The Outcome of Patent Applications - Does Experience Matter?

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2007

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October 30, 2007

Abstract

The aim of this paper is to study the determinants of the outcome of patent applications (withdrawal, refusal or grant). The application process at the European Patent Office (EPO) is modelled in three stages, using a Trivariate Probit model with double selectivity correction in order to test whether the applicant's patenting history has an effect on the outcome of the current application. I investigate the behavior of the applicant after the patent office has established the "state of the art", a precondition to an invention being patentable. The main results of the paper are that (i) Experienced applicants behave differently than unexperienced ones. Firms having large patent portfolios follow a "trial and error" strategy by applying for large numbers of patents and stay the course only when the expected probability of grant is high, (ii) there is no evidence for declining quality of patent examination once observable characteristics related to the "quality", the value or the cost of applications are controlled for and (iii) the outcome of prior art search by the EPO is a critical driver of applicants' behavior and of the propensity of the patent office to grant the patent or not.

Keywords: patents, intellectual property rights

JEL: O31, O32, O34

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Acknowledgments: Financial support from the Danish Research Council (Statens Samfundsvidenskabelige Forskningsråd) under the research project "Human Capital, Patenting Activity and Technology Spillovers" is gratefully acknowledged. A first draft of this paper was written while I was visiting the University of Tel Aviv. I thank the host institution and Manuel Trajtenberg for useful comments and numerous discussions. I am indebted to the Danish-Israeli foundation (Dansk-Israelsk Studiefond til minde om Josef og Regine Nachemsohn) and to the Research Foundation at the University of Southern Denmark (Syddansk Universitets Forskningsfond) which made this stay possible. This paper benefited greatly from inputs by Ulrich Kaiser and François Laisney. In addition, I thank Dietmar Harhoff, Thomas Rønde, Bruno Van Pottelsberghe, Stefan Wagner and EPO staff members Alejandro Flores Jiménez and Bettina Reichl for helpful comments, as well as the audience at the first annual conference of the EPIP Association and seminar participants at Inno-Tec, University of Munich. I also thank Marie Ebbensgaard, Søren Johansen and Lars Frederik Scharling for helpful research assistance and Karin Hoisl who provided me with the EPO/OECD citations database.

1 Introduction

A surge in patenting took place in the early 1990s 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 increased volume of patent applications, documented in e.g. OECD (2004), raises doubts about patent offices' capacity to maintain high examination standards. This issue is crucial, given the impact of patents on innovation and on firms' competitive strategy.

However, very little is known about the inner workings of patent offices and even less about the behavior of patent applicants throughout the procedure. There are at least two reasons. First, before the 2000 reform in the US, only granted patents were disclosed at the USPTO whereas all patents that were withdrawn by the applicant or refused a grant by the patent office remained secret. The second reason is the difficulty to access procedural data and specific patent-based information. In this paper I take advantage of a newly created dataset recently made available by the EPO and the OECD containing detailed information on the allocation of citations to all patents applied for at the EPO, that I merged with procedural data of patents applied for by Danish firms at the EPO.

Recent research shows that the use of patents has changed dramatically in the past decade (see for example, Hall and Ziedonis, 2001, 2007 or Lerner, 2007), with firms applying for an increasing share of marginal inventions. There is also a good deal of anecdotal evidence suggesting that some applicants try to obtain patents of dubious merit[1], and given the possible impact of these changes on the overall "quality" of patent examination, one can legitimately wonder what the consequences for applicants and patent offices are.

The aim of this paper is twofold. The first more general objective is to identify the main factor that determine the outcome of a patent application at the EPO. The second motivation is to conduct an exploratory investigation the behavior of patent applicants at the different stages of the application procedure in order to test whether experienced applicants behave differently throughout the procedure.

Within the EPO procedure, the patent office establishes the state of the art by issuing a search report that contains a list of prior art. The applicants then have the possibility to withdraw their applications if they consider that the search report is negative, i.e. if it contains evidence that the claimed invention is not novel or does not involve an inventive step, or to maintain it if their expected probability of getting a grant is high. Substantial examination follows if the application is maintained until the patent office makes its final decision. The EPO procedure differs from the USPTO and the JPO, in which the search and substantive examination are undertaken in one phase.

In this paper, the outcomes of the patent procedure are modeled by taking into account

[1] The "one-click patent" obtained by amazon is probably the best known example.

the sequential aspect of the applicant's and patent office's decisions within an econometric framework using a Trivariate Probit Model with double selection. In addition, applicants heterogeneity and patent citation measures are taken into account by using a database linking patents, citations and firms data, where earlier work only studied the effect of patent-based variables.

The main results of the paper are that (i) Experienced applicants behave differently than unexperienced ones. Firms having large patent portfolios follow a "trial and error" strategy by applying for large numbers of patents and stay the course only when the expected probability of grant is high, (ii) there is no evidence for declining quality of patent examination once observable characteristics related to the "quality", the value or the cost of applications are controlled for and (iii) the outcome of prior art search by the EPO is a critical driver of applicants' behavior and of the propensity of the patent office to grant the patent or not.

Section 2 briefly summarizes the application process at the EPO. Section 3 presents the economic background; the data are introduced in Section 4, while Section 5 describes the variables used and Section 6 provides summary statistics. The empirical model and the results are presented in Section 7, which is followed by concluding remarks.

2 Application process, outcomes and cost of patenting at the EPO

I first describe the application procedure at the EPO and then the associated costs.

2.1 The patent application process

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. The EPO system allows the applicants to choose the jurisdictions, among the contracting states of the EPC, in which protection is sought for. Thus, a patent provides 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 previously been applied for at a national patent office, within twelve months after the first application (priority application).

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

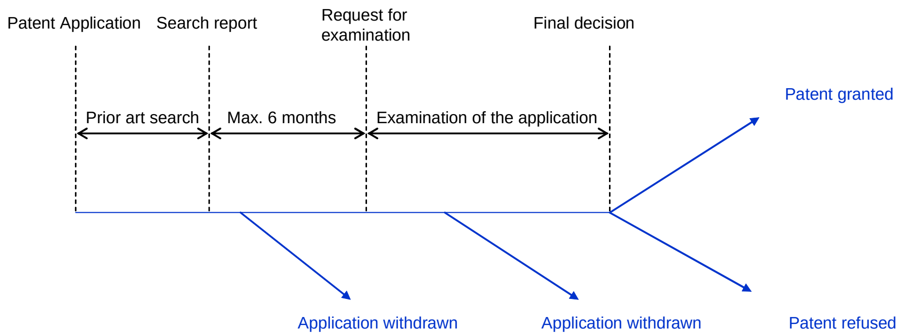

Figure 1 provides a simple presentation of the application process at the EPO. The application is published 18 months after the European or national priority application was filed. A search report describing the state of the art is published either with the application or later on. It contains references to prior patents or scientific publications, classified in different categories according to their relevance for the final decision. After the search report is published, applicants have six months to decide whether or not to pursue their application by requesting substantive examination. If no request for examination is filed within the six months, or the renewal fee or any other fee were not paid in due time the application is *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 contains evidence that the claimed invention is not novel, or does not involve an inventive step, 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*. Yet, a request for examination does not necessarily lead to a final *grant/refusal* decision by the EPO, in the sense that the applicants still have the possibility to withdraw their application after having requested examination[2]. Under examination, applicants receive additional information on the patentability of the invention and can then choose whether to withdraw the application, or to wait until the EPO's final decision.

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 filing, if it is consecutively renewed.

[2]I thank Stefan Wagner for pointing this fact out.

If the applicants seek patent protection in several countries, they have the possibility to file an application under the Patent Cooperation Treaty (PCT, effective since the early 1980s), to be filed at the World Intellectual Property Organization (WIPO). Since a large share of applications in this study are filed under the PCT, it is worth describing the procedure briefly. The PCT is an international agreement for filing patent applications having effect in all designated countries. Although the PCT system does not provide for the grant of an international patent, it does simplify the process of filing patent applications. Under the PCT, an inventor can file a single international patent application in one language, with one patent office in order to simultaneously seek protection for an invention in up to 183 countries. Such a procedure gives the applicant more time to decide whether or not to apply for the patent and in which of the 183 PCT member countries. Our database contains PCT applications in which the applicants have designated the EPO, so called "Euro-PCT" applications.

Chapter I of the PCT procedure consists of 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 (1) transfer the application to national or regional patent offices among those designated in his application, (2) elect an International Preliminary Examination, or (3) withdraw the application.

Chapter II of the PCT procedure comes into play once the international preliminary examination is chosen by the applicants. If the Euro-PCT application is transferred to the EPO, the outcome of the preliminary search report is taken into account.

As indicated by Harhoff and Wagner (2005), a PCT filing can be advantageous for the following reasons: (1) it allows the expansion of patent protection to a large number of countries without incurring the full costs and complexity of national application paths, (2) the applicant receives 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 and (3) it allows the applicant to delay decisions about the number of designated countries up to 30 months after the priority date, which is helpful if the value of the invention is uncertain for the applicant.

2.2 The cost of patent applications

The cost an applicant incurs throughout the whole patenting procedure is an important factor for the decision to maintain or terminate the application. The applicant will maintain the application in the process as long as the prospects for future profits are greater than the cost of the application. Thus it is worth mentioning the main components of the cost of a patent application at the EPO. However, given the variety of situations an applicant can face and the complexity of the procedure, this cost can hardly be summarized with a single figure. In this subsection, I give a brief overview of the fees an applicant will have to pay at the different stages of the application procedure.

The nature of the fees and costs can be divided into three categories:

- **Pre-filing costs** comprise all the elements related to the drafting of the first application.

- **Procedural fees** have to be paid once the application has been filed at the EPO. These costs are summarized in Table 1 and do not include the administrative costs an applicant can be asked to pay.

Table 1: Procedural fees

Nature of fee		*Amount (€)*
Filing fee *		90.00
Search fee		690.00
Designation fee **		75.00
Renewal fee for the application	3rd year	380.00
	4th year	405.00
	5th year	430.00
	6th year	715.00
	7th year	740.00
	8th year	765.00
	9th year	970.00
	>10th year	1,020.00
Examination fee		1,430.00
Grant fee ***		715.00

* if filed online, € 160.00 otherwise
** per contracting designated state, up to seven countries
*** incl. printing up to 35 pages, €10.00 per additional page
source: "Schedule of fees and costs", supplement to official Journal OJ EPO 2/2005

Notice that this schedule only applies to "Euro-direct" applications. If the application has been applied through the PCT route, additional fees have to be paid. For example, the fee for the preliminary examination of an international application is € 1,530. The same applies if the patent was applied for at a national patent office prior to the EPO application. The applicant also has the possibility to hire a patent attorney or a legal representative for guidance throughout the procedure which leads to additional expenses.

- **Post-grant costs** are probably the most expensive part of the procedure. Once a patent is granted by the EPO, the applicants have to translate the document in each official language of each designated state. Van Pottelsberghe and François (2006) estimate this cost at about € 1,700 per language. In addition, the patent has to be enforced and maintained in each jurisdiction by paying the renewal fees in each of them.[3]

Van Pottelsberghe and François (2006) estimate that the procedural and translation cost of the "average" patent that designates three countries (the UK, Germany and France) is € $8,070$. The same patent that designates 13 countries will cost about € $20,175$. These figures can be compared to the cost of application (excluding renewal fees) at the USPTO (€ $1,856$) and at the JPO (€ $1,541$).

It is difficult to quantify the cost of application at the EPO with accuracy. Thus, in the analysis, I will use indirect measures such as the number of designated states, PCT applications, number of claims or if a patent attorney acted as a legal representative.

3 Background

3.1 Literature background

As mentioned in the introduction, literature on the inner workings of patent offices is scarce. Van Dijk and Duysters (1998) find that, not surprisingly, basic research, which explores more novel and unknown paths, meets the patentability requirement more often, whereas Guellec and Van Pottelsberghe (2000, 2002) show that some patent specific characteristics like for example application ways can partly explain the probability to get a grant. Harhoff and Wagner (2005), Popp et al. (2004) as well as Régibeau and Rockett (2007) study the duration of patent examination, in order to test whether "important" patent are processed faster by the patent office and find contradictory results. Cockburn et al. (2002) study the relationship between patent examiners characteristics and litigation outcomes. One of their main finding is that there is no effect of examiners experience or workload on the probability that the patent will be found invalid in lawsuit.

The usual way to model patenting behavior in economic theory is to consider two or more firms "racing" for an invention. The winner of the race will then patent the invention, that is assumed to be granted with probability one. However, the outcome of a patent application is essentially the result of a strategic interaction between the patent office and the applicant. Literature on the strategic interaction between applicants and patent offices in the theoretical literature is meager too. For example, Langinier and Marcoul (2007) study such a model allowing the applicant not to reveal all prior art in order to increase the probability to be granted a patent, whereas Caillaud and Duchêne

[3] These renewal fees have to be paid separately in each designated state after a grant by the EPO in addition to the renewal fees for the application. The payment of the latter ends once the application is granted, withdrawn or refused.

(2006) assume that the overload problem of the patent office leads examiners to make erroneous judgment, issuing patent on low quality inventions. Régibeau and Rockett (2007) assume that the applicant maximizes its private profit, while the patent office maximizes a social welfare function. In their model, the decision made by the patent office is imperfect, in the sense that there is a probability of erroneous judgement, i.e., that the patent office confers patent protection to a invention that is not novel or that the patent office rejects an application that meets the patentability requirements. The probability of error is a decreasing function of time, as longer examination periods enable more thorough reviews, lowering the probability of error that will enter the firm's profit function.

To explain early or late withdrawals, one could think that the distance between the actual quality of the invention and the quality standard set by the patent office enters the erroneous judgement function. The higher this distance is, the easier it is for the patent office to demonstrate lack of novelty or inventive step. The actual quality of the application is however observed with some noise by the patent office, which might be influenced by its capability to perform efficient searches and examinations or by the desire of the applicant to hide the true potential of the application. In some cases, unexperienced applicants might even be unaware of the quality of their own inventions, compared to the quality standard of the patent office.

In that event, applicants might withdraw their applications because the search report demonstrates that conflicting prior art exists. These early withdrawals take place when the quality of the invention is low compared to the patent office's standard.

If the lack of novelty is more difficult to demonstrate, possibly because the applicant tries to hide the true quality of the application, substantial examination will be requested, where the firm gets additional information on the patentability of the invention and updates the expected probability of grant. In this scenario, the application will be maintained as long as the probability of erroneous judgment enables positive private profits.

3.2 Uncovering the process through which experience in patenting affects the current outcome

A variety of studies have explored the impact of experience on different economic variables. There is a substantial literature that shows that new firms suffer from a liability of newness (Delmar and Shane, 2006). For example Peters (2007) shows that innovation experience enhances significantly the probability to innovate in the future while Kaiser and Kongsted (2007) and Roberts and Tybout (1997) show that firms' past export behavior has a strong and positive effect on the current export status of firms.

Does this type of reasoning also apply to patenting activity? Are experienced applicants more successful with their current applications? Given the complexity of the patenting procedure and the cost of a patent application one could hypothesize that experienced applicants can benefit from prior patent applications. As any new economic activity, applying for a patent can be "learned" and implies specific costs. A common explanation for the effect of experience on any type of economic activity is the presence of sunk costs. Theory predicts that in the presence of sunk investments, current performance is affected by prior experience (Dixit, 1989). If a firm decides to start some patenting activity, it has to incur costs that cannot be recovered, by, for example setting up an IP department, or by training and hiring IPR personnel (lawyers, representatives, etc). Thus, these sunk costs will represent risky investments for unexperienced firms since success is uncertain.

Other explanations of the effect of past applications, might be that applicants 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, or that they have created informal networks at the patent office and are receiving a favorable treatment due to these social ties to the patent office. Finally, experienced applicants might be more successful because they know the relevant prior art in the area they are active in.

4 Data sources

The data was compiled from four main sources:

1. The **CEBR patent database** contains all the patents applied for by at least one Danish firm at the EPO since the creation of the EPO in 1978 and up to 2003. The initial database contains 12,109 patent applications. A major advantage of this database is that a unique firm identifier has been attached to the patent assignees, the so-called “CVR” number (central firm registry number) 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 identify 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 have been assigned unique identification 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** 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** provides 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/. This dataset is described in detail in Bennedsen et al. (2006)

4. Finally, 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 (the number of citations received from subsequent patents) 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.

5 Variables

The dependent variables and explanatory variables are described in turn.

5.1 Dependent variables

All dependent variables are binary. The purpose is to explain both the decision to withdraw an application, after search report and during examination, or to maintain it, and the subsequent decision made by the patent office to grant the patent or not. The application procedure outlined in Section 2 shows that withdrawals can take place before or during the substantial examination phase. These decisions might be driven by different factors, thus they are going to be analyzed in different equations.

My empirical model considers three dependent variables of which the final decision by the EPO is observed if the application has not been withdrawn during examination, which in turn is conditional upon a request for examination after the search report has been received by the applicant.

Request for Examination/withdrawal after search report. This variables takes the value 1 if the applicants have requested for examination and 0 if the application was withdrawn before examination.

Final decision/withdrawal during examination. For each patent application, we know whether the applicant decided to maintain it until the EPO makes a final decision, or to withdraw it. The variable takes the value 1 if the application is maintained and 0 if it is withdrawn during examination.

Decision of the EPO. If the applicant indeed decided to maintain the application, we observe the decision by the EPO to grant (= 1) or to refuse (= 0) the patent.

5.2 Explanatory variables

This section introduces the explanatory variables used in the multivariate analysis, as well as the expected effects of experience and control variables on the outcome of patent applications.

5.2.1 Experience variable

The purpose of this paper is to evaluate the effect of patenting history on the outcome of current applications. In particular, I would like to test first whether applicants with a bigger patent applications portfolio have a higher probability to be successful. Second, I want to assess whether experienced applicants have different strategies than unexperienced ones throughout the procedure. Thus, the main explanatory variable will be:

Stock of patent applications. The effect of this (lagged) stock variable with declining balance depreciation will be tested. The variable is constructed using the perpetual inventory method and is defined as:

$$A_{it} = (1 - \delta)A_{it-1} + N_{it} \tag{1}$$

Where A_{it} is the stock of applications of firm i at time t, N_{it} is the number of patents applied for by firm i at time t and δ is the depreciation rate of the patent stock from year $t-1$ to year t. As noted by Czarnitzki et al. (2005), the use of a depreciation rate is justified by the fact that knowledge tends to decay or become obsolescent over time, losing economic value due to advances in technology. We will make the usual assumption that $\delta = 15\%$, see for example Hall (1990). In case of multiple applicants, the sum of the stocks of the collaborating firms is taken.

A similar variable has been used in Lanjouw and Schankerman (2004) in an empirical model of patent litigation in the US. The authors use the portfolio of granted patents, while in this paper I use the stock of all patent applications made by a given firm, since the hypothesis is that something can be learned even from unsuccessful prior applications.

5.2.2 Control variables

Following the literature on patent "quality", instrinsic attributes of the patent and the underlying technology need to be controlled for. In principle, applications with a higher quality should have better chances to be granted and if not, should be abandoned less quickly by the applicant as shown by Harhoff and Wagner (2005). I only include "time-zero" value correlates in the analysis in order to avoid endogeneity problems. "Time-zero" variables reflect either the perception of the value of the invention that the applicant has or the assessment of the "quality" of the invention that the patent office makes *at the time of the application.* These variables are:

Number of citations made (backward citations). The search report issued by the EPO lists all the documents regarding prior art that are relevant for the examiner's decision on patentability. Harhoff et al. (2005) describe in detail how to use citations assigned to EPO patents. Empirical evidence tend to confirm a positive impact of backward citations on the "quality" or the private value of a patent (Gambardella et al, 2006).

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

- The number of "type X" citations. References classified in this category indicate that the claimed invention cannot be considered to be novel or cannot be considered to involve an inventive step when the referenced document is taken alone.
- The number of "type Y" citations, indicating that the claimed invention cannot be considered to involve an inventive step when the referenced document is combined with one or more other documents of the same category, such a combination being obvious to a person skilled in the art.
- The number of "type D" citations, referring to patent references already mentioned in the description of the patent application and approved by the examiner. Harhoff et al. (2006) report that only 7.5% of all citations are classified in this category.

It is obvious that a high number of type X and type Y citations reflects a negative search report, since they imply that the invention is not novel or less "radical", which is expected to lead the applicant to withdraw the application or the patent office to refuse the grant.

Type D citations are references already mentioned by the applicant when the application was submitted. This type of citations could reflect the fact that the applicant has a good command of prior art. The probability to maintain the application up to the final decision is expected to increase with the number of type D citations.

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 for 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 a measure of the complexity of the invention (Harhoff and Wagner, 2005).

Number of claims. In the same way as 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 (2004).

Both these variables can thus be interpreted in contradictory ways, as each additional claim and/or IPC assignments could either mirror a broad patent by increasing its scope or breadth, or make the description of the invention more precise, narrow and specific, thus reducing the scope of the patent. However, theses two variables have been found to be "time-zero" value indicators.

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)[4]. Harhoff et al. (2003) and Lanjouw et al. (1998) show that family size is a patent value correlate.

The total number of designated states has been found to be a "time-zero" value correlate (like the number of IPC assignments and the number of claims, see above). This is very intuitive, since applicants have to pay an additional fee for each jurisdiction in which protection is sought for, thereby increasing the geographical scope of protection.

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 potential of their invention 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. In their analysis, Guellec and Van Pottelsberghe (2000, 2002) find that applications that went

[4] The EPO members 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)

trough the first part of the PCT application procedure only (PCT I for short) have a lower grant rate, which they interpret as an unclear market potential. They argue that applicants only want to benefit from the longer delay to decide in which jurisdictions to apply, whereas applicants going through the whole PCT procedure (PCT II) are more aware of the value of their inventions.

Legal Representative. Any applicant at the EPO may be represented by a professional representative on the list maintained to this purpose by the EPO (Art. 134(1) of the EPC), a legal practitioner (Art. 134(7) EPC)[5], or an employee (Art. 133(3) EPC), typically from the IP department. The employee(s) must work for the applicant and not for an economically connected company.

I introduce a dummy variable indicating wether the applicant had any legal representation. Although the effect of legal representation has not been investigated in the economic literature, it is expected to have a positive influence on the probability to maintain an application, as legal representatives are familiar with the procedure.

Ownership structure. I introduce dummy variables which indicate the legal form of each firm involved in the application, in order to control for this type of firm specific heterogeneity. These dummies can, to some extent, also be interpreted as a proxy for firm size, but there are strong within differences.

Large firms, in our case stock listed firms, are expected to have a higher propensity to pursue their applications, since such firms have more resources and typically have an IP department.

6 Descriptive statistics

6.1 Outcomes of the patent applications

The number of Danish patent applications has been steadily increasing since 1978, following a trend at the EPO level, see Kaiser et al. (2005). A major challenge related to this unprecedented increase in patent applications and increasing workload is to maintain high quality in patent examination.

Figure 2 presents the timing of the application process with the number of occurrences at the different stages. A patent grant is the most frequent outcome, followed by withdrawals during examination. Relatively few applications are directly refused a grant by the EPO.

[5] A legal practioner may act as representative if he/she fullfils the following criteria:
1. is qualified in one of the Contracting States,
2. has his place of business within such State, and
3. is entitled, within the said State, to act as a professional representative in patent matters.

Figure 2: Timing of the application process

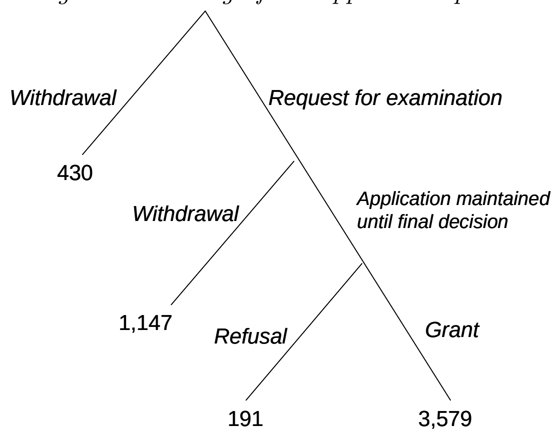

Figure 3 displays the distribution of the outcomes of the patent examinations by application years from the beginning of 1978 to the end of 1997. A majority of patent applications, 66%, is granted in the time window covering the application years of this study, from 1978 to 1997, while a relatively high number of applications, 29%, are withdrawn by the applicants. As pointed out by Harhoff and Wagner (2005), the withdrawal of a patent application generally occurs after the applicant received a "sufficiently negative search report or skeptical communication from the examiner". In addition, about 3.6% of all applications end up with a refusal. The 316 pending applications (for which the outcome is not known yet) are discarded from the analysis. The sample under consideration contains 5, 347 observations.

Figure 3: Distribution of outcomes

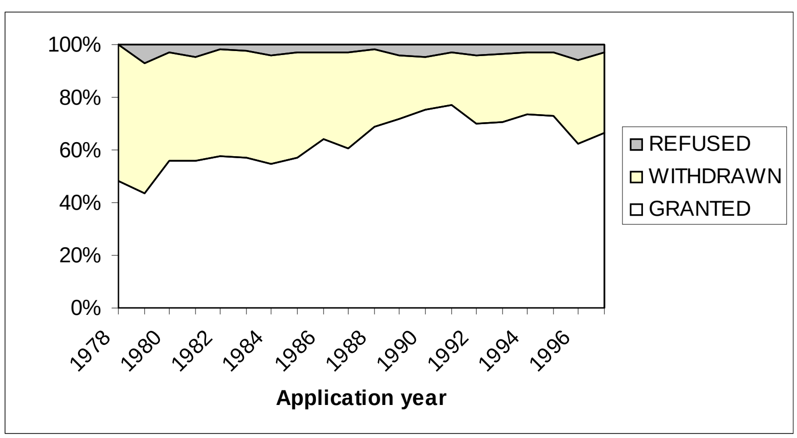

Table 2 summarizes the outcome of the applications between 1978 and 1997 by technology class, using the so called OST classification, provided by the "Office des Sciences et Techniques", the French Patent Office (INPI) and the Fraunhofer ISI Institute, which is based on a concordance with IPC classes. 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 63.8% in "mechanical engineering" (technology class V) to 69.9% in "Processing Engineering" (technology class 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, 69.7%, in "organic fine chemicals" (area 9), which is the area where the Danish patent applicants are most active in (446 applications) and in "Macromolecular chemistry, polymers" (area 10) in which the grant rate is 80.7% with 119 applications.

Table 2: Outcomes by technology areas

area	OST technology class	Granted (%)	Refused (%)	Withdrawn (%)	Total	% of total
	I Electricity - Electronics	**66.30**	**2.99**	**30.71**	**368.00**	**6.88**
1	Electrical devices - electrical engineering	65.87	3.59	30.54	167.00	
2	Audiovisual technology	71.43	3.81	24.76	105.00	
3	Telecommunications	69.64	1.79	28.57	56.00	
4	Information technology	51.52	0.00	48.48	33.00	
5	Semiconductors	42.86	0.00	57.14	7.00	
	II Instruments	**68.94**	**3.05**	**28.01**	**689.00**	**10.73**
6	Optics	71.11	6.67	22.22	45.00	
7	Analysis, measurement, control	65.64	3.37	30.98	326.00	
8	Medical engineering	72.01	2.20	25.79	318.00	
	III Chemicals, pharmaceuticals	**67.41**	**3.16**	**29.44**	**1,488.00**	**23.17**
9	Organic fine chemicals	69.73	3.59	26.68	446.00	
10	Macromolecular chemistry, polymers	80.67	1.68	17.65	119.00	
11	Pharmaceuticals, cosmetics	59.05	3.81	37.14	210.00	
12	Biotechnology	59.38	1.96	38.66	357.00	
13	Materials, metallurgy	76.47	1.31	22.22	153.00	
14	Agriculture, food	70.44	5.91	23.65	203.00	
	IV Process engineering	**69.86**	**3.37**	**26.77**	**919.00**	**14.31**
15	General technological processes	72.55	1.96	25.49	153.00	
16	Surfaces, coatings	51.72	3.45	44.83	29.00	
17	Material processing	71.13	3.78	25.09	291.00	
18	Thermal techniques	68.89	2.22	28.89	135.00	
19	Basic chemical processing, petrol	66.67	2.78	30.56	144.00	
20	Environment, pollution	71.86	5.39	22.75	167.00	
	V Mechanical engineering	**63.78**	**4.57**	**31.65**	**1,226.00**	**19.09**
21	Mechanical tools	65.55	5.04	29.41	119.00	
22	Engines, pumps, turbines	77.95	2.36	19.69	127.00	
23	Mechanical elements	62.77	5.19	32.03	231.00	
24	Handling, printing	63.24	3.78	32.97	370.00	
25	Agriculture & food machinery	58.33	5.95	35.71	252.00	
26	Transport	63.25	4.27	32.48	117.00	
27	Nuclear engineering	66.67	0.00	33.33	3.00	
28	Space technology, weapons	42.86	14.29	42.86	7.00	
	VI Other	**65.91**	**3.81**	**30.29**	**657.00**	**10.23**
29	Consumer goods & equipment	59.75	3.46	36.79	318.00	
30	Civil engineering, building, mining	71.68	4.13	24.19	339.00	
	Total	66.93	3.57	29.49	5,347.00	**100.00**

6.2 Firm-level data

There are 2,510 unique applicants in the dataset, on which information is summarized in Table 3 with respect to their ownership structure. Table 4 indicates the weight of each company form in the total number of patent applications. 34% of the firms in the dataset are stock listed limited companies (A/S), accounting for 64% of the patents applied. The database counts a high number of "persons" or private applicants (25.7% of the applicants) which are involved in 10.7% 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 or (iii) the applicant could neither be found by our manual nor by our automatic searches. Sole proprietorships, foreign (co-) applicants and private limited companies (ApS) follow. Notice that the legal form could not be determined for 1.4% of the applicants, corresponding to 0.7% of the applications. These firms were typically out of business by the time we made the search and 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 3: Firm structures - Number of unique applicants

Legal form	Number of firms	%
Limited company (A/S)	850	33.9
Person	645	25.7
Foreign firm (with no connexion to Denmark)	369	14.7
Sole proprietorship	283	11.3
Private limited compagny (APS)	246	9.8
Form unknown	35	1.4
General partnership (I/S)	29	1.2
Foundation (FON)	11	0.4
Public firm	8	0.3
Non-profit association	8	0.3
Cooperative with limited liability (AmbA)	7	0.3
Limited partnership (K/S)	5	0.2
Cooperative (AND)	4	0.2
Foreign firm-wich has registered a branch or place of business in Denmark	3	0.1
Branch of foreign limited company (FAP)	2	0.1
Insurance company (FAS)	2	0.1
Commercial foundation (ERF)	1	0.0
Company with limited liability (SmbA)	1	0.0
Limited partnership by shares (P/S)	1	0.0
total	2,510	100.0

Table 4: Distribution of outcomes by firm structure

Legal form	Number of patents	%	Granted (%)	Refused (%)	Withdrawn (%)
Limited company (A/S)	4,009	64.5	70.4	3.4	26.2
Person	666	10.7	56.6	4.1	39.3
Foreign firm (with no connexion to Denmark)	563	9.1	74.4	2.8	22.7
Private limited compagny (APS)	380	6.1	63.9	3.7	32.4
Sole proprietorship	347	5.6	59.1	4.6	36.3
Non-profit association	50	0.8	50.0	4.0	46.0
Form unknown	45	0.7	55.6	2.2	42.2
General partnership (I/S)	35	0.6	54.3	5.7	40.0
Public firm	33	0.5	84.8	0.0	15.2
Foundation (FON)	23	0.4	65.2	0.0	34.8
Foreign firm (wich has registered					100.0
a branch or place of business in Denmark)	17	0.3	76.5	0.0	23.5
Limited partnership (K/S)	15	0.2	73.3	0.0	26.7
Cooperative with limited liability (AmbA)	10	0.2	40.0	10.0	50.0
Cooperative (AND)	8	0.1	75.0	0.0	25.0
Branch of foreign limited company (FAP)	6	0.1	100.0	0.0	0.0
Limited partnership by shares (P/S)	5	0.1	20.0	0.0	80.0
Company with limited liability (SmbA)	3	0.0	33.3	33.3	33.3
Insurance company (FAS)	2	0.0	100.0	0.0	0.0
Commercial foundation (ERF)	1	0.0	0.0	0.0	100.0
total	6,218	100.0			

6.3 Experience and outcome of the patent application: non-parametric evidence

Since the relationship between experience and outcome of the patent application is central in our analysis, it deserves further attention. An advantage from having applied for patents at the EPO in the past is expected. One may therefore expect patenting history to affect the applicants' chances of getting their patents granted. I will study the effect of application portfolios, as a measure of firms' experience.

The relationship between the stock of applications and the outcome in Table 5 is not clear. The grant rate increases with the stock of applications up to a certain threshold and then decreases, while the refusal rate decreases steadily. This issue will be discussed in Section 7.2, together with the other results.

Table 5: Applications stock and incidence on outcomes

	Outcome			
Application stock	Grant	Refusal	Withdrawal	Total
0	1,083	77	695	1,855
	58.4%	*4.2%*	*37.5%*	*100.0%*
(0, 10]	1,242	69	431	1,742
	71.3%	*4.0%*	*24.8%*	*100.0%*
(10, 100]	846	29	189	1,064
	79.5%	*2.7%*	*17.7%*	*100.0%*
>100	408	16	262	688
	59.5%	*2.3%*	*38.2%*	*100.0%*
Total	3,579	191	1,577	5,347
	66.9%	*3.6%*	*29.5%*	*100.0%*

Pearson chi2(6) =184.1900 Pr = 0.000

Pearson's Chi squared test, given at the bottom of the table, rejects the hypothesis of independence between applications stock and outcomes. Thus, there seems to be a relationship between applicants' patenting history and the outcome of the focal application.

6.4 Explanatory variables

Summary statistics for all variables used in the analysis are presented in Table 6. Firms have, on average, 44.5 applications in their stock. However, the median, 1.99, indicates that the distribution is highly skewed and that large application portfolios are owned by few firms. The number of patent references ranges from 0 to 26, with, on average, 0.83 type X citations, 0.55 type Y citations, and 0.16 type D citations per patent. The patents have on average two IPC assignments and 12.57 claims. The applicants typically designate about eleven states. 16.3% of all applications went through the PCT Chapter I procedure and 48.6% through Chapter I and II. The number of claims ranges from one to 170.

Table 6: Descriptive statistics

	All applications				
Variables	**mean**	**sd**	**min**	**max**	**median**
Stock of applications	44.55	103.14	0	510.84	1.99
Backward citations	4.22	2.42	0	26	4
Backward citations=0	2.15%		0	1	
Number of type X citations	0.83	1.50	0	17	0
Number of type Y citations	0.55	1.24	0	20	0
Number of type D citations	0.16	0.54	0	6	0
Number of IPC assignments	2.09	1.19	1	6	2
Number of claims	12.57	11.94	1	170	10
Number of designated states	11.28	4.17	2	18	11
PCT Chapter I only	16.3%		0	1	
PCT Chapter I & II	48.6%		0	1	
Legal representative	87.8%		0	1	
Number of observations			5347		

Table 6 (continued)

	Applications withdrawn after search report				Applications withdrawn during examination				non-withdrawn applications			
Variables	**mean**	**sd**	**min**	**max**	**mean**	**sd**	**min**	**max**	**mean**	**sd**	**min**	**max**
Stock of applications	6.73	33.07	0	360.32	78.49	141.29	0	510.83	38.53	91.35	0	509.42
Backward citations	5.00	2.88	0	18	4.17	2.53	0	26	4.14	2.30	0	26
Backward citations=0	3.26%		0	1	3.31%		0	1	1.67%		0	1
Number of type X citations	1.00	1.90	0	17	0.97	1.62	0	15	0.77	1.40	0	12
Number of type Y citations	0.55	1.37	0	8	0.62	1.37	0	20	0.52	1.19	0	15
Number of type D citations	0.10	0.42	0	4	0.15	0.51	0	5	0.18	0.56	0	6
Number of IPC assignments	1.73	0.97	1	6	2.14	1.18	1	6	2.11	1.21	1	6
Number of claims	8.53	7.84	1	91	13.41	11.72	1	90	12.78	12.30	1	170
Number of designated states	9.20	3.69	2	18	11.753	4.41	2	18	11.37	4.08	2	18
PCT Chapter I only	46.9%		0	1	17.3%		0	1	12.5%		0	1
PCT Chapter I and II					52.2%		0	1	53.1%		0	1
Legal representative	43.8%		0	1	84.8%		0	1	94.0%		0	1
Number of observations		430				1147				3770		

The comparison between the groups of withdrawn and non-withdrawn applications shows interesting differences. The average stock of applications is surprisingly lower for non-withdrawn applications compared to the ones withdrawn under examination. A possible explanation is that there are strategic decisions involved. One could think that applicants with large applications portfolios apply for a high number of patents, possibly for the same invention, and wait for a final decision by the patent office only when the probability of grant is high, that is, when no conflicting prior art has been found and when positive information has been received from the examiner.

The average number of "type X" and "type Y" references are higher for withdrawn applications, whereas the number or forward citations is much higher for non-withdrawn applications.

Two other important variables seem to be the presence of a legal representative and PCT Chapter II applications. The number of IPC assignments, the number of claims and the number of designated states are higher for non-withdrawn applications, but the difference is very small.

7 Empirical analysis

7.1 Econometric specification

Suppose y_{i1}^* and y_{i2}^* are latent variables representing the expected net present (private) profits to the firms (or individuals) applying for patent i, after receiving the search report and during examination respectively. Moreover, assume that y_{i3}^* is the social welfare function that the patent office seeks to maximize. These variables are not directly observable. However, we can observe whether the applications are withdrawn or not and whether they are granted or refused by the patent office. Suppose that the latent variables are functions of observable value and quality characteristics of the patent (x_i) and an unobserved part (ϵ_i) assumed to be jointly normally distributed, which leads to a Trivariate Probit Model with Double Selection, an extension of the 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 also related to the applicants' choice to withdraw the application or not, prior to the patent office's decision. In this model, data on a variable y_3 (the EPO's decision to grant the patent or not) are observed only when another variable, y_2 (the applicants decision to request for the EPO's final decision or to withdraw the application) is equal to one, which in turn, is only observed when the third binary variable y_1 (the applicants decision to request for examination or to withdraw the application before the substantial examination phase) equals one. Formally we have:

$$
\begin{aligned}
y_{i1}^* &= \beta_1 x_{i1} + \epsilon_{i1},\ y_{i1} = 1 \text{ if } y_{i1}^* > 0, \text{ 0 otherwise} \\
y_{i2}^* &= \beta_2 x_{i2} + \epsilon_{i2},\ y_{i2} = 1 \text{ if } y_{i2}^* > 0, \text{ 0 otherwise} \\
y_{i3}^* &= \beta_3 x_{i3} + \epsilon_{i3},\ y_{i3} = 1 \text{ if } y_{i3}^* > 0, \text{ 0 otherwise}
\end{aligned} \tag{2}
$$

$$
\begin{pmatrix} \epsilon_{i1} \\ \epsilon_{i2} \\ \epsilon_{i3} \end{pmatrix} \sim N \left[\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho_{12} & \rho_{13} \\ . & 1 & \rho_{23} \\ . & . & 1 \end{pmatrix} \right]
$$

$$
(y_{i2}, x_{i2}) \text{ is observed only when } y_{i1} = 1
$$

$$
(y_{i3}, x_{i3}) \text{ is observed only when } y_{i2} = 1
$$

Thus, there are four types of observations with unconditional probabilities that need to be taken into account in the construction of the log-likelihood function:

$$
\begin{aligned}
L \quad = \quad & \sum_{y_1=0} \ln \Phi\left(-\beta_1 x_{i1}\right) + \sum_{y_1=1, y_2=0} \ln \Phi_2\left(\beta_1 x_{i1}, -\beta_2 x_{i2}, \rho_{12}\right) \\
& + \sum_{y_1=1, y_2=1, y_3=0} \ln \Phi_3\left(\beta_1 x_{i1}, \beta_2 x_{i2}, -\beta_3 x_{i3,} \rho_{12}, \rho_{23}, \rho_{31}\right) \\
& + \sum_{y_1=1, y_2=1, y_3=1} \ln \Phi_3\left(\beta_1 x_{i1}, \beta_2 x_{i2}, \beta_3 x_{i3,} \rho_{12}, \rho_{23}, \rho_{31}\right),
\end{aligned} \tag{3}
$$

where Φ, Φ_2 and Φ_3 denote, respectively, the univariate, bivariate and trivariate normal cumulative distribution functions, and the ρ_{ij} are the correlation coefficients between the error terms. The likelihood function is maximized with respect to the β_k and ρ_{ij} $(k, i, j = 1, 2, 3,\ i \neq j)$.

As Equation 2 suggests, sample selection arises because the observation of y_3 (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 under examination) and $y_1 = 1$ (the applicants request for examination). If the correction was not specified, the model would take into account the outcomes that are not feasible.

If all the $\rho_{ij} = 0$, the model can be estimated using three independent probit regressions. However, if the ρ_{ij} are significantly different from zero, using single equation estimates will generate inconsistent coefficients.

This model requires the evaluation of a trivariate normal density which is computationally intractable using numerical or analytical methods. One way to overcome this problem is to estimate the model by Maximum Simulated Likelihood using the GHK simulator, (see for example Gourieroux and Montfort, 1996 or Train, 2003). The GHK simulator is based on the Cholesky factorization of the covariance matrix, therefore, the only restriction that needs to be made is that the latter be positive definite.

In order to render the bias and noise induced by simulation negligible, I use 100 Halton draws. Draws derived from Halton sequences have the advantage of both improving coverage of the domain of integration and inducing a negative correlation between the draws from different observations, which are two desirable properties (see Train, 2003). Starting values were derived from three independent probit regressions.

Identification of the model requires exclusion restrictions. The grant/refusal equation is identified by excluding the "legal representative" dummy. Strictly speaking, the role of a representative is to help the applicant write the application document and to guide him/her through the application process, but a patent attorney cannot influence the final decision of the examiner.[6] In principle we cannot rationally exclude any other patent-based variable from the selected equations, since each of them might potentially affect the outcome at each stage of the model. The only variables that can be excluded from the final decision/withdrawal and grant/refusal equations but not from the first selection equation are the 30 technology dummies presented in Table 2. These variables account for differences across sub-fields and heterogeneity across these sub-fields might be relatively strong in the first stage, because of the different practices with respect to patent activity and different strategies and motives for filling an application. But once the application enters the substantive examination phase, this heterogeneity is expected to be much lower because examiners and applicants follow a standardized procedure. That's why, I only insert the 6 aggregated technology classes (also presented in Table 2) in the last two stages of the model.

Before turning to the results, I will discuss a potential caveat of this specification. The first decision (y_1) is fully tied to the payment of the examination fee (see table 1). However, the second decision (y_2,withdraw during examination or stay the course) does not only depend on the payment of a given fee. Table 1 shows that if the procedure takes more than three years, renewal fees have to be paid yearly, provided that examination was requested. Thus the decision problem of the applicant is not discrete and is in reality more complex than the one presented here. However, unreported results of an unconditional survival model give similar results to the ones discussed below.[7] The discrete modelling of this equation is favoured in order to keep the model tractable, thus the corresponding coefficients of the second equation should be interpreted as "overall" probabilities. Nevertheless, this specification is sufficient to answer the main question of this paper (does experience matter?) and the results of the different robustness checks

[6] In specifications in which this variable is included in the grant/refusal equation, the corresponding coefficient is indeed not significant.

[7] These results are available upon request.

provided in Section 7.3 corroborate those of this specification.

7.2 Results

Table 7 shows the result of the Trivariate Probit estimation. In this section, I discuss the implication of the estimation results for the set of hypotheses discussed in Section 5.2.

The stock of applications has a positive effect on the probability to request for examination in Table 7, while the effect is negative on the probability to pursue the application under examination and then positive again on the grant rate[8]. The intuition of this result is that firms with large portfolios proceed by "trial and error", meaning that they apply for a high number of patents (in the hopes of some issuing), maintain the applications until they receive full information on the patentability of the invention through the search report and informal communications (or negotiations) with the examiner and thereafter wait for a final decision only when the probability of grant is high. This is fully reflected by the positive effect of the variable in the third stage. The results suggest that experienced firms push the application as far as possible in the procedure and only wait for a final decision by the EPO when the chances to be granted a patent are high. From a social welfare perspective, this result does not suggest that experienced firms are able to obtain patents of dubious validity. My interpretation of this result is that experienced firms have an optimal application strategy in order to minimize their costs. In other words, they know better than unexperienced firms when the probability of grant of their applications is closer to one or to zero. This result shows that experience does indeed matter in the patent application process and that experienced applicants behave differently than less experienced ones.

Applications containing high numbers of type X citations tend to be withdrawn more often. This result is intuitive, given that this type of citations is 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. During examination the effect of X references is also negative (*final decision/withdrawal under examination* equation), as well as the Y references, which were insignificant at the first stage. This result suggests that applicants withdraw their applications after they receive the search report only when the existence of conflicting prior art is obvious (X references). On the other hand, applications for which the demonstration of the existence of damaging prior art is more subtle (Y references, that have to be combined with each other in order to

[8] A quadratic specification of the stock of applications leads to similar results, i.e., the squared term was non significant. Interactions between the stock of applications and the different ownership structures are insignificant too.

demonstrate conflict with prior art) are more likely to be withdrawn during examination, possibly because of communications between the examiner and the applicants. This means that information given to the applicant by the examiner is consistent with the results of the search report. In the *Grant/Refusal* equation, the number of type X citations, the most harmful to the novelty requirement, has a negative impact on the probability of grant, as expected.

D references (those already mentioned in the application) do not have a significant impact on any of the stages of the procedure. One reason, could be that, unlike at the USPTO, applicants do not have the legal "Duty of Candor" in disclosing prior art information. In other words, inclusion of references to prior art by the applicant is not mandatory, thus interpretation of the effect of this variable is not straightforward.

The technical characteristics (number of claims and number of IPC assignments) are insignificant in the grant/refusal stage, suggesting that the breadth of the application and/or the precision of the description of the claimed invention has no effect on the outcome.[9] However, applications containing more claims have a higher probability to go through examination, which suggests that these applications are abandoned less quickly.

Regarding the number of designated states, no significant effect is observed.[10] Time-zero value correlates have in general almost no effect on the application process. This result has strong managerial implications, since it could be a sign that applicants are either unaware of the potential value of their invention, or if they are aware, they do not act consequently.

This presumption is reinforced by the result on applications that went through the PCT procedure. PCT Chapter I applications are more likely to be withdrawn during examination, while PCT Chapter I & II applications have a positive impact at this stage. This confirms the results found by Guellec and Van Pottelsberghe (2002). PCT I applications have unclear market potential given that it provides the applicants with more time to decide whether to extend the right of the patents, whereas applicants who wait until their application reaches the Chapter II procedure are usually more aware of the market potential of the invention.

Professional representatives are found to be successful in pushing the application as far as possible in the procedure.

[9] A linear relationship between the number of claims and the outcome gave the same result.

[10] Different non-linear specifications have been tested regarding the designated states, following Guellec and Van Pottelsberghe (2000, 2002), with the same result.

Finally, regarding the ownership structures, the stock listed firms, typically big firms, are the only ones to carry a positive and significant effect, on the probability to wait until the grant/refusal decision. Publicly traded firms have typically less financial constraints and can thus be assumed to be less risk averse than other type of applicants.

These results highlight another interesting point. The year effects are not significant in the grant/refusal equation, which means that after controlling for observable firm and patent characteristics the average propensity to grant a patent did not vary over time.[11] This is a crucial question from a policy point of view, since concerns are currently expressed about the "quality" of the examination procedure given the rising workload of patent offices worldwide. There are empirical evidence suggesting that the USPTO has reacted to this increase in the demand for patents by allowing low quality patents to slip through the procedure (see Lemley, 2001), which led to an increase in the overall grant rate, while the (actual) grant rate at the EPO decreased from 1980 to 1989 and then remained fairly constant (see Martinez and Guellec, 2003). A variety of studies suggest that there is a decline in the standard of patent applications at the USPTO (see for example Harhoff and Hall, 2004 for a detailed discussion on this issue). On the basis of my results, one cannot conclude that the examination standards at the EPO weakened over time.

[11] The year dummies are significantlty positive in the first two equations from 1988 onwards in the *request for examination/withdrawal* equation and from 1978 to 1987 in the second stage of the model. Thus it seems that applicants tend to withdraw their applications on average later than before.

Table 7: Estimation results (1)

	Request for Exam./ Withdrawal		Final Decision/ Withdr. during exam.		Grant/refusal	
	Coeff.	S.D.	Coeff.	S.D.	Coeff.	S.D.
Experience variable						
Stock of applications	0.006***	0.001	-0.001 ***	0.0002	0.001***	0.0004
Patent characteristics						
Backward citations=0	-0.713***	0.207	-0.358***	0.140	0.034	0.260
Number of backward citations	-0.020	0.015	-0.004	0.010	0.001	0.017
Number of type X citations	-0.051**	0.022	-0.036***	0.015	-0.050 **	0.024
Number of type Y citations	-0.025	0.027	-0.058***	0.017	-0.002	0.028
Number of type D citations	0.014	0.064	0.024	0.040	-0.034	0.062
Number of IPC assignments	0.039	0.035	0.020	0.018	-0.018	0.029
Number of claims	0.012***	0.004	-0.000	0.001	0.003	0.003
Number of designated states	-0.002	0.009	0.001	0.005	-0.011	0.009
PCT Chapter I only	0.395***	0.102	-0.205***	0.071	-0.184	0.118
PCT Chapter I & II			0.223***	0.058	-0.159	0.099
Legal representative	2.228***	0.098	0.383***	0.102		
Ownership structure						
Stock listed firms	0.448***	0.183	0.457***	0.095	0.211	0.156
Persons	0.469***	0.181	0.075	0.094	0.126	0.153
Foreign firm	0.671***	0.179	0.081	0.066	0.101	0.113
Limited compagnies	0.171	0.192	0.211**	0.108	0.187	0.174
Sole proprietorships	0.685***	0.211	-0.021	0.106	0.067	0.171
Other type of firms	0.389**	0.199	-0.081	0.106	-0.055	0.170
Constant	-1.609***	0.324	-0.294	0.245	1.732***	0.326
Technology areas	30 sub-classes		6 areas		6 areas	
Bi-annual dummies	Included		Included		Included	
ρ12; ρ31; ρ32	-0.065 (0.188); -0.562 *** (0.185); -0.709 *** (0.183)					
Number of Observations	5.347					
Log-Likelihood	-4,100.872					

*** p<0.01, ** p<0.05, * p<0.1

7.3 Sensitivity analysis and robustness checks

The specification of the trivariate model described in the previous Sub-Section included the same set of patent characteristics in all equations. The assumption was that "valuable" inventions are more likely to be granted a patent. However, some of the indicators used reflect the private value of the invention *as perceived by the applicant*, which does not necessarily mean that these invention fulfill the patentability requirements. Thus, I estimate the trivariate model by excluding the number of claims, number of IPC assignments and PCT application variables from the *grant/refusal* equation. The results are reported in Table 8 and do not change significantly.

Table 8: Estimation results (2)

	Request for Exam./ Withdrawal		Final Decision/ Withdr. during exam.		Grant/refusal	
	Coeff.	S.D.	Coeff.	S.D.	Coeff.	S.D.
Experience variable						
Stock of applications	0.006***	0.001	-0.001 ***	0.0002	0.001***	0.0004
Patent characteristics						
Backward citations=0	-0.713***	0.207	-0.358***	0.140	0.031	0.262
Number of backward citations	-0.020	0.015	-0.004	0.010	0.002	0.017
Number of type X citations	-0.051**	0.022	-0.036***	0.015	-0.056 **	0.024
Number of type Y citations	-0.025	0.027	-0.058***	0.017	-0.010	0.028
Number of type D citations	0.014	0.064	0.024	0.040	-0.030	0.061
Number of IPC assignments	0.039	0.035	0.020	0.018		
Number of claims	0.012***	0.004	-0.000	0.001		
Number of designated states	-0.002	0.009	0.001	0.005		
PCT Chapter I only	0.395***	0.102	-0.205***	0.071		
PCT Chapter I & II			0.223***	0.058		
Legal representative	2.228***	0.098	0.383***	0.102		
Ownership structure						
Stock listed firms	0.446***	0.183	0.457***	0.095	0.234	0.161
Persons	0.467***	0.181	0.075	0.094	0.103	0.154
Foreign firm	0.670***	0.179	0.081	0.066	0.127	0.116
Limited compagnies	0.170	0.192	0.211**	0.108	0.201	0.177
Sole proprietorships	0.684***	0.211	-0.021	0.106	0.063	0.173
Other type of firms	0.387**	0.199	-0.081	0.106	-0.035	0.171
Constant	-1.607***	0.324	-0.292	0.247	1.626***	0.331
Technology areas	30 sub-classes		6 areas		6 areas	
Bi-annual dummies	Included		Included		Included	
ρ12; ρ31; ρ32	-0.079 (0.202); -0.657 *** (0.261); -0.593 ** (0.248)					
Number of Observations	5.347					
Log-Likelihood	-4,104.193					

*** p<0.01, ** p<0.05, * p<0.1

I also perform several robustness checks. Appendix C reports the result of a probit model of the probability to grant against the other outcomes (i.e. the two types of withdrawals and the refusals are pooled), one can see that it is much more difficult to define which effect is induced by which player and at which stage. Moreover, the application stock has an overall negative effect, which is difficult to interpret.

Withdrawals during examination can be interpreted as expected refusals, since applicants typically withdraw their applications once the examiner asserted that the application is likely to be refused a grant. In Appendix D estimates of a bivariate probit model with selection are reported, in which refusals and withdrawals that took place under examination are pooled, since the latter can be considered as refusals. In addition, I also perform an estimation in which the two types of withdrawals are pooled. The results do not change very much, but again, the overall negative effect of the stock of applications is difficult to interpret. The results in Table 7 show that the most "important" or valuable inventions are maintained until the EPO's final decision is taken, which suggests that refusals and withdrawals should be treated separately.

In Appendix E, I report the estimation results of an ordered probit model. The dependent variable is assumed to be ordered, because outcomes can be ranked with respect to their implications for the profits of the applicant, i.e., a refusal is assumed to be the worst outcome possible for the applicants followed by a withdrawal and a grant. There is no major difference with the models previously estimated, but again, the stock of applications carries a negative sign.

8 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 5,347 patent applications over the period 1978-1998 and applied a Trivariate probit model accounting for self-selection.

The applicants' patenting history, as measured by the stock of applications, is found to be an important factor in all stages of the application process, which shows that experienced applicants indeed behave differently than unexperienced ones. It seems that firms having large patents portfolios act following a "trial and error" strategy, by applying for large numbers of patents and thereafter maintain the application only when the expected probability of grant is high, leading to a positive effect of the size of the applications portfolio on the probability of grant.

The paper also investigates the determinants of the withdrawal decision of patent applications. The results show that the outcome of the search report is a crucial driver of the applicant and patent office's behaviors. Applicants tend to withdraw their applications when the result of the preliminary search report issued by the patent office is negative. Thus, the applicants update their information set after receiving the search report and if the expected probability of grant is low, that is, the search report shows evidence that the claimed invention is not novel, they tend to withdraw their application. Withdrawals also occur during examination, where the applicant can obtain additional information from the examiner regarding the patentability of the invention. The results show that this information is consistent with the results of the search report, since withdrawals are more likely to occur when conflicting prior art exists. A withdrawal can then be viewed as an expected refusal.

Other important results of the paper are the following:

- Time-zero value correlates have little explanatory power.
- After controlling for observable patent characteristics, we cannot conclude that examination standards at the EPO have been declining over time.

- the grant/refusal decision made by the patent office is more difficult to predict than earlier studies using an unconditional grant/other outcomes suggest.

From an economic policy point of view these results confirm the findings of Harhoff and Hall (2004), that the EPO maintained higher examination standards than the USPTO. In addition to the economic considerations, implications for the strategic management of intellectual property rights can also be derived from the empirical model. The fact that "time-zero" value indicators do not play a big role in explaining the final outcome could mean that applicants are either unaware of the potential value of their invention or that they do not act accordingly (i.e. they try to obtain a patent of dubious validity). The results also underline that applicants should be aware of the market potential of their applications and use the appropriate application ways and filing strategies. Filing 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 very costly for the applicants.

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Appendix

A Probit estimation

Probit model, probability to grant against all other outcomes

	Coeff.	S.D.
Experience variable		
Stock of applications	-0.001***	0.000
Patent characteristics		
Backward citations=0	-0.465***	0.128
Number of backward citations	-0.005	0.009
Number of type X citations	-0.063***	0.014
Number of type Y citations	-0.061***	0.015
Number of type D citations	0.050	0.037
Number of IPC assignments	0.028*	0.017
Number of claims	0.001	0.001
Number of designated states	-0.006	0.005
PCT Chapter I only	-0.101*	0.062
PCT Chapter I & II	0.376***	0.052
Legal representative	0.963***	0.066
Ownership structure		
Stock listed firms	0.498***	0.088
Persons	0.124	0.087
Foreign firm	0.141**	0.062
Limited compagnies	0.225**	0.099
Sole proprietorships	0.062	0.099
Others	-0.042	0.099
Constant	0.269*	0.163
Technology areas	6 areas	
Bi-annual dummies	included	
Number of Observations	5.347	
Log-Likelihood	-3,044.655	

*** p<0.01, ** p<0.05, * p<0.1

B Bivariate probit with selectivity

Here we estimate a Bivariate Probit Model with sample selection due to Van de Ven and Van Praag (1981). In this model, data on a variable y_1 are observed only when another variable, y_2 is equal to one. Formally we have:

$$\begin{aligned} y_{i1}^* &= \beta_1 x_{i1} + \epsilon_{i1},\ y_{i1} = 1 \text{ if } y_{i1}^* > 0, 0 \text{ otherwise} \\ y_{i2}^* &= \beta_2 x_{i2} + \epsilon_{i2},\ y_{i2} = 1 \text{ if } y_{i2}^* > 0, 0 \text{ otherwise} \\ &(\epsilon_{i1}, \epsilon_{i2}) \sim BVN(0,0,1,1,\rho) \\ &(y_{i1}, x_{i1}) \text{ is observed only when } y_{i2} = 1, \end{aligned} \tag{4}$$

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:

$$
\begin{aligned}
L = & \sum_{y_1=1,y_2=1} \ln\left[\Phi_2\left(\beta_1 x_{i1}, \beta_2 x_{i2}, \rho\right)\right] + \sum_{y_1=0,y_2=1} \ln\left[\Phi_2\left(-\beta_1 x_{i1}, \beta_2 x_{i2}, -\rho\right)\right] \\
& + \sum_{y_2=0} \ln\left[1 - \Phi\left(\beta_2 x_{i2}\right)\right], \qquad (5)
\end{aligned}
$$

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.

Bivariate probit with selectivity estimation

	Model 1				Model 2			
	Final decision/ Pooled withdr.		grant / refusal		Request for exam./ withdrawal		grant / (refusal or withdrawal)	
	Coeff.	S.D.	Coeff.	S.D.	Coeff.	S.D.	Coeff.	S.D.
Experience variable								
Stock of applications	-0.001***	0.000	0.001***	0.000	0.003***	0.001	-0.001***	0.000
Patent characteristics								
Backward citations=0	-0.480***	0.128	0.061	0.258	-0.912***	0.233	-0.302**	0.137
Number of backward citations	-0.006	0.009	0.003	0.016	-0.018	0.016	-0.003	0.009
Number of type X citations	-0.050***	0.013	-0.047**	0.022	-0.064**	0.026	-0.045***	0.014
Number of type Y citations	-0.064	0.016	-0.004	0.027	-0.078**	0.031	-0.051***	0.016
Number of type D citations	0.061	0.038	-0.042	0.063	0.214***	0.072	0.006	0.038
Number of IPC assignments	0.033*	0.017	-0.026	0.029	0.066*	0.039	0.012	0.017
Number of claims	0.000	0.001	0.004	0.003	0.003	0.005	0.001	0.001
Number of designated states	-0.002	0.005	-0.009	0.009	-0.001	0.011	-0.002	0.005
PCT Chapter I only	-0.072	0.063	-0.168	0.114	0.917***	0.117	-0.266***	0.068
PCT Chapter I & II	0.455***	0.054	-0.187**	0.094	3.296***	0.315	0.097	0.059
Legal representative	0.988***	0.064			2.818***	0.127	0.311***	0.089
Ownership structure								
Stock listed firms	0.463***	0.089	0.206	0.158	0.449**	0.205	0.471	0.092
Persons	0.089	0.088	0.135	0.157	0.311	0.204	0.103	0.091
Foreign firm	0.125**	0.064	0.126	0.115	0.760***	0.188	0.085	0.063
Limited compagnies	0.172*	0.102	0.195	0.178	0.188	0.221	0.251**	0.105
Sole proprietorships	0.033	0.101	0.088	0.176	0.472**	0.238	-0.007	0.102
Other type of firms	-0.039	0.100	-0.024	0.171	0.408*	0.222	-0.096	0.103
Constant	-1.101***	0.191	1.722***	0.324	-1.857***	0.365	-0.291**	0.220
Technology areas	6 areas				30 sub-classes		6 areas	
Bi-annual dummies	included				included			
ρ	-0.899 (0.154)***				-0.381 (0.138)**			
Number of Observations	5.347				5.347			
Log-Likelihood	-3,044.655				-3,418.312			

*** p<0.01, ** p<0.05, * p<0.1

C Ordered Probit estimation

Ordered Probit estimation

(0=refusal, 1=withdr., 2=grant)

	Coeff.	S.D.
Experience variable		
Stock of applications	-0.001***	0.000
Patent characteristics		
Backward citations=0	-0.370***	0.118
Number of backward citations	-0.003	0.008
Number of type X citations	-0.055***	0.012
Number of type Y citations	-0.049***	0.014
Number of type D citations	0.036	0.035
Number of IPC assignments	0.018	0.016
Number of claims	0.001	0.001
Number of designated states	-0.005	0.004
PCT Chapter I only	-0.083	0.058
PCT Chapter I & II	0.283***	0.050
Legal representative	0.662***	0.057
Ownership structure		
Stock listed firms	0.439***	0.083
Persons	0.125	0.082
Foreign firm	0.146**	0.059
Limited compagnies	0.217**	0.094
Sole proprietorships	0.060	0.093
Other type of firms	-0.025	0.092
Cut point 1	-0.667***	0.172
Cut point 2	0.784***	0.171
Technology areas	6 areas	
Bi-annual dummies	Included	
Number of Observations	5.347	
Log-Likelihood	-3,745.117	

*** p<0.01, ** p<0.05, * p<0.1