Modeling the Duration of Patent Examination at the European Patent Office

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Abstract

We analyze the duration of the patent examination process at the European Patent Office (EPO). Our data contain information related to the patent's economic and technical relevance, EPO capacity and workload as well as novel citation measures which are derived from the EPO's search reports. In our multivariate analysis we estimate competing risk specifications in order to characterize differences in the processes leading to a withdrawal of the application by the applicant, a refusal of the patent grant by the examiner or an actual patent grant. Highly cited applications are approved *faster* by the EPO than less important ones, but they are also withdrawn less quickly by the applicant. The process duration increases for all outcomes with the application's complexity, originality, number of references (backward citations) in the search report and with the EPO's workload at the filing date. Endogenous applicant behavior becomes apparent in other results: more controversial claims lead to slower grants, but faster withdrawals, while relatively well-documented applications (identified by a high share of applicant references appearing in the search report) are approved faster and take longer to be withdrawn.

Keywords: patents, patent examination, survival analysis, patent citations, European Patent Office

JEL Classification: C15, C41, D73, O34

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1 Introduction

The design of patent systems has recently become a major concern to public policy decision-makers. A number of prominent policy panels in the U.S. have recently studied the US patent system and have issued recommendations for patent examination and related issues.[1] One major question in this debate concerns the timing of and level of scrutiny employed in patent examination processes.[2] While patent systems are to some degree idiosyncratic due to the territorial nature of patent rights, important insights can nonetheless be learned from analyzing examination processes in different institutional and legal settings. Our study seeks to contribute to the current debate by providing a detailed analysis of the duration of examination processes at the European Patent Office (EPO). Together with the USPTO (U.S. Patent and Trademark Office) and JPO (Japanese Patent Office), the EPO belongs to the three largest patent offices worldwide. More than half of the applicants at the EPO come from non-European countries.[3] A study of EPO practices is therefore not only of relevance to scholars interested in patent system design in general, but also to European and non-European policy-makers and users of the EPO system.

In this paper, we seek to identify the major determinants of the duration of EPO decision-making processes. We consider three broad groups of factors that influence pendencies: the patent office's capacity and backlog of pending applications which reflect the workload relative to existing capacity; the complexity of the examination task at hand, including measures of the application's quality; and factors that may lead to de- or acceleration for strategic reasons.

The last two decades have seen a strong increase in patent applications at the EPO. Figure 1 shows the number of applications and grants filed at the EPO. The figure distinguishes between PCT (Patent Cooperation Treaty) applications and applications filed directly at the EPO. While the increasing demand for patent protection provides an important source of variation for our study, the figure also demonstrates that our analysis addresses an urgent policy need, as the EPO situation is typical for all major patent offices which are nowadays confronted with the question of how to find the right balance between precision of examination and the duration of patent examination.[4]

Given a certain level of demand for patent examination and a constant-quality policy as propagated at the EPO, one of the most obvious determinants of the duration

[1]See Federal Trade Commission (2003) and National Research Council (2004).

[2]See Lemley (2001), Cockburn et al. (2003) and Régibeau & Rockett (2003).

[3]See European Patent Office (2003, 22, Fig. 6).

[4]Examination at the USPTO and the EPO appear to follow very different philosophies with regard to application pendencies. The USPTO appears to view itself as a service agency with the mission of allowing patent applicants to obtain their patent rights as early as possible (Lemley 2001). The EPO, while also acknowledging its obligations towards its users and customers, in particular the group of patent applicants, insists that it needs to maintain high quality in patent examination. See European Patent Office (2005, pp.6-8)

of patent examination is the office's examination capacity. In the absence of adjustment costs, examination capacity should not play any role for the duration of examination processes. But typically, patent offices will not be able to adjust their search and examination capacities at short notice. For example, examiners in some mechanical field cannot be retrained quickly to examine patents in mobile telephony.[5] Moreover, experienced patent examiners cannot be hired quickly in the labor market either, since patent examiners typically have to undergo a training period of several years to become fully productive in a given technical field. Unanticipated growth in the demand for patent examination in a particular technical field is therefore likely to lead to increases in decision lags.[6] Clearly, within any longitudinal study of decision-making at the patent office, changes in the demand for patent examinations as well as examination capacity of the office should be taken into account. We do so by computing a measure of pending examination cases per examiner at the EPO. We date this information to the filing date of our patents.

A second major determinant of the duration of examination processes is the complexity and comprehensiveness of the individual examination task as well as the quality of the patent examination. We use the number of claims and various citation-based measures to operationalize the complexity of the patent examination task and the quality of the patent application. Our data reveal that over time the number of claims and the number of references to earlier patents and to non-patent literature have been increasing considerably. As to quality differences, we consider an application to have high quality if relatively many of its claims refer to novel elements in the invention and have high inventive step (non-obviousness), or if the applicant has written the application in a transparent way. Obviously, higher application quality would reduce the examiner's efforts, ceteris paribus. A high-quality application is likely to be approved faster by the examiner as quality of the application reduces the examiner's effort.[7] The quality measures used in the paper are again derived from citations in the EPO search reports. Our citation measures are particular informative since they make use of a classification scheme employed in EPO (and WIPO) search reports which indicates if the novelty and inventive step of claims in the application are affected by prior art. Taking these measures into account increases the fit of our models considerably.

We also include institutional indicators as third group of major determinants of the duration of EPO examination processes. Institutional heterogeneity is a consequence of the increasing use of PCT applications which require a somewhat different treatment than applications filed directly at the EPO (Euro-direct applications). In particular,

[5]Shortages in examiners in this area were apparently responsible in the late 1990s for increased pendencies at the EPO. See European Patent Office (1999, p. 26).

[6]The term 'lag' is used here as a neutral description and thus synonymous with the term 'duration'.

[7]We note in the paper that quality in itself is endogenous and that high quality will signal that the applicant is considering the effort of investing in application quality worthwhile - in other words, patent quality is likely to be associated with private patent value as well (see below).

PCT filings give applicants a longer time period to make decisions about important features of the actual application process, such as the countries for which patent protection is actually sought. Applicants also have more leeway to modify PCT filings than patents submitted directly to the EPO. Such modifications in the characteristics of patent applications pose an additional challenge to patent office personnel.

We also seek to answer the question if more important and valuable patents typically have longer pendencies than less important ones. The impact of patent value on durations is a complicated issue that has not been discussed properly in previous work. It is important to note that the relationship does not come about as a consequence of a conscious efforts on behalf of the examiner to treat potentially valuable patents differently from less valuable ones. The EPO's *Guidelines for Substantive Patent Examination* explicitly preclude examiners from taking economic considerations such as the value of the patent into account when performing the examination.[8] Rather, the relationship between value and pendencies stems from two other sources. First, the characteristics discussed before may have a systematic statistical association with value. For example, if broad patents are particularly valuable, but difficult to evaluate, there will be a positive relationship between value and duration. Even if we control for the number of claims, value may be correlated with unobserved aspects of patent complexity. Second, the relationship is complicated by the fact that the duration of examination is not just a function of examiner behavior, it is also affected endogenously by the applicant. The owner of a potentially valuable patent will be willing to spend considerable time and effort in the negotiation process with the examiner if the grant is at risk. Thus, we expect that the withdrawal of a potentially valuable application will tend to occur relatively late. Conversely, if the examiner is willing to grant the patent, the owner is presumably willing to accelerate the communication process. Following earlier studies, we use citation measures to approximate the private value of patent rights. We also argue that requests for accelerated examination indicate value and employ a dummy variable to capture this information.

There is controversy in the literature as to whether important patents are approved faster or slower than less important ones. Popp et al. (2003) argue that this is the case for USPTO-granted patents, while Régibeau & Rockett (2003) come to a different conclusion.[9] None of these studies can take selection effects into account since prior to the year 2000, all USPTO applications which did not lead to a patent grant remained secret. Therefore, in U.S. patent data, the population of applications filed at the patent office is unknown.[10] Hence, these studies are not able to control for the

[8] See `http://www.european-patent-office.org/legal/gui_lines/e/c.htm` for an online version of the guidelines. Latest visit March 26, 2006.

[9] Popp et al. (2003) analyze the duration of patent examination at the USPTO using a large data set across technical fields and application years. Régibeau & Rockett (2003) concentrate on patents covering genetically modified plants. For these patents, the authors have in-depth information on the patents' importance, scope and other characteristics.

[10] Since March, 29th, 2000, the USPTO is publishing patent applications under the eighteen-month

differential impact of patent characteristics on the competing durations of withdrawals, refusals and grants of patent applications. Our study explicitly estimates the duration of the processes leading to these different outcomes. A competing risk model of the durations is employed to account both for selection and heterogeneous effects of patent characteristics as well as other determinants on the competing outcomes. To the best of our knowledge, ours is the first study to do so.

To summarize our results, we find that the estimated hazard functions differ significantly across outcomes. We find that some of the coefficients reverse their signs across outcome equations in accordance with our expectations. Highly cited applications are approved *faster* by the EPO than less important ones, but they are also withdrawn *less quickly* by the applicant. The process durations increase for all outcomes with the application's complexity, number of references (backward citations) in the search report and with the EPO's workload at the filing date. Endogenous applicant behavior becomes apparent in several of our results: more controversial claims lead to slower grants, but faster withdrawals, while relatively well-documented applications (identified by a high share of applicant references appearing in the search report) are approved faster and take longer to be withdrawn. We use these results to discuss various implications for the design of fee structures and patent office capacity planning.

The remainder of the paper proceeds as follows. In section 2 of the paper the institutional background of the patent examination processes at the European Patent Office is set out in broad terms. Section 3 develops a qualitative notion of the determinants of the decision-making lags at the EPO. We start with a discussion of normative aspects which is complemented by a discussion of private incentives of patent applicants to delay or accelerate examination, and of the impact of legal rules at the EPO. In section 4, the data set used for the analysis is briefly described. It represents a random sample of all EPO applications filed from the start of EPO's operation on June 1^{st}, 1978 to July 25^{th}, 2003. Further, the variables constructed from the raw data are discussed. In section 5, a descriptive analysis of the duration data is provided before competing risk hazard rate models are estimated. In the multivariate analysis, we model the process durations relying on Cox's Proportional Hazard model. Section 6 concludes and states implications of the findings for future research and the current debate on patent policy.

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publication provisions of the American Inventors Protection Act of 1999 (AIPA). Applicants who only seek protection for their invention at the USPTO, but not in other jurisdictions, can be exempted from publication. Patent applications filed before that date are only published if they led to a patent grant and remain secret otherwise. See `http://www.uspto.gov/web/offices/dcom/olia/aipa/index.htm`, latest visit March, 24^{th}, 2005.

2 Institutional Background: Patent Applications at the European Patent Office

The EPO offers a harmonized application and examination path for applicants seeking patent protection in signatory states to the European Patent Convention (EPC). In an EPO application, the applicant designates the EPC member states for which patent protection is requested. To obtain patent protection in any of the EPC countries, applicants could alternatively seek to obtain patent grants directly from the respective national patent offices. However, the EPO application path is typically preferred over the individual national paths once the applicant seeks protection in more than three EPC countries, since the total cost of a European patent amounts to approximately EUR 29,800, roughly three times as much as a typical national application.[11]

Figure 2 provides a highly simplified presentation of the examination process of patent applications at the EPO. Once an EPO application has been filed, a search report is generated by the The Hague office of the EPO.[12] The search report describes the state of prior art regarded as relevant according to EPO guidelines for the patentability of the invention, i.e., it contains a list of references to prior patents and/or non-patent sources. Unlike in the U.S. system, applicants at the EPO are not required to supply a full list of prior art (see Michael & Bettels 2001, p. 191 and Meyer 2000*b*, p. 109). The search report is made public by the EPO typically with the publication of the application which takes place eighteen months after the priority date of the patent application (see Figure 2).[13]

Within 6 months after the announcement of the publication of the search report in the EP Bulletin, applicants may request the examination of their application.[14] If examination is not requested (which may be the case if the search report reveals considerable prior art that would make a patent grant seem unlikely), the patent application is *deemed to be withdrawn* according to Art. 94(3) EPC. The patent application may also be withdrawn explicitly. A withdrawal (explicit or implicit) of the application is one potential outcome of the application procedure.

In the actual examination process, the examiner determines whether the patent application has merit according to the patentability criteria at the EPO: novelty, in-

[11]See EPO notes on '*Cost of an average European patent as at 1.7.99*', http://www.european-patent-office.org/epo/new/kosten_e.pdf, latest visit October, 11th, 2006.

[12]The EPO has recently initiated a major change in its search and examination processes. Under the heading *BEST – Bringing Examination and Search Together* both processes are executed by one searcher/examiner (http://www.european-patent-office.org/epo/president/e/2003_05_08_e.htm, latest visit March, 16th, 2005). For the bulk of the data used in this paper, BEST was not used and search and examination were executed by at least two individuals separately.

[13]Note that the date of publication is often only six months after the application at the EPO, since many applicants choose to first file their application at one of the national offices before deciding to enter the European application path. They may do so within the priority year, so that the EPO publication frequently appears about six months after the application has been filed at the EPO.

[14]See Art. 94(2) EPC.

ventive step and industrial applicability. After an examination has been performed, the EPO either informs the applicant that the patent will be granted as specified in the original application or requires the applicant to agree to changes in the application. Once an agreement has been found between the applicant and the examiner, the patent is granted by the EPO. The applicant may then take the EPO decision to the national patent offices where the patent is issued for the respective designated state and is translated into the relevant national language.[15] During the examination process, the applicant may decide not to pursue the patenting effort since the prospect of actually obtaining a valuable patent may be weak. This outcome (*withdrawal*) is again reflected in the data. The EPO may decline to grant a patent as requested by the applicant. This *refusal to grant* is another potential outcome of the application process. The most frequent outcome with about two thirds of the cases is an actual *patent grant*. In rare cases, the patenting process is terminated because an independent inventor has deceased and the heirs do not pursue the application. In other cases, it is decided to merge the patent application with another one that was initially submitted. These cases account for less than 0.1 percent of all applications and we treat them as withdrawals.

Applications filed under the Patent Cooperation Treaty (PCT) require particular attention, since they now constitute a large share of all filings at the EPO and are subject to specific institutional treatments (see Figure 1). Strictly speaking, a PCT filing is not a patent application, but grants the filing party the option to launch patent applications in up to 133[16] PCT signatory countries within 30 months of the filing date (which becomes the priority date). Any patent application already filed can be turned into a PCT filing within the priority year. Figure 3 contains a simplified presentation of the PCT application path. PCT filings are advantageous for several reasons. First, they allow the expansion of patent protection to a large number of countries without incurring the full costs and complexity of national application paths. Second, 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. The search report is generated and published by one of seven ISAs (International Search Authorities) 18 months after the priority filing of the application (see Figure 3). Third, the PCT filing, when compared to a national or regional application[17], has greater option value, since it allows applicants to delay the choice of countries for which they designate the application for up to 30 months after the priority date. Costly decisions can thus be deferred for 30 months (and not just for the duration

[15]The issuing of EPO-granted patents by the national offices is referred to as validation.

[16]As of October, 2006 (see `http://www.wipo.int/treaties/en/ShowResults.jsp?country_id=ALL&start_year=ANY&end_year=ANY&search_what=C&treaty_id=6`, latest visit October, 11^{th}, 2006).

[17]National applications are filed at the respective national patent office. The term 'regional application' refers to filings at the EPO which is the granting authority for countries that have signed the European Patent Convention (EPC).

of the priority year, as with national and regional applications). PCT filings can also receive a preliminary international examination which is authoritive, but not binding for the national or regional offices finally examining the patent. Applicants have to file the demand for the international examination within 4 months after the publication of the search report. The World Intellectual Property Organization (WIPO) also claims that "(...) any patents subsequently granted by the national or regional Offices on the international application can be relied on by the applicant to a greater extent than would have been the case without the benefit of the international search report and the international preliminary examination report" implying a greater legal certainty for PCT applications than for other applications (World Intellectual Property Organization 2002). Finally, PCT applications are not subject to certain cost rules, e.g. claims fees as they exist at the EPO and the USPTO.

3 Theoretical Background and Hypotheses

In this section, we briefly describe potential determinants of the decision-making lags in EPO examinations and develop our hypotheses. We start by considering the relatively sparse theoretical literature and previous empirical studies in this field.

3.1 Previous Studies and Normative Issues

Many theoretical models in the industrial organization literature use the assumption of perfect or imperfect patent protection. This assumption allows researchers to come to a convenient and tractable *post*-invention market structure. For example, the classical patent race models developed by Loury (1979) or Lee & Wilde (1980) assume that a patent entitles the winner of the R&D race to full patent protection which is equivalent to some prize, while the losers will receive nothing (winner-takes-all). In some models (see, e.g., De Fraja 1993), the winner-takes-all assumption is relaxed in order to accommodate more realistic conditions under which even the second-in-place can earn some prize.[18] But irrespective of what is assumed in the industrial organization literature about the extent or potency of patent protection, the assumption that the patent unfolds its efficacy immediately has not been subject to a detailed and differentiated analysis. Moreover, the stochastic nature of the patent examination process is usually not taken into account.[19] Yet, the fact that applicants are facing a process with unknown duration and unknown outcome is likely to have some impact on their actual behavior. The anticipated behavior of the patent examiner even has direct im-

[18]For a more detailed survey of the literature see Tirole (1989, ch. 10) or Bester (2004, ch. 5).

[19]An important exception is the study by Lemley & Shapiro (2005) highlighting that 'a patent does not confer upon its owner the right to exclude but rather a try to exclude by asserting the patent in court'. In addition to the effect of uncertainty about the commercial significance the authors analyze the effect of uncertainty about the validity and scope of legal protection on the incentives to enforce and to litigate a patent.

plications on the way in which patent applications are drafted by patent attorneys. This is pointed out in a qualitative study of patenting behavior by Harhoff & Reitzig (2001).

A formal model of all trade-offs involved in determining the socially optimal duration of patent examination would be beyond the scope of this paper. However, important aspects of these trade-offs have been analyzed in recent work by Régibeau & Rockett (2003). They develop and apply a model to patent data covering subject matter related to genetically modified food. Régibeau & Rockett (2003) examine the relationship between the length of patent examination and the importance of inventions and specify a simple model of the patent approval process. A key feature of the model is that patent granting decisions are imperfect, but their precision can be improved by delaying the examination of the applications, as more information arrives costlessly over time. Hence longer approval delays make for better decisions.

In the model of Régibeau & Rockett (2003) firms can engage either in costless non-innovative projects or in costly innovative projects. They can apply for patent protection irrespective of the type of project pursued. Moreover, non-innovative as well as innovative projects are only profitable for the firms if patent protection is obtained. Since patent approvals are assumed to be imperfect, patents on non-innovative projects are granted with a certain probability which is negatively related to the duration of examination. Erroneous patent grants on non-innovative activities reduce social welfare. On the other hand, innovative projects are welfare enhancing irrespective whether the undertaking firm receives patent protection or not.

In this setting firms will engage in innovative (and welfare enhancing) activities only if the expected profits from innovations exceed their opportunity cost, i.e., the sum of the cost of innovation plus expected benefits from erroneously patented non-innovative activity. The model shows that an increase in the duration of patent examination increases social welfare since it lowers the probability of erroneously granted patents on non-innovative activity. This decreases the expected value of this kind of project and increases the incentive to engage in innovative activity. At the same time, increasing examination durations decrease the private value of innovative projects (which is also dependent on the importance of the underlying invention) since profits are realized only after the patent has been granted and have therefore to be discounted for a longer period of time.

Relying on this trade-off, Régibeau & Rockett (2003) find that controlling for a patent's position in the technology cycle, the optimal patent examination time decreases with the importance of the invention to be protected. Hence, one of the main findings from this model is that it is welfare enhancing if important patents are granted faster.

While the model of Régibeau & Rockett (2003) contains a comprehensive discussion of the trade-offs involved in determining an optimal approval delay, it does not cover some aspects which we consider important. These turn on the tradeoff between ex post litigation costs and ex ante dilutions of incentives due to delayed examination. In this context, one can ask which arguments would favor a very quick examination of patent rights (in the extreme case a mere registration system) versus a view in which it is advantageous to let some time pass in order to subject the patent to a thorough review, particularly in the light of new information that arrives some time after the application has been filed. The first argument that speaks in favor of (relatively) thorough examination of patents is that this process is presumably less costly – socially and privately – than litigation of patents. According to this view, patents serve to signal to patent holders and possible rivals an ex ante assessment of the actual distribution of rights that would be maintained even after litigation has taken place. The more 'robust' a patent is in the legal sense, the less necessity for litigation will exist. With a mere registration system, on the other hand, a large number of court decisions have to be expected that will actually declare void a large number of patent rights. Hence, registration systems will – in this regard – provide less certainty for investors than examination systems.

At the same time, this argument helps to understand that a very long examination period may also be counterproductive. Typically, patent applicants have – during the examination period – only limited protection against infringement. In most legal systems, patent owners are not entitled to full damages during the examination phase. Hence, the longer the examination period, the more precise the delineation of the patent right becomes; conversely, the weaker will be investment incentives due to the weak legal position the patent holder has. While this constitutes a positive *ex post* effect on welfare since there is more competition in product markets, *ex ante* research incentives will suffer.

A second argument in favor of extending the period of examination (at the margin) is that the quality of the patent office's decision-making is likely to improve over time due to new information becoming available.[20] As new scientific and technological information arrives, examiners will be able to determine more precisely the optimal scope and breadth of the patent when it issues. Granting too broad a patent will harm *ex post* welfare by creating too much market power, systematically granting too narrow a patent would harm *ex ante* research incentives.

It is beyond the scope of this paper to determine the optimal tradeoff between the precision of patent examination on the one hand and its duration on the other. Yet, the question will become more important as policy-makers have discovered the issue and argue for a reduction of grant lags. In the U.S., the recent growth in demand for patent protection has led to some increase in the duration of examination.[21] At the same time,

[20] This argument is already taken into account by Régibeau & Rockett (2003).

[21] Popp et al. (2003, Figure 4) show that the grant lag was at an all-time low with 26.5 months in 1990 but has increased to more than 31 months in 1996. However, since they have no data on pending cases, no information is available for years after 1996.

the USPTO is currently being criticized for a number of weaknesses, including the bad quality of patent examination.[22] In Europe, the development of patent examination over time has not been studied as of yet. The empirical analysis below is meant to cast some light on the actual process of patent examination at the European Patent Office.

3.2 Determinants of Decision-Making Lags at the European Patent Office

The following discussion focuses on the behavioral and institutional aspects of decision-making in the course of patent examination. After all it appears unlikely that patent offices implement examination following merely the above normative logic. The determinants that are within the focus of this study belong to the three categories described in the introduction above: the examination capacity at the patent office (combining information on the number of examiners as well as new and pending applications), the difficulty of the individual examination task itself, and institutional factors that would – ceteris paribus – lead to an acceleration or deceleration of the examination process. We emphasize that we do not consider patent value *per se* as a causal determinant of examination lags because there is no convincing theoretical argument for doing so, and we discuss this point below in more detail.

First, in the short-run a patent office will not be able to adjust search and examination staff optimally to short-term changes in the demand for patent protection unless quality standards are allowed to deteriorate.[23] The EPO provides a telling example in this context. Since the training of patent examiners takes up to three years at the EPO, one should expect major lags in the adjustment of examination capacity. Increases in patent office workload should therefore lead to slower patent examination and longer lags. We seek to test this hypothesis later on by taking pending patents relative to patent office examination and search employees as a measure of EPO capacity utilization.

Second, the nature of patent examination has changed over time. Patent applications are increasing in complexity and volume (van Zeebroeck et al. 2005, Harhoff 2006). Both factors should lead to longer examination durations, ceteris paribus. Below, various measures of an application's complexity are introduced, including the number of claims, the number of technical fields, and the number of backward and forward citations. The development of these characteristics over time is also documented in Section 4.

[22]See Graham et al. (2002) and Hall & Harhoff (2004) for a discussion of these issues and further references.

[23]By patent quality, we mean the degree to which the patent examiner takes into account the full state of prior art and the extent to which the applicant is forced to reveal its invention fully. While the first aspect reflects the quality of document search in the patent office, the second is a measure of how skillful the examiner is in the negotiation with the patent applicant. A broader discussion of patent quality is included in Hall et al. (2003).

Third, various statutory and legal provisions have direct implications for the processing of patent applications. These need to be considered carefully in order to avoid spurious results in a multivariate setting. For example, PCT applications allow patent applicants to delay major decisions for thirty months past the priority date. Inevitably, this institutional characteristic of PCT patents will have implications for the duration of examination. Moreover, institutions like the request for accelerated examination (which concedes accelerated examination to the patent applicant for the payment of a certain fee, see Notice of the President of the EPO, OJ 7/1997, p. 340 and E-VIII, p. 3) are likely to reduce the overall time of examination.

Finally, it should be taken into account that the examination process is subject to various strategic incentives of the patent applicant. These incentives should be especially pronounced in cases where the patent applicant attaches high private value to the underlying invention. On the one hand, applicants might show a higher level of cooperation with the examiner during the examination (e.g. by responding faster to requests) in order to shorten examination time and to get full patent protection earlier. On the other hand, if patent applicants receive restrictive search reports or the examiners requests drastic changes in the claims which could reduce the value of the patent, applicants might be more willing to engage in lengthy negotiations with the examiner if the underlying invention is potentially valuable. Moreover, some applicants, e.g., in biotechnology, may seek to delay the patent grant, since it triggers the need to initiate the relatively expensive national validation of the EPO grant immediately. This is an effect that we cannot identify at this point, but we control for it using technical field dummies. Clearly, this issue requires attention in future work. We try to disentangle different incentives in the empirical part of the part. The data and variables used are introduced in the next section.

4 Data and Descriptive Statistics

4.1 Data Source

The European Patent Office (EPO) provides comprehensive patent information with its *Online European Patent Register* at http://www.epoline.org. This database covers published European patent applications as well as published international patent applications (PCT) seeking patent protection via the EPO in one or more member states of the European Patent Convention. It provides bibliographic data and also procedural information covering legal decisions made over the life span of an individual patent application. The dataset used for this study is an image of this data as provided by the EPO on March, 31^{st}, 2003 via www.epoline.org and covers 1,266,506 patent files with application dates ranging from June, 1^{st}, 1978 to July, 25^{th}, 2002. In addition, we have obtained information on the number of claims from the EPASYS directory excerpts which were kindly made available by the EPO. Moreover, in order to have an estimate of the EPO's processing capacity, the average number of employees by year has been obtained from the EPO's Annual Report 2003.

The inclusion of forward citations (see below) in the multivariate analysis requires a restriction of the dataset to patents with application dates prior to February, 14^{th},1998. This restriction eliminates truncation problems in the number of citations received by other patents which is computed as the total number of citations within five years after application.

4.2 Variables

In the following, we briefly describe the variables computed from our data sources.

Decision lag. The data from the Online European Patent Register include the date of filing of a patent application and the date of the termination of the subsequent examination procedure as well as the outcome of the process. Using this information, we compute the total duration of the examination period as the difference between the two dates. This variable reflects the duration we want to model in the subsequent part of the paper.

Status of the application. For each application it is known whether it is still under examination (PENDING) or whether the examination procedure has been terminated by the end of the observation period. Once an application has been granted (GRANT) or once the examiner has issued a final refusal to grant a patent (REFUSED), the examination procedure is closed. Additionally, the examination can also be terminated for reasons which lie outside the control of the patent office: First, the patent applicant might decide to withdraw (WITHDRAWN) his application from the office – perhaps due to unsatisfying results contained in the search report. Withdrawals are inferred by the EPO if the applicant does not request examination within six months of receipt of the search report or if the applicant ceases to communicate with the EPO at some point after having requested examination. Second, applications might drop out of the examination procedure for extra-ordinary reasons like the death of the applicant or the non-payment of fees. Since the number of these losses is extremely small and causes for these types of losses are outside of the procedural focus we apply here, we code these cases also as withdrawals.

Workload. We compute this variable in order to characterize the capacity situation at the EPO. Workload is defined as the number of pending cases divided by the number of examiners ('a-posts') at the EPO at a given point in time. The number of pending cases is computed on a daily basis, but the employee figures reflecting the recruiting policy of the EPO are only available on an annual basis. We distinguish the number of pending cases for 30 different technical fields[24] and compute a WORKLOAD variable as an approximation for the workload within each class defined by the number of pending cases in a technical field divided by the total number of examiners at the EPO at a given point of time.[25]

Number of claims. Each patent contains a set of claims that marks the boundaries of the patent. The claims of a patent state essential features of the underlying invention. The economic interpretation of the total number of claims is not straight forward. On the one hand, it can be argued that each additional claim raises the probability of an infringement and therefore increases the breadth and the value of a patent. On the other hand, each additional claim in a patent makes the description of the claimed invention more specific and might narrow the scope of the protected area and hence the value of the property right (see Lanjouw & Schankerman (1999) for a discussion of this trade-off). We employ the number of claims with a more neutral interpretation in mind – the number of claims simply indicates the complexity of the cases to be examined by the patent office; hence, a larger number of claims should lead to an increase in the time needed for examination (irrespective of the examination outcome), since each claim must be checked and validated by the examiner.[26]

Number of designated states. As any EPO patent becomes a bundle of national patent rights once it is granted, each applicant has to specify the countries in which he wants to obtain patent protection for his invention.[27] The more countries are designated in an application the higher the resulting expected fees for keeping the patent alive in each designated country. Harhoff et al. (2003) show that the number of designated countries is correlated with patent value while Guellec & Pottelsberghe (2000) come to more ambiguous findings.

References to patent literature. The search report published by the EPO yields information on the state of the art relevant for the patentability of the application. The state of the art is mostly documented by references to patents or to the non-patent literature. Relevant documents are referenced in the search report and are subsequently also published in the patent role. One major advantage of the EPO citation data we use in our study over the USPTO citation data is the assignment of references to certain

[24]The categorization is based on the OST-INPI/FhG-ISI technology nomenclature (see Organisation for Economic Co-operation and Development 1994, p. 77).

[25]This is only a rough measure of the capacity situation in the 30 technical fields. A more refined measure would take the number of examiners in a given field as its denominator but field-specific personnel data are not available.

[26]Régibeau & Rockett (2003) also use the number of claims as a measure of complexity in their estimations. Popp et al. (2003) include the number of claims, the number of references, the number of drawings and the number of pages of a patent application in their analysis.

[27]Currently, a patent application at the EPO can designate 36 states which are either members or affiliated to the European Patent Treaty.

categories. All documents cited in the search report are identified by a particular letter in the first column of the search report representing the cited category (combinations are possible). Table 1 contains a brief description of the meaning of the different categories. X citations are the most important ones as to patentability of an invention. In case an application receives an X citation this indicates that the claimed invention does not meet the requirements novelty or inventive step. Type Y references – when taken together or in conjunction with other documents – may have the same effect, but less directly so. Type A references merely provide technical background information. We will use these classification below in order to construct more specific patent citation indicators than has been possible with USPTO citations.

In our analysis several variables based on references to the patent literature are included. First, we consider the total number of patent references, also referred to as backward citations. Additionally, we include the share of citations which are particularly relevant if combined with another document of the same category (type Y references), the share of citations indicating that the claimed invention cannot be considered to be novel or to involve an inventive step (type X references) and the share of documents already cited in the patent application and considered relevant by the examiner (type D references). A detailed description of the use of patent citations in economic analysis can be found in Michael & Bettels (2001) and Harhoff et al. (2006).

References to the non-patent literature. In order to document the prior state of the art the patent office also refers to non-patent literature (mainly scientific publications). A simple count of the total number of references to non-patent literature is included in the following analysis. We argue that the number of references to non-patent literature measures the strength of a patent's science linkage. For a survey of the literature on this topic see Meyer (2000*a*).

Forward citations. Similar to scientific publications, citations received from subsequent patents are an indicator that the cited patent has contributed to the state of the art in a certain field. For each patent in our sample, we compute the number of forward citations as the number of citations a patent received from subsequent European patents within five years after application. Numerous studies found that forward citations are highly correlated with the monetary value of patents (see Harhoff et al. (1999), Lanjouw & Schankerman (1999) or Trajtenberg (1990)).[28] In order to construct a more refined citation measure we include the share of type Y, type X and type D citations in our regressions.

[28]The intricacies of working with European patent citations are well-known by now. We follow the recommendations made in Harhoff et al. (2006) for computing citation counts.

Measures of originality and generality. The ORIGINALITY and GENERALITY indicators are citation-based indices which measure different aspects of the patented innovation and their links to other innovations. The GENERALITY measure is based on the forward citations a patent receives and is defined as

$$GENERALITY = 1 - \sum_{k=1}^{n_i} s_{ik}^2$$

where s_{ik}^2 is the percentage of citations received by a patent i that belong to patent class k out of n_k patent classes. The GENERALITY index will be high, if a patent is cited by subsequent patents that belong to a wide range of fields and low, if most referring citations are concentrated in a few fields. Hence, a high GENERALITY index suggests that the patent influenced subsequent innovations in a variety of different fields and is more general. ORIGINALITY is defined in the same way except that it is based on references to the patent literature made in the patent's search report. A low ORIGINALITY index indicates that the patent's search report cites only patents from a narrow set of technologies and is therefore less original than an patent with a high ORIGINALITY index. Both measures have been first proposed by Trajtenberg et al. (1997). For the analysis we compute both indices distinguishing between 30 different technical fields.

Number of International Patent Classification (IPC) assignments. A patent is assigned to one or more 9-digit categories of the IPC system during the examination period depending on its applicability in different technical fields. We interpret the number of IPC classes as a measure of complexity of the examination task.

Request for accelerated examination. When filing a patent application the applicant can request an accelerated examination leading to a shortened examination procedure (see Section 2). A binary variable indicating whether this is true or not for the patent under consideration is included in the analysis.

PCT-Application. For each patent we include a dummy variable indicating, whether an international application within the PCT-framework (see Section 2 for details) has been filed.

In addition to the variables described above we further control for the filing date and the technical field a patent application was assigned to by the EPO. In order to do so, we include dummy variables for the year of application as well as dummy variables for 30 technical fields based on the OST-INPI/FhG-ISI Technology classification (see Organisation for Economic Co-operation and Development 1994, p. 77).

4.3 Descriptive Statistics

Before working with datasets that are random samples from the total population, we present descriptive statistics of the overall population outcomes. Table 2 displays basic statistics on decision lags by year of application. The larger share of EPO applications is granted – in the time window covering the years from 1978 to 1995, the grant rate is 63.5 percent. Only 5.1 percent of the cases are actually explicitly refused by the patent examiner, while 27.4 percent are withdrawn by the applicants themselves after receiving a sufficiently negative search report or 'skeptical' communication from the examiner. Note that even restricting the sample to applications from 1978 to 1995, 3.9 percent of all cases are still pending. The final two columns show that of the refused cases, a relatively large share (on average about one fifth) enter the appeal against refusal to grant, and about half of these cases are subsequently awarded a patent grant.

In Table 3, the OST-INPI/FhG-ISI Technology classification is used to distinguish between different technical fields (see Organisation for Economic Co-operation and Development 1994, p. 77). We would expect to see some variation in decision-making processes depending on the relative novelty and complexity of the technical matter embedded in the patent applications. The grant rate varies between 56.5 percent in consumer goods and equipment (area 29) and 70.8 percent in nuclear engineering (area 9). Low grant rates are concomitant with high shares of withdrawals, while the share of applicants receiving an explicit refusal is quite stable across technical fields. Exceptions exist, though: in semiconductors (area 5), macromolecular chemistry (area 11), and chemical engineering (area 18) the rate of refusals exceeds six percent. In semiconductors, almost every third refusal is contested in the appeals procedure, and only one third of them are successful. This may attest to the rivalry around intellectual property in this field.

Taking a look at the demand side of patent protection, we find that applications rose from an annual number of 12,384 in 1979, the first full year of operation of the EPO, to more than 100,000 in 2001 (see Figure 4). Since the examination of each patent application takes several years, the growth in application numbers led to the emergence of a backlog of pending cases at the EPO, which grew to more than 400,000 pending patent applications at the end of 2000 (see Figure 4). The most evident explanation for this strong growth of the backlog is an insufficient expansion of the workforce at the EPO leading to a growing workload for each examiner and hence longer examination duration for individual patents. In fact, the number of examiners (A-posts) at the EPO grew from 545 to 3,861 in the period from 1978 to 2001 (European Patent Office 2003). Dividing the number of pending cases by the according number of examiners yields the average workload of each examiner which dramatically increased since the foundation of the EPO (see Figure 5). This strong increase in the workload of the patent examiner might be one explanation for the lengthening of the examination procedure.

Another potential explanation for the lengthening of the examination procedure can be found in the growing complexity of patent applications over the last two decades. Table 4 shows the development of several measures of an application's complexity on an annual basis. The average number of claims per patent, for example, rose by more then 50% from 9.84 in 1978 to 15.36 in 1998. Since an examiner has to validate the formulation and the justification of each of the claims, we expect that a growing number of claims leads to a longer examination period, everything else being equal.

Additionally, the fraction of patent applications at the EPO that were filed as PCT applications grew even faster: by 1998, 50% of the applications filed also applied for international patent protection under the PCT, which is more than the eightfold of the level in 1978. The examination of a combined EPO/ PCT-application is more time-consuming than a pure EPO-application, since various aspects of search and examination of the application have to take different legal frameworks into account – the EPO and the PCT guidelines. Table 4 also shows the average number of references made to previous patents and to non-patent literature. While the number of backward citations to previous patents rose slightly at the end of the 90s, the number of references to non-patent literature (mostly scientific publications) rose by almost 50% within the same period. Both variables indicate higher demand for the search capacity at the EPO and could possibly have led to longer examination lags.

5 Survival Analysis

5.1 Model Specification

In order to analyze the determinants of the duration of the examination process at the European Patent Office, we consider survival time as a nonnegative random variable T.[29] A basic concept for the analysis of survival times is the hazard function $\lambda(t)$, which is defined as the limit

$$\lambda(t) = \lim_{\Delta t \to 0} \frac{P(t \leq T < t + \Delta t \mid T \geq t)}{\Delta t} \tag{1}$$

and measures the instantaneous failure rate at time t, given that the individual survives until t. In the following, different survival models are estimated, where the hazard function depends on a set of covariates $x' = (x_1, \ldots, x_p)$ that influence the survival time T.

The reference model for multivariate survival analysis is Cox's Proportional Hazard (PH) model (Cox 1972), where the hazard rate is assumed to be the product

$$\lambda(t, x) = \lambda_0(t) \exp(x_1\beta_1 + \ldots + x_p\beta_p) = \lambda_0(t) \exp(x'\beta). \tag{2}$$

[29]The survival time is the time between the filing of a patent application at the patent office and the final decision on the application.

In this model, the baseline hazard rate $\lambda_0(t)$ which is a function of survival time remains unspecified and, through the exponential link function, the covariates x act multiplicatively on the hazard rate.

Under this model, the ratio of the hazard functions HR for two subjects with differing covariate values x_1 and x_2 is

$$HR = \frac{\lambda_0(t)\exp(x_1'\beta)}{\lambda_0(t)\exp(x_2'\beta)} = \frac{\exp(x_1'\beta)}{\exp(x_2'\beta)} = \exp\beta((x_1 - x_2)). \tag{3}$$

The parameter estimates from this model are obtained by maximizing the partial log-likelihood function

$$\ln L = \sum_{j=1}^{D}[\sum_{k \epsilon D_j} x_k'\beta - d_j \ln \sum_{i \epsilon R_j} \exp(x_i'\beta)] \tag{4}$$

where j indexes the ordered failure times $t_{(j)}$ $(j = 1, ..., D)$, D_j is the set of d_j observations that fail at $t_{(j)}$, d_j is the number of failures at $t_{(j)}$, and R_j is the set of observations k that are at risk at time $t_{(j)}$,i.e., all k such that $t_{0k} < t_{(j)} \leq t_k$ (Kalbfleisch & Prentice 2002).

Accelerated failture time (AFT) models are an alternative to the Cox PH model. In these models, the hazard function is specified as

$$\lambda(t, x) = \lambda_0(t\exp(x'\beta))(\exp(x'\beta)). \tag{5}$$

Here, the effect of the explanatory variables on the survival time is direct, accelerating or decelerating the time of failure. Moreover, this model can be specified relating the logarithm of the survival time to its explanatory variables with

$$\ln T = X\gamma + \epsilon \tag{6}$$

where $\gamma_j = -\beta_j$ for $j = 1, ..., p$ and T follows a log-logistic distribution. Estimation of the parameters is carried out by maximizing the according log-likelihood.

All covariates in our regression are time-invariant. Since we include the number of forward citations received within 5 years after application the sample is restricted to the years between 1978 to 1998. Since the EPO started its operations only in 1978 there might be a 'starting-effect' due to new processes for examiners and applicants causing longer examinations. We therefore exclude the first three years of operations from our regression analysis. Further, for ease of computation we draw a 25% sample from the remaining patents. Therefore, the estimations are based on the resulting random sample of 215,259 patents.

5.2 Results

In order to characterize differences in the processes leading to either withdrawal of the application, a refusal of the patent grant or an actual patent grant, we present not only results from the survival analysis based on pooled data, ignoring the outcome of the examination process, but also results from competing risk specifications. In the competing risk specification we distinguish between examinations which lead to a grant, withdrawal or refusal of the patent application. Fixed effects are included for 30 technical fields and for each year of the observational period which we do not report here for reasons of brevity.[30]

We comment on the pooled risk estimates before discussing to the competing risk specification (see Table 5, column (1)).[31] This column would be relevant for a policy-maker who knows that all three outcomes consume the same amount of resources or who does not attach any other form of relevance to the different outcomes. Most coefficients are statistically relevant and carry the expected sign. Our estimation confirms the expectation with regard to current capacity situation at the EPO. An increase in the workload per examiner at the time of application leads to longer examination lags.

Moreover, characteristics which are related to the complexity of the examination task are associated with longer examination times. We observe highly significant effects of the number of references in the search report, of the number of different four-digit IPC classes a patent is classified to be in and also of the number of claims which have to be examined. Turning to the patent characteristics which we derived from the references and citations we observe that patents which are more original require longer examination. This is perfectly in line with expectations, since the search for prior art is more complicated if more different technical fields have to be checked. Moreover, we observe an increase in examination times caused by higher shares of type X references (backward citations) which lower the chances of getting the patent granted. We assume that patent applicants engage in more intensive negotiations with patent examiners in these cases, thus lengthening the whole examination process. An interesting finding is that – in the pooled risk specification – the examination of patents which are more important according to our measure forward citations, require more time than the examination of less often cited patents. However, the competing risk specification will show that this finding stems from the combination of effects which affect examination outcomes differentially.

In columns (2), (3) and (4) of Table 5, the results from the competing risks specification are presented. We test whether exits to different states in the competing risk specification are behaviorally distinct (rather than simply incidental) relying on the test proposed by Narendranathan & Stewart (1991) which is a test of the hypothesis that the cause-specific hazards are all proportional to one another (i.e. that all parameters except the intercepts are equal across the hazards). The test statistic TS

[30]Results for the fixed effects and the time dummies are available upon request.

[31]In Table 5 we report estimated coefficients rather than hazard rates. Coefficients smaller than zero indicate that an increase in a variable decreases the likelihood of an exit in $t + \Delta t$. Negative coefficients therefore indicate that an increase in the corresponding variable is associated with longer examination periods.

proposed by Narendranathan & Stewart (1991) is given by

$$TS = 2[\ln(L_{CR}) - \ln(L_{SR}) - \sum_j n_j \ln(p_j)] \tag{7}$$

where $\ln(L_{RC})$ is the maximised log-likelihood from the competing risk model (the sum of those from the component risk models), $\ln(L_{SR})$ is the maximised log-likelihood from the single-risk model, n_j is the number of exits to state j and $p_j = n_j / \sum_j n_j$, where there are $j = 1, \ldots, J$ destination states. The test-statistic is distributed Chi-squared with degrees of freedom equal to the number of restrictions. For our model we can reject the null hypothesis of risk proportionality at 1% of significance ($TS = 323,515.13$), i.e., we reject that the different forms of exit are behaviorally equal.[32]

The results from the competing risk specification are interesting, since they demonstrate that some of the effects apparent in column (1) come about as a complex combination of individual risk determinants. For example, while the generality variable affects the overall hazard negatively, it has a positive effect on the grant hazard (column 2) and it lengthens the time period until patents are withdrawn. We observe also a strong significant influence of the share of X references which are damaging to the claimed novelty or inventive step of the invention underlying the patent application. A high share of type X references slows down the granting process while leading to early withdrawals. We find the inverse effect for the share of type D references. These are documents which have already been referenced in the patent application by the applicant and have been considered relevant by the examiner. The estimation results confirm our expectation that a search report which contains a high share of type D references is an indication for a well documented patent application alleviating the search for prior art during its examination. In line with this interpretation a higher share of D references leads to earlier patent grants. Moreover, applications which are well documented by the applicant according to this measure are withdrawn less early.

More important, for granted patents we find a positive impact of the number of forward citations on the hazard (Column 2) while the effect is negative in the case of withdrawn and refused applications (Columns 3 and 4).[33] This is presumably reflecting an endogenous component of an applicant's behavior. Inventions which are cited frequently by subsequent patents are potentially valuable if they receive a patent grant – they are not abandoned as quickly as other patent applications. It should be noted that our finding that more important applications are processed faster by the EPO is in line with theoretical predictions from a model on the optimal length of patent examination provided by Régibeau & Rockett (2003). Moreover, our results suggest

[32]Reported test statistics are based on the Cox PH specification. Results for the AFT specification are similar.

[33]Note that the number of designated countries which is also correlated to patent value has a different effect. However, this effect is small in magnitude compared to the effect of forward citations. Removing the number of designated countries from the regressions does not alter the results for the number of forward citations.

that the conclusion of Johnson & Popp (2003) that more important patents experience longer grant lags at the USPTO than less valuable patents cannot be confirmed for the EPO. Moreover, we find that a high share of type D citations decreases the duration of examination processes leading to a patent grant while increasing the duration for withdrawals and refusals. Type D citations typically result from self-citations (Harhoff et al. 2006), i.e., citations from patent applications of the same applicant. Therefore patents with a high share of type D citations are likely to be part of a sequence of technically related patent applications and therefore be of particular importance to the applicant. The effect of the share of type D citations might therefore again reflect endogenous applicant behavior as described above.

Finally, the competing risk specification confirms our hypotheses with regard to legal provisions. The grant lags of patent applications filed under the PCT-treaty are significantly longer than for non-PCT applications. Another interesting effect concerns the request for accelerated examination (RACCEXAM) which is statistically unsurprising in column (1) and a significant determinant of all three risks when these are treated separately. Grants are accelerated by this request, while withdrawals are slowed down and refusals are not affected significantly. We conclude that the request signals potentially valuable patents which applicants are hesitant to give up. We also observe a qualitatively homogenous effect of the number of claims on the different outcomes. An increase in the number of claims clearly increases the length of the examination period of patent applications irrespective of the outcome. This could be explained by the fact that each additional claim requires some extra-time in the examination process.

In addition to the Cox PH model we also fit AFT models and report estimation results for pooled and competing risk specifications in Table 6. The results from these purely parametric specifications largely confirm the findings from the semi-parametric Cox PH models, but allow us to determine the percentage change of pendency times associated with a one-unit increase of the independent variables.[34] The most important effects on the duration of the examination are associated with institutional features of the application process. In fact, the filing of a request for accelerated examination reduces its duration by 17.9% in the pooled model. Again, this effect is the combination of a reduction of examination times by 26.3% in the case of granted applications and a prolongation of durations by 59.8% for withdrawn applications. These opposite effects reflect endogenous behavior of the applicants (see above). We obtain slightly different reuslts for applications filed via the PCT path. While the duration of examination for granted application is increased by only 3.9%, withdrawals are delayed by 19.9%. Moreover, we also observe significant effects associated with the complexity of the examination task. For example, one additional claim in the patent application lengthens

[34]Note that we report exponentiated coefficients of the AFT specification in Table 6 which can directly be interpreted as percentage change of pendency times associated with a one-unit increase of the respective variable.

the duration of examination by 0.5%, one additional patent reference by 0.8% and one additional non-patent reference by 2.8% in the pooled model. The different effect of patent and non-patent references can be attributed to the fact that it is harder for patent examiners to research non-patent references like scientific journals than to research prior patents.

6 Conclusion

The growth in patenting has been felt by all major patent offices, confronting them with the challenge of dealing with an increasing workload in the processing of patent applications. In particular, the number of patent applications at the EPO almost tripled between 1990 and 2000 and led to a considerable backlog of more than 400,000 pending patent applications in 2000. This development caused a significant increase in the pendency times of EPO patent applications in the 90s which drew the interest of policy makers and researchers.

In this paper, we have presented first results from a comprehensive analysis of the decision-making lags and the outcomes of patent examination at the EPO. We have presented estimates from a duration analysis in which we modeled the pooled hazard of outcomes as well as separate hazards of the applications becoming granted patents, being withdrawn or being refused. In order to disentangle different sources of the recent increase in examination lags, we include variables which are correlates of the capacity situation at the EPO, of the complexity of the examination task, and of legal institutions influencing the duration of examination. In line with our theoretical expectations, we find that the observed increase in pendency times is not only caused by the increase in application figures leading to a higher workload at the EPO. In fact, increasing complexity of patent applications also leads to longer pendency times since decisions on more complicated applications require more time than decisions regarding an average patent. Allowing for a competing risk specification, we find more complex patterns which reflect largely the endogenous behavior of the applicants. In particular, we find that applicants are less willing to abandon applications relating to inventions which are potentially valuable compared to other applications. The duration of the examination period is lengthened for important patent applications, if the patent is not granted. Moreover, we find that more important patents are approved faster than other patents, which is in line with the predictions of a model on the optimal length of patent examination provided by Régibeau & Rockett (2003).

In a reaction to the challenge posed by the increase in application figures and pendency times, the EPO initiated several projects aiming at ameliorating the current situation.[35] However, it should be noted that the problem is not confined to the EPO

[35]For an introduction see 'Mastering the Workload', EPO Document CA/132/02, available at `http://mtw.european-patent-office.org/workload/site/en/reference.html`, latest visit

alone, as previous studies of Popp et al. (2003) and Régibeau & Rockett (2003) have shown. Application figures rose similarly at the USPTO and the JPO. Further, the share of patents which are filed under the PCT considerably increased over the last years, pointing to another international dimension of the problem.

March, 22nd, 2005.

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7 Figures and Tables

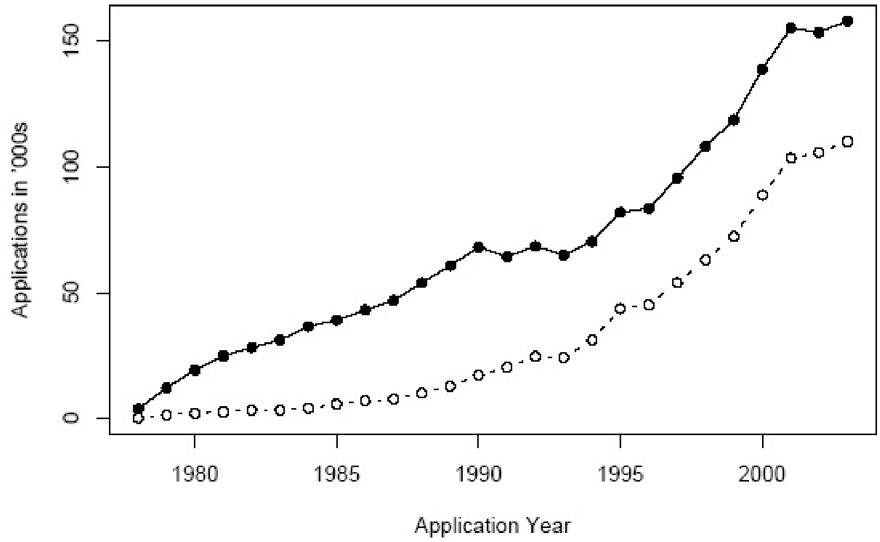

Figure 1: Number of patent applications at the EPO: — All Applications, - - - Applications filed under PCT.

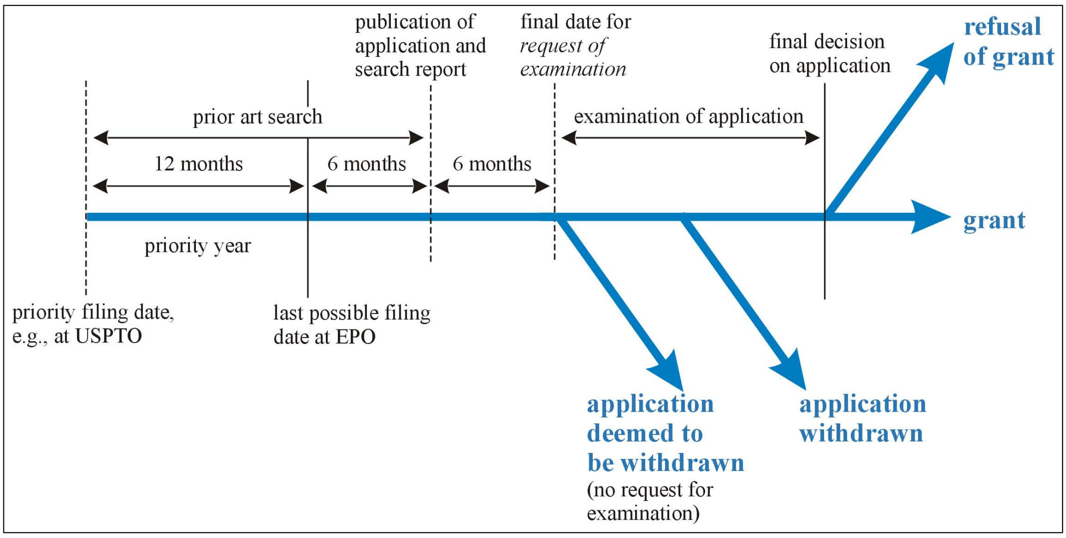

Figure 2: Examination of patent applications at the European Patent Office.

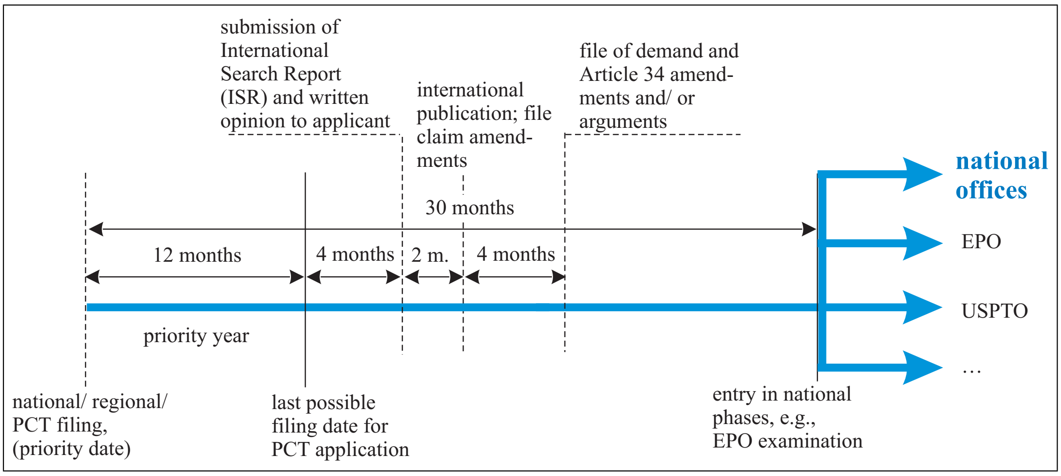

Figure 3: Application path under PCT Chapter 2.

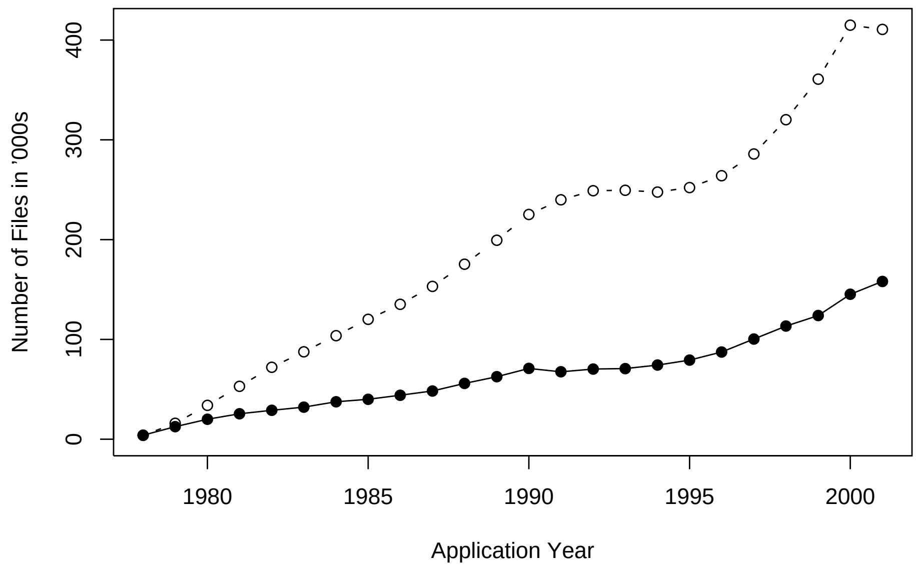

Figure 4: - - Number of pending cases at the EPO, — Number of patent applications at the EPO.

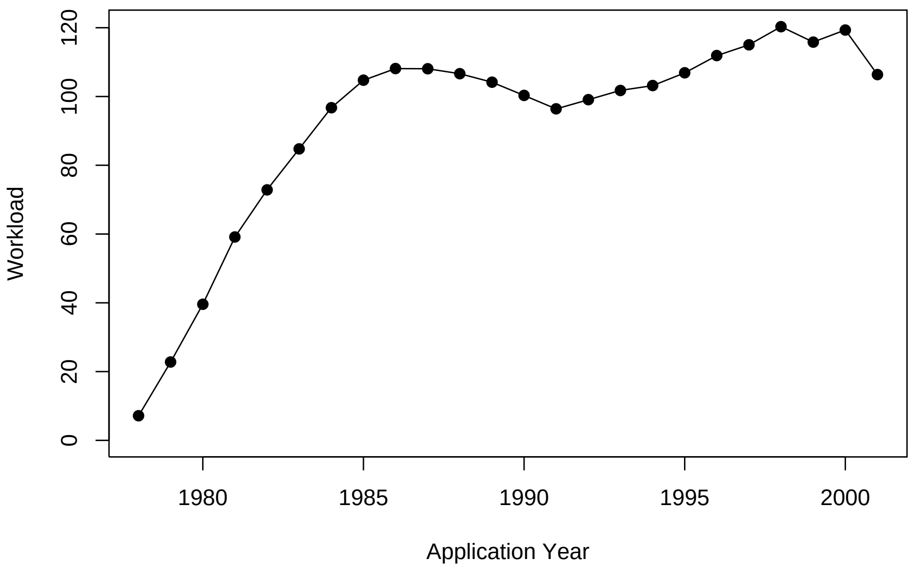

Figure 5: Number of pending cases per examiner (WORKLOAD) at the EPO.

Type	Description
X	Particularly relevant documents when taken alone (a claimed invention cannot be considered novel or cannot be considered to involve an inventive step)
Y	Particularly relevant if combined with another document of the same category
A	Documents defining the general state of the art
O	Documents referring to non-written disclosure
P	Intermediate documents (documents published between the date of filing and the priority date)
T	Documents relating to theory or principle underlying the invention (documents which were published after the filing date and are not in conflict with the application, but were cited for a better understanding of the invention)
E	Potentially conflicting patent documents, published on or after the filing date of the underlying invention
D	Document already cited in the application
L	Document cited for other reasons (e.g., a document which may throw doubt on a priority claim)

Table 1: Overview over different types of references included in the search report by the EPO. Source: EPO Guidelines for Examination in the European Patent Office, 2003.

Application Year	Cases	PCT Application %	Directly Granted %	Withdrawal of Application %	Refusal of Grant %	Application Pending %	Appeal against Grant Refusal %	Granted after Appeal %
1978	3,902	6.4	70.0	25.2	4.6	0.2	2.5	1.5
1979	12,392	8.9	69.6	24.1	6.2	0.1	2.4	1.4
1980	19,724	9.1	69.3	24.2	6.5	0	1.7	1.0
1981	24,957	8.5	68.7	25.4	5.9	0	1.3	0.8
1982	28,518	9.1	69.0	25.8	5.2	0	1.1	0.6
1983	31,609	9.4	68.3	26.5	5.2	0	1.3	0.8
1984	36,952	8.8	67.4	27.9	4.7	0	1.2	0.7
1985	39,371	12.0	67.0	28.9	4.1	0.1	1.0	0.5
1986	43,080	12.7	66.1	29.0	4.8	0.1	1.2	0.6
1987	45,803	13.1	65.3	29.4	5.2	0.1	1.1	0.6
1988	52,165	15.0	64.5	29.8	5.5	0.2	1.0	0.5
1989	57,669	15.6	62.6	31.3	5.7	0.4	0.9	0.5
1990	63,811	19.0	64.4	29.3	5.6	0.7	0.8	0.4
1991	59,092	24.2	65.2	27.9	5.6	1.3	0.8	0.3
1992	60,186	25.7	64.2	27.8	5.4	2.5	0.7	0.2
1993	59,448	30.3	63.6	25.6	5.2	5.5	0.7	0.2
1994	60,924	34.8	58.3	25.0	4.7	11.9	0.6	0.1
1995	63,402	39.9	47.8	23.7	3.7	24.8	0.4	0.1
Total (1978-1995)	**763,005**	**20.1**	**63.5**	**27.4**	**5.1**	**3.9**	**0.9**	**0.9**

Table 2: EPO patent applications and application outcomes by application year. (Note: The category 'application withdrawn' also includes cases in which patents were consolidated or applications were suspended. These are typically less than 0.1 percent of all applications in any year.)

Area	Area Name	Cases	PCT Applications %	Directly Granted %	Withdrawal of Application %	Refusal of Grant %	Appeal against Grant Refusal %	Granted after Appeal %
1	Electr. Machinery, Electrical Energy	19,276	13.0	64.1	30.4	5.3	0.8	0.5
2	Audiovisual Technology	10,454	11.6	70.7	24.6	4.4	1.1	0.6
3	Telecommunications	13,126	13.8	67.5	26.3	5.8	1.2	0.6
4	Information Technology	10,288	12.9	62.9	30.8	5.8	1.1	0.5
5	Semiconductors	6,813	9.9	59.9	30.3	9.0	3.1	1.1
6	Optics	12,087	13.0	67.6	27.3	4.6	0.9	0.4
7	Analysis, Measurement, Control Tech.	22,061	19.1	62.8	31.9	5.1	0.9	0.5
8	Medical Technology	11,522	22.9	61.2	32.8	5.7	1.1	0.5
9	Nuclear Engineering	1,989	11.2	70.8	24.0	5.1	1.0	0.5
10	Organic Fine Chemistry	23,045	11.6	63.4	30.3	5.9	0.7	0.3
11	Macromolecular Chem., Polymers	15,453	9.1	62.1	31.2	6.5	1.7	0.9
12	Pharmaceuticals, Cosmetics	8,337	24.3	62.4	30.7	6.0	1.0	0.4
13	Biotechnology	6,684	25.0	55.1	36.1	5.9	0.8	0.4
14	Agriculture, Food Chem.	2,824	16.0	64.0	31.3	4.6	0.7	0.4
15	Chem. & Petrol Ind., Basic Mat. Chem.	8,335	13.9	67.0	27.6	5.4	1.4	0.8
16	Surface Technology, Coating	5,910	16.7	66.4	28.2	5.2	0.9	0.6
17	Materials, Metallurgy	9,131	13.8	69.9	24.9	5.1	0.8	0.4
18	Chemical Engineering	10,020	18.0	65.3	28.6	6.1	1.7	1.1
19	Mat. Proc., Textiles, Paper	13,743	13.4	66.7	28.8	4.4	0.7	0.4
20	Handling, Printing	15,883	13.5	67.7	27.6	4.5	0.6	0.4
21	Agricultural & Food Proc.	4,328	14.3	60.3	34.6	5.1	0.9	0.5
22	Environmental Technology	2,213	17.7	62.8	31.8	5.3	1.5	0.7
23	Machine Tools	8,572	16.1	65.2	30.2	4.5	0.8	0.4
24	Engines, Pumps, Turbines	7,124	17.7	70.6	24.7	4.7	1.1	0.6
25	Thermal Proc. & Apparatus	4,321	16.4	64.3	30.2	5.4	1.3	1.0
26	Mechanical Elements	10,817	15.1	69.5	26.5	4.0	0.6	0.4
27	Transport	12,213	13.9	69.5	26.1	4.4	0.4	0.2
28	Space Technology, Weapons	1,970	13.8	62.3	33.3	4.4	0.6	0.2
29	Consumer Goods & Equipment	12,803	15.5	56.5	39.2	4.2	0.5	0.3
30	Civil Eng., Building, Mining	10,536	15.1	64.9	30.4	4.7	0.8	0.4
	Total	**301,899**	**15.0**	**64.8**	**29.7**	**5.2**	**1.0**	**0.5**

Table 3: EPO application outcomes by technical field (application years 1980–1990). (Note: Pending cases are not documented here.)

Application Year	Number of Claims	Share of Applications via PCT	References to patents	References to non-patent literature
1978	9.84	0.06	4.47	0.39
1979	9.97	0.09	4.96	0.40
1980	10.06	0.09	4.73	0.47
1981	10.41	0.09	4.45	0.50
1982	10.73	0.09	4.42	0.55
1983	10.52	0.09	4.36	0.60
1984	10.85	0.09	4.22	0.61
1985	11.16	0.12	4.30	0.67
1986	11.18	0.13	4.27	0.73
1987	11.40	0.13	4.23	0.80
1988	11.54	0.15	4.13	0.81
1989	11.82	0.16	4.11	0.87
1990	12.03	0.19	4.14	0.91
1991	12.32	0.24	4.21	0.98
1992	12.44	0.26	4.30	0.98
1993	12.95	0.30	4.49	0.99
1994	13.29	0.35	4.61	0.98
1995	13.79	0.39	4.73	0.94
1996	14.34	0.45	5.02	0.93
1997	14.80	0.47	4.98	0.90
1998	15.36	0.50	4.84	0.86
Average	**13.40**	**0.30**	**4.18**	**0.80**

Table 4: Mean values of selected patent indicators by application year.

Duration	Pooled	Competing Risks		
		Granted	Withdrawn	Refused
	(1)	(2)	(3)	(4)
Capacity Measure				
WORKLOAD	-0.055**	-0.097**	0.017*	-0.055**
	(0.004)	(0.005)	(0.007)	(0.019)
Patent Characteristics				
ORIGINALITY	-0.176**	-0.160**	-0.168**	-0.348**
	(0.021)	(0.026)	(0.039)	(0.104)
GENERALITY	-0.057**	-0.008	-0.129**	0.023
	(0.021)	(0.025)	(0.046)	(0.111)
PCT APPLICATION	-0.136**	-0.086**	-0.269**	-0.026
	(0.006)	(0.007)	(0.011)	(0.027)
ACCELERATED EXAM.	0.318**	0.645**	-0.859**	-0.018
	(0.015)	(0.017)	(0.047)	(0.084)
CLAIMS	-0.012**	-0.015**	-0.005**	-0.014**
	(0.000)	(0.000)	(0.000)	(0.001)
IPC CLASSES	-0.042**	-0.060**	-0.005	-0.044**
	(0.002)	(0.002)	(0.003)	(0.008)
DESIGNATED COUNTRIES	0.000	-0.011**	0.019**	0.024**
	(0.001)	(0.001)	(0.001)	(0.003)
Reference Measures				
NO. OF PAT. REFERENCES	-0.020**	-0.034**	0.012**	-0.015**
	(0.001)	(0.001)	(0.002)	(0.004)
NO. OF NON-PAT. REF.	-0.059**	-0.065**	-0.051**	-0.031**
	(0.002)	(0.002)	(0.004)	(0.009)
SHARE OF X REFERENCES	-0.209**	-0.536**	0.417**	-0.198**
	(0.008)	(0.011)	(0.014)	(0.039)
SHARE OF Y REFERENCES	-0.127**	-0.285**	0.233**	-0.128**
	(0.009)	(0.011)	(0.016)	(0.043)
SHARE OF D REFERENCES	0.093**	0.266**	-0.381**	0.142**
	(0.011)	(0.013)	(0.023)	(0.053)
Citation Measures				
NUMBER OF CITATIONS	-0.016**	0.012**	-0.108**	-0.071**
	(0.001)	(0.001)	(0.002)	(0.005)
SHARE OF X CITATIONS	-0.067**	-0.070**	-0.007	-0.043
	(0.011)	(0.014)	(0.021)	(0.053)
SHARE OF Y CITATIONS	-0.043**	-0.014	-0.036	-0.179*
	(0.014)	(0.017)	(0.027)	(0.071)
SHARE OF D CITATIONS	-0.012	0.190**	-0.556**	-0.233**
	(0.016)	(0.018)	(0.036)	(0.082)
Observations	215,259	215,259	215,259	215,259
Exits	200,040	132,697	58,485	8,858
Log Likelihood	-2,251,713.3	-1,469,520	-677,407.74	-97,027.23
LR $\chi^2(63)$	43,647.85	46,248.87	10,590.02	2,325.60

Table 5: Estimation results from Cox Proportional Hazards Models. Estimates from a pooled and a competing risk specification are displayed. The estimation includes year dummies and dummy variables for 30 technological fields.
**: 1% significant, *: 5% significant. Standard errors in parentheses.

Duration	Pooled	Competing Risks		
		Granted	Withdrawn	Refused
	(1)	(2)	(3)	(4)
Capacity Measure				
WORKLOAD	1.019**	1.028**	0.990*	1.012*
	(0.002)	(0.001)	(0.004)	(0.006)
Patent Characteristics				
ORIGINALITY	1.070**	1.052**	1.109**	1.117**
	(0.009)	(0.008)	(0.024)	(0.034)
GENERALITY	1.038**	1.011	1.091**	0.984
	(0.008)	(0.007)	(0.027)	(0.032)
PCT APPLICATION	1.087**	1.039**	1.199**	0.987
	(0.002)	(0.002)	(0.007)	(0.008)
ACCELERATED EXAM.	0.821**	0.737**	1.598**	1.025
	(0.005)	(0.004)	(0.040)	(0.026)
CLAIMS	1.005**	1.005**	1.003**	1.004**
	(0.000)	(0.000)	(0.000)	(0.000)
IPC CLASSES	1.014**	1.018**	1.004*	1.015**
	(0.001)	(0.001)	(0.002)	(0.002)
DESIGNATED COUNTRIES	0.999**	1.002**	0.990**	0.993**
	(0.000)	(0.000)	(0.001)	(0.001)
Reference Measures				
NO. OF PAT. REFERENCES	1.008**	1.012**	0.994**	1.004**
	(0.000)	(0.000)	(0.001)	(0.001)
NO. OF NON-PAT. REF.	1.025**	1.023**	1.032**	1.012**
	(0.001)	(0.001)	(0.002)	(0.003)
SHARE OF X REFERENCES	1.063**	1.197**	0.778**	1.067**
	(0.003)	(0.004)	(0.006)	(0.012)
SHARE OF Y REFERENCES	1.051**	1.110**	0.875**	1.037**
	(0.004)	(0.004)	(0.008)	(0.013)
SHARE OF D REFERENCES	0.982**	0.915**	1.252**	0.956**
	(0.004)	(0.004)	(0.016)	(0.015)
Citation Measures				
NUMBER OF CITATIONS	1.011**	0.999**	1.062**	1.021**
	(0.000)	(0.000)	(0.001)	(0.002)
SHARE OF X CITATIONS	1.027**	1.024**	1.008	1.012
	(0.004)	(0.004)	(0.012)	(0.016)
SHARE OF Y CITATIONS	1.024**	1.010*	1.026	1.053*
	(0.005)	(0.005)	(0.015)	(0.022)
SHARE OF D CITATIONS	1.024**	0.946**	1.368**	1.069**
	(0.006)	(0.005)	(0.026)	(0.025)
Observations	215,259	215,259	215,259	215,259
Exits	200,040	132,697	58,485	8,858
Log Likelihood	-119,239.41	-72,997.354	-140,040.07	-28,890.64
LR $\chi^2(63)$	45,074.63	57,563.44	11,869.45	2,446.98

Table 6: Estimation results from an accelerated failure time model using a log-logistic specification. Estimates from a pooled and a competing risk specification are displayed. Estimated coefficients are exponentiated. The estimation includes year dummies and dummy variables for 30 technological fields.
**: 1% significant, *: 5% significant. Standard errors in parentheses.