Successful patenting—not only how, but with whom: the importance of patent attorneys

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Abstract

The role of patent attorneys is usually overlooked in empirical analyses of patents. Using a large dataset of Polish patent applications, 2006–2015, and the econometric model of logistic regression with interactions, the article identifies factors contributing to the successful patenting outcomes. Patents are more likely to be granted for applications filed by multiple applicants, particularly if a scientific organization is involved. Industry, region and decisions to apply for international protection were found as relevant variables affecting the patent grants. The involvement of attorneys was found to be a strong predictor of the outcome, and the study considered multiple variables characterizing the prior experience of attorneys, including their performance, effectiveness, work with scientific or business clients and support for patent applications that were also filed for international protection. The findings offer novel insights into sources of patenting success, indicating that it's not only important how the patent applications are drafted and what their detailed contents are, but also who exactly prepares them.

Keywords Patents · Patent applications · Patent attorneys · Logistic regression

Mathematics Subject Classification O340 · O320

Introduction

The article explores the sources of success in patenting, by looking at various characteristics of patent applications, applicant organizations and patent attorneys, which contribute to the positive patenting outcomes. The research objectives focus on uncovering the variables that increase the likelihood of a patent grant or reduce the risk of an application being rejected by the patent office (i.e. lack of negative decisions, interpreted as patent grants or decisions still pending).

The study is based on a large set of patent applications from Poland, covering 10 years (2005–2016). Multiple variables are used to characterize the patent applications, including: counts of applicants, inventors and patent classes, sectors of applicants, type of

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technologies, as well as the R&D intensity of industries and regions from which the applications originate. These variables were combined with diverse characteristics of patent attorneys, who supported the filing of patent applications. The features of attorneys are derived from the patent dataset and include: the attorney's performance, effectiveness, international, technological and sectoral experiences. The study verifies detailed hypotheses by means of quantitative analyses: econometric modelling based on the model of logistic regression with interactions.

The results reveal particular importance of patent attorneys and their specific characteristics in ensuring the successful outcomes of patenting processes. The importance of patent attorneys has rarely been discussed in the literature, with only limited insights based on empirical research. Hence, the article fills in an important gap in innovation management scholarship by analyzing the contributions of patent attorneys to the outcomes of patenting processes. The research findings indicate that the patenting success is not only attributable to specific patent drafting techniques but can also be linked to the features of attorneys, who prepare the patent application. Importantly, the study points to the selected characteristics of patent attorneys, which increase the likelihood of successful patenting outcomes. The findings could support the selection of attorneys by patent applicants, helping them identify the most suitable service providers whose features are more likely to lead to the success of the patenting process.

Theory and hypotheses

The successful patentability is linked not only to the features of inventions, but also to characteristics of applicants and their representatives, as well as choices made during the filing process and approaches to drafting the application. Some of the features are determined by the nature of the invention and the R&D activities in which it originated, but others could be influenced by the applicants, such as the decision to rely on the professional support provided by patent attorneys and the choice of specific service provider. This section will summarize the variables that might impact the patenting outcomes, based on previously documented empirical studies.

Patents tend to be used as proxy measures of innovations (Acs et al., 2002), even though their actual values are highly differentiated (Czarnitzki et al., 2009) and the patent owners treat them often rather as signals towards investors and customers than actual means of safeguarding their industrial property (Lai, 2017; Long, 2002). The value of patents can be measured *ex-ante* (prior to or at the time of granting a patent) or *ex-post* (following the passage of time after the patent has been granted) (Higham et al., 2021). Patent value is not directly related to the likelihood of successful patenting outcome, but the existing literature offers insights into variables that enrich the value of patent applications, and could also be hypothesized to contribute to the patentability. *Ex-ante* indicators of value rely on the features of patent documents, such as: the number of claims, backward citations, patent classes or international jurisdictions selected for patent protection, as well as efficiency measures of the patenting process including the grant lag, which indicates the time elapsed since the date of application (Higham et al., 2021, pp. 16–19). Other *ex-ante* indicators could also take into account the ownership of patents, the number of applicants, the count of co-inventors, specific patent drafting and filing strategies adopted by applicants or their agents (Reitzig, 2004, p. 941), as well as the collaboration with scientific organizations while developing the inventions (Belderbos et al., 2014, p. 849).

Ex-post measures capture the outputs of patenting processes, including: patent renewal decisions, citations received, economic indicators documenting the commercial success of patent-based products or the applicant organization (Higham et al., 2021, p. 4). The emergence of a patent opposition or the pursuit of patent lawsuits could also suggest the increase in value of the underlying industrial property rights (Reitzig, 2004, p. 941; van Zeebroeck, 2011, p. 36), similarly as the follow-up investments in the exploitation of patents (Lai, 2017, p. 832). In addition, the patent citation data appear readily available and frequently used as proxies of patent value (Jaffe et al., 1993; Lee & Sohn, 2017; Nair et al., 2011; Trajtenberg, 1990; van Zeebroeck, 2011, p. 36). The use of forward citations has nevertheless been criticized as insufficiently explaining the variance in the actual values of patents (Bessen, 2008, p. 940; Cotropia et al., 2013, p. 852). Many citations registered in patent databases were assigned by patent office examiners not inventors or applicants, so their analyses might not adequately represent the extent of the prior art that had actually been considered by developers of new technologies (Cotropia et al., 2013, p. 853). Qualitative patent assessment by domain experts is bound to yield promising *ex-post* results, identifying patents that are important for future technologies or difficult to invent around (Reitzig, 2003), but such assessments would require in-depth analyses that could not be easily reduced to numerical variables.

While the body of knowledge on the sources of patent value is extensive, it might come as a surprise that far less is known about the factors that lead to a successful patent granting decision. The majority of empirical studies related to industrial property use the statistics on granted patents and disregard the more comprehensive sets of patent applications. The granting decision could act as a trigger for the patent value (van Zeebroeck, 2011, p. 36), and some of the *ex-ante* measures of value might also indicate the likelihood of the patent grant, but the values of granted patents vary considerably, with some highly valuable inventions not awarded the industrial protection and many granted patents deprived of value. Patent regulations and standards define the patentability criteria and in most jurisdictions, they call for the existence of a technological invention, having potential industrial applications, which could be characterized by its novelty and involves an inventive step (see e.g. EPO, 2021). Complying with the patent office's requirements does not necessarily guarantee a successful patenting decision. Practitioner-oriented literature instructs inventors and R&D managers how to maximize the likelihood of patent grant through careful drafting of the patent applications. At the same time, only few empirical studies were looking at how the patent grants are affected by selected features of patent applications. A recent example of such modelling approach is found in Khachatryan and Muehlmann (2017, p. 1367), focused on a narrowly defined technological field. Guellec and van Pottelsberghe de la Potterie (2000) looked at the factors increasing the likelihood of patent grants, including countries of origin, technological fields and co-operation among applicants. Webster et al. (2007) confirmed the role of a country, in which the priority filings were done, for the ultimate patenting outcomes. Singh and Fleming (2010) were interested in the collective dimension of patenting and established that the collaboration between co-inventors could increase the probability of a successful patent grant. In a similar manner, Gaudry (2012) documented the lower success rates of inventors who chose to represent themselves while pursuing a patent application compared with inventors supported by professional attorneys. Koenen and Peitz (2012) offered additional explanations for the diversified length and efficiency of patent examinations across countries and patent offices. The patenting outcomes may also depend on the implicit standards adopted by a given patent office (Grilliches, 1998, p. 322), or even a specific "production function" of the local patent office, linked to its efficiency, counts of available patent examiners and the supply of

applications (Grilliches, 1998, pp. 323–324). Nevertheless, this fragmented research landscape offers only limited empirical insights into the factors improving the likelihood of successful patent grants.

The present study aims to fill the identified research gap based on a comprehensive dataset of patent applications, using multiple indicators that characterize the patent documents and their origins. It aims to identify the factors that increase the likelihood of successful patenting outcomes. In particular, the study will verify the relevance of various characteristics, which were identified in previous, related studies (albeit these studies did not directly describe patent grants, but rather *ex-ante* sources of patent value).

The patent data will be analyzed based on two complementary approaches, which respectively take into account negative and positive decisions of patent office examiners. Patent applications may generate threefold patenting outcomes: rejections (negative patent decisions), patent grants (positive decisions) and the remainder of patent documents for which the decision still remains pending. The subset of pending patent documents accounts for a sizeable share of applications and calls for additional investigations. Recently filed applications would obviously not trigger patenting decisions, as patent examiners process the documents for up to several years. For older applications, positive decisions might not be possible without supplementary data or explanations provided by applicants upon the requests of examiners. The quantitative analyses presented in this article distinguish between two distinctive scenarios, which differ in how they treat the data on pending applications. The hypothesis H1 and its sub-hypotheses refer to the dichotomy of negative decisions versus granted/pending applications (i.e. they verify whether certain variables decrease the likelihood of the negative patenting outcome). The hypothesis H2 with sub-hypotheses focuses in turn on the successful results of the patenting process, contrasted with rejected/pending applications (i.e. they confirm features of patent applications that increase the odds for a patent grant). Both hypotheses will be decomposed into sub-hypotheses, referring to specific variables, which will be mirrored for H1 and H2.

H1 Patent applications are less likely to be rejected during the patent office examination if they:

H2 Patent applications are more likely to turn into successfully granted patents if they:

~H1a/H2a are submitted by multiple applicants.

The co-ownership of patents by more than one organization increases the forward citations of such patents (Briggs, 2015), and this might be explained by the co-owners attaching more importance to the contents of the jointly created, negotiated and submitted documents. The presence of multiple applicants is also expected to increase the patent value (Belderbos et al., 2014; Reitzig, 2004, p. 941). In the present study, it is hypothesized that this co-ownership might increase the likelihood of having the patent granted, as previous literature did not specifically analyze this interdependency.

~H1b/H2b involve a scientific organization as an applicant.

The involvement of scientific organizations could positively influence the likelihood of a patent grant, with numerous studies confirming the impacts of science-industry collaboration for patenting (Belderbos et al., 2014; Petruzzelli, 2011). Universities in many

countries have accumulated expertise in intellectual property management that facilitates the protection and transfer of academic inventions (Czarnitzki et al., 2009; Geuna & Nesta, 2006; Grimaldi et al., 2011; Mowery et al., 2001). Technology transfer offices of universities are expected to generate revenues from patent licensing, and they professionally deal with the matters related to the legal protection of academic inventions (Veer & Jell, 2012). For scientists, patents often serve as quality signals rather than commercial tools, helping them build up the individual recognition and academic reputation (Göktepe-Hulten & Mahagaonkar, 2010, p. 407; Lissoni, 2013), and motivating them to strive for patenting excellence. In Europe, universities hold smaller patent portfolio than their US counterparts, but they still offer significant contributions to their countries' patenting records (Lissoni, 2010, p. 844). Academic patents tend to receive more forward citations compared to the non-academic ones (Czarnitzki et al., 2011; Geuna & Rossi, 2011, p. 1075). Furthermore, not only universities but also public research institutes complement the landscape by patenting focused on their thematic specialties, generated from publicly sponsored research or industrial collaboration (Link et al., 2011).

~H1c/H2c were submitted by applicants with larger scale of operations.

Patent applicants include individual inventors and organizations, with various scales of operations. The availability of financial and organizational resources is expected to translate into the ability to successfully apply for patent protection. Individuals and smaller entities, including newly established technological companies, might not be able to cope with the high patenting costs (Goel & Goktepe-Hulten, 2013, p. 474), while larger companies can commit more resources to elaborate their applications (Laplume et al., 2015, p. 40). The patenting motives of smaller entities differ, as startups focus on monetization of their inventions as proxies of technological and managerial excellence (Lai, 2017, p. 826), while individuals unaffiliated with companies might file applications without clear financial expectations (Veer & Jell, 2012, p. 514). Larger organizations will leverage their inhouse expertise, experiences from previous patenting endeavors, structures, procedures and institutional memory, which are usually not available to smaller entities or individual applicants, whose patent applications might in turn be less successful.

~H1d/H2d were created by multiple inventors.

The co-inventorship increases the probability of patent grants (Guellec et al., 2000, p. 109). Inventors working on their own are less likely to achieve breakthroughs and might yield mediocre results (Singh & Fleming, 2010), with rare exceptions of highly valuable radical inventions created by gifted individuals (Dahlin et al., 2004). Higher counts of co-inventors on a patent document are hypothesized to increase the likelihood of having the patent granted.

~H1e/H2e represent multiple patent classes.

Classes of the International Patent Classification (IPC) correspond to fields of technology represented by the invention and the specific patent scope (Lerner, 1994). Multiple patent classes assigned to the same application indicate its technological complexity (Benner & Waldfogel, 2008) and stand for the convergence of technologies (Caviggioli, 2016), with radical inventions emerging as a combination of different technologies or patent classes

(Schoenmakers & Duysters, 2010). Previous studies offered conflicting evidence on the role of IPC counts in the success of patent applications. The higher technological diversity of applications represented by higher counts of assigned IPC classes was found to decrease the likelihood of a patent grant (Guellec et al., 2000, p. 112), even though others confirmed the positive impact of the counts of IPCs on the patent value (van Zeebroeck et al., 2011, p. 553).

~H1f/H2f represent industries with high levels of R&D expenditures.

Patenting patterns are heterogeneous across industries, with differentiated propensity to use patent protection for low and high technology industries. This heterogeneity is captured by the concept of sectoral systems of innovation (Malerba, 2004). Industries differ in the scale of returns expected from patented inventions, with particularly promising results observed in chemicals, biotechnology, pharmaceuticals and medical equipment, but less impressive outputs of other technological fields (Bessen & Meurer, 2008, pp. 106–108; Guellec et al., 2007, p. 67). The technological field of the invention is considered an important variable influencing the patent grant success (Guellec et al., 2000, p. 112; Webster et al., 2007).

~H1g/H2g originated in regions with high levels of R&D expenditures.

Regional systems of innovation may promote or inhibit the generation and exploitation of knowledge (Cooke, 2004, p. 3). The geography has the potential to influence patenting outputs (Buerger et al., 2012; Hoekman et al., 2009), albeit this is sometimes also dependent on the specific industry, e.g. Mariani's (2004) findings suggest geographically-agnostic results for more traditional technologies in the chemical industry, but stronger regional embeddedness of biotechnologies, thus indicating potential interactions between industry (H1e/H2e) and region (H1f/H2f) that deserve additional explorations in the present study. The location of a patent applicant can be an important factor influencing the likelihood to receive patent rights, although previous studies on patent granting focused rather on countries than regions (Guellec et al., 2000, p. 109; Webster et al., 2007, p. 367). Prior research confirms the heterogeneity of regional patenting results (Clark et al., 2010), relations between patenting and R&D assets of regions (including R&D expenditures and employment) (Bottazzi & Peri, 2003) and linkages between patenting and multiple variables that describe the regional economic performance (Paci & Usai, 2000).

~H1h/H2h were also submitted for international patent protection via PCT route.

The international patent protection—filing patents in jurisdictions other than the applicant's home country—requires substantial investments and is usually reserved for the most commercially promising inventions (Eaton & Kortum, 1996, 1999; Watanabe et al., 2001; Caviggioli, 2011). The modalities offered by the World Intellectual Property Organization under the Patent Cooperation Treaty (PCT) simplify the filings for patent protection in multiple jurisdictions, using a synchronized and standardized procedure. Patent applications whose owners had decided to follow the PCT route were found to be more likely to result in patent grants (Guellec et al., 2000, p. 112). International protection via the PCT route is not the only available scenario for patent applicants, who may also directly file for patent protection in selected patent offices.

~H1i/H2i have been acknowledged through forward citations.

Citations received by patent documents belong to the most frequently used indicators of patent value (Jaffe et al., 1993; Lee & Sohn, 2017, p. 280; Nair et al., 2011; Reitzig, 2004, p. 941; Trajtenberg, 1990; van Zeebroeck, 2011, p. 36). Nevertheless, patents might be cited for reasons other than the recognition of their relevance (Abrams et al., 2018). The citations could either be assigned by applicants citing the prior art or by patent examiners (Cotropia et al., 2013; Criscuolo & Verspagen, 2008). The latter references have an important legal function, but do not represent acknowledgements by members of the technological community and thus, they play different roles than citations in scientific papers (Callaert et al., 2014, p. 1619). It must also be remembered that increasing numbers of patents remain uncited (Gandal et al., 2021), regardless of their actual novelty. Some empirical studies questioned the usefulness of patent citations as variables that would explain the variance in patent values (Bessen, 2008, p. 940; Cotropia et al., 2013, p. 852), especially as self-citations may also be included. While linkages between citations and patent values were discussed in literature, previously analyzed correlations between cited and granted patents appear unsatisfactorily weak (Beukel, 2019, p. 47). This phenomenon could additionally be explained by the separation between the granting and citing processes, with the technological community more likely to notice and cite patents that have already been granted (citations might be considered consequences of granting, not its explanations). The scarcity of evidence calls for the verification of the role of citations in the present study.

~H1j/H2j were submitted with the involvement of an external patent attorney.

Patent documents emerge from collective processes, in which experts codify and transform the underlying inventions into professionally prepared applications (Beukel, 2019, p. 93). Their contents have multiple authors, including not merely the initial inventor(s) but also the attorney (Reiffenstein, 2009, p. 572), usually responsible for substantial parts of the written matter.

Attorneys use professional patent drafting techniques, and the patenting process could be described as "an exercise in negotiation" over the ways of codifying and communicating the technological knowledge (Reiffenstein, 2009, p. 572). The reliance of patent applicants on professional agents—patent attorneys—can strengthen the probability of the successful patent grant (Khachatryan & Muehlmann, 2017, p. 1361). Larger applicant organizations might employ inhouse IP experts, but external service providers are still used due to the specific expertise in the field of invention, skills in editing complex patent applications or to outsource more troublesome elements of the IP-related work (Süzeroğlu-Melchiors, 2017; Wagner, 2006). Patenting outputs depend not merely on R&D activities but also on the sound expertise in the intellectual property law (Somaya et al., 2007, p. 924). Patent drafting techniques applied by the attorneys have the potential to influence the value of patents and the outcomes of patent examinations (Reitzig, 2004, p. 945). These influences may also affect the patent scope, international coverage of the protection and the speed of patenting process (Süzeroğlu-Melchiors et al., 2017). Applications supported by expert attorneys were found to include on average more claims and ensure better compliance with formal requirements of the patent office than documents prepared by inventors themselves (Gaudry, 2012, pp. 3–4). Patent attorneys act as intermediaries between applicants and examiners from the patent office, reacting to requests and supporting the flow of communication (Süzeroğlu-Melchiors

et al., 2017, p. 1125). They are familiar with legal and technical procedures and requirements, so they are able to "shepherd inventions through the patent office's application process" (Lamoreaux & Sokoloff, 2002, p. 14). Moreover, they also play "the role of guardian and nursemaid to the invention, seeing it through to the maturity of innovation" (Macdonald & Lefang, 1998, p. 9). At times, patent attorneys were also acting as facilitators of technology licensing or sales transactions, e.g. in the nineteenth century Japan (Nicholas & Shimizu, 2013, p. 127), in the early twentieth century United States (Lamoreaux & Sokoloff, 2002) and in the contemporary China (Li et al., 2015).

Empirical studies of patent attorney's roles in patenting processes remain scarce. Patent databases typically used for quantitative studies did not include variables describing patent attorneys (Goto & Motohashi, 2007, p. 1432–1434; Hall et al., 2001; Kang & Tarasconi, 2016, pp. 58–59; Motohashi, 2008, p. 226, 2020, p. 2). In 2013, the World Intellectual Property Office published recommendations for national patent offices to include in their databases dedicated fields with the name of attorney supporting a given application (WIPO, 2013). The data on legal representatives have recently become available in the PATSTAT Register database (de Rassenfosse et al., 2017), but only for European applications. Previous studies using data on patent attorneys had to extract details from patent office bulletins, information services or sources external to patent offices, matching them with the patent datasets (Andriosopoulos et al., 2022; de Rassenfosse et al., 2021; Frietsch et al., 2015; Heikkilä, 2018; Moeen et al., 2013; Somaya et al., 2007; Süzeroğlu-Melchiors, 2017; Wagner et al., 2014).

Publications on patent attorneys include descriptive case studies (Lamoreaux & Sokoloff, 2002; Li et al., 2015; Nicholas & Shimizu, 2013) and quantitative analyses (Beukel, 2019; Frietsch & Neuhäusler, 2019; Khachatryan & Muehlmann, 2017; Koller & Ebersberger, 2015; Somaya et al., 2007; Süzeroğlu-Melchiors et al., 2017), most of which considered the involvement of patent attorneys as the explanatory variable. Some studies went a step further and explored the patenting outcomes depending on the attorney's experience, interpreted as the cumulated number of previous patent filings overseen by the attorney (Andriosopoulos et al., 2022; Frietsch & Neuhäusler, 2019; Koller & Ebersberger, 2015). De Rassenfosse et al. (2021) developed an index of patent attorney firm quality, computed based on multidimensional activities of the firms in multiple patent jurisdictions.

The present article expands the scope of possible analyses of the role of patent attorneys by considering multiple additional variables that more specifically characterize experiences and competencies of patent attorneys.

The hypotheses related to the involvement of patent attorneys are further extended by a series of sub-hypotheses, which aim to verify the patenting outcomes depending on the attorney's performance (overall number of patent applications prepared by the attorney), effectiveness (as a rate of granted patents compared with the counts of filed applications), experience in patenting advanced technologies (contrasted with patents in low technology fields), overseeing patents that were later also submitted for international protection via the PCT route, as well as working on patent applications filed by scientific organizations or companies. It must be mentioned that the PCT filings were not necessarily drafted by the focal patent attorney, but the attorney had opportunities to understand requirements of national and PCT procedures, and leverage these experiences while working for other clients. This set of variables constitutes multi-dimensional profiles of patent attorneys and identifies characteristics that might contribute towards the successful patent grants, as expressed by the following hypotheses:

H3 Patent applications are less likely to be rejected during the patent office examination if the patent attorney who prepared the application is more:

H4 Patent applications are more likely to turn into successfully granted patents if the patent attorney who prepared the application is more:

~H3a/H4a active (high number of patent applications).

~H3b/H4b effective (high rate of granted patents).

~H3c/H4c experienced in advanced technologies (high rate of medium/high technology patent applications).

~H3d/H4d experienced with applications that had international counterparts (high rate of PCT applications).

~H3e/H4e experienced in supporting scientific organizations (high rate of applications submitted by scientific organizations).

H3f/H4f experienced in supporting companies (high rate of applications submitted by companies).

Data and methods

The research is based on quantitative analyses leveraging the potential of patent data mining (see e.g. Porter & Cunningham, 2005). It aims to identify relationships between patenting outcomes and their possible predictors, derived from the patent dataset.

The analyzed dataset covers patent applications submitted to the Polish Patent Office between 2006 and 2015 (10 years), which represent a variety of low, medium and high tech industries. The collected data represent 33 (sub-)classes of NACE, delineated based on IPC classes in accordance with the method proposed by van Looy et al. (2014). Low technology industries included: C10, C11, C12, C13, C14, C15, C16, C17, C18, C20.2, C22, C23.3, C23.4, C23.5, C25.7, C30.1, C31, C32.4, C32.5, F42, F43, while the identified medium and high technology industries were: C19, C20.3, C20.4, C21, C27.1, C27.2, C27.3, C27.5, C28.3, C29, C30.2, C30.3 (the division was based on the average size of R&D expenditures per company in Poland, 2006–2015, derived from the Eurostat database, in accordance with Eurostat (2016)). The data were downloaded from the patent office website in April and May 2018, and combined with patent forward citations and data on PCT applications, derived from the PATSTAT database maintained by the European Patent Office. The dataset was cleaned by removing granted patents that were subsequently invalidated due to successful oppositions.

The resultant dataset included 17,589 patent applications, based on which 9145 patents were granted (51.9%), 2194 filings concluded with negative decisions (12.5%) and 6253 applications were still pending (35.6%). The data were divided based on the sector of applicants and fields of technology. 12,263 applications were represented by external patent attorneys (69.7%), and 5326 were directly filed by applicants (30.3%). The share of *pro-se* patent applications—filed by applicants without involving external patent attorneys

(Gaudry, 2012) is similar to levels observed in other patent offices (Heikkilä, 2018, p. 5; Wagner et al., 2014, p. 1676), but EPO patent applications tend to have higher shares of applications formally represented by attorneys (de Rassenfosse et al., 2017, p. 115; Frietsch et al., 2015, p. 7). The differences are rooted in diverging patenting regimes, as legal regulations in Poland do not require patent applicants to use services of external attorneys (with the exception of foreign applicants, without activities or offices in Poland, filing to extend a prior international application, but the present dataset only includes applications with priority in Poland). Patent applications may be drafted and submitted directly by the applicants, and the involvement of inhouse IP specialist would not be indicated in the patent filings. The database of the Polish Patent Office registers only the cases when an applicant has appointed an external representative, authorized to file the application, so the variable clearly delineates applications supported by external patent attorneys. Furthermore, the profession of patent attorneys is strictly regulated in the Polish legal framework. Patent attorneys have master degrees in technical or legal fields, complete 3 years of dedicated professional training combined with an internship, concluded with the qualifying examination. They are also required to comply with professional standards and engage in continuous professional development in order to retain their rights to represent applicants in patenting procedures. It worth noting that the entry barriers to the patent attorney profession vary across countries, and the Polish regulations are comparably demanding. The patent attorneys may operate own practices or work for patent law firms, but the patent applications and the resulting database registers the names of attorneys as natural persons (individuals not companies).

Table 1 presents a comparison of variables describing the patent application sub-sets based on the involvement of external attorneys or lack of thereof. Table 1 includes also Spearman correlation indicators, comparing each patent descriptor with the dichotomous variable confirming whether a patent attorney was involved in drafting the applications. The correlations turned out to be statistically significant for each variable, but at the same time very low. Negative correlations were observed for negative decisions (as patents are less likely to be rejected if external patent attorneys represent applicants) and for advanced technologies (since drafting and defending low technology applications might be relatively

Table 1 Descriptors of the patent applications

Variable	Without attorney	With attorney	Spearman rho (p)
Patents granted	2432	6713	0.083 (p < .001)
Negative decisions	1711	4542	−0.195 (p < .001)
Applications pending	1184	1010	0.047 (p < .001)
Company involved as applicant	1711	5539	0.122 (p < .001)
Scientific organization involved as applicant (university or research institute)	1816	5250	0.082 (p < .001)
Cited (applications received forward citations)	158	623	0.047 (p < .001)
PCT (applications filed also for international protection via PCT route)	152	658	0.055 (p < .001)
Low technology	2024	5027	0.028 (p < .001)
Medium-to-high technology	3302	7236	−0.028 (p < .001)
All applications	5326	12,263	

Source of data Polish Patent Office and PATSTAT databases

easier for attorneys). The findings encouraged the authors to look for further explanations by means of econometric modelling, especially as 37% of applications represented by external attorneys were still rejected, so the patenting outcomes were expected to depend on multiple inter-related variables rather than the mere involvement of attorneys.

An additional, categorical variable was introduced to account for the scale of operations of the patent applicant (H1d/H2d). It divided the applicants into three groups: individuals (with limited financial and organizational resources), mid-sized applicants (commercial partnerships and non-governmental organizations, not equipped with inhouse R&D support structures or extensive patenting expertise) and large organizations (limited liability and joint-stock companies, research institutes and universities). Figure 1 introduces the relations between the scale of operations, the reliance on patent attorneys and the patenting success rates, revealing the increased use of external attorneys and higher shares of granted patents among the largest applicants. Individuals applying for patent protection are the least frequent users of patent attorney support (48%), and on average, their applications are more likely to be rejected (26%). The propensity to work with patent attorneys and also the patenting success rates increase with the size of applicant organization: mid-sized applicants use attorneys in 73% of applications (16% negative decisions), and as many as 76% applications from large organizations were drafted by attorneys (8% negative decisions). 32% of applications filed by individuals were granted patents, but for individuals using patent attorneys, the share of granted patents nearly doubled to 61%, thus indicating that attorneys are instrumental for the patenting success. It must also be mentioned that on average, 46% of all negative decisions concerned applications prepared by attorneys, so the use of professional services was not the sole source of the potential success, and thus econometric modelling of the interdependencies is needed.

Figure 2 presents the use of external patent attorneys in various industries (corresponding to NACE classes), compared with the respective success rates and counts of applications filed in each industry. The industrial and technological domains of patent applications revealed a significant cross-industry variation of the propensity to use external patent attorneys. Most industries had majority of applications drafted by patent
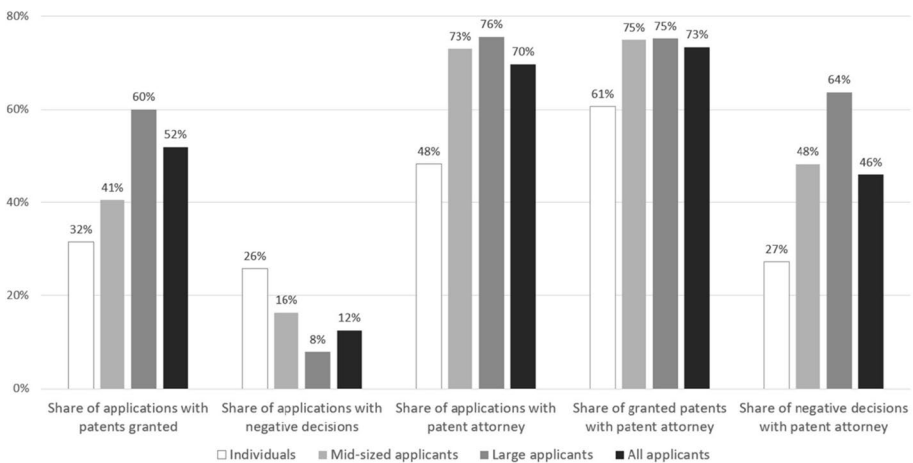

Fig. 1 Patenting success and the use of patent attorney depending on the applicants' scale of operations. *Source of data* Polish Patent Office database
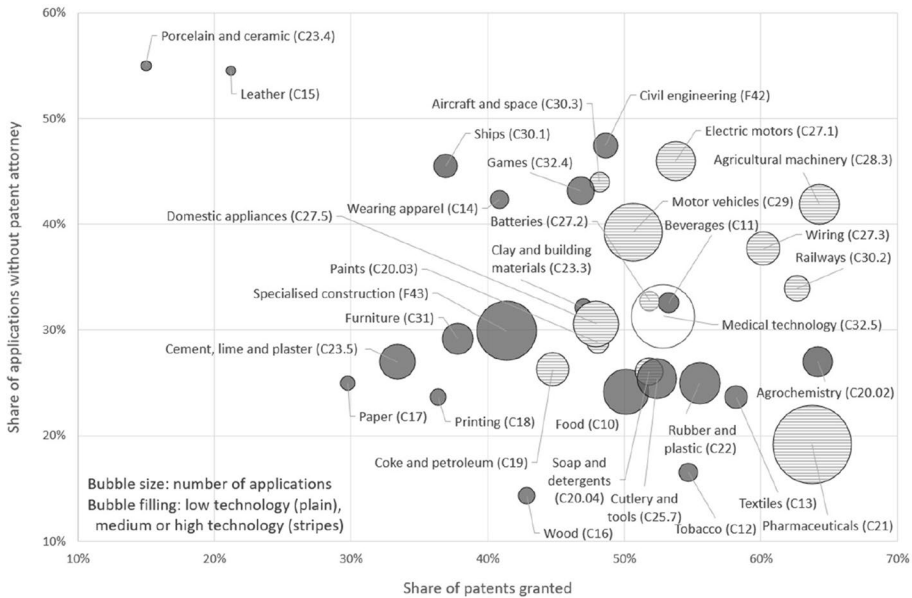
Fig. 2 Selected characteristics of patent applications representing specific industries (NACE classes). *Source of data* Polish Patent Office database

attorneys, with the largest shares identified in: pharmaceuticals, tobacco, wood, agrochemistry, food, soap and detergents, rubber and plastic, printing, cutlery and tools. Comparably lower propensity to use attorneys was found in: porcelain and ceramic, leather, civil engineering and ships, but also in technologically advanced industries: aircraft and space, electric motors and agricultural machinery. Shares of applications supported by attorneys and prepared without such support were not found to directly influence the patenting success, although in general, applications from technologically advanced industries were more likely to be granted (many low technology applications were filed by individuals or smaller companies, and not drafted in accordance with formal requirements of patenting procedures). In the subsequent modelling, the domains were aggregated into low and medium-to-high technologies, based on their R&D intensity (due to low counts of applications in most industries and lack of identified interdependencies characteristic for specific industries).

In the following step, a dataset describing external patent attorneys was built. Features of all patent attorneys indicated on 17,589 patent applications from 2006 to 2015 were collected from the applications, including the counts of filed applications, success rates, types of clients and technologies supported as well as citation and internationalization indicators. Altogether, 578 individual patent attorneys were identified as legal representatives listed on the analyzed applications. Key characteristics of the attorneys are summarized in Table 2.

Selected data on 578 patent attorneys are plotted in Fig. 3, revealing the number of drafted applications and success rates of individual attorneys, their experiences with medium-to-high technology applications and work for scientific institutions as clients. The plot indicates an important tendency, which will subsequently be analyzed through quantitative modelling, namely the existence of a small subset of highly active and successful

Table 2 Descriptors of patent attorneys

Counts per patent attorney	Max	Min	Mean	SD
Applications	282	1	21.22	37.16
Patents granted	200	0	11.61	23.81
Company involved	238	0	9.58	18.00
Scientific organization involved	261	0	9.08	28.08
Applications cited	49	0	1.08	2.93
Applications with PCT counterparts	73	0	1.14	4.04
Medium-to-high technology	218	0	12.52	25.03

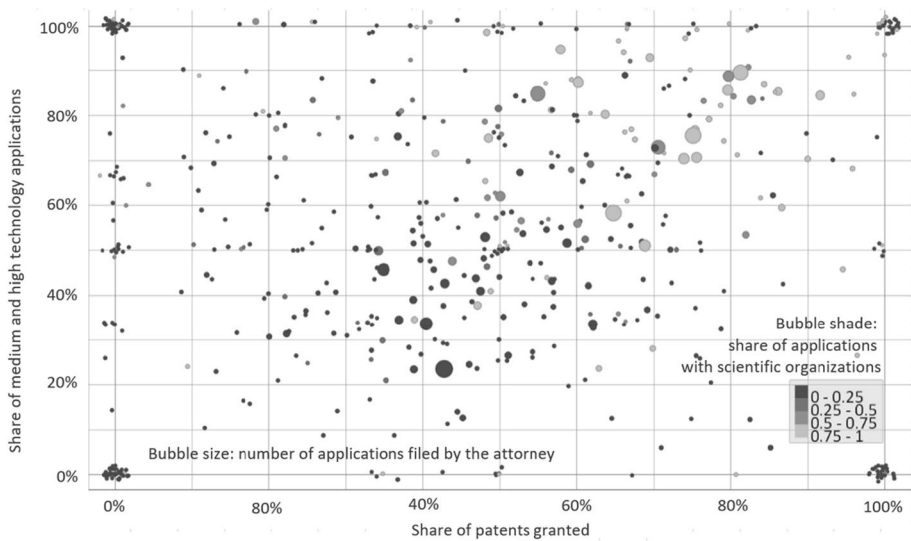*Source of data* Polish Patent Office and PATSTAT databases

Fig. 3 Selected characteristics of patent attorneys. *Source of data* Polish Patent Office database

attorneys, focusing on advanced technology applications and working predominantly with scientific clients (consistent with hypotheses H4a, H4b, H4c and H4e, verified below).

The patent application data were matched with variables describing the average annual expenditures on Research & Development incurred in 2006–2015 respectively by industries—NACE classes (normalized by the count of active companies per industry) and by regions (per capita), using data from the Polish Statistical Office.

The explained variables were dichotomous, distinguishing between the patenting outcomes that were negative (H1, H3) or positive (H2, H4). The set of 17,589 patent applications from 2006 to 2015 was divided into a training dataset containing 75% of applications ($N=13,188$) and a test dataset with the remainder of 25% applications ($N=4401$). The hypotheses were verified based on the training data set. Subsequently, the predictors were analyzed by means of the stepwise logistic regression algorithm based on the ROC curve applied to the training dataset. The year of application was included in the models as a controlled variable (since more recent patent applications can be expected to be less likely to be granted due to insufficient time available to patent examiners). The regression models were built using six best predictors that had the highest values of OR (odds ratio), and the

model was further extended by the identified interactions between moderators. Two models were developed, taking into account the distinction between negative decisions and pending/granted (H1, H3) or patent grants and pending/negative outcomes (H2, H4). In the final step, the models were validated on the test data, with the accuracy and sensitivity of predictions measured. The detailed results of this econometric modelling will be presented in the following section of the article.

Analysis and results

The hypotheses were verified based on the patent-related and economic variables, and the detailed results of this analysis are presented in Table 3. While verifying H1/H2, the highest values of OR were found for: the involvement of scientific organization as (co-)applicant, the involvement of patent attorney and the number of inventors. Counts of applicants and forward citations were not significantly significant. Most of the analyzed characteristics of patent attorneys (H3/H4) were confirmed as significantly impacting the patenting outcomes, with H4f being the only sub-hypothesis that yielded non-conclusive outcomes (patent attorney's experience in supporting companies). Table 3 confirms the verification of the following sub-hypotheses: H1b/H2b, H1c/H2c, H1d/H2d, H1e, H2f, H1h, H1j/H2j, H3a/H4a, H3b/H4b, H3c/H4c, H3d/H4d, H3e/H4e and H3f.

The data were subsequently used to develop two logistic regression models, representing scenarios described by the hypotheses H1/H3 and H2/H4, using predictors that were identified based on the ROC curve, with the addition of the application year as the controlled variable and the inclusion of interactions between predictors. The applicants' scale of operations and patent attorney's exposure to international procedures (high rate of applications with PCT counterparts) were not used in the models since they were highly correlated with other predictors used in both models, respectively: the involvement of scientific organization and the attorney's effectiveness (high rate of granted patents). Table 4 lists the predictors included in both models, predicting the dichotomous variables that confirmed whether the decision was negative versus pending/granted (model 1—for H1/H3), or negative/pending versus granted (model 2—for H2/H4).

Model 1 predicted the likelihood of non-negative outcome (granted patents or pending applications) based on the involvement of a scientific organization as (co-)applicant, reliance on PCT procedures in addition to the local patenting, work of a patent attorney who had a good track record (in terms of the share of granted patents) and the international experiences (measured by prior applications that had PCT counterparts). Furthermore, patent applications originating in regions with high levels of R&D expenditures per capita and coming from R&D-intensive industries were more likely to enjoy these non-negative outcomes.

Two non-obvious, statistically significant interaction effects were also identified. The first interaction concerned patent applications coming from R&D-intensive industries and regions with disproportionally high R&D investments, as this combination increased the odds for a negative decision. This interaction could be interpreted as a consequence of the relative crowdedness of technological fields and geographical areas, with many applicants interested in using the scarce resource: services of local patent attorneys who have domain expertise. The second interaction occurred when patent applications were submitted by effective patent attorneys (attorneys with high rate of granted patents), combined with the involvement of scientific organizations as (co-)applicants. In such cases, the likelihood of

Table 3 Results of the hypothesis verification process

Hypothesis	Predictor	H1/H3: negative versus pending/granted			H2/H4: negative/pending versus granted		
		Coefficient β	OR	Verified?	Coefficient β	OR	Verified?
H1a/H2a	No. of applicants	−.085 (0.044)	.94	−	−.176*** (0.033)	.84	−
H1b/H2b	Scientific organization involved	1.186*** (.067)	3.27	+	1.157*** (.038)	3.18	+
H1c/H2c	Applicants with larger scale of operations						
	~ Mid-sized applicants versus individuals	.571*** (.072)	1.77	+	.476*** (.065)	1.61	+
	~ Large applicants versus individuals	1.400*** (.51)	4.06	+	1.490*** (.46)	4.42	+
H1d/H2d	No. of inventors	.025*** (.019)	1.29	+	.134*** (.009)	1.14	+
H1e/H2e	No. of IPC classes	.166*** (.020)	1.18	+	.001 (.011)	1.01	−
H1f/H2f	Industry with high level of R&D expenditures per company	.083 (0.053)	1.09	−	.351*** (.035)	1.42	+
H1g/H2g	Region with high level of R&D expenditures per capita	.069 (.053)	1.07	−	−.059 (.035)	.94	−
H1h/H2h	PCT application	.298* (.140)	1.35	+	.143 (.084)	1.15	−
H1i/H2i	Forward citations	−.751*** (.102)	.47	−	−.696*** (.087)	.50	−
H1j/H2j	Patent attorney involved	1.170*** (.054)	3.22	+	.360*** (.038)	1.43	+
H3a/H4a	~ Active (high number of applications)	1.231*** (.054)	3.43	+	.426*** (.037)	1.53	+
H3b/H4b	~ Effective (high rate of granted patents)	1.211*** (.061)	3.36	+	1.059*** (.036)	2.88	+
H3c/H4c	~ Experienced in advanced technologies (high rate of medium/high technology applications)	.899*** (.063)	2.46	+	.545*** (.036)	1.72	+
H3d/H4d	~ Exposed to international procedures (high rate of applications with PCT counterparts)	1.252*** (.058)	3.50	+	.696*** (.035)	2.00	+
H3e/H4e	~ Experienced in supporting scientific organizations (high rate of applications submitted by scientific organizations)	1.185*** (.057)	3.27	+	.488*** (.035)	1.63	+
H3f/H4f	~ Experienced in supporting companies (high rate of applications submitted by companies)	.259*** (.065)	1.26	+	−.304*** (.041)	.74	−

OR odds ratio, *p* statistical significance

Table 4 Predictors included in the models of patenting outcomes

No.	Predictor	Model 1: negative versus pending/granted			Model 2: negative/pending versus granted		
		Coefficient β	Marginal effects	OR	Coefficient β	Marginal effects	OR
1	Year of application	.465*** (.012)	.039*** (.001)	1.59	−.132*** (.007)	−.028*** (.001)	.87
2	Scientific organization involved	1.183*** (.104)	.088*** (.007)	3.26	1.386*** (.061)	.238*** (.009)	4.00
3	PCT application	.547*** (.156)	.046*** (.013)	1.73	–	–	–
4	Effective patent attorney (with high rate of granted patents)	1.280*** (.083)	.099*** (.006)	3.60	1.050*** (.049)	.180*** (.008)	2.86
5	Patent attorney experienced in supporting companies (high rate of applications submitted by companies)	–	–	–	.204** (.048)	.044* (.010)	1.23
6	Industry with high level of R&D expenditures per company	.085 (.083)	−.010* (.005)	1.09	.293*** (.052)	.032*** (.008)	1.34
7	Region with high level of R&D expenditures per capita	.201** (.084)	−.001 (.005)	1.22	.067 (.052)	−.018* (.008)	1.07
6×7	Industry with high level of R&D expenditures per company × Region with high level of R&D expenditures per capita	−.454*** (.121)	–	.64	−.312*** (.076)	–	.73
2×4	Scientific organization involved × Effective patent attorney (high rate of granted patents)	−.482** (.153)	–	.62	−.592*** (.081)	–	.55
	Constant	−934.370*** (24.991)	–	–	264.971*** (14.046)	–	–
		Log-likelihood: −4993.115			Log-likelihood: −9129.753		
		Pseudo R^2 = .26			Pseudo R^2 = .11		
		LR chi-square(8) = 2573.00			LR chi-square(8) = 1943.00		
		Prob > chi-square = 0.000			Prob > chi-square = 0.000		
		N = 13,188			N = 13,188		

OR odds ratio, p statistical significance

negative patenting outcomes increased. This could be explained by the motivations of scientists, using patents as signals of their research competence, focusing on the pursuit of academic careers rather than commercialization of patented technologies, and interfering in the process of patent drafting in ways that decrease the performance of otherwise highly successful attorneys. In the Polish science system, the publishing and patenting activities are separately analyzed in evaluations of scientific institutions, awards of higher scientific degrees and performance appraisals, so both individual scientists and their host institutions might derive benefits from filing patents they do not intend to implement.

In order to interpret the interactions, a simple effect analysis on the training dataset was conducted. The odds ratio for an R&D-intensive industry if the patent applicant comes from a region with higher R&D expenditures per capita was equal to OR = 0.85 [0.73; 0.99], $p < .05$. The odds ratio for an R&D-intensive industry if the patent applicant comes from a region with lower R&D expenditures per capita was equal to OR = 1.22 [1.06; 1.40], $p < .01$. Hence, even though applications from regions with higher R&D expenditures were more likely to enjoy non-negative patenting outcomes, the odds for an advanced technology application not being rejected were actually higher if the patent applicants were located in regions with lower R&D expenditures.

In a similar manner, the odds ratio for an effective patent attorney (with higher rate of granted patents) working with a scientific organization as a (co-)applicant was equal to OR = 1.99 [1.57; 2.54], $p < .001$. The odds ratio for effective attorneys submitting a patent applications on behalf of applicants who did not include a scientific institution was equal to OR = 3.21 [2.77; 3.73], $p < .001$. Consequently, a patent attorney with higher rate of granted patents increased the chances for the filed application not being rejected by the patent office, but this effect was stronger if a scientific organization was not included among the patent applicants.

The model was validated based on the test data. This verification revealed the accuracy of predictions equal to 88.4% [87.4%; 89.3%], which was significantly better than no information rate, $p < .05$. The sensitivity of predictions was equal to 0.97, with the specificity equal to 0.26.

Model 2 predicts the positive patenting outcomes contrasted with a rejection or a pending decision. It included similar predictors and interactions as model 1, albeit without the PCT applications. When compared with model 1, a new, statistically significant predictor was the attorney's experiences in supporting companies (an attorney with high rate of applications submitted on behalf of companies).

The interaction effects were interpreted in a way analogous to model 1. The odds ratio for granting patents when applications came from R&D-intensive industries and regions with higher R&D expenditures per capita was equal to OR = 1.22 [1.10; 1.35], $p < .001$, while for regions with lower R&D investments, the ratio amounted to OR = 1.65 [1.50; 1.81], $p < .001$. Patent applications from industries with higher R&D expenditures per company were more likely to be granted, and this effect was even stronger if applicants were located in regions with lower R&D expenditures.

The involvement of effective patent attorneys (attorneys with higher rates of granted patents) increased the chances for the patent to be granted, but this effect appeared stronger if a scientific organization was not involved in the patenting. The odds ratio for an effective patent attorney and the involvement of a scientific institution was equal to OR = 1.70 [1.50; 1.93], $p < .001$, while without any scientific (co-)applicants, the ratio reached the level of OR = 2.97 [2.71; 3.27], $p < .001$.

The validation of model 2 based on the testing dataset revealed the prediction accuracy of 67.2% [65.8%; 68.6%], which turned out to be significantly better than no information

rate, $p < .001$. The sensitivity of predictions was equal to 0.69, with the specificity equal to 0.64.

In order to look for possible additional predictors in both models, the patent dataset was also processed by the random forest algorithm as an alternative analytical approach, leveraging the potential of machine learning. No further, statistically significant predictors were identified and attempts to supplement the models by additional variables were actually decreasing the predictive power.

Predictors included in both models were further assessed in terms of collinearity. Table 5 presents Pearson's correlation coefficients between all predictors included in the model alongside the values of tolerance and variance inflation factors. All correlation coefficients were lower than 0.6 and collinearity indicators were at acceptable levels. The average value of the tolerance statistics for all predictors was equal to 0.78, which is higher than the threshold value of 0.2, suggested by Menard (1995). Moreover, none of the variance inflation factor (VIF) values exceeded 10, suggested as the threshold value by Myers (1990).

Conclusions

The research suggests that in many cases, positive patenting outcomes do not merely depend on patent drafting techniques but also on who drafts the patent application. The patenting success was found to be associated with the involvement of a patent attorney (H1j/H2j), since a professional agent can leverage specialist knowledge of technologies and legal frameworks to prepare the patent application and help the applicant maneuver through the complex patenting procedure. The attorney's characteristics identified as particularly strong predictors of a new application's patenting success were: the attorney's effectiveness (measured as the high share of successful patent grants in previously submitted applications, prepared by the attorney, H3b/H4b) and exposure to international patenting (in terms of high rates of PCT applications derived from priority applications drafted by the attorney, H3d/H4d). Other relevant features were: the attorney's performance (number of filed applications, H3a/H4a), the experience in advanced technologies (share of applications from these fields, H3c/H4c), the experience in supporting scientific applicants (H3e/H4e) and prior references in working with companies as applicants (H3f confirmed, but H4f not confirmed).

Previous studies acknowledged the collective character of the patent drafting process, which involves not only inventors and employees of the applicant organization, but also patent attorneys (Beukel, 2019; Reiffenstein, 2009). The present research sheds light on the specific role of attorneys, whose previous experiences are found to be relevant predictors of the patenting outcomes. Importantly, only few publications referred to the consequences of the patent attorneys' involvement (Andriosopoulos et al., 2022; de Rassenfosse et al., 2021; Gaudry, 2012; Khachatryan & Muehlmann, 2017; Reitzig, 2004; Somaya et al., 2007; Süzeroğlu-Melchiors et al., 2017), and previous empirical analyses focused on the comparison of patents filed with or without attorneys, devoid of more detailed considerations of the individual differences among attorneys. Some studies looked at the accumulated experience of patent attorneys, based on the total counts of previously submitted applications (Andriosopoulos et al., 2022; Frietsch & Neuhäusler, 2019; Koller & Ebersberger, 2015), while the present article analyzed also the attorneys' prior track record, domain expertise,

Table 5 Correlations between predictors and collinearity diagnostics

Variables	1	2	3	4	5	Tolerance	VIF
1. Scientific organization involved	–					.72	1.39
2. PCT application	–.037**	–				.97	1.03
3. Effective patent attorney (with high rate of granted patents)	.289**	.051**	–			.52	1.91
4. Patent attorney experienced in supporting companies (high rate of applications submitted by companies)	–.404**	.019**	–.038**	–		.76	1.32
5. Industry with high level of R&D expenditures per company	.194**	0.013	.069**	–.103**	–	.96	1.05
6. Region with high level of R&D expenditures per capita	.034**	.068**	–0.013	–.037**	.006	.99	1.01

VIF variance inflation factor

sectoral and international focus. The empirical research confirms the importance of the attorneys' performance, effectiveness, as well as their prior international, sectoral and technological exposure.

The findings are novel in the light of the body of scientific literature, and only two recent, yet unpublished studies analyzed the relations between specific characteristics of patent attorneys and the patenting outcomes. De Rassenfosse et al. (2021) developed an index of patent attorney firm quality, with values computed based on data from multiple patent offices, difficult to replicate by applicants planning to select their legal representatives. Andriosopoulos et al. (2022) used the counts of patent applications filed by a given attorney and the shares of applications resulting in granted patents. The present study identified new, important variables that may help patent applicants select the most adequate attorney with a view to maximize the likelihood of the patent grant, or could be used as the basis for ranking attorneys within an innovation system.

Hypotheses and regression models confirmed also other variables that influence the patenting outcomes. The strongest predictors were the involvement of a large organization as an applicant (H1d/H2d) or a scientific institution (H1b/H2b). While preparing patent applications, scientific organizations including universities and research institutes leverage their thematic expertise and research excellence, as well as collective learnings from prior patenting. Such an institutional memory is usually not available to companies, with the exception of the largest organizations, which possess the in-house intellectual property expertise and comprehensive R&D support structures (H1d/H2d). Therefore, many smaller, innovative companies will draft patent applications in ways inferior to universities or research institutes, especially if doing it for the first time and with limited resources, but the science-industry collaboration might actually increase their success rates. Applications with multiple inventors (H1d/H2d) were also found to have a statistically significant link to the patenting outcomes, and these findings was aligned with various previous studies that highlighted the benefits of collective inventorship practices.

Another interesting set of findings related to variables that do not seem to influence the patenting pathways, bearing no statistically significant relations to the patenting outcomes. The research did not confirm the relevance of multiple applicants or co-owners (H1a/H2a). The acknowledgement of applications by forward citations was not related to the chances for patents to be granted (H1i/H2i). This non-obvious result could be explained by the nature of the data analyzed, since the citations were collected from PATSTAT database that primarily derived citations from international patents referring to the Polish applications (only 781 applications were cited, 4.44% of the analyzed dataset). Mixed results were noted for several variables, with only some variants of hypotheses confirmed: multiple IPC classes per application (H1e), application from an R&D-intensive industry (H2f), application filed also for international protection via the PCT route (H1g). The interdependencies were further explored in two models of logistic regression with moderators: industries and regions with high R&D expenditures were included in the models with their reciprocal interactions. Even though the sectoral or regional origins of applications mattered for the successful patenting outcomes (particularly if industries or regions spend more on R&D), the interactions indicated also better odds for patent grants (or applications not being rejected) if applications originated in an R&D intensive industry but applicants were located in regions with lower R&D expenditures. This might be interpreted as a case of tacit leniency of patent examiners, who differentiate applications based on their geographical origins, being less inquisitive towards applicants from the less R&D-intensive regions.

Research limitations and future directions

The study was based on the dataset from the Polish Patent Office, including only applications for which the selected priority territory was in Poland. The Polish system of innovations can be characterized by sizeable counts of patented inventions, outperforming other countries of the Central and Eastern Europe, but Poland still lags behind the leading Western European and Eastern Asian economies when the levels of R&D expenditures and the extent of patenting are considered. Despite these concerns, the Polish patent applications cover a broad range of technologies, IPC classes and industries, resembling the diversified structure of innovation systems in technologically and economically advanced countries. When transposing the research findings to other economies, institutional differences need to be considered, including: the admissibility of *pro-se* applications (without patent attorneys), professional standards and educational backgrounds of legal representatives in patenting procedures (especially as applicants in some countries may also be represented by lawyers who are not patent attorneys), and the patenting propensity of scientific institutions.

It must also be noted that comparably detailed data about patent attorneys supporting individual patent applications are not widely available, so the present study offers novel insights thanks to the unique set of variables.

The research looked at patenting pathways and thus, it also included applications that described solutions that were not genuinely innovative. Some of the documents had no commercial value, were describing widely known solutions and were devoid of novelty or inventive steps. However, the inclusion of all submitted applications was necessary to model the patenting outcomes and identify factors that differentiate the successful and unsuccessful applications.

Further limitations include: the reliance on logistic regression models (with majority of variables being dichotomous not continuous), the analysis concerning the historical period of 2006–2015 (when the Polish economy went through structural transformations, almost doubling the investments in innovations by going up from 0.56% of GDP invested in R&D in 2006 to 1.0% of GDP in 2015, so the approaches of patent applicants might also have changed during this 10 years-long period), or the need to combine data from two databases that were not fully commensurable (the database maintained by the Polish Patent Office, with extensive descriptors of each patent application but without any data on citations or PCT applications, and the more fragmented PATSTAT database, maintained by the European Patent Office and providing less details on patent applications submitted to national patent offices, but used to supplement the national dataset with data on forward citations and PCT route). The analyzed dataset included applications filed without the support of external patent attorneys, and some of these applications might have been prepared by inhouse attorneys, employed by the largest patent applicants but not identified on the application (i.e. a small subset of applications analyzed as filed without the professional support of patent attorneys would still actually leverage the support of inhouse experts). Despite the above-listed limitations of the research data and methods, the study was able to demonstrate the important roles of patent attorneys in the successful patenting outcomes and to identify their characteristics that are particularly beneficial for patent applicants.

Future studies might also consider additional variables that might explain the patenting outcomes, including: the accumulated thematic expertise of attorneys (counts of patent applications in a given technological domain), alternative operationalizations offinternational patenting experiences (an attorney's experiences in drafting international

applications and sizes of supported patent families), as well as the size of R&D budgets and headcount of applicants. Furthermore, researchers might investigate additional variables that were used in previous studies on the success of attorneys in law. The attorney's gender or age might matter for the case outcomes (Collins et al., 2017), alongside the size of the attorney's firm, which corresponds to the organizational resources that could be committed to support the case (Dumas et al., 2015). The attorney might need to reach a minimum threshold of domain expertise, measured by previous cases in that specific domain in order to be credible for the decision makers (Haire et al., 1999), and the more frequently an attorney works on cases, the better she understands the procedures (McGuire, 1995; Szmer et al., 2007), so the patenting chances might increase with the passage of time and the accumulation of experiences. The attorney's workload might reduce the probability of success (Miller et al., 2015), especially when the number of cases exceeds her processing capacity and impairs the quality of outputs.

Court decisions depend also on the characteristics of judges and their relations with specific attorneys (Lazarus, 2008; Ryo & Peacock, 2021), with an attorney's success based on the relational expertise (Sandefur, 2015), so analyses of patent attorneys-examiners pairs might offer interesting insights into the likelihood of patent grants.

Implications

The article discussed the role of patent attorneys in achieving positive patenting outcomes. It empirically confirmed the usefulness of involving attorneys in drafting patent applications and highlighted the attorneys' relevant characteristics, based on their track record and previous experiences. The findings fill in an important knowledge gap in the innovation management literature, offering novel insights into the antecedents of successful patent applications. In particular, they reveal that apart from specific patent drafting techniques or characteristics of the applications, it also matters who exactly is involved in the patent filing process.

Patent applicants can benefit from the research results in multiple ways. First of all, they might consider the involvement of an external patent attorney to support the filing process, even if they employ inhouse IP experts. External attorneys leverage the experiences of various patenting cases, involving other applicants, as well as the familiarity with multiple technologies and procedural steps that might enhance the quality of application drafting. Secondly, the attorneys' selection should take into account their capacity and accomplishments, which could be verified by looking into previous patenting applications and their results, listed in a patent office database. The key selection criterion is the attorney's effectiveness or the success rate, calculated as the share of filed applications that resulted in successfully granted patents. Another important aspect, revealed by the study, was the international exposure—the attorney would not need to have personal experiences in filing patent applications in international jurisdictions, but some of the patent applications filed nationally by the attorney should have international counterparts (be filed for international protection via PCT route or otherwise). The rationale for this criterion is the opportunity to understand differentiated patenting requirements and use the insights in the work for future clients. Furthermore, attorneys who used to work for scientific organizations as clients were found to increase the likelihood of patent grants, possibly due to the higher sophistication of technological descriptions in patent applications and knowledge transfer resulting from these scholarly

encounters. Finally, the successful attorneys had also experiences with medium-to-high technology inventions and support for companies (not only individual inventors).

Patent attorneys might also derive practical implications of the study to shape the market expansion strategies and decide about technologies and clients to focus on. Experiences in working with scientific clients are beneficial or the attorneys, increase their professional capabilities and enhance the reputation (also: in the eyes of patent examiners). Another important source of learning is the experience of international extension of the locally filed patent applications, e.g. via PCT route. Even if the international patenting is not directly supported by the attorney, she should be actively involved in discussing the details of the PCT procedure with the client, as important lessons learnt could be drawn and used in future patent filings. It's also advisable to patent inventions from advanced technological fields and work with companies as clients, as these experiences might further enhance the attorney's capabilities and consequently, increase the patenting success rates. Importantly, high numbers of drafted patent applications might not necessarily build the attorney's expertise, as excessive workloads translate into mediocre patenting results, while thematic and sectoral specialization, alongside continuous improvements of patent drafting techniques are key to the patenting success.

The list of specific features of patent attorneys help better protect inventions, strengthening their potential to turn into professionally prepared applications that will later be accepted by the patent examiners. The study highlights the importance of patent attorneys, who play important but usually overlooked roles in the system of innovations. Their profession deserves more attention of the R&D community and innovation management scholars, with the present study paving ways for further research. Researchers are encouraged to replicate the analytical framework used in this study to analyze patent data from other jurisdictions or look for further, relevant characteristics of patent attorneys that could contribute towards the success of patent applications.

Declarations

Conflict of interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Research involving human and animal rights The research did not involve human participants or animals, and the article does not include information related to identifiable individuals.

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