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The Duration of Patent Examination at the European Patent Office

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We analyze the duration and outcomes of patent examination at the European Patent Office utilizing an unusually rich data set covering a random sample of 215,265 applications filed between 1982 and 1998. In our empirical analysis, we distinguish between three groups of determinants: applicant characteristics, indicators of patent quality and value, and determinants that affect the complexity of the examination task. The results from an accelerated failure time model indicate that more controversial claims lead to slower grants but faster withdrawals, whereas well-documented applications are approved faster and withdrawn more slowly. We find strong evidence that applicants accelerate grant proceedings for their most valuable patents, but that they also prolong the battle for such patents if a withdrawal or refusal is imminent. This paper develops implications of these results for managerial decision making in research and development and innovation management.

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1. Introduction

The last three decades have seen an unprecedented growth in patent filings at all major patent offices of the world. Patents are in high demand, because their tactical and strategic importance has grown (Granstrand 1999, Kortum and Lerner 1999, Lev 2001, Hall 2005, von Graevenitz et al. 2008). Managing a corporation's intellectual property (IP), and patents in particular, has become a challenge in strategic planning, research and development (R&D), and other corporate functions related to innovation. Patents and their management are also becoming a topic for boardroom discussions, and the timing of patent grants is sometimes crucial for maximizing chances to commercialize a technology (Rivette and Kline 2000, Gans et al. 2008). Information about the typical response times of patent offices can therefore be helpful in determining optimal patent filing strategies. At the same time, policy makers are interested in reducing the backlogs at patent offices and raise questions with regard to a welfare-optimizing allocation of scarce examination capacity. Our paper seeks to contribute new insights to these questions by studying the duration and the outcomes of patent examination in an exploratory patent-level analysis.

From a firm's perspective, the examination process determines whether a patent is granted or not and also affects the date of the patent grant, which carries important strategic, legal, and financial implications. First, at the time of the grant, full rights to injunctive relief and other legal instruments are bestowed upon the receiver of the patent. Prior to the grant date, only limited options for enforcement are available. Second, only the grant of a patent resolves remaining uncertainty with regard to its exact delineation and thus further facilitates legal action against infringers. The removal of uncertainty also alleviates negotiating and closing licensing contracts (Gans et al. 2008). It should be noted, however, that a patent grant is associated with financial consequences, such as payments for fees, translations, renewal, etc. These consequences may make it attractive for patent owners to *delay* the patent grant. Delaying the patent grant may also be appealing for strategic reasons, because a pending application creates uncertainty for rivals and may be modified in the course of further discussions with the examiner. Being able to predict and influence the timing and outcomes of patent examination is therefore of utmost importance for managing a corporation's patent portfolio.

A profound understanding of the examination process is not only relevant for being able to manage one's own patent applications, but also highly important for technology monitoring purposes because patents are a particularly promising path for obtaining information about rivals (Day and Schoemaker 2005, Christensen and Overdorf 2000, Gray and Meister 2006). However, the growth in the number and volume of patent applications has made the patent system increasingly opaque, and practitioners frequently point out that some applicants are actively seeking to induce uncertainty and intransparency (McGuinley 2008). In interviews with patent attorneys and senior officials from the European Patent Office (EPO), we gathered considerable anecdotal evidence that the timing of examination processes is of high importance for applicants and their rivals.[1] Our interviews confirm that the timing is considered important by applicants, that applicants may choose to accelerate or delay proceedings, and that delays in one's own examination processes can be an instrument to increase uncertainty for rivals.

From a policy perspective, an important question concerns the relationship between duration of examination and patent value. Regibeau and Rockett (2009) argue that more important patents should be processed faster by patent offices than less important ones to maximize overall welfare. Prior research has not been conclusive on the empirical relation between value and the duration of examination.[2] Based on a rich set of value measures that have previously not been available and a comprehensive data set, our results suggest that more valuable patents are characterized by shorter pendency times than less valuable patents. Although being welfare maximizing in the sense of Regibeau and Rockett (2009), we argue that this acceleration is likely to be driven by applicants' behavior.

In our analysis of the duration of patent examination, we empirically analyze a large random sample of 215,265 EPO applications. Whereas earlier contributions had access to data on granted patents only, we also have data on refused and withdrawn applications, allowing us to convincingly address selection issues that have been neglected in earlier work. Using survival models, we utilize information on the duration of all three outcomes of patent examination—grant, refusal, and withdrawal—jointly and detect patterns of applicant behavior that would not be apparent in a simple analysis of grant or overall decision-making duration. Because of the complexity of the examination process, we do not attempt to provide a comprehensive formal model of patent examination, but follow a reduced-form approach where we estimate the examination duration as a function of three groups of determinants and of a number of control variables. The first group of variables describes applicants in broad terms of size of patent portfolio and applicant nation. The second one is composed of variables that characterize the application and are related to the potential value of the patent. A third group of variables allows us to control for the patent-specific complexity of the examination task and the quality of the application.

Contrary to previous studies, we identify valuable patent applications employing a number of distinct value correlates, such as patent citations, the size of the patent family, and the number of claims.[3] Because the use of multiple value correlates can conceivably lead to collinearity problems, we also employ a second approach. Using information on renewals of granted patents beyond their 10th year after filing, we construct a composite value indicator that predicts the potential value of applications. Both approaches yield evidence that (potentially) valuable applications are approved *faster* by the EPO than less important ones, but that applications of this type are also withdrawn *less quickly* by the applicant. This pattern of countervailing effects points to efforts by the applicant to either accelerate promising examination processes or to delay those approaching a negative outcome. Applicant efforts to accelerate or decelerate examination also become apparent in several other results: more controversial claims lead to slower grants but faster withdrawals, whereas relatively well-documented applications are approved faster and take longer to be withdrawn. The process duration increases for all outcomes with the application's complexity and with the EPO's workload at the filing date. Our results have a number of intriguing managerial implications, which we discuss in detail in the Conclusion section.

The remainder of this paper proceeds as follows. In §2, we describe the institutional background of the patent examination processes at the EPO. Section 3 summarizes prior work in the field and develops our rationale regarding the applicant's benefits of early versus late patent grants. In §4, we describe the data set used for the analysis and discuss the variables constructed for our multivariate analysis. In §5, descriptive statistics and multivariate duration estimates are

[1] We thank Jürgen Lachnit and Markus Herzog for detailed discussions on filing strategies, and Ciaran McGuinley, Nils Stevnsborg, and Nikolaus Thumm for sharing insights from the patent office's perspective.

[2] See the contributions in Johnson and Popp (2003), Popp et al. (2004), and Regibeau and Rockett (2009). Whereas the first two papers point to a positive relationship between value and process duration, the latter one finds evidence to the contrary. We discuss these results in detail in §3.

[3] See Gambardella et al. (2008) for a detailed discussion of value correlates and possible indicator variables.

presented and discussed. Section 6 concludes and lays out implications of our findings for managerial decision making.

2. Patent Examination 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 individual national paths once the applicant seeks protection in more than three EPC countries, because the total cost of a European patent amounts to approximately EUR 29,800, roughly three times as much as a typical national application (Harhoff and Reitzig 2004).[4]

Figure 1 provides a highly simplified presentation of the examination process at the EPO. Once an application has been filed, a search report is generated. It describes the state of prior art regarded as relevant according to EPO guidelines for the patentability of the invention. Most importantly, it contains a list of references (backward citations) to prior patents and/or nonpatent sources that are deemed relevant by the examiner. Unlike in the U.S. system, applicants at the EPO are not required to supply a full list of prior art (see Michel and Bettels 2001, p. 191; Meyer 2000, p. 109) but they may do so. The inclusion of references in the search report is fully controlled by the examiner who also classifies the references into different categories: Type X references refer to prior art documents that, taken by themselves, call the novelty or inventive step of a claim into question. Type Y references do so in conjunction with other documents. Type A references simply describe the state of the art, but do not call claims in the patent application into doubt. Finally, a type D classification (which can be combined with the X, Y, and A categories) is assigned to references that have been supplied by the applicant indicating that the results from the applicant's prior art search were considered relevant by the examiner. The classification of patent references allows us to control for the quality of an application. If a search report contains many type X or type Y references, then the claimed invention may not meet the requirements of novelty or inventive step in a given claim. This may increase the likelihood of withdrawal or refusal. Moreover, the classification information is used in our paper to distinguish between different types of forward citations. If a patent is cited as a type X or Y reference, then the cited patent effectively blocks subsequent patents. We interpret patents receiving numerous type X or Y citations as particularly important.

The search report is made public by the EPO typically with the publication of the application 18 months after the priority date of the patent application (see Figure 1). Within six months after the publication of the search report in the EPO Bulletin, applicants may request the examination of their application.[5] If examination is not requested, the patent application is *deemed to be withdrawn* according to EPC Article 94(3) (European Patent Office 2007). This is likely to be the case in situations where the search report reveals considerable prior art that would make a patent grant seem unlikely. The patent application may also be withdrawn explicitly by the applicant.

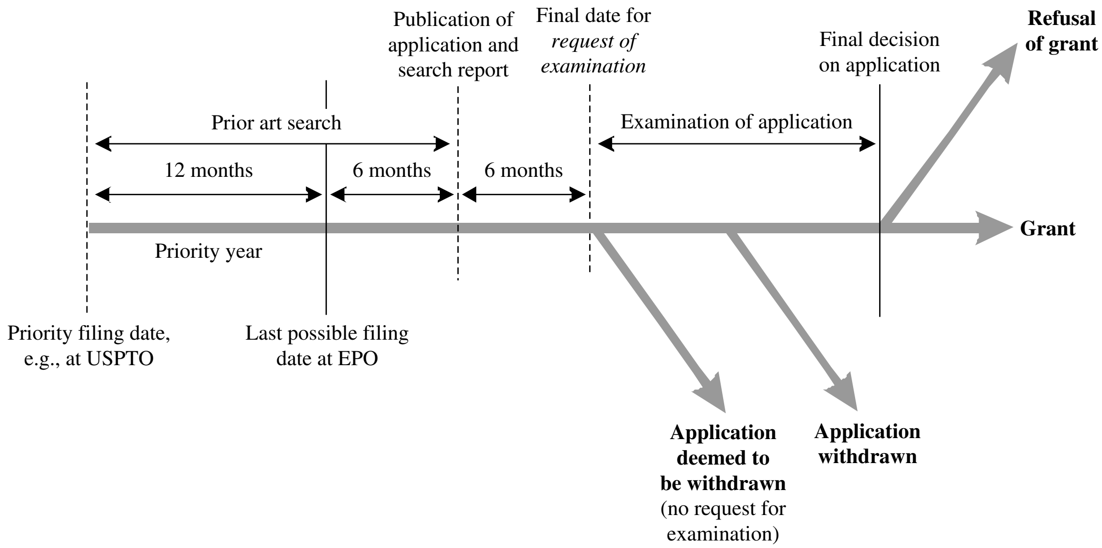
If examination has been requested, the examiner determines whether the patent application has merit according to the patentability criteria at the EPO: novelty, inventive step, and susceptibility for industrial application. After examination, the EPO either informs the applicant that the patent will be granted as specified in the original application or it requires the applicant to agree to changes in the application. If an agreement between the examiner and the applicant has been found in the resulting negotiation process, the patent is granted by the EPO. The applicant may then take the EPO decision to the national patent offices where the patent is validated for the respective designated state and translated into the relevant national language. Validation and translation are relatively costly steps, followed by annual renewal fees in the designated countries. Conversely, during examination the applicant only has to pay a relatively low annual renewal fee at the EPO.[6] During the examination, the applicant may decide not to continue the process. This decision can be based on various reasons: the probability of finally receiving a patent grant might be perceived as low by the applicant, or the examiner might require changes in the formulation of the patent that would decrease the value of a granted patent or a combination of both. The *withdrawal* of

[4] Note that national patent systems might be appealing application paths (even at a slightly enhanced cost compared to an EPO application) if they offer strategic advantages to the applicant. Such an advantage could be the lack of a comparably cheap opposition mechanism in the national patent systems.

[5] See EPC Article 94(2) (European Patent Office 2007).

[6] For details, see http://www.european-patent-office.org/epo/new/costs_ep_2005_de.pdf, accessed September 5, 2008. An average patent with 18 pages, designated for six EPC states and renewed up to its 10th year will cost about EUR 32,000. Of this amount, *national* renewals account for 32%, validation and translation for 22%, and fees at the EPO for only 14%. The remainder (32%) is spent on legal representation.

Figure 1 Examination of Patent Applications at the EPO



Note. The time between the filing of an application at the EPO and the occurrence of the final outcome of the procedure (withdrawal, grant, or refusal) is the dependent variable studied in the duration analysis.

an application is again reflected in the data. Alternatively, 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.

Applications filed under the Patent Cooperation Treaty (PCT) require particular attention, because they now constitute a large share of all filings at the EPO and are subject to a specific institutional treatment. Strictly speaking, a PCT filing is not a patent application, but offers the filing party the option of launching patent applications in up to 141[7] PCT signatory countries within 30 months of the filing date. 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. Third, the PCT filing, when compared to a national or regional application,[8] has greater option value, because 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 of the priority year, as with national and regional applications. Finally, PCT applications are not subject to certain cost rules, e.g., claims fees as they exist at the EPO and the U.S. Patent and Trademark Office (USPTO).

[7] This number is as of June 2009 (see World Intellectual Property Organization 2009).

[8] 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 EPC.

3. Literature Review and Conceptual Issues

3.1. Previous Studies

Since the 1990s, management scholars have increasingly undertaken studies of corporate IP policies (e.g., Pitkethly 2001), on the role of IP in the context of dynamic firm capabilities (e.g., Teece et al. 1997), on the optimization of IP strategies (e.g., Harhoff and Reitzig 2001), and more recently on the systematic buildup of organizational capabilities in the area of IP (Reitzig and Puranam 2009). Reitzig and Puranam (2009) undertake a firm-level study of 30 firms' European patent applications over four years and conclude that organizational arrangements are an important determinant of a firm's capability to receive early patent grants. The duration of examination processes has also been investigated in a number of earlier studies (Johnson and Popp 2003, Popp et al. 2004, Regibeau and Rockett 2009). These authors have analyzed the duration of patent granting at the USPTO using duration data for granted patents only. A crucial issue is the question of whether valuable patents take longer to evaluate than less valuable ones. Johnson and Popp (2003) and Popp et al. (2004) find that valuable patents (as indicated by citations as a single proxy variable) take longer to be granted than less valuable ones. Regibeau and Rockett (2009) take exception to this result and demonstrate that, in a carefully selected sample of plant biotechnology patents, valuable patents are approved by the USPTO more quickly than less valuable ones. Thus, the empirical evidence regarding this crucial issue is contradictory at this point. Regibeau and Rockett (2009) assume that patent granting decisions are imperfect, but their precision can be improved by delaying the examination of the applications, as more information arrives over time. Longer approval delays make for better decisions and decrease the risk of reduced social welfare due to erroneous patent grants. Trading off welfare losses due to deferred investment decisions in cases of longer examination periods, Regibeau and Rockett (2009) find that faster grants of important patents are welfare enhancing. Our results shed more light on these issues because they provide detailed empirical evidence on the relation of patent value and examination time.

Patent protection has traditionally been treated in a highly stylized manner in formal models. In particular, in the industrial organization literature (e.g., Loury 1979, Lee and Wilde 1980, or De Fraja 1993), the date of R&D success and patent protection coincide. A patent unfolds its legal effect immediately and with certainty in these models. As in Lemley and Shapiro (2005), our paper builds on the more realistic view that patent applicants are facing a process with unknown duration and unknown outcome. The probabilistic nature of patents complicates managerial decision making considerably. The uncertainty surrounding patents has at least three dimensions: (i) it is not certain that an application will be granted, (ii) the date at which a patent actually receives a grant is uncertain, and (iii) the scope of patent protection for those applications turned into grants is uncertain, too. We study the first two of these three dimensions of uncertainty in our paper—the outcome and the timing of patent examination. Whereas it is obvious that the outcome of examination is of great importance, the relevance of timing is less clear and has been discussed very little in the managerial literature (a notable exception is Gans et al. 2008). We treat these aspects jointly in accelerated failure time (AFT) models to identify outcome-specific patterns from our data.

3.2. Costs and Benefits of Early or Late Patent Approval

To be able to interpret the results from the following empirical analysis, we briefly discuss the relative advantages and drawbacks of an early compared to a late patent grant. Among the key advantages of an early patent grant are (i) obtaining some certainty regarding the state of one's own patent portfolio and (ii) the option of early utilization of an injunction or other legal instrument for the prosecution of infringers, i.e., the full availability of legal recourse. These aspects (in particular the second one) are of utmost importance for valuable patents. If the patent holder sees her position threatened by an infringer and ex post awards of damages are unlikely to fully compensate for the infringement, then obtaining an early grant should be a central concern to the patent applicant. Moreover, applicants in some industries will profit more than others from early grants—in sectors with short innovation cycles, fast patent protection is more desirable than in other sectors such as biotechnology and pharmaceutics. In the latter industries, applicants will typically not accelerate proceedings because the option value from waiting as discussed below will dominate the rationale of the applicant.

On the other hand, relatively late arrival of the grant may offer the advantage of deferred payments (costs, e.g., for translation), of imposing uncertainty on rivals, and the possibility of fine tuning the patent right to technological and market developments. Strategic behavior of this sort may be advantageous even though the patent is not a "submarine" that can emerge as a complete surprise to competitors.[9] Patent law leaves sufficient leeway for applicants to modify their applications in ways that can impose costs and uncertainty on rivals, even if the initial application has been published (von Graevenitz et al. 2007).

Because we are not able to observe the motivation and efforts undertaken by the applicant or the examiner to influence the examination process, we relate observable characteristics of individual patent applications and early decisions made by the applicant to the duration of the respective examination. We argue that the resulting estimates are informative about the effect of choices that managers can make on the expected duration of patent examination. In the following, we distinguish three broad categories of determinants in our regressions: (i) applicants' characteristics, (ii) patent characteristics related to the value of the patent, and finally, (iii) the complexity of the examination task itself. Some of the measures introduced below can not be attributed exclusively to only one of these three groups. In particular, indicators of patent value might be related to applicant characteristics or to the complexity of the examination task. We will take these ambiguities into account when interpreting our results.

4. Data and Descriptive Statistics

4.1. Data Source

European patent data enable us to analyze not only granted patents (as in Popp et al. 2004 or Johnson and

[9] Because EPO applications are published 18 months following the priority date, they cannot be "submarine" patents in the classical sense.

Popp 2003) but also applications that are withdrawn by the applicant or rejected by the patent office. Moreover, we propose novel measures of patent characteristics that can be derived from the EPO's search reports and are not available if U.S. patent data are used. Our data were obtained from the *Online European Patent Register* database provided by the EPO 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. It provides bibliographic data (e.g., on search reports) and also procedural information covering decisions made over the life span of an individual patent application. The data set used for this study is an image of the information published by March 31, 2003. To have an estimate of the EPO's processing capacity, the average number of employees by year was obtained from the EPO's 2003 annual report (European Patent Office 2003). Additional information on the number of claims was made available by the EPO. In August 2008, we updated the information on the outcome of the examination procedures of the patents in our sample. The total number of international equivalent filings was obtained from the publicly available EPO PATSTAT database as of March 2008. We use renewal data (i.e., renewal for more than 10 years) to construct a value measure in our multivariate analysis. To obtain this information without censoring in spring of 2008 our data set had to be restricted to patents with application dates prior to February 1998. Whereas our descriptive statistics cover the full application cohort of 1998, the multivariate analysis is restricted to patents with application dates prior to February 1998.

4.2. Variables

4.2.1. Dependent Variables.

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 (see also Figure 1). Using this information, we compute the total duration of the examination period as the difference between the two dates measured in fraction of years (number of days divided by 365).

Status of the application. The examination status of each application is known effective as of March 2008. Once an application has been granted or once the examiner has issued a refusal to grant a patent, the examination procedure is closed. Additionally, the examination can also be terminated for reasons that lie outside the control of the patent office: the patent applicant might decide to withdraw his application from the office, perhaps because of unsatisfying results contained in the search report. Withdrawals are inferred 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 after having requested examination or does not pay some required fee.[10]

4.2.2. Applicant Characteristics.

Number of annual patent applications. To control for scale effects and for the experience that a patent applicant has in interactions with the EPO, we include the total *number of applications* filed by a patentee in a given year.[11] We assume that relatively large applicants are likely to achieve an acceleration of grants, but that they will also tend to fight harder for applications that are on the verge of being refused.

Country of origin. European, Japanese, and U.S. patentees account for more the 95% of all patent applications at the EPO. We include dummy variables in our regressions to control for different filing strategies of applicants from different countries. We distinguish between UK, U.S., Japanese, and other non-European applicants, using continental European applicants as a reference group. The reason for separating out the UK from other European countries is the strong influence of US patenting habits in that country. We expect that UK, U.S., and Japanese patents contain a larger fraction of applications that support the buildup of defensive patent portfolios. For such applications, the applicant may allow more time until grant To modify the applications strategically while they are being processed.

4.2.3. Patent Characteristics and Value Correlates.

Request for accelerated examination. We hypothesize that applicants who expect their patent to have high potential value will intend to accelerate the examination of their application. Applicants may request an accelerated examination in this case, resulting in a shortened examination procedure. A binary variable indicating whether accelerated examination has been requested is included in the analysis. Because of their very nature, requests for accelerated examination could conceivably reduce the duration across all outcomes. However, because requests of accelerated examination are also an indicator that applicants attach a high value to a patent, withdrawals

[10] Applications may also drop out of examination for extraordinary reasons, such as the death of the applicant. The number of these cases is extremely small—between 1978 and 1998, these cases accounted for 0.14% of all patent applications filed at the EPO. We code these cases also as withdrawals. Our results are not affected if we drop these changes altogether.

[11] To compute the variable, we have to consolidate applicant names. We rely on the name consolidation that is provided by the EPO within its system of assigning applicant identifiers to patent applications. Applications with multiple applicants are counted fractionally.

and refusals should be delayed because of applicants' incentive to avoid negative outcomes. It is worth noting that accelerated examination does not require the payment of a fee—the only cost implication is that all fees for examination, etc., have to be paid at the time when the request is made. But there may be an implicit cost of the request: Harhoff and Reitzig (2004) show that in biotechnology and pharmaceuticals, accelerated examination is associated with a substantial increase in the likelihood of opposition.

PCT application. For each patent we include a dummy variable indicating whether an international application within the PCT framework (see §2 for details) has been filed. Because of the institutional delay caused by a PCT filing, the observed duration of patent examination should be increased across all outcomes.

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 three years after application. Numerous studies found that forward citations are positively correlated with the monetary value of patents (see Harhoff et al. 1999, Lanjouw and Schankerman 2004, Trajtenberg 1990). Taking into account the incentives of the applicant, a high number of citations should then be related to shorter durations for patent grants. On the other hand, for more valuable patents, longer pendencies can be expected if a withdrawal or a refusal occurs. To construct a more refined citation measure, we include the share of type Y, type X, and type D citations in our regressions. We expect the share of type X and Y citations to be correlated with patent value. Similarly, type D citations are likely to reflect higher effort and thus higher value in the eyes of the applicant.

Number of EP equivalents. European patent (EP) applicants may derive more than one EPO patent application from a priority filing, which is particularly likely if they intend to build a patent portfolio or thicket of relatively similar patents related to one invention (von Graevenitz et al. 2007). In this case, the applicant may not be interested in enforcing the patent but in deterring rivals from filing closely related applications. We expect that such patent applications will be processed more slowly across all outcomes because the applicant has no strong motivation for obtaining the patent early.

Total number of equivalents (*patent family size*). We count the *number of equivalents* of the focal patent application in all jurisdictions. A large international patent family indicates that the applicant is incurring significant costs to have the invention protected in a large number of countries. This variable is likely to reflect the patent's underlying value and should therefore accelerate patent grants while delaying withdrawals and refusals.

Generality of an application. The *generality* index is based on the technological distribution of forward citations received by an application and is defined as $generality = 1 - \sum_{k=1}^{n_k} s_{ik}^2$, where s_{ik} is the percentage of citations received by patent i that originate from patents belonging to patent class k out of n_k patent classes (Trajtenberg et al. 1997). The *generality* index will be high if a patent is cited by subsequent patents that belong to a wide range of technological fields. A high *generality* index suggests that the patent influenced subsequent innovations in a variety of different technological fields and is broadly applicable across fields. We compute *generality* distinguishing between 30 different technical fields.[12] It can be assumed that patents that are applicable in different technologies (more general patents) should be more valuable. Therefore, high *generality* measures should go along with faster grants and slower withdrawals and refusals.

4.2.4. Complexity of Examination Task.

Number of references. The search report published by the EPO yields information on prior art relevant for the patentability of an application by referencing previous patents or nonpatent literature. We consider the total number of patent references (also referred to as backward citations) as well as references to nonpatent documents as a measure of the examiner's search effort. Because each referenced document has to be identified and validated by the examiner, a larger number of references can be expected to increase duration of examination across all outcomes.

Share of type X, type Y, and type D references. As described in §2, all references in the search report are classified in different categories or combinations thereof (see Michel and Bettels 2001, Harhoff et al. 2006 for detailed information). We use this information to characterize patents with respect to their quality.

A high share of type D references, for instance, signals that the applicant has conducted relevant prior art searches, which is likely to be the case for highly important applications. As the examiner's task of identifying prior art is facilitated, the duration of examinations should be shortened per se. However, a larger share of type D references would also be correlated with patent value and should therefore delay withdrawals and refusals as applicants try to avoid

[12] The categorization is based on the OST-INPI/FhG-ISI technology nomenclature, which aggregates the IPC classification to 30 technological areas (see Organisation for Economic Co-operation and Development 1994, p. 77).

negative outcomes while accelerating patent grants. Moreover, we expect that applicants who receive a search report containing a large share of type X and type Y references are more likely to withdraw their application from the process. On the other hand, if they choose to pursue the application despite a negative search report, more intense negotiations with the examiners are likely to take place. This should increase the duration of examination leading to either a grant or a refusal of the patent.

Originality of an application. The *originality* indicator is measured similar to *generality* with the exception that patent references are used instead of citations received. A high *originality* index indicates that the patent's search report refers to prior art from a relatively wide set of technologies. We assume that these patent applications are typically more complex to examine, because a prior art search has to be carried out in a broader range of distinct technical fields. Therefore, we expect high *originality* to be correlated with longer examinations across all outcomes.

Number of claims. Each patent contains a set of claims that marks the boundaries of the patent. The economic interpretation of the total number of claims is not straight forward. On the one hand, each additional claim might raise the probability of an infringement and therefore the value of a patent. On the other hand, additional claims make 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 (Lanjouw and Schankerman 2004). 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; a larger number of claims should lead to an increase in the time needed for examination (irrespective of the examination outcome), because each claim must be checked and validated by the examiner.

Number of International Patent Classification assignments. A patent is assigned to one or more categories of the International Patent Classification (IPC), system during the examination period, depending on its relatedness to different technical fields. We interpret the *number of IPC classes* (similar to the *originality* index) as a measure of complexity of the search for prior art because more diverse prior art has to be identified if a patent is assigned to several IPC classes. A higher number of IPC classes is therefore likely to increase the process duration, irrespective of the outcome.

4.2.5. Further Controls. At the aggregated level, pendencies will be affected by the overall capacity situation at the patent office.[13] Because 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 workload should therefore lead to slower patent examination and longer lags. We include a variable defined as the number of pending cases divided by the number of examiners ("A-posts") at the EPO. We distinguish the number of pending cases for 30 different technical fields and compute a workload variable as an approximation 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 in time.[14] We expect that increasing workload is associated with longer procedural duration for all outcomes.

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. 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). The control for technology fields is supposed to capture any time-invariant differences between technical fields that we cannot observe directly.

4.3. Descriptive Statistics

Before working with data sets that are random samples from the total population, we present descriptive statistics of the overall population. Table 1 displays basic statistics on decision lags by year of application. The larger share of EPO applications is granted—in the time window covering the application years from 1978 to 1998, the grant rate is 59.1%. Only 3.9% of the cases are actually explicitly refused by the patent examiner, whereas 26.5% are withdrawn by the applicants themselves after receiving a sufficiently negative search report. Note that even when restricting the sample to applications from 1978 to 1998, 10.5% of all cases are still pending. On average, applicants withdraw from their applications after 3.16 years. Patent grants occur after 4.25, years whereas refusals take slightly more time with 4.43 years (see Table 1).

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 90,000 in 1998 (see Table 1). Because the examination of each patent

[13] Existing studies control for the capacity situation only indirectly by including time dummy variables, whereas we are proposing a direct measure of the capacity situation at the level of technical fields.

[14] The number of pending cases is computed on a daily basis, but the employee figures reflecting the recruiting policy of the EPO are available only on an annual basis.

Table 1 Characteristics of EPO Patent Applications and Application Outcomes by Application Year

			Outcomes of patent examination							Patent characteristics			
			Grants		Withdrawals		Refusals		Pending				
Year	Filings in *t*	Pending cases	Share	Duration	Share	Duration	Share	Duration	Share	PCT Share	Number of claims	References to patents	References to nonpatent literature
1978	3,902	3,900	71.50	2.84	25.76	1.98	2.46	3.62	0.28	9.9	9.84	4.47	0.39
1979	12,390	15,964	70.97	2.94	24.57	2.15	4.35	3.65	0.11	11.9	9.97	4.96	0.40
1980	19,722	33,943	70.33	3.20	24.54	2.32	5.06	3.58	0.07	12.0	10.06	4.73	0.47
1981	24,957	53,196	69.55	3.36	25.64	2.51	4.72	3.76	0.09	11.1	10.41	4.45	0.50
1982	28,522	72,429	69.70	3.57	25.94	2.64	4.22	3.97	0.14	11.8	10.73	4.42	0.55
1983	31,608	88,062	69.14	3.79	26.68	2.87	3.97	4.12	0.21	11.6	10.52	4.36	0.60
1984	36,952	104,507	68.22	3.98	27.98	3.05	3.60	4.32	0.20	11.1	10.85	4.22	0.61
1985	39,375	120,997	67.79	4.21	29.10	3.16	3.02	4.59	0.10	14.8	11.16	4.30	0.67
1986	43,083	136,294	67.12	4.21	29.25	3.21	3.52	4.81	0.11	15.3	11.18	4.27	0.73
1987	45,815	154,642	66.46	4.35	29.45	3.46	3.80	4.88	0.29	13.6	11.40	4.23	0.80
1988	52,184	176,991	65.59	4.38	29.71	3.53	4.15	4.69	0.55	15.0	11.54	4.13	0.81
1989	57,724	200,971	63.83	4.44	30.84	3.46	4.44	4.76	0.88	15.6	11.82	4.11	0.87
1990	63,903	227,359	65.85	4.34	29.36	3.39	4.39	4.61	0.40	19.0	12.03	4.14	0.91
1991	59,269	242,777	67.20	4.36	28.29	3.46	4.26	4.67	0.25	24.2	12.32	4.21	0.98
1992	60,605	252,884	67.26	4.35	27.82	3.52	4.14	4.70	0.79	25.5	12.44	4.30	0.98
1993	60,048	254,299	69.15	4.45	26.11	3.77	4.04	4.79	0.69	30.0	12.95	4.49	0.99
1994	61,974	253,643	68.45	4.57	26.41	4.07	3.90	4.99	1.24	34.2	13.29	4.61	0.98
1995	65,233	259,218	66.69	4.82	27.44	4.44	3.82	5.24	2.06	38.8	13.79	4.73	0.94
1996	71,281	271,943	63.94	5.04	28.85	4.67	3.60	5.22	3.61	43.8	14.34	5.02	0.93
1997	80,270	295,083	59.70	5.19	31.57	4.71	2.92	5.13	5.81	45.6	14.80	4.98	0.90
1998	90,479	330,322	54.89	5.10	33.80	4.57	2.01	5.00	9.30	47.7	15.36	4.84	0.86
Total	**1,009,296**	**169,020**	**65.41**	**4.45**	**28.85**	**3.72**	**3.73**	**4.74**	**2.01**	**26.86**	**13.40**	**4.18**	**0.80**

Notes. Duration is reported in years. We report the outcome of patent applications as of March 2008. The category "application withdrawn" also includes cases in which patents were consolidated or applications were suspended. These are 0.14% of all applications over the total period.

application takes several years, the growth in application numbers has led to the emergence of a backlog of pending cases at the EPO, which grew to more than 330,000 pending patent applications at the end of 1998 (see Table 1). The most evident explanation for this strong growth of the backlog is a slow 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 2,662 in the period from 1978 to 1998 (European Patent Office 2003). The number of pending cases per examiner (the average workload of each examiner) increased since the foundation of the EPO from about 24 pending cases per examiner to more than 120 in 1998. This strong increase in the workload of the patent examiner may be one explanation for the lengthening of the examination procedure.

Another potential explanation can be found in the growing complexity of patent applications over the last two decades. Table 1 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. 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 1978 level. The examination of a combined EPO/PCT application is more time consuming than a pure EPO application, because search and examination have to take different legal frameworks into account—the EPO *and* the PCT guidelines. Table 1 also shows the average number of references. Whereas the number of backward citations to previous patents rose slightly at the end of the 90s, the number of references to nonpatent 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, too.

5. Survival Analysis

5.1. Model Specification

We are interested in examining the determinants of the duration of completing patent examination leading to a patent grant, a withdrawal, or a refusal. Simple ordinary least squares regression techniques would be inappropriate for this type of analysis because they cannot cope with the most important features of our data. First, pending cases in our data (see Table 1) needed to be excluded in common regression frameworks despite conveying information on process durations. Second, if one particular outcome is reached, other outcomes cannot conceivably be reached anymore. Both problems can be addressed by employing survival time models.

AFT models are a common choice for the analysis of survival time. These models express the natural logarithm of survival time as a linear function of the covariates X with $\ln T = X\beta + \epsilon$. If ϵ follows a logistic distribution, the log-logistic regression model is obtained and will be used in the following. In this case, the underlying survival function is given by $S(t) = [1+(\lambda t)^{1/\gamma}]^{-1}$. The implementation of the model is based on the parametrization $\lambda = \exp(-X\beta)$ treating γ as the scale parameter to be estimated from the data. In this specification, positive coefficients β indicate an increase in the expected waiting time for failure. It is worth noting that AFT models imply parametric assumptions about the underlying survival and hazard function. In this respect, AFT models differ from the semi-parametric Cox proportional hazards (PH) model, which is not based on parametric assumptions for the survival curve (Cox 1972, Kalbfleisch and Prentice 2002). The major advantage of using AFT models is that the estimated coefficients can be interpreted directly as changes of duration, whereas coefficients from the Cox PH model relate to the relative risk of exiting the sample in a specified period.[15]

The process of patent examination can be terminated by three different outcomes k (withdrawal, grant, or refusal of the application; see §2), and the influence of some of our determinants might differ across alternative outcomes. The analysis of these differences is our primary interest. However, we do not aim at explaining the dependence structure of distinct failure types. Therefore, we apply competing risks models which are based on different random variables T_k describing the duration until examination ends via exit k. Only the smallest of these durations is observed with $T = \min\{T_k\}$. Destination-specific effects can be estimated by treating spell endings other than the one under consideration as right censored at the point of exit (Cox and Oakes 1984).[16] It is worth noting that the interpretation of the estimated coefficients requires care, because the signs of coefficients and the signs of marginal effects on durations for particular outcomes may not coincide.[17] Thomas (1996) therefore proposes to report marginal effects instead. In the following analysis we report estimated coefficients and marginal effects on expected survival, based on a standard deviation increase of continuous variables or a discrete change in dummy variables.

Note that all covariates in our regression are time-invariant. To use renewal data (renewal for more than 10 years) the sample is restricted to the years 1978 to 1998. Because the EPO started its operations only in 1978, there might be a "startup effect," and we therefore also exclude the first three years of operation. Furthermore, for ease of computation we draw a 25% sample from the remaining patents. Therefore, the estimations are based on the resulting random sample of 215,265 patents (see Table 2 for descriptive statistics).

5.2. Results and Discussion

We are interested in differences in the processes leading to a withdrawal, a refusal, or an actual grant for the respective applications. The results from the survival analysis based on pooled outcomes and from competing risk models are presented in the following section. Fixed effects are included for 30 technical fields and for each application year of our period of observation in all our regressions.

In the pooled estimation, most coefficients are statistically relevant (see Table 3, columns 1 and 2). Positive coefficients indicate that an increase in the corresponding variable is associated with longer examination periods.[18] We will discuss these results in comparison with those from a competing risks specification, which are presented in columns 3–8 of Table 3. The comparison is interesting because it demonstrates that some of the effects apparent in columns 1 and 2 come about as a complex combination of outcome-specific risk determinants. In particular, the competing risk specification confirms our expectations that some of the determinants discussed in §4 have a differential effect on pendency times for withdrawals, grants, and refusals. Although in the pooled estimation the value correlates (with the exception of the request of accelerated examination) increase the duration of patent examination, the competing risk results indicate that grants occur earlier for more valuable patents, whereas withdrawals are delayed. We interpret this as a clear indication that applicants can influence the duration of patent examinations at the EPO.

The results with regard to the request for accelerated examination support our hypothesis of applicant efforts to accelerate or decelerate examination. Grants are accelerated by this request, whereas withdrawals

[15] The results we present in the following are based on AFT models. In robustness tests, we also estimated Cox PH models and found similar results.

[16] Given our data we would not be able to identify the degree of dependence of different outcomes using this approach. However, the coefficients of the determinants of examination duration can be estimated within this framework even if the risks are correlated (Kalbfleisch and Prentice 2002, Chap. 8).

[17] This problem is well known in the context of the multinomial logit model (see, e.g., Wooldridge 2001, p. 498).

[18] In Table 3 we report both the estimated coefficients and marginal effects on the mean survival time conditional on leaving the sample via exit k.

Table 2 Descriptive Statistics for the 215,265 Patent Applications Included in Our Sample

Variable	Description	Mean	Std. dev.	Min	Max
Duration	Duration between filing of the application and the final decision of the EPO/withdrawal of the applicant.	4.331	2.140	0.019	26.632
Applicant characteristics					
Applicant size	Annual number of patent filings at the EPO	106.596	201.860	1	1, 985
EU applicant	Patent applicant from a European country (excluding UK)	0.437	—	0	1
UK applicant	Patent applicant from UK	0.058	—	0	1
Japanese applicant	Patent applicant from Japan	0.176	—	0	1
U.S. applicant	Patent applicant from the U.S.	0.292	—	0	1
Other	Patent applicant from other nations	0.037	—	0	1
Patent characteristics and value correlates					
Accelerated exam.	Indicator of whether the applicant requested accelerated examination for the patent application (0/1).	0.021	—	0	1
PCT application	Indicator of whether a patent applications was filed as a PCT application (0/1).	0.257	—	0	1
Number of citations	Total number of citations a patent receives within 3 years after the filing date.	0.677	1.384	0	50
Share of X citations[a]	Share of patent citations indicating that the focal (cited) patent document is limiting the patentability of the invention underlying the citing patent application.	0.090	0.258	0	1
Share of Y citations	Share of patent citations indicating that the focal (cited) patent document is limiting the patentability of the invention underlying the citing patent application when combined with other documents.	0.051	0.196	0	1
Share of D citations	Share of patent citations indicating that the focal (cited) patent document is based on an invention related to the invention underlying the citing patent application but not limiting the latters patentability.	0.034	0.145	0	1
EP equivalents	Number of EPO applications originating from one initial priority filing.	1.050	0.363	1	15
Family size	Family size (number of international patent applications related to a EPO application)	6.097	5.716	1	250
Generality	Distribution of the citations a patent received across technology areas.	0.027	0.111	0.000	0.810
Complexity of examination task					
No. of pat. references	Total number of references to patents contained in the search report.	4.320	2.618	0	71
No. of nonpat. references	Total number of references to nonpatent documents contained in the search report.	0.860	1.306	0	58
Share of X references[b]	Share of references to patent documents that have been classified as limiting the patentability of the examined invention.	0.173	0.280	0	1
Share of Y references	Share of references to patent documents that have been classified as limiting the patentability of the examined invention when combined with other documents.	0.134	0.252	0	1
Share of D references	Share of references to patent documents that have been classified as related invention that do not limit the patentability of the examined invention.	0.093	0.204	0	1
Originality	Distribution of the references contained in a patent's search report across technology areas.	0.026	0.110	0.000	0.800
Claims	Number of claims contained in the patent application.	12.538	9.754	0	442
IPC classes	Number of different IPC classifications assigned to the patent application by the EPO.	2.182	1.506	1	27
Further controls					
Workload	Number of pending patent applications in a technology area divided by the number of patent examiners.[c]	4.457	1.989	0.373	10.549

Note. Those patents represent a 25% random sample from the total population of patents filed at the EPO between 1978 and 1998.

[a]The *share of X citations* has been computed relative to the total number of citations a patent receives irrespective of their classification. This also applies for the *share of Y and D citations*.

[b]The *share of X references* has been computed relative to the total number of references a patent's search report contains irrespective of their classification. This also applies for the *share of Y and D references*.

[c]The number of examiners is not available on the level of technology areas. We therefore use the aggregate measure as denominator.

Table 3 Estimation Results from AFT Models

	Pooled		Granted		Withdrawn		Refused	
	Coeff. (1)	Marg. effects (%) (2)	Coeff. (3)	Marg. effects (%) (4)	Coeff. (5)	Marg. effects (%) (6)	Coeff. (7)	Marg. effects (%) (8)
Applicant characteristics								
Annual number of applications (log)	−0.002**	−0.34	−0.013**	−2.85	0.023**	5.00	−0.010**	−2.17
	[0.000]		[0.000]		[0.001]		[0.002]	
UK applicant	0.024**	2.39	0.119**	12.59	−0.213**	−19.16	−0.112**	−10.60
	[0.004]		[0.004]		[0.009]		[0.015]	
Japanese applicant	0.231**	25.96	0.164**	17.84	0.442**	55.62	0.256**	29.14
	[0.003]		[0.002]		[0.007]		[0.012]	
U.S. applicant	0.128**	13.71	0.208**	23.07	−0.086**	−8.24	−0.028**	−2.75
	[0.002]		[0.002]		[0.005]		[0.009]	
Other non-European applicants	0.080**	8.32	0.163**	17.68	−0.126**	−11.85	0.001	0.05
	[0.005]		[0.005]		[0.011]		[0.020]	
Patent characteristics								
Request for accelerated examination	−0.230**	−20.53	−0.332**	−28.28	0.430**	53.67	0.031	3.17
	[0.006]		[0.006]		[0.024]		[0.033]	
PCT application	0.087**	9.11	0.061**	6.33	0.040**	4.11	−0.070**	−6.72
	[0.002]		[0.002]		[0.006]		[0.010]	
Citations received within 3 years	0.007**	0.93	0.004**	0.58	0.012**	1.74	−0.003	−0.41
	[0.001]		[0.001]		[0.002]		[0.003]	
Share of type X citations	0.002	0.05	0.001	0.02	−0.032**	−0.83	−0.036*	−0.91
	[0.004]		[0.004]		[0.009]		[0.015]	
Share of type Y citations	0.003	0.05	−0.007	−0.14	−0.017	−0.34	−0.001	−0.02
	[0.004]		[0.004]		[0.012]		[0.020]	
Share of type D citations	0.036**	0.53	−0.028**	−0.40	0.251**	3.71	0.081**	1.18
	[0.006]		[0.006]		[0.018]		[0.028]	
Number of EP equivalents	0.092**	3.39	0.178**	6.67	−0.014	−0.49	0.334**	12.89
	[0.003]		[0.003]		[0.008]		[0.019]	
Total number of equivalents	0.006**	3.75	−0.013**	−6.92	0.114**	92.07	0.046**	29.77
	[0.000]		[0.000]		[0.001]		[0.001]	
Generality	0.054**	0.60	−0.005	−0.05	0.227**	2.54	0.031	0.35
	[0.008]		[0.008]		[0.022]		[0.036]	
Complexity of examination task								
Number of patent references	0.010**	2.83	0.013**	3.64	0.002*	0.58	0.008**	2.28
	[0.000]		[0.000]		[0.001]		[0.001]	
Number of nonpatent references	0.024**	3.43	0.029**	4.09	0.017**	2.41	0.022**	3.15
	[0.001]		[0.001]		[0.002]		[0.003]	
Share of type X references	0.073**	2.06	0.183**	5.26	−0.183**	−5.01	0.079**	2.26
	[0.003]		[0.003]		[0.007]		[0.014]	
Share of type Y references	0.048**	1.23	0.102**	2.62	−0.111**	−2.76	0.029*	0.74
	[0.003]		[0.003]		[0.008]		[0.015]	
Share of type D references	−0.012**	−0.25	−0.071**	−1.45	0.162**	3.38	−0.064**	−1.30
	[0.004]		[0.004]		[0.012]		[0.018]	
Originality	0.050**	0.55	0.050**	0.55	0.038	0.42	0.113**	1.25
	[0.008]		[0.008]		[0.020]		[0.036]	
Number of IPC classification	0.013**	9.11	0.017**	6.33	0.004*	4.11	0.017**	−6.72
	[0.001]		[0.001]		[0.002]		[0.003]	
Number of claims	0.004**	3.74	0.004**	3.91	0.004**	3.60	0.005**	4.79
	[0.000]		[0.000]		[0.000]		[0.000]	
Further controls								
Workload at the EPO	0.018**	3.70	0.029**	5.88	−0.016**	−3.07	0.029**	6.02
	[0.001]		[0.001]		[0.003]		[0.006]	
Time dummies included	YES	YES	YES	YES	YES	YES	YES	YES
Technology dummies included	YES	YES	YES	YES	YES	YES	YES	YES
Constant	0.704**	—	0.774**	—	1.303**	—	1.483**	—
	[0.010]		[0.010]		[0.026]		[0.048]	
Observations	215,265		215,265		215,265		215,265	
Exits	213,097		143,038		61,709		8,350	
Log likelihood	−115,766		−86,782		−121,825		−27,294	
Likelihood ratio χ^2	64,432		78,092		46,267		5,966	

Notes. Estimates from a pooled and a competing risk specification are displayed. Marginal effects relate to the effect of a standard deviation increase for continuous variables or a discrete change for dummy variables on the mean survival time conditional on the respective exit. Marginal effects have been evaluated at the mean of continuous variables, whereas dummy variables have been set to zero. Standard errors are in square brackets.

*5% significant; **1% significant.

are slowed down, and refusals are not affected significantly. The magnitude of this effect is quite large: Whereas the request reduces the time to grant by more than 28%, applicants delay withdrawals by about 54% (see Table 3). Similar results are obtained for the total number of equivalent filings in national jurisdictions (family size) of a given application—an alternative value correlate. Patents being characterized by a large international family size receive earlier grants (a standard deviation increase reduces examination time by about 7%) while being withdrawn and refused late. Note that a large number of within-EPO equivalents increases the duration until a final decision from the office is issued for grants (but with a slightly smaller marginal effect than the total number of equivalents), and refusals whereas withdrawals are not effected. Also, search reports containing a high share of type D references (which is an indication of a well-documented patent application) lead to earlier patent grants and are withdrawn less early. Additionally, the *generality* variable affects the time until a patent is withdrawn positively (columns 5 and 6) indicating that applicants are less willing to give up these applications. We do not find evidence, however, that patents that are more generally applicable are granted or refused by the patent office faster than other patents.

Surprisingly, we find that the number of forward citations (which has been used as primary value indicator in previous studies) lengthens the examination period for grants and withdrawals (columns 3–6). This contradicts our expectation that highly cited patents are processed faster due to applicants trying to get early patent grants. It should be noted, however, that the observed effect is small in magnitude. A standard deviation increase in the number of citations increases duration by only 0.6% in the case of granted patents. The reported coefficient might, however, underestimate the true effect of forward citations on the duration of patent examination because a request for accelerated examination is more likely filed for valuable patents.[19]

Given the ambiguous results with regard to the individual effect of the different value correlates (in particular citations versus family size and request of accelerated examination), we constructed a composite value indicator that predicts a patent application's potential value based on renewal data. Because of the cost of renewing patents, renewal information should convey reliable information on patent value. Because renewal data is available only for granted patents, we relate the value indicators used in the initial analysis to the likelihood that a patent was maintained at least 10 years. The results from a probit regression (see the appendix) are then used to predict the potential value of all patents in our sample using the predictor $X\hat{\beta}$ as a value indicator. We use this prediction in the duration analysis instead of the individual value correlates. The results of this exercise are presented in Table 4. At this more aggregate level of value measurement we are able to confirm our expected pattern: the grant of valuable patents is accelerated, whereas withdrawals and refusals for such applications are delayed significantly. This result is in line with our expectations and sheds some light on previous controversial results on the relation between patent value and pendency times. Johnson and Popp (2003) use a value measure based primarily on the number of citations received and find that valuable patents are characterized by longer grant lags. In contrast, our findings support the finding of Regibeau and Rockett (2009) that valuable patents are granted earlier. Although Regibeau and Rockett (2009) take a welfare-maximizing perspective, they argue that the acceleration may largely be driven by applicant behavior, which is in line with our interpretation.

Confirming our expectations, more complex applications require more time to be processed across all three risks. The effect of the *number of claims*, the *number of references*, and the *originality* measure is positive and highly significant, indicating longer pendencies. The effect of the *share of X references* which are damaging to the claimed novelty or inventive step, is also strongly significant. A high share of X references slows down the granting process while leading to early withdrawals. Finally, we find that larger applicants are able to accelerate decision making at the EPO (both grants and refusals occur earlier for larger applicants), and they are less willing to withdraw early. We reckon that this is a consequence of having more experience in dealing with the EPO. Our control for the capacity situation at the EPO also has the expected influence—the examiner takes more time to derive a final decision in situations of high workload. Interestingly, we also observe that applicants are more likely to withdraw early in these situations, possibly in cases where a late grant would not generate much value for them.

Fixed effects for 30 different technology areas that are not reported here in detail have been included in all estimations. It is worth noting that we observe positive and significant effects of large magnitude for the biotechnology, telecommunications, information technology, and semiconductor areas. On the other hand,

[19] We want to thank one anonymous referee for pointing to that fact. In estimations excluding the dummy variable indicating whether an accelerated examination has been requested, the magnitude of the coefficient of the number of forward citations is almost not altered, which indicates the robustness of our results. Further variations in the set of explanatory variables did not change our findings significantly.

Table 4 Estimation Results from AFT Models

	Pooled		Granted		Withdrawn		Refused	
	Coeff. (1)	Marg. effects (%) (2)	Coeff. (3)	Marg. effects (%) (4)	Coeff. (5)	Marg. effects (%) (6)	Coeff. (7)	Marg. effects (%) (8)
Applicant characteristics included	YES	YES	YES	YES	YES	YES	YES	YES
Predicted value	0.228**	4.46	−0.156**	−2.94	1.939**	44.90	0.896**	18.69
	[0.005]		[0.005]		[0.019]		[0.029]	
Complexity of examination task								
Number of patent references	0.012**	3.41	0.014**	4.00	0.005**	1.33	0.006**	1.70
	[0.000]		[0.000]		[0.001]		[0.001]	
Number of nonpatent references	0.026**	3.73	0.031**	4.45	0.015**	2.19	0.016**	2.31
	[0.001]		[0.001]		[0.002]		[0.003]	
Share of type X references	0.068**	1.93	0.184**	5.32	−0.220**	−5.99	0.057**	1.61
	[0.003]		[0.003]		[0.008]		[0.014]	
Share of type Y references	0.050**	1.27	0.101**	2.59	−0.114**	−2.84	0.018	0.46
	[0.003]		[0.003]		[0.008]		[0.015]	
Share of type D references	−0.036**	−0.73	−0.091**	−1.85	0.143**	2.98	−0.056**	−1.14
	[0.004]		[0.004]		[0.012]		[0.019]	
Originality	−0.005	−0.06	0.038**	0.42	−0.112**	−1.22	0.090*	1.00
	[0.008]		[0.008]		[0.020]		[0.037]	
Number of IPC classification	0.013**	1.94	0.018**	2.72	0	−0.07	0.015**	2.24
	[0.001]		[0.001]		[0.002]		[0.003]	
Number of claims	0.004**	3.91	0.004**	3.84	0.004**	4.18	0.004**	4.44
	[0.000]		[0.000]		[0.000]		[0.000]	
Further controls								
Workload at the EPO	0.017**	3.39	0.031**	6.33	−0.026**	−5.05	0.024**	4.98
	[0.001]		[0.001]		[0.004]		[0.006]	
Technology areas	YES	YES	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES	YES	YES
Constant	0.734**	—	0.949**	—	0.954**	—	1.692**	—
	[0.010]		[0.010]		[0.026]		[0.046]	
Observations	215,265		215,265		215,265		215,265	
Exits	213,097		143,038		61,709		8,350	
Log likelihood	−118,010		−91,404		−130,783		−28,070	
Likelihood ratio χ^2	59,943		68,847		28,351		4,413	

Notes. Estimates from a pooled and a competing risk specification are displayed. Marginal effects relate to the effect of a standard deviation increase for continuous variables or a discrete change for dummy variables on the mean survival time conditional on the respective exit. Marginal effects have been evaluated at the mean of continuous variables, whereas dummy variables have been set to zero. Standard errors are in square brackets.

*5% significant; **1% significant.

examination requires less time in areas such as transportation, mechanical elements, or handling/printing. These differences can be explained by a strong growth of patent applications in the former areas and a resulting difficulty of adjusting the number of examiners accordingly.[20]

6. Conclusion

In our study we relate the timing and the outcomes of patent examination to observable characteristics of the patent and the patent holder. With our analysis, we seek to provide users of the patent system with valuable information to better manage their filing process and to make statistically sound predictions about the likely fate of a patent filing and the decision date. The statistical relationships developed here not only have strong implications for technology monitoring purposes but also provide new insights for the controversial discussion on the relation between patent value and the length of the examination process.

Our major conclusion with regard to technology monitoring is that managers can learn about latent characteristics of patents held by their rivals from their observation of examination durations. We demonstrate that useful information is contained in a number of readily observable patent characteristics. With regard to patent value, we find that potentially valuable patents will be granted significantly earlier than less valuable ones, and that a withdrawal of such patents will be delayed considerably. This finding strongly supports previous evidence presented by

[20] In an alternative regression specification we included the annual growth rates of the number of patent applications in 30 technology areas. Our major results remained largely unchanged. Detailed results of this specification can be obtained from the authors upon request.

Regibeau and Rockett (2009) that valuable patents have lower pendency times. Given the assumptions of their model, this is welfare enhancing because important investment decision can be made earlier. Moreover, it seems that patent value is mostly revealed in how hard patent owners fight for a grant and, thus, how long they drag out a withdrawal or a refusal.

The effect of patent value on the duration of patent examination has been analyzed controlling for the complexity of the examination task. We find that these controls (*claims*, *number of patent references*, and *non-patent references*, *originality*, and *number of IPC classifications*) are associated with delays across all outcomes. Questionable patent claims (as identified by a large number of type X and Y references) lead to delays in grants and to accelerated withdrawals. We suggest that managers may take these patterns into account when studying the application stocks of their rivals.

Obviously there are several caveats to our study. We have assumed that the examiner responds in a controlled way to efforts and actions undertaken by the applicant. In that regard, we may have neglected heterogeneity among examiners and the incentive schemes employed at the patent office discussed in Friebel et al. (2006). Moreover, although we can point to a stable set of multivariate results, we clearly do not yet have a refined set of diagnostic tools that could be used for technology monitoring. However, we suggest that the above results may very well offer some conceptual and empirical foundations for such a toolbox. Moreover, although our data set has been representative, we have largely not been able to employ direct measures of acceleration or delay. In principle, such data can be obtained by looking at the public communication between examiner and applicant. However, given the resource needs for collecting data of this type, we want to reserve this approach for a small sample study. In such a context, it would also be possible to explore in more detail whether the screening criteria defined here are also successful in predicting whether rivals will engage in opposition and litigation against particular patents. Despite some progress that we have hopefully made with this research, extracting useful information from the patent system to support managerial decision making will remain a fruitful topic for future research.

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Appendix. Prediction of Patent Value: Results from a Probit Estimation Relating a Patent's Value Indicators to the Likelihood That It Is Uphelp More Than 10 Years

	Probability that a patent is upheld more than 10 years
Request for accelerated examination	0.060**
	[0.022]
PCT application	–0.019*
	[0.009]
Citations received within 3 years	0.072**
	[0.003]
Share of type X citations	0.063**
	[0.015]
Share of type Y citations	0.074**
	[0.019]
Share of type D citations	0.082**
	[0.023]
Number of EP equivalents	0.101**
	[0.013]
Total number of equivalents	0.019**
	[0.001]
Generality of application	0.389**
	[0.033]
Constant	0.215**
	[0.014]
Observations	143,038
Log likelihood	−86,195
Likelihood ratio $\chi^2(9)$	2,523

Note. Standard errors are in square brackets.
*5% significant; **1% significant.

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