The determinants of patent applications outcomes - Does experience matter?

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Abstract

The aim of this paper is to analyze the determinants of the outcomes of patents applied for by Danish firms at the European Patent Office by focusing on the impact of firms' past patenting history. We use a database of 6540 patent applications over the period 1978-1998 linked with firm level data. While more than half of all patent applications indeed receive a grant, 44 percent of all patent applications are withdrawn by the applicants and only 3 percent are refused a grant by European Patent Office. This paper analyzes the decision of the patent office to grant the patent or to reject it, according to the applicants' antecedent decision to request for examination or to withdraw their application, using a Bivariate Probit model with sample selection. The main results are (i) patents applied for by firms with a high share of previous successful applications are more likely to request for examination, possibly due to a greater familiarity with the procedure (ii) the patent office makes its decision according to the quality of the application only (iii) application ways and strategies are important determinants for the continuation or the withdrawal of the application (iv) the granting process is more difficult to predict than earlier studies tend to show, reflecting a higher uncertainty of a patent application (v) cooperation between applicants is a major key of success.

Keywords: patents, intellectual property rights
JEL: O31, O32

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1 Introduction

Firms' patenting activity is of great interest to economists and policy makers, as patent counts measure, though in an imperfect way, innovation. A surge in patenting took place since the mid 1980s in the three main patent offices, the U.S. Patent and Trademark Office (USPTO), the European Patent Office (EPO) and the Japanese Patent Office (JPO). This worldwide growth in patent applications has been described e.g., in OECD (2004).

Economic policy makers and Intellectual Property Rights (IPRs) managers alike focus attention on patent applications and patent grants. While more than half of all patent applications indeed receive a grant, a large number of all patent applications are withdrawn by the applicants and only a few of them are refused a grant by the EPO. This paper analyzes the outcomes of a patent procedure within an econometric framework, using a Bivariate Probit Model with Sample Selection.

To qualify for a patent at the EPO, an invention must demonstrate novelty, an inventive step and industrial applicability. Since patent applications have grown in complexity and volume (see Van Zeebroeck et al., 2005), one can legitimately wonder whether the decision to grant a patent or not relies only on the characteristics of the underlying invention and, given the increased workload, if patent examiners did not grant low quality patents. The patent system is very costly both in terms of time and money. It is therefore important from the point of view of the society to have a well-functioning patent system. Moreover, the application process directly affects firms' R&D incentives. It is therefore desirable to have a fair and transparent system that minimizes the risks and uncertainties that firms are exposed to.

The aim of this paper is to study the determinants of the outcomes of patent applications and more specifically, whether firms which already experienced successful applications in the past have a higher probability to see their current application granted.

Van Dijk and Duysters (1998) found that basic research, which explores more novel and unknown paths, meets the patentability requirement more often, whereas Guellec and Van Pottelsberghe (2000, 2002) show that the characteristics that increase the probability of a grant at the EPO are:

- PCT-chapter II applications
- research cooperation between domestic researchers
- research cooperation with foreign researchers
- international co-applications
- the designation of Germany, France, the United Kingdom, and up to three other countries for patent protection.

This paper extends previous studies in several ways. First, by using a unique dataset

containing all the patents applied for by Danish firms linked with firm-level information (ownership structure of the applicants, past patenting activity). Second, by studying a phenomenon that most of the previous studies have ignored, namely the withdrawal of patent applications. This is an important fact, since more than 40% of all patent applications are withdrawn by the applicant before the patent office makes its decision. Then, from the methodological point of view, I show that it is important to correct for the selectivity bias arising, since the observation the patent office's decision to grant the patent or to reject it depends on the antecedent decision made by the applicants to request for examination or to withdraw the application. This issue is dealt with by applying a bivariate probit model with sample selection/censoring.

The main results are (i) patents applied for by firms with a high share of previous successful applications are more likely to request for examination, possibly due to a greater familiarity with the procedure (ii) the patent office makes its decision according to the quality on the application only (iii) application ways and strategies are important determinants for the continuation or the withdrawal of the application.

Section 2 briefly summarizes the application process at the EPO. Section 3 presents the data, while Section 4 describes the variables used and Section 5 provides summary statistics. The empirical model and the results are presented in Section 6, which is followed by concluding remarks.

2 Application process and outcomes at the EPO

The EPO was founded in 1978 as the result of the European Patent Convention (EPC). Within this framework, a single and centralized application is made, designating the signatory states of the EPC in which protection is sought for. A patent grant will provide the applicant with protection in all the designated states. If patent protection is sought for in more than three EPC countries, an EPO patent application is less costly than direct applications in each national patent office. Applicants may, however, apply for a patent at the EPO for an invention that had already been claimed to a national patent office previously, within twelve months after the first application (priority application).

Figure 1: Examination of patent applications at the EPO
(source: Harhoff and Wagner, 2005)

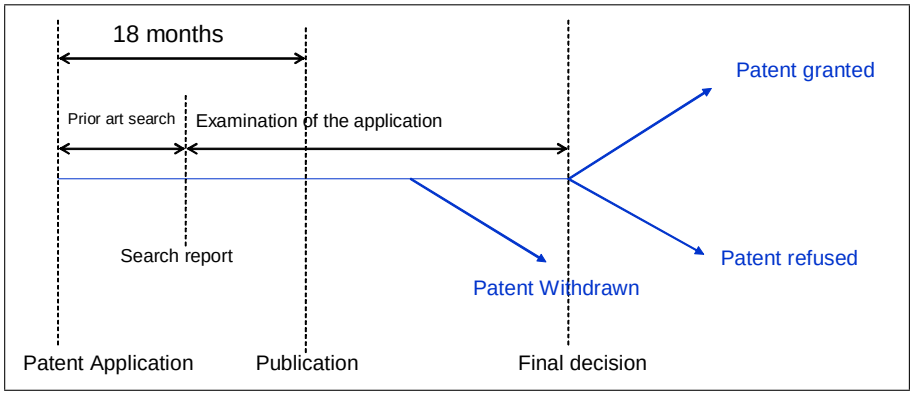

Figure 1 provides a simple presentation of the application process at the EPO. The application is published 18 months after the date on which the European or national priority application was filed. A search report, describing the state of art is published either with the application or later on. It contains references to prior patents or scientific publications, classified in different categories according to their relevance for the final decision. After the search report was published, applicants have six months to decide whether or not to pursue their application by requesting substantive examination. If no request for examination has been filled within the six months, the application is *deemed to be withdrawn*. If the renewal fee or any other fee were not paid in due time, the application is also *deemed to be withdrawn*. The *withdrawal* of the application can also be explicit, under the form of written correspondence between the applicant and the patent office, at any time before or during the examination process. A *withdrawal* typically takes place when the search report issued by the patent office is negative, in the sense that the applicant expects the patent not to be granted.

If examination was requested by the applicant, the application is examined by the patent office according to three criteria: novelty, inventive step and industrial applicability. The application then may end up with a *grant* or a *refusal to grant*. According to the EPC, If a European patent is granted, competence is transferred to the designated contracting states, where it affords the same level of legal protection as a national patent and is valid for 20 years from the date of filling, if it is consecutively renewed.

If the applicants seek patent protection in several countries they have the possibility to fill a PCT application (Patent Cooperation Treaty, effective since the early 1980s), to be filed at the WIPO (World Intellectual Property Organization). While a PCT application

is not an actual patent application, it provides the applicants with the possibility to apply for a patent in the future in an easier way. Such a procedure gives the applicant a longer delay to decide whether to apply for the patent or not and in which of the 183 member countries. Our database contains PCT applications in which the applicants have designated the EPO, so called "Euro-PCT" applications.

The Chapter I of the PCT procedure consists in sending the application to an International Searching Authority (ISA), which is a national or regional patent agency, for carrying out the search on the state of the art. The EPO is responsible for more than half of the searches. Once the report is provided by the ISA, the applicant has three possibilities:

- Transfer the application to national or regional patent offices among those designated in his application

- Elect an International Preliminary Examination

- Withdraw the application.

The Chapter II of the PCT procedure occurs if the international preliminary examination is chosen by the applicants. If the Euro-PCT application is transferred to the EPO, the outcome of this examination is taken into account.

As indicated by Harhoff and Wagner (2005), PCT filings are advantageous for the following reasons:

- They allow the expansion of patent protection to a large number of countries without incurring the full costs and complexity of national application paths.

- Applicants will receive an international search report within a relatively short time period, informing them about prior art that may be relevant for the own application's likelihood of being granted.

- They allow applicants to delay decisions about the countries for which they want to designate the application for up to 30 months after the priority date.

3 Data sources

The data was compiled from four main sources:

1. The **CEBR patent database**, that contains all the patents applied for by Danish firms at the EPO since the creation of the EPO in 1978, up to 2003. The initial database contains 12,109 patent applications. A unique firm identifier has been attached to the patent assignees, the so-called "CVR" number (central firm registry number), in order to find exact matches between the firm names and addresses in the patent data and the firm name and addresses in the financial data (the KOB data, see below).We identified a total of 2,822 unique Danish non-person patent applicants,

a total of 1,152 Danish private applicants (see below for the definition of "private applicants") and a total of 591 foreign (co-) applicants. Both the Danish private applicants and the foreign applicants we assigned unique identifying numbers. We therefore have the entire population of patents applied for by Danish firms at the EPO, with an exact match with the firm-level data. More details on the database and how it was constructed can be found in Kaiser and Schneider (2005).

2. The **EPO/OECD citations database** that contains information on citations made in the patent applications, as well as information on the citations received by all EPO patents applied before October 2004. More information on the citation database can be found in Webb et al. (2005)

3. The **KOB data** that provide us with firm level data. KOB A/S is a private firm that has specialized in collecting and processing data on Danish businesses. Our dataset is an image of the data that can be found on http://www.kob.dk/

4. Eventually, the **number of claims** has been searched manually for each patent application via http://ep.espacenet.com/

In order to include the number of forward citations (within five years after the patent application) and allow for ample examination time, I restrict the dataset to patents that were applied for before January 1st 1998.

4 Variables

4.1 Dependent variables

Both dependent variables in the bivariate analysis are binary. As mentioned before, the purpose is to explain both the decision to withdraw an application or to request for examination and the subsequent decision made by the patent office to grant the patent or to refuse it.

The request for examination or the withdrawal of the application. For each patent application, we know whether the applicant(s) decided to maintain it, or to withdraw it. The variable takes the value 1 if the application is maintained and 0 if it is withdrawn.

Decision of the EPO. If the applicant(s) indeed decided to maintain the application, the decision by the EPO to grant or refuse it is observed.

4.2 Explanatory variables

This section introduces the independent variables used in the multivariate analysis.

Number of designated states. The "family size" is the number of jurisdictions in which patent protection is sought for. We do not, however observe the entire patent family, thus I use the number of designated states member of the European Patent Convention (EPC). Harhoff et al. (2003), Putnam (1996), Lanjouw (1998) and Lanjouw et al. (1998) show that the family size is a patent value correlate. The effect of this variable can obviously be expected to be nonlinear, therefore I extract the following dummy variables:

- If the applicants designated Germany, France or the United Kingdoms (G3), as an application in any of these countries should be valued more than an application in a smaller country like Monaco for example.

- If the applicants designated Denmark (i.e., the applicants country of residence)

- If the applicants designated all the potential EPO members[1] at the date of application.

PCT application. A dummy variable indicates whether PCT chapter I or II applications have been filed for the invention. Guellec and Van Pottelsberghe (2002) give arguments for and against a positive role of PCT applications:

- The PCT procedure provides the applicants with a longer period to decide whether to apply for a patent or not, which enables them to assess the market potentials more thoroughly. The decision to transfer the applications to the EPO might therefore be an indicator of higher quality.

- On the other hand, the PCT procedure might be a sign of inventions with unclear market potential.

Priority application. A dummy variable indicates whether the patent under consideration has been applied for at another patent office before the EPO application. The argument for and against a positive correlation between a priority application and a patent grant at the EPO are very similar to those mentioned for the PCT procedure. On the one hand, it enables the applicants to draft an application prior to the EPO applications, permitting them to observe this first outcome before transferring it to the EPO, but it might also be a sign that the applicants are not aware of the market potential of their inventions.

[1] The EPO memebers are Belgium, Federal Republic of Germany, France, Luxemburg, the Netherlands, Switzerland, United Kingdom (from Oct. 7, 1977), Sweden (joined May 1, 1978), Italy (Dec. 1, 1978), Austria (May 1, 1979), Lichtenstein (April 1, 1980), Greece and Spain (Oct. 1, 1986), Denmark (Jan. 1, 1990), Monaco (Dec. 1, 1991), Portugal (Jan. 1, 1992), Ireland (Aug. 1, 1992), Finland (March 1, 1996), Cyprus (April 1, 1998)

Number of IPC assignments. During the examination period, a patent is assigned to a number of codes from the International Patent Classification (IPC) system, according to its applicability in different technology areas. Lerner (1994) interprets the number of (IPC) assignments of a patent as the scope of this patent, whereas other authors prefer to take it as the complexity of the invention (Harhoff and Wagner, 2005).

Number of claims. In the same way than the number of IPC assignments, the number of claims, which delimit the boundaries of a patent, by describing precise features of the invention, can be interpreted as the scope or breadth of a patent as well as an indicator of complexity, see Harhoff and Reitzig (2004) or Lanjouw and Schankerman (1999). According to the EPO rules, if the application documents on which the European grant procedure is to be based comprise more than ten claims, a claims fee is payable for the eleventh and each subsequent claim. Applicants, seems to be sensitive to this rule, as more than 60% of the patents in our sample contain ten claims or less. Therefore, I include a dummy variable for applications containing more than ten claims.

Both these variables can thus be interpreted in contradictory ways, as each additional claim and/or IPC assignments could:

- mirror a broad patent by increasing its scope or breadth.
- make the description of the invention more precise, narrow and specific, thus reducing the scope of the patent.

Success rate. This variable captures time variant information and is defined for firm i in year t as the ratio of the number of patents granted to the number of patent applications made by firm i in year t. This variable is going to measure the effect of firms' past successes.

Number of citations made (backward citations). The search report issued by the EPO lists all the relevant documents regarding prior art, that are relevant for the examiner in order to make a decision on the patentability of the application. Harhoff et al. (2005) describe in detail how to use citations assigned to EPO patents.

an interesting feature of the search report made by the EPO for our purpose, is that the patent references are classified in different categories according to their relevance. In addition to the total number of backward patent citations, I will also use:

- The share of type A citations, defining the general state of the art.
- The share of type X citations, indicating that the claimed invention cannot be considered to be novel when taken alone.

- The share of type Y citations, indicating that the claimed invention cannot be considered to be novel when the referenced document is combined with other documents of the same category.
- The share of type D citations, referring to patent references already mentioned in the description of the patent application.

Reference to the Non-Patent Literature (NPL), might also be a relevant variable to include in the regression. However, these data are only available for patents applied for after 1990. Therefore they will be discarded from the analysis.

Number of citations received (forward citations). Trajtenberg (1990) showed that the number of citations received from subsequent patents is highly correlated with the value of the underlying invention. Since then, this indicator has been, by far, the most validated indicator of the value of the patent rights, see e.g. Harhoff et al. (1999). Thus, the number of citations the patents receive from other EPO patents within five years after the application date will be included. Here, the number of forward citations should be interpreted as an indicator that the patent has contributed to the state of the art.

Ownership structure. I introduce dummy variables which indicate the legal form of each firm involved in the applications, in order to check whether the firm structure has an impact on either stage of the model. These dummies can, to some extend, also be interpreted as a proxy for the firms' size.

Number of applicants. This variable is included in order to measure the importance of collaborations in patent applications.

5 Descriptive statistics

5.1 Outcomes of the patent applications

Figure 2 shows that the number of Danish patent applications has steadily increased since 1978, following the trend at the EPO level. One can then wonder whether this unprecedented increase in patent application is compatible with high quality in patent examination and if the increasing workload will not lead examiners to grant low quality patents.

Figure 2: Danish patent applications by application year, absolute numbers

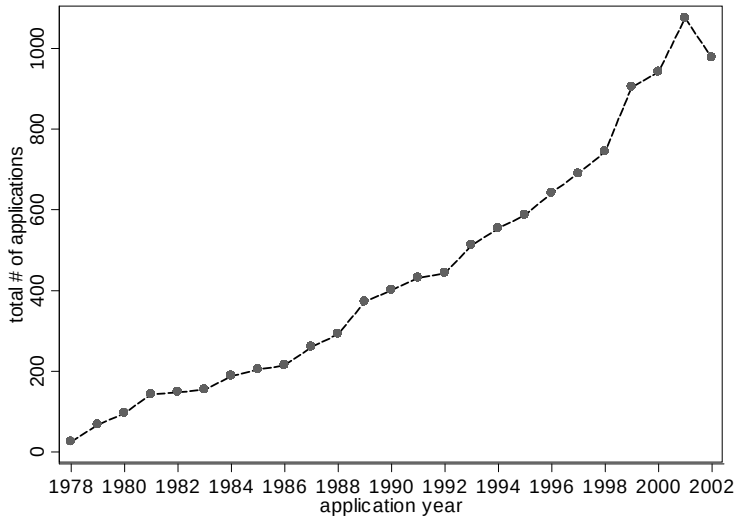

Figure 3 displays the distribution of the outcomes of the patent examinations by application years from 1978 to 2003. A majority of patent applications, 51%, is granted in the time window covering the application years of this study, from 1978 to 1998, while a relatively high number of applications, 41%, are withdrawn by the applicants. As pointed out by Harhoff and Wagner (2005), the withdrawal of a patent application occurs generally after the applicant received a "sufficiently negative search report or skeptical communication from the examiner". In addition, about 3% of the applications end up by a refusal and 4.6% of the applications are still pending. The initial sample contains 6421 observations (i.e. patent applications), but I discard the 294 patents for which the outcome is not known yet, reducing the sample to 6127 observations.

Figure 3: Distribution of outcomes

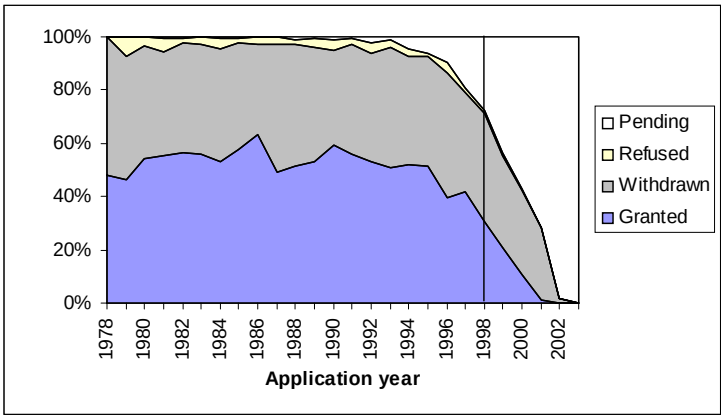

Table 1 summarizes the outcome of the applications, between 1978 and 1997, by technology class, using the so called OST classification, provided by the "Office des Sciences et Techniques", the French Patent Office (INPI) and the Fraunhofer ISI Institute, which is based on concordance with the IPC classes. The table shows an uneven distribution of outcomes across technology classes. When considering the six aggregated technology classes, one can see that the grant rate varies from 48.3% in "mechanical engineering" (technology class V) to 57.1% in "process engineering" and "chemicals and pharmaceuticals" (technology classes III and IV). In the 30 more narrow areas, the differences are even stronger, but the low number of applications in some of the areas makes it difficult to compare them. Notice, however, the relatively high grant rate, 60.4%, in "organic fine chemicals" (area 9), which is the area where the Danish patent applicants are the most active in (500 applications).

Table 1: Outcomes by technology areas

area	OST technology class	Granted (%)	Refused (%)	Withdrawn (%)	Total	% of total
	I Electricity - Electronics	**52.1**	**2.5**	**45.4**	**436**	**7.1**
1	Electrical devices - electrical engineering	52.5	2.9	44.6	204	
2	Audiovisual technology	55.5	3.6	40.9	110	
3	Telecommunications	52.7	1.4	46.0	74	
4	Information technology	41.5	0.0	58.5	41	
5	Semiconductors	42.9	0.0	57.1	7	
	II Instruments	**56.0**	**2.6**	**41.4**	**797**	**12.4**
6	Optics	56.4	5.5	38.2	55	
7	Analysis, measurement, control	53.9	3.0	43.1	371	
8	Medical engineering	58.0	1.9	40.2	371	
	III Chemicals, pharmaceuticals	**57.1**	**2.5**	**40.4**	**1524**	**23.7**
9	Organic fine chemicals	60.4	2.8	36.8	500	
10	Macromolecular chemistry, polymers	68.4	2.6	29.0	38	
11	Pharmaceuticals, cosmetics	48.2	2.9	49.0	243	
12	Biotechnology	49.1	1.6	49.3	367	
13	Materials, metallurgy	68.1	1.2	30.7	166	
14	Agriculture, food	62.9	3.8	33.3	210	
	IV Process engineering	**57.1**	**2.9**	**40.1**	**1046**	**16.3**
15	General technological processes	59.8	1.1	39.1	184	
16	Surfaces, coatings	40.0	2.9	57.1	35	
17	Material processing	56.4	3.4	40.2	321	
18	Thermal techniques	59.3	2.1	38.6	145	
19	Basic chemical processing, petrol	56.3	2.5	41.1	158	
20	Environment, pollution	57.6	4.4	37.9	203	
	V Mechanical engineering	**48.3**	**3.3**	**48.5**	**1548**	**24.1**
21	Mechanical tools	51.0	4.1	44.9	147	
22	Engines, pumps, turbines	56.0	1.7	42.3	175	
23	Mechanical elements	51.1	4.1	44.7	266	
24	Handling, printing	48.4	2.4	49.2	455	
25	Agriculture & food machinery	43.7	4.4	51.9	318	
26	Transport	42.8	2.9	54.3	173	
27	Nuclear engineering	50.0	0.0	50.0	4	
28	Space technology, weapons	30.0	10.0	60.0	10	
	VI Other	**50.3**	**3.2**	**46.5**	**776**	**12.1**
29	Consumer goods & equipment	42.8	2.9	54.3	376	
30	Civil engineering, building, mining	57.7	3.5	38.8	397	
99	Misc or unclassified	0.0	0.0	100.0	3	
	Total	53.5	2.9	43.6	6127	**100.0**

5.2 Firm-level data

There are 2822 unique applicants in the dataset, which are summarized in Table 2 with respect to their ownership structure. Table 3 indicates the weight of each company form in the total number of patent applications. 31% of the firms in the dataset are stock listed limited companies (A/S), accounting for 62.1% of the patents applied. The database counts a high number of "persons" or private applicants (29.8% of the applicants) which are involved in 14.1% of the applications. An applicant is defined as being "private" if (i) there is no indication that the applicant is non-private (for example there is no "A/S" for stock listed firms), (ii) the applicant name is a family name followed by first names and (iii) the applicant could not be found by our manual and automatic searched. Sole proprietorships, foreign (co-) applicants and private limited companies (ApS) follow. Notice that the legal form could not be determined for 5.8% of the applicants, corresponding

to 2.7% of the applications. These firms were typically dead by the time we made the search, that's why we were not able to find information about them. The other company forms account for less than 1% of the applications. The table shows that the grant rate is rather high for applications in which foreign firms are involved, as well as for applications by public firms or stock listed companies. The grant rate is lower than the average for applications involving private applicants (persons) and sole proprietorships.

Table 2: Firm structures

Legal form	Number of firms	%
Limited company (A/S)	876	31.0
Person	840	29.8
Sole proprietorship	346	12.3
Foreign firm (with no connexion to Denmark)	251	8.9
Private limited compagny (APS)	264	9.4
Form unknown	163	5.8
General partnership (I/S)	29	1.0
Public firm	9	0.3
Non-profit association	9	0.3
Foundation (FON)	8	0.3
Cooperative with limited liability (AmbA)	7	0.2
Cooperative (AND)	5	0.2
Limited partnership (K/S)	5	0.2
Foreign firm-wich has registered a branch or place of business in Denmark	3	0.1
Commercial foundation (ERF)	2	0.1
Branch of foreign limited company (FAP)	2	0.1
Company with limited liability (SmbA)	1	0.0
Limited partnership by shares (P/S)	1	0.0
Insurance company (FAS)	1	0.0
total	2822	100.0

Table 3: Distribution of outcomes by firm structure

Legal form	Number of patents	%	Granted (%)	Refused (%)	Withdrawn (%)
Limited company (A/S)	4635	62.1	59.8	2.7	37.6
Person	1052	14.1	41.6	3.0	55.3
Sole proprietorship	513	6.9	46.0	2.9	51.1
Foreign firm (with no connexion to Denmark)	443	5.9	67.3	3.2	29.6
Private limited compagny (APS)	391	5.2	51.7	2.1	46.3
Form unknown	202	2.7	38.1	5.9	55.9
Non-profit association	57	0.8	43.9	3.5	52.6
General partnership (I/S)	41	0.5	31.7	4.9	63.4
Public firm	40	0.5	62.5	0.0	37.5
Foundation (FON)	26	0.3	53.9	0.0	46.2
Foreign firm (wich has registered a branch or place of business in Denmark)	23	0.3	78.3	0.0	21.7
Cooperative with limited liability (AmbA)	10	0.1	30.0	10.0	60.0
Cooperative (AND)	9	0.1	66.7	0.0	33.3
Limited partnership (K/S)	7	0.1	42.9	0.0	57.1
Limited partnership by shares (P/S)	7	0.1	14.3	0.0	85.7
Branch of foreign limited company (FAP)	6	0.1	100.0	0.0	0.0
Commercial foundation (ERF)	2	0.0	0.0	0.0	100.0
Company with limited liability (SmbA)	2	0.0	50.0	0.0	50.0
Insurance company (FAS)	1	0.0	100.0	0.0	0.0
total	7467	100.0			

5.3 Past success and outcome of the patent application

Since this issue is central in our analysis, it deserves further attention. An advantage from having experienced successful applications at the EPO in the past is expected. One may therefore expect a history of prior successes to increase the applicants' chances of getting their patents granted.

Table 4 shows that the probability of the patent to be granted increases monotonically with the success rate, whereas the withdrawal rate decreases. The group of patents for which the average success rate is greater than 50% are granted in 69.1% of all cases and is withdrawn for only 30.2% of all applications.

Table 4: Success rate and incidence on outcomes

	Outcome			
Success rate (%)	Grant	Refusal	Withdrawal	Total
0	1521	103	1563	3187
	47.7%	*3.2%*	*49.0%*	*100.0%*
(0, 30]	1125	50	774	1949
	57.7%	*2.6%*	*39.7%*	*100.0%*
(30, 50]	448	21	257	726
	61.7%	*2.9%*	*35.4%*	*100.0%*
>50	183	2	80	265
	69.1%	*0.8%*	*30.2%*	*100.0%*
Total	3277	176	2674	6127
	53.5%	*2.9%*	*43.6%*	*100.0%*

Pearson chi2(6) = 104.2022 Pr = 0.000

Preliminary hypothesis can be made to explain the importance of the applicants' past experiences:

- Firms with a high share of past successful applications have intrinsically a higher capability to generate good ideas.

- Firms with higher past successes have learned how to draft the documents well, if only due to a greater familiarity with the application procedure, which increases the chances of future success.

- Firms with high past success created informal networks at the patent office and are receiving special treatments

- Firms with past experience know the relevant prior art in the area they are active in.

5.4 Dependent variables

Summary statistics for all variables used in the analysis are presented in table 5. On average, the success rate is about 13%. The number of patent references ranges from 0 to 26, with, on average 52.8% type A citations, 21% type X citations, 12.3% type Y

citations, and 3.5% type D citations. The number of forward citations ranges from 0 to 35, with a mean of 1.52 citations received per patent and has the typical skew distribution, see figure 4 in Appendix A. The patents have on average close to two IPC assignments and 12.27 claims. The applicants designate typically about twelve states. 7.7% of the applications involve at least one foreign inventor. A large share of applications have been applied at another patent office prior to the EPO application (94%), 18.4% went through the PCT Chapter I procedure and 53.6% through Chapter II. Regarding the number of claims, comprised between one and 170 in our data, the division into three sub-groups is motivated by the fact that applicants, seem to be sensitive to the rule stating that a fee is to be paid for each claim above the tenth. Moreover, the number of claims has a mode of ten, see the distribution of the number of claims in figure 5 (Appendix B). Therefore, I divide this variable in three groups of dummy variables.

Table 5: Descriptive statistics

Variables	mean	sd	min	max
Succes rate	0.13	0.17	0	0.92
Citations				
Backward citations	4.24	2.40	0	26
Share of type A citations	52.8%	0.41	0	1
Share of type X citations	21.0%	0.32	0	1
Share of type Y citations	12.3%	0.26	0	1
Share of type D citations	3.5%	0.13	0	1
Forward citations	1.52	2.76	0	35
Technical characteristics				
Number of IPC assignments	2.06	1.17	1	6
Number of claims	12.27	11.86	1	170
Number of claims>10	38.0%			
Application ways				
Number of designated states	12.01	4.25	1	18
Designates G3 countries	99.7%			
Designates DK	53.1%			
Designates all potential EPO members	37.0%			
Priority applications	94.0%			
PCT Chapter I	18.4%			
PCT Chapter II	53.6%			
Number of applicants	1.70	1.19	1	18

6 Empirical analysis

6.1 Methodology

Table 6 explores the relationship between patent and firm characteristics and outcomes, using a Bivariate Probit Model with Sample Selection due to Van de Ven and Van Praag

(1981). The choice of this model is motivated by the fact that it may not be appropriate to analyze the patent office's decision to grant the patent or to refuse the grant by using a single-equation model, since this decision is related to the applicants' choice to request for examination or to withdraw the application prior to the patent office's decision. In this model, data on a variable y_1 (the EPO's decision to grant the patent or not) are observed only when another variable, y_2 (the applicants decision to request for examination or to withdraw the application) is equal to one. Formally we have:

$$\begin{aligned} y_{i1}^* &= \beta_1 x_{i1} + \epsilon_{i1},\ y_{i1} = 1 \text{ if } y_{i1}^* > 0,\ 0 \text{ otherwise} \\ y_{i2}^* &= \beta_2 x_{i2} + \epsilon_{i2},\ y_{i2} = 1 \text{ if } y_{i2}^* > 0,\ 0 \text{ otherwise} \\ (\epsilon_{i1}, \epsilon_{i2}) &\sim BVN(0, 0, 1, 1, \rho) \\ (y_{i1}, x_{i1}) &\text{ is observed only when } y_{i2} = 1 \end{aligned} \tag{1}$$

where the x_i are the characteristics for the ith patent. Thus, there are three types of observations with unconditional probabilities that need to be taken into account in the construction of the log-likelihood function:

$$\begin{aligned} L \quad = \quad & \sum_{y_1=1, y_2=1} \ln\left[\Phi_2\left(\beta_1 x_{i1}, \beta_2 x_{i2}, \rho\right)\right] + \sum_{y_1=0, y_2=1} \ln\left[\Phi_2\left(-\beta_1 x_{i1}, \beta_2 x_{i2}, -\rho\right)\right] \\ & + \sum_{y_2=0} \ln\left[1 - \Phi\left(\beta_2 x_{i2}\right)\right] \end{aligned} \tag{2}$$

Where Φ and Φ_2 denote, respectively, the univariate and bivariate normal cumulative distribution function, and $\rho = cov(\epsilon_{i1}, \epsilon_{i2})$. The likelihood function is maximized with respect to β_1, β_2 and ρ.

As equation 1 suggests, sample selection arises because the observation of y_1 (the patent is granted or refused) is not random, but conditional on the observation of $y_2 = 1$ (the applicants do not withdraw the application). If the correction was not specified, the model would take into account the outcomes that are not feasible (i.e., $y_1 = 1$, $y_2 = 0$ and $y_1 = 0$, $y_2 = 0$).

If $\rho = 0$, the model can be estimated using two independent probit regressions. However, if ρ is significantly different from zero, using single equation estimates will generate biased coefficients.

6.2 Results

Before discussing the results in table 6, it is worth mentioning that the correlation between the residuals of both equations, ρ, is significantly different from zero, thereby validating the methodological choice made for this study.

In the equation *Request for examination/Withdrawal*, a significant effect of the success rate is observed, confirming the intuition that firms with a high share of success rate are less likely to withdraw their applications.

Applications containing high shares of type X and Y citations tend to be withdrawn more often. This result is intuitive, given that these types of citations are potentially damaging to the novelty requirement of the claimed invention. This mirrors a scenario, in which firms withdraw their applications after receiving a negative search report. The share of type D citations, which are already mentioned by the firms in the application and the share of type A citations, which define the state of the art, are associated with a positive coefficient. This can be interpreted by the fact that firms which report references to the patent literature themselves know the relevant prior art in the area they are active in, resulting in a lower withdrawal rate. The number backward citations measure is not significant. Our estimation also confirms the expectation regarding the number of forward citations, which is associated with a positive and significant coefficient, meaning that patents which contribute to the state of art have lower withdrawal rates.

Regarding the application ways, a positive effect only for patents that designate the G3 countries is observed. Applications designating Denmark and/or all the potential EPO members are more likely to be withdrawn, as well as applications that went through the PCT procedure (Chapter I or II). Guellec and Van Pottelsberghe (2002), argue that patenting in a large number of countries is synonymous to a lack of maturity of the applicant with respect to intellectual property rights strategies. Regarding the negative effect of PCT applications, it confirms that applications that went through this channel before the EPO channel have unclear market potential given that it provides the applicants with more time to decide whether to extend the right of the patents. Finally, applications that have been applied for at a national patent office prior to the EPO application have no significant effect. The total number of applicants has a positive effect, which underlines the importance of collaborations for successful applications.

Finally, regarding the ownership structures, the stock listed firms are the only ones to carry a positive and significant effect. The effect of all the other firm types is non significant.

I now turn to the *Grant/Refusal* equation. Regarding the backward citation measures, the share of type X citations, the most harmful to the novelty requirement has a negative

impact on the probability of grant as expected. Other backward citation variables are insignificant. Patents which have contributed to the state of art, or valuable patents are more likely to be granted, as the positive sign associated to the number of forward citations indicates.

In this equation again, the number of applicants plays an important role

Once examination has been requested, the ownership form of the applicants does not have any significant effect on the probability of grant.

The estimation results of the grant/refusal equation shows that the decision of the patent office only relies on the characteristics of the patent, meaning that applications are more likely to be rejected when the search report contains high shares of type X citations, but patents tend to be granted to important applications as measured by the number of forward citations. The identity of the applicants does not play a role at this stage. However, cooperation between different applicants increases the probability of grant.

These result highlight another interesting point. Only three variables in the grant/refusal equation are significant, compared to 13 in the Request for examination/Withdrawal equation. This means that the granting process itself is more difficult to predict than shown by earlier studies, reflecting a higher uncertainty in the outcome of a patent application.

Table 6: Estimation results

	Request for examination/ Withdrawal		Grant/Refusal	
	Coeff.	S.D.	Coeff.	S.D.
Success rate	0.189 *	0.109	0.408	0.250
Citations				
Number of Backward citations	-0.005	0.007	-0.013	0.016
Share of type X citations	-0.222 ***	0.070	-0.317**	0.164
Share of type Y citations	-0.137 *	0.081	-0.171	0.201
Share of type A citations	0.118 **	0.061	-0.200	0.153
Share of type D citations	0.431 ***	0.139	-0.226	0.253
Number of Forward citations	0.122 ***	0.006	0.037 *	0.021
Technical characteristics				
Number of IPC assignments	-0.002	0.015	-0.036	0.031
Number of claims>10	0.043	0.037	0.053	0.081
Application ways				
Designates G3 countries	0.656 *	0.414	-9.857	672.177
Designates DK	-0.529 ***	0.062	0.036	0.117
Designates all potential EPO members	-0.321 ***	0.040	0.074	0.086
Priority application	0.008	0.072	-0.156	0.165
PCT Chapter I	-0.632 ***	0.058	0.003	0.127
PCT Chapter II	-0.105 ***	0.050	-0.048	0.107
Number of applicants	0.265 ***	0.017	0.128 ***	0.050
Ownership structure				
Stock listed firm	0.275 ***	0.093	-0.242	0.211
Limited company	-0.048	0.093	-0.145	0.199
Sole proprietorship	-0.079	0.066	-0.163	0.173
Foreign firm	0.154	0.101	-0.167	0.207
Other	-0.005	0.098	-0.211	0.204
Person	-0.103	0.115	-0.182	0.239
Public institutions	0.324	0.317	9.322	112385.710
Constant	-1.230 **	0.579	15.482	146542.360
ρ	-0.829 ** (0.449)			
Observations	6540			
Log-Likelihood	-4512.816			

*** significantly different from the rejection rate at the 1 percent level

** significantly different from the rejection level at the 5 percent level

* significantly different from the rejection level at the 10 percent level

Annual year dummies are included in both equations.

7 Conclusion

The aim of this paper was to analyze the determinants of the outcomes of patents applied for by Danish firms at the EPO and to study the impact of the firms' experience on these outcomes. I used a database of 6127 patent applications over the period 1978-1998 and applied a bivariate probit model accounting for sample selection.

The applicants' past patenting history, as measured by the success rate, is found to be an important factor in the first stage of the application process, when the applicants have

to decide wether they are going to request for examination or to withdraw the application. However, in the second stage, the EPO's decision, this factor is found to be insignificant. This means that firms which have a greater familiarity with the application procedure are more likely to cope with the patentability requirements at the EPO, as they tend to request for examination and thus expect the patent office to grant their patent.

Another finding of this paper is that the patent office's decision to grant the patent or not, relies on the patent "quality" (number of forward citations, share of backward citations damaging the novelty step, precision in the description of the invention) and that firm-specific characteristics, such as the success rate or the ownership structure, do not play any role. In addition, cooperations between applicants seem to be an important factor in both stages of the model.

Moreover, the results show that the EPO's decision to grant a patent or not is more difficult to predict than what has been found in previous studies, reflecting a higher uncertainty of the decision process.

Implications for the strategic management of intellectual property rights can also be derived from the empirical model. Applicants should be aware of the market potential of their applications and use the appropriate application ways. Filling an application under the PCT treaty before sending the application to the EPO in order to gain more time is not necessarily a good strategy and can be costly for the applicants. In the same vein, the applicants should designate a limited number of countries in their EPO application, according to the market potential of their invention.

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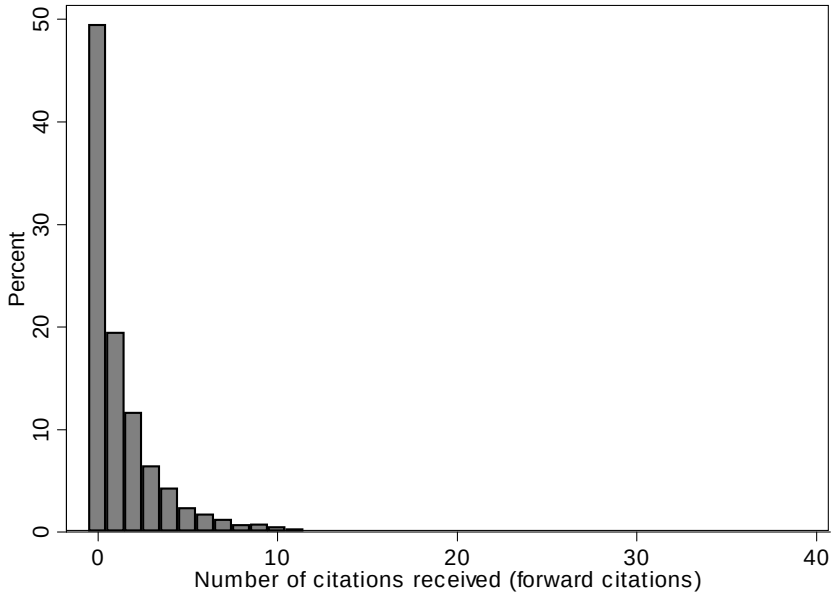
Appendix

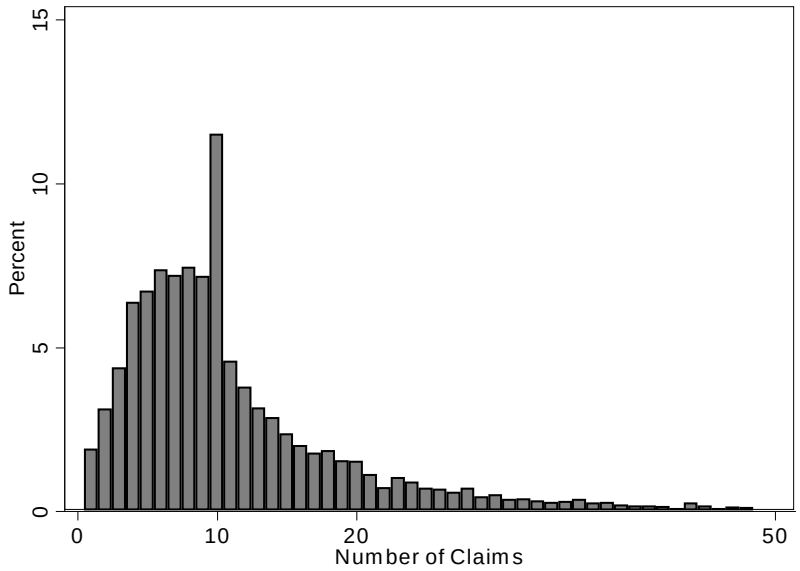
A Distribution of forward citations

Figure 4: Distribution of forward citations



B Distribution of the number of claims

Figure 5: Distribution of claims[2]



[2] The distribution is censorded when the number of claims is greater than 50.