53 patent applications. After Poland joined the EU, notified the Convention on the Grant of European Patents, and became a member of the EPO, the trajectory reversed and numbers started to increase, reaching a peak of 122 patent applications per 1 million inhabitants in 2015, before levelling off in 2018.

**Figure 4.** Patent applications filed by domestic entities per 1 million inhabitants and per 1 billion PLN GERD



Source: Urząd Patentowy Rzeczypospolitej Polskiej (2003–2018).

**Table** Residents' patent applications by place of residence of the main applicant per 1 million inhabitants

Voivodship	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Dolnośląskie .....	90	77	65	112	97	100	110	115	157	134	151	152	115	118	128
Kujawsko-Pomorskie .....	43	36	40	45	40	56	59	74	81	81	55	78	81	81	65
Łódzkie .....	61	48	46	60	62	70	83	111	131	124	94	97	123	113	94
Lubelskie .....	34	29	29	48	59	64	57	97	95	90	100	98	86	119	66
Lubuskie .....	39	33	19	14	28	23	27	49	46	38	28	60	66	59	138
Małopolskie .....	62	62	62	57	62	78	93	100	125	139	102	157	118	114	130
Mazowieckie .....	99	84	93	91	96	123	133	146	184	178	171	184	158	133	140
Podkarpackie .....	31	21	27	26	40	33	39	56	48	53	52	91	109	93	95
Pomorskie .....	63	47	53	59	63	97	88	97	105	102	90	110	91	80	89
Śląskie .....	87	75	80	87	82	81	94	117	125	113	122	131	107	107	115
Warmińsko-Mazurskie .....	19	19	19	32	21	25	41	44	57	51	37	75	68	55	47
Wielkopolskie .....	66	52	59	56	64	83	91	119	124	104	85	134	134	97	106
Zachodniopomorskie .....	48	41	49	51	56	64	67	85	80	100	113	123	121	111	117
Świętokrzyskie .....	24	34	23	42	38	37	38	53	55	38	66	59	52	72	51
Opolskie .....	49	38	53	43	63	73	69	94	84	52	76	78	76	75	60
Podlaskie .....	22	21	14	29	40	42	47	61	67	32	59	50	93	89	116

Sources: Urząd Patentowy Rzeczypospolitej Polskiej (2003–2018) and Główny Urząd Statystyczny (2020).

Furthermore, the above-mentioned indicator can be further fragmented into regional-level data. Table depicts the number of residents' patent applications by place of residence of the main applicant per 1 million inhabitants over the period of 2004–2018. Longer periods are unavailable due to the lack of sufficient data at the regional level. A significant stratification and divergence can be observed between the values of the indicator. Mazowieckie and Małopolskie voivodships led the rating with approximately 130–140 residents' patent applications per 1 million inhabitants. Mazowieckie itself accounted for about 20% of the total applications filed in Poland, thus vastly distancing other voivodships. Dolnośląskie, Śląskie, Zachodniopomorskie, and Podlaskie voivodships followed Mazowieckie in the respective order.

Interestingly, Lubuskie voivodship recorded almost a threefold increase in 2018 compared to 2017, this being the result of an intensified participation of local entrepreneurs in projects involving innovative activities. However, at this point it cannot be stated whether Lubuskie has become more innovative-oriented permanently, or the good results in the above-mentioned years should be treated as exceptions.

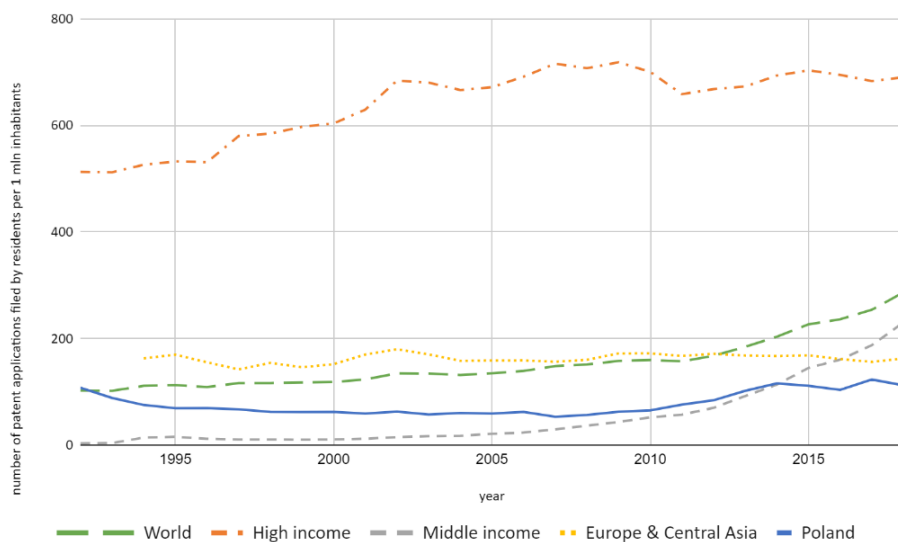
On the other hand, the fewest numbers of innovators were located in Warmińsko-Mazurskie and Świętokrzyskie voivodships, with only about 50 domestic entities' patent applications per 1 million inhabitants. However, in most cases, an upward trend was observed since the relatively low initial levels noted in the first few years following Poland's accession to the EU. The analysis shows large gaps between regions, and considerable effort should be made to bridge them in order to enhance the patenting activity at the regional level.

Then the results were compared with other countries, either European or the Central Asian markets, due to the fact that the data on patent applications provided by the World Bank and the Polish Patent Office were consistent. Figure 5 shows the statistics for country groups which illustrate trends in patenting activity worldwide, calculated per 1 million inhabitants. The World Bank classifies Poland as a part of the region of Europe and Central Asia, and at the same time as a country whose income is comparatively high.

As the figure below shows, in the early 1990s the initial outcomes for Poland and the world were comparable. Over time, however, the average figures for the world tripled to the level of 302 patent applications per 1 million inhabitants in 2018, while the patenting activity in Poland fluctuated, finally reaching the number of 111 the same year. What is more, even the countries from the middle-income group have developed steadily in terms of patenting activity, achieving a result twofold higher than Poland (258 patent applications in 2018). A minimal convergence can be observed in terms of the outcomes of the group of Europe and Central Asia (154 patent applications in 2018) and Poland, but still, the figures for the country are low. The most concerning are the conclusions resulting from comparing Poland with other countries from the high-income group. Over the period of 1990–2018 Poland's

distance from the other members of that group increased substantially, resulting in the country's outcome six-fold lower (666 patent applications in 2018), thus unveiling Poland's weak position within the said group in terms of patenting activity in 2018.

**Figure 5.** Patent applications filed by domestic entities per 1 million inhabitants – worldwide trends



Source: World Bank (n.d.).

Therefore, in general terms, we can state that the trend for the world and the above-mentioned specific groups of countries is upward, but the figures for Poland indicate a relative stagnation in patenting activity. In conclusion, in order to equalise Poland's results with those of the rest of the world, this country has to put much effort into activities enhancing innovativeness. It must be noted that the presented results are not fully reflected in the literature of the subject, and the causes and determinants of the above-described situation call for further investigation.

To sum up, several trends can be observed on the basis of the obtained results. First of all, in terms of the number of patent applications and patent grants, the analysed period can be divided into two sub-periods: before Poland's accession to the EU and after that. The first period saw a dynamic increase in both of these figures, mainly due to foreign entities' activity before 2004. In terms of foreign patent grants, the numbers started to decrease slightly later, which can be attributed to the long period between filing an application and obtaining a patent. As regards the numbers

of domestic applications and patent grants, both of them were decreasing before Poland's joining the EU and rising afterwards, which seems a common phenomenon when developing countries access international organisations (see Bombardini et al., 2018; Iacovone et al., 2011; Liu et al., 2016). As could be expected, the above result remains the same when applying the 'per 1 million inhabitants' calculation.

It should also be mentioned that the world average, high- and middle-income countries' patenting activity increases slowly, gradually converging with the regional (Europe and Central Asia) average. On the other hand, the patent-to-R&D expenditure ratio was constantly decreasing over the analysed period.

Throughout the analysed period, according to the sectoral disaggregation of the patenting activity in Poland, Chemistry and metallurgy and Performing operations and transporting were the leading sectors in terms of the volume of aggregate patenting activity. The above-mentioned changes do not seem to impact the industrial structure to a great extent.

From the regional (NUTS-2) perspective, Mazowieckie voivodship was the most active in terms of patent applications in the analysed period, while Warmińsko-Mazurskie was the least active. The causes of regional disparities should be, however, further investigated.

## 5. Conclusions

The paper aims to investigate recent trends in the patenting activity in Poland, and to present the main ones worldwide. Compared to other such studies concerning Poland, we analysed a significantly longer period of time, and researching trends at aggregate and regional levels. In the light of the results obtained during the analysis, it is clear that Poland still has a relatively long way to go before its level of patenting activity comes close to that of developed countries. The country is definitely on a different trajectory in terms of the propensity to patent than other high-income or even middle-income economies. As mentioned before, in Poland, the largest country of the 'Emerging Europe' group, the level of patenting activity is still low mainly due to historical factors (involving a transition to a market-based economy) and the failure to develop the 'innovation culture'.

As time shows, after 16 years of the EU membership, Poland still struggles with patenting activity, both at the country, regional, and sectoral level. Firstly, dissimilarities in the development and involvement in innovative activities of specific regions implicate poor outcomes for the country as a whole. Secondly, the general outflow of foreign patent applications (and consequently patents granted) from the PPO to the EPO after the country's accession to the EU caused changes in the structure of the patenting activity in Poland. Even though the data for domestic entities show an

upward trend, the average number of patent applications filed by domestic entities calculated per 1 million inhabitants is lower than that observed in developed economies.

Interestingly, the data indicates a decreasing patent-to-R&D ratio, which in practice means that the increase in innovative activity funding (innovation-input measure) does not yield a proportional output, i.e. patents. On the other hand, it means that at the aggregate level, 'producing' a patent is becoming more expensive. These two conclusions are concerning at both the government and company levels.

It should be stressed that the level of patenting despite its common use as a proxy for innovations, does not fully reflect innovativeness of a country or a region. The relation between the propensity to patent and innovativeness is complex, and thus they cannot be regarded as the same phenomenon (Acs & Audretsch, 1989).

Furthermore, the above analysis makes several policy recommendations possible to be formulated. Firstly, the data for patent citations at the PPO is not available (and to the authors' best knowledge, it is not collected by the PPO). The lack of data makes the analysis of patent quality impossible; moreover, it may also affect companies' valuation by the market.

Secondly, the example of the Bayh-Dole Act indicates that a novel approach toward legislation can boost the innovative activity of a country. Although several changes have been introduced in recent years in the intellectual property law in Poland, no significant effects on the propensity to patent have been observed by the PPO. Thus the effectiveness of the intellectual property law in Poland should be critically reviewed in the future.

Finally, the decreasing patent-to-R&D ratio can be partially caused by a non-optimal allocation of R&D subsidies. Nevertheless, both R&D effectiveness in terms of patenting activity as well as the propensity to patent among Polish firms and citizens should be further investigated.

## Acknowledgements

The authors have been supported in writing this article by the National Science Centre [UMO-2017/25/B/HS4/00162] 'Intensity of competitive rivalry and innovative behaviour of enterprises'.

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