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A Survey of the Economics of Patent Systems and Procedures

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Abstract:

The last several decades have seen increases in patenting activity worldwide, as well as growing issues related to patent quality. In response to these quality issues a recent patent literature has emerged, that investigates the behavior and incentives of patent examiners, applicants, and third parties. In this paper, we provide an overview of patent procedures, patent systems and a survey of the new economic literature on patent systems. Both theoretical and empirical papers are considered. Policy implications coming from this literature are presented.

Keywords: *Patents, Patent Examination, Patent Systems, Innovation, Incentives*

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1. Introduction

The last several decades have seen growth in patenting activity in many countries (e.g., in the U.S. and Europe, the numbers of patent applications and granted patents[1] have more than doubled from 1990 to 2010). This surge has been accompanied by increased backlogs at many patent offices, increased time periods from patent applications to decisions (pendency time), problems in retaining patent examination staff, increased litigation, and allegations of low quality patents being granted (Bessen and Meurer, 2008; van Pottelsberghe, 2011).

Several reasons for the surge in patent activity and accompanying problems have been proposed, including higher research and development expenditures and increases in invention rates, an increased propensity to file for patents abroad, new patent strategies and management practices, and lower examination standards.[2] The increase in patenting and litigation has also been attributed in part to important legal decisions that have allowed the granting of patents for software and business methods, an area in which patent boundaries may be unclear and infringement difficult to avoid (Bessen and Hunt, 2007; Mulligan and Lee, 2012). Hall and Ziedonis (2001) and Hall (2005) suggest that patenting activity growth in the U.S. has been focused primarily on "electrical, electronics, computing and scientific instruments" industries, and that patent growth may be the result of firms accumulating patents to defend against infringement claims and to bolster their positions in cross-licensing negotiations.

While the problems of the U.S. have been experienced in other countries to a lesser degree,[3] these countries could see patent activity increase as the set of patentable material is

[1] Annual statistics can be found in WIPO world reports; see http://www.wipo.int/ipstats/en/statistics/patents/ (last accessed September 10, 2012).
[2] See Kortum and Lerner (1999), Hall and Ziedonis (2001), Langinier (2005) and Bessen and Meurer (2008).
[3] Between 1990 and 2010, applications in Japan have decreased while in Canada they have first increased before been relatively stable. During the same period, the number of granted patents has increased in Japan and Canada.

expanded. For example, in 2010, the Federal Court of Canada overturned a Canadian Intellectual Property Office (CIPO) decision denying a patent to Amazon for its "one-click" technology for online shopping; this patent was subsequently allowed by CIPO in 2011. It has been suggested that increasing the patentability of such business methods could increase the number of patent applications, with one reporter noting that "if the case isn't appealed, IP lawyers expect clients to instruct them to request examination for a pile of pending business method applications. The bottom line is that this decision will likely result in more patents being granted."[4]

The problems being experienced by patent offices, and the potential for these problems to increase, motivate a consideration of possible policy responses. This, in turn, requires an understanding of the economics behind the patent systems and procedures that govern the submission and drafting of patent applications, their examination, their granting, and their potential to be challenged by third parties. The purpose of this paper is to provide an overview of the recent and rapidly growing economic literature on these issues. The intent is to go beyond the traditional economic literature on patents that has mainly focused on the role of patents in encouraging invention and the disclosure of technology, and on the optimal design (in terms of length and scope) of patent rights (for surveys see Mazzoleni and Nelson, 1998; Gallini, 2002; Langinier and Moschini, 2002; Rockett, 2010; Hall and Harhoff, 2012). This traditional literature has largely ignored the internal working of patent offices,[5] and its impact on examiners, applicants and third parties. Our focus is on the details of the patenting process from application to opposition, and on the incentives, information, and interaction of three types of agents: applicants, patent examiners, and third parties. Both theoretical and empirical studies are

[4] Hasselback, D. (2010), "Businesses can patent their methods," *Calgary Herald* , Nov. 10, 2010, pp. C.8. An appeal of the *Amazon* decision was submitted by CIPO on November 15, 2010. The Federal Court of Appeal directed CIPO to reassess Amazon's claims.

[5] Except in Hall and Harhoff (2012) where a brief overview of the patent office governance is discussed.

considered.

Several key themes emerge in this literature. First, attention has been focused on the heterogeneity of the patentability of innovations and the private information potential applicants possess regarding patentability. Changes to application and examination procedures have the potential to affect whether and when applicants submit their applications, but also how they act strategically to conceal or reveal their private information. Second, this literature highlights the importance to patent system outcomes of heterogeneity of abilities across patent examiners, and the responses of individual examiners to particular incentives created by the patenting agency and outside opportunities. Third, it focuses on the role of third parties in the patenting process through a post-grant review mechanism or through litigation.

In light of the complexity of the interaction between the different agents involved, policies designed to expedite examinations or promote international harmonization should be adopted with caution. While certain policies, such as increased international cooperation and harmonization or strengthened incentives for examiners, have been considered, concerns have been raised that such changes could reduce patent quality. This may be particularly relevant in industries involving complex patent examinations with little available prior information. The difficulty of policy analysis is increased further by data limitations as patent research is rife with data measurement and availability issues.

The remainder of the paper is organized as follows. Section 2 presents an overview of the basic economics of patents, along with a review of patent rules and procedures. In Section 3, we focus on the new economic literature on patent prosecution, organization and incentive. We discuss the behavior of stakeholders (applicants, examiners and competitors) and its impact on the design of patent systems. Section 4 concludes and discusses policy implications.

2. The Basics of Patents and Patent System Procedures

Absent patents, many inventions would exhibit public good attributes: even though the innovation cost is borne by inventors, competitors can benefit from the inventions. Because of the resulting free–riding problem, too few innovations would be developed. Patents address this problem by endowing innovators with property rights on their inventions. A patent confers its owner a temporary right to exclude others from exploiting the innovation. In exchange for the exclusionary right, the patent holder must disclose details about the innovation. Patent rights extend typically for a maximum of twenty years from the date of filing. Patents can be exploited by their owner, traded through license agreements or sold.

Traditionally, patents have been seen as a necessary evil, involving a tradeoff between providing incentives for innovation and disclosure on the one hand, and the creation of a temporary monopoly on the other hand. The main advantages of patents are that they may (i) promote new discovery, (ii) assist in the dissemination of knowledge, (iii) encourage technological transfer and commercialization, (iv) facilitate entry of new small firms, and (v) allow the trading of knowledge (Hall, 2007). Disadvantages of patents include: (i) the social inefficiency of monopoly, (ii) a duplication of spending (patent races), and (iii) increased transaction costs that may delay new inventions (Langinier and Moschini, 2002). Furthermore, a patent provides only an imperfect protection since monitoring to detect infringement must be done by the patent holder (Crampes and Langinier, 2002).

Private and public benefits from patents differ. Firm level surveys find that many U.S. firms report not relying on patents to appropriate a return on their innovation (Levin et al., 1987; Cohen et al., 2002) and that patents provide weak incentives to innovate (Graham et al., 2009). The main reported reasons for patenting are keeping competitive advantage, securing financing, preventing technology copying and enhancing reputation (Graham et al., 2009). Patenting activity may also be motivated by strategic concerns, including blocking competitors and strengthening a firm's bargaining position in the negotiation of licensing agreements (Blind et al., 2006; Langinier, 2005; Hall and Ziedonis, 2001).

In most jurisdictions, the innovation must demonstrate similar attributes to be patentable: an innovation must be novel (not already in the public domain), non-obvious (to a person with ordinary skills in the field), and useful (to have at least one application).[6] Jurisdictions vary in terms of the material that is patentable; the U.S. seems to have a more liberal approach to patentable material than elsewhere (Maskus, 2005). Differences across jurisdictions include the patentability of genetically modified animals developed for medical research, the treatment of surgical and medical methods and the treatment of software and business methods.[7]

Patent rules and procedures are broadly consistent across countries. An innovator files an application for a patent with a patent office, typically at the national level. However, European patent applications can be submitted to the European Patent Office (EPO). Applicants may also choose to file applications under the Patent Cooperation Treaty (PCT); such applications pass through an international examination phase before proceeding to individual national patent offices, which ultimately decide whether to grant national patents. The application may be subject to an examination, including a consideration of "prior art" (related inventions or patents) to determine whether a patent should be granted. In general, the examination follows a report and response format between the applicant and examiner. In many countries, patent applications are

[6] As defined in the U.S. See http://www.uspto.gov/web/offices/pac/doc/general/index.html#patent to obtain general information on U.S. patents (last accessed November 1, 2012). Basic information on patenting at the European Patent Office is available at http://www.epo.org/applying/basics.html (last accessed November 1, 2012).

[7] Business methods were opened up to patenting in the U.S. in State Street Bank and Trust Co., Inc. v. Signature Financial Group, inc., 149 F. 3d 1368 (Fed. Cir. 1998). The patenting of software has been associated with decisions in the early to mid 1990s. See Hall and MacGarvie (2010) for more details.

available for public inspection 18 months after filing; in some countries, applicants can request that applications not be published. The public is generally given the opportunity to oppose an application. After it is made public, anyone may file prior art, or protest the granting of a patent. In case of a negative result, the applicant has avenues for appeal (for details see Hall et al., 2004). A country's rules regarding patentable material and the patent process are contained in legislation, with further details provided in patent office manuals.

Patent applicants must pay several fees at various stages of their application, as well as after a patent is granted. Such fees are essential, since patent offices are typically self-funded agencies. In general, fees include filing, examination, granting and maintenance fees.[8] Fees to maintain the patent rights must be paid every year in Europe, and three times in the U.S. In some countries, lower fees are required of applicants who identify themselves as "small entities," although the definition differs.[9]

While patent systems and procedures are similar, there exist potentially important differences across offices. For instance, in the U.S. an application enters the queue for examination as soon as it has been filed and fees are received. In other jurisdictions (Europe, Japan and Canada), after submitting an application and associated fees, an applicant must submit a separate request for examination.[10] This request must be made within three years of filing in Japan, five years in Canada, and six months of the search report being published at the EPO.[11]

In addition, while in most patent offices patents are awarded according to the first-to-file

[8] Information on fees is available at http://www.uspto.gov/web/offices/ac/qs/ope/fee2009september15.htm for the U.S., and at http://www.epo.org/applying/forms-fees/fees.html for Europe (last accessed September 12, 2012).
[9] In the U.S. a small entity is a person, small business (500 or fewer employees) or a non-profit organization.
[10] See London Economics (2010), p. 8 for an international comparison.
[11] The U.S. permits provisional applications, with non-provisional applications that trigger examination being required within 12 months.

rule, the U.S. has awarded patents to the first to invent until now.[12] The tradeoff is between encouraging early communication of research results under a first-to-invent rule, and the greater certainty and lower cost of a first-to-file rule (Maskus, 2005; van Pottelsberghe, 2011).

The role of third parties and the timing of their involvement also differ. The European post-grant opposition system is such that third parties can oppose a patent within nine months of its granting (Hall and Harhoff, 2004). In contrast, in the U.S. enforcement occurs primarily through the court system. However, few U.S. patents (1 to 2%) are litigated or go to trial, and about 95% of litigated patents settle out of court (Lanjouw and Schankerman, 2001; Bessen and Meurer, 2005). Since 1982, a single U.S. Federal Circuit Court is dedicated to intellectual property appeals, which seems to be favorable to patent holders (Maskus, 2005). Recent U.S. policy changes open the patent examination process to public participation. Indeed, the U.S. Patent and Trademark Office (USPTO) has extended a peer to patent pilot program to applications in biotechnology, bioinformatics, telecommunications, and speech recognition.[13]

Even though certain basic trends in patenting activity across countries can easily be compared, comparisons of grant rates, backlogs and pendency times are complicated. First, it is difficult to measure grant rates. Calculating the grant rate as the number of patents divided by the number of applications in a given year does not account for the lag between filing and granting. Using a three year lag for the number of applications (average pendency time) corrects this measurement error, but still provides only a rough estimate because pendency times vary across technological fields. As a result, estimates of grant rates vary widely, depending on methodology. While U.S. grant rates estimated by the USPTO have ranged from 54% to 66% (as

[12] The Leahy-Smith America Invents Act was passed by Congress and was signed by President Obama on September 16, 2011. This new patent reform bill includes a switch from a "first-to-invent" system to a "first-to-file" system that will occur in 2013.
[13] http://www.uspto.gov/news/pr/2010/10_50.jsp (last accessed January 24 2013).

reported in Lemley and Sampat, 2008), considering 'continuation' applications (rejected applications that have been resubmitted), Quillen and Webster (2001; 2006) find that 87 to 95% of U.S. applications are granted a patent. By using abandoned applications, Lemley and Sampat (2008) find a range of grant rates of 72% to 76% for 2008. Furthermore, the likelihood of being granted a patent depends on the technological field (Lemley and Sampat, 2008), and the number of citations (Popp et al., 2004).

In addition, cross-country comparisons are complicated by differences in patent systems. For instance, in many countries, applicants apply for several patents with the same innovation (patent flooding), or extend their patents through continuation in parts applications (Quillen and Webster, 2001; van Pottelsberghe, 2011). Countries also differ in terms of whether applicants apply for a small number of broad patents, or a large number of narrow patents.

Cross-country comparisons of backlogs and pendency times are also difficult (van Pottelsberghe, 2011). Because the duration of examination varies across offices, using the number of pending patents as a measure of the backlogs provides a biased proxy. As well, in some countries applicants may choose to delay the examination, meaning that longer pendency times may be due to applicant behavior rather than to the patent office (Palangkaraya et al., 2008). In its review of backlogs and delays, London Economics (2010) report that "our research indicated that, not only is there no commonly accepted measure of backlogs across patent offices, in practice the publicly available data regarding either patent backlogs or (for many patent offices) the number of pending applications outstanding is scarce."

Bearing in mind these concerns, London Economics (2010) indicates that average pendency time has increased in the U.S. from 20 to 40 months, in Japan from 22 to 27 and in

Canada from 60 to over 90 over the 1996 to 2008 period; in contrast, at the EPO it has fallen.[14] However, these numbers include the time between filing and request for examination when those occur separately. As well, they show that, after controlling for examiner counts or the number of disposals per year, there are no general trends in backlogs across patent offices over time. Indeed, while according to these measures, backlogs have increased since 2001 at the trilateral patent offices, CIPO workloads appear to have fallen.

Finally, it would be interesting to make cross-country comparisons of patent quality if quality was not subject to multiple interpretations[15] and difficult to measure (Hall and Harhoff, 2004; Lemley and Sampat, 2008; van Pottelsberghe, 2011). Legal definitions focus on whether a patent meets statutory requirements (novel, non-obvious and useful). From an economics perspective, patent quality would go further by considering the social welfare implications of the patent. The social benefits (through encouraging invention and commercialization and increased disclosure) and costs (deadweight loss from monopoly, restriction of use through license fees and uncertainty over validity) must be analyzed (Guellec, 2007; Hall and Harhoff, 2004). Furthermore, patent quality and quality of the patent system are two different concepts, although they are positively correlated (van Pottelsberghe, 2011).

3. Economic Literature on Patent Prosecution, Organization and Incentives Within Patent Offices

In response to questions regarding backlogs, pendency times and concerns over the quality of granted patents, a recent economic literature focusing on the patent process and

[14] Pendency statistics are computed using PATSTAT. London Economics (2010) reports that, based on CIPO data, from 2003 to 2009, pendency time from request for examination increased from 45 to 52 months.
[15] In May 2012, EPO held a workshop on patent quality where the lack of definition was pointed out (see website http://documents.epo.org/projects/babylon/eponot.nsf/0/bbc8744dd3ff80b8c1257a690046953d/$FILE/workshop_patent_quality_en.pdf).

procedure has emerged. This literature, both theoretical and empirical, addresses questions about how patent rules affect the decision to apply for a patent and the preparation of the application, the examination of the patent, and the subsequent litigation process.[16]

At least three different types of agents are considered: patent applicants, patent examiners, and third parties. These agents are expected to differ in their objectives and in the information they possess. Applicants may know more about the patentability of their innovation than examiners, and examiners may have a better knowledge of their own skills and efforts than the patent office. Such information asymmetries can lead to strategic behavior on the part of the more informed party. Patent offices are large organizations that employ many examiners, and it seems unlikely that patent offices and examiners have congruent objectives. Importantly, the actions of one type of agent may "feed back" into the behavior of the other agents. Changes to examiner incentives that result in a more stringent examination process may affect the number and type of applications submitted. Policy changes that encourage applications by certain innovators may increase demand for examiner services and reduce examination quality. Policies that encourage third party participation may have an impact on patent quality.

3.1. Patent Examiner Behavior

While the patent prosecution process is partially standardized by office manuals and legislation, the behavior of individual examiners will likely influence the patent examination outcome. In general, the examination of an application begins with a review of legal formalities and an analysis of the claims. When processing a patent application, an examiner must analyze the information submitted by the applicant, search for relevant (complementary) information

[16] For a review of patent system differences across the three major patent offices and their possible effects on patent quality, along with a discussion of relevant economic literature, see van Pottelsberghe (2011).

including prior art, and determine whether the innovation meets patentability requirements. In the U.S. the applicant must disclose the entire prior art he is aware of, whereas in Europe disclosure of the prior art by the applicant is not obligatory. The effort required to search for prior art might then differ across countries.

The information provided by the applicant and the way he has been drafting his application will likely influence the work of the examiner. For instance, unclear applications will affect the ability of the examiner to identify prior art. The outcome of the patenting process may thus depend upon the availability of relevant information, the examiner's experience, skill and familiarity with the field, and his incentives to complete examinations thoroughly. Several questions, therefore, arise. How dependent is the outcome of the patent process on the skills and talents of examiners? To what extent are examiners influenced by the incentives developed for them by patent offices, as well as external incentives such as the possibility of new employment? How effective are policies designed to encourage examination quantity and/or quality?

In most countries, there is no easily accessible information regarding patent examiners; as a result, the number of studies in this area is limited. However, existing empirical evidence suggests that the abilities of individual examiners have a measurable impact on patent system outcomes. In one of the first empirical analyses of the examiner behavior, Cockburn et al. (2003) use U.S. data from a survey of 187 examiners of patents invalidated by the Court of appeals from 1997 to 2000 and find evidence of significant heterogeneity among examiners, particularly in the search stage of the examination process. They also find that there are differences in the quantity of citations provided by examiners but also in the citations received. Lemley and Sampat (2012) use data on pending U.S. applications and find that experienced examiners cite less prior art and have a significant higher grant rate. In identifying whether issued claims are different from original drafted claims, Lichtman (2004) finds evidence that examiners have different styles.

Because individual examiners may influence patent system outcomes, it is important to understand how examiners respond to the incentives provided by different patent offices. Historically, the USPTO has used a formal bonus and award system based on whether examiners exceed pre-determined production goals[17] with few errors.[18] Production goals vary according to experience and technological field, as examiners are grouped according to technological categories.[19] The quality of examination is monitored through both random and routine checks. According to the USPTO, the error rate has been relatively constant and low over time.[20] A high quality examination should lead to a high quality patent where there should be little uncertainty concerning the validity of the patent.

The establishment of incentives for examiners involves a tradeoff between quality and quantity; an examiner may devote more effort into searching for invalidating information, thus increasing examination quality, at the expense of processing fewer applications (Langinier and Marcoul, 2012b). Furthermore, setting up the appropriate incentives for quality versus quantity is complicated by the fact that while quantity is easily contractible (e.g., the U.S. quota system), defining, measuring and verifying examination quality is problematic. It is thus difficult to write incentive contracts that include a targeted quality. Some quality goal can still be implicitly set and verified by more senior examiners (who might be able to subjectively assess quality), but it cannot be included in a formal contract. For instance, the patent office can informally promise a reward to examiners if they reach a certain quality goal. However, because it is not formal this

[17] This system, in place since 1976, has been recently updated. In February 2010, a new examiner count system was implemented, and “new, more comprehensive procedures for measuring the quality of patent examination” were adopted by the USPTO in October 2010.
[18] Because of the subjective nature of qualitative criteria, it is unclear what would be considered an error, and how many would be considered “few.”
[19] In the U.S., examiners are assigned to eight technological centers divided into three categories: Chemical, Electrical and Mechanical. Each technological center is divided into Work Groups, which are made up of Art units.
[20] The error rate was 6.6% in 2000 and 5.3% in 2004 (NAPA, 2005).

type of contract relies on trust: if the patent office honors its promise and pays the reward accordingly, examiners will trust the office to respect its engagement. If examiners cannot trust the patent office, implicit contracts are unlikely to provide incentives. Langinier and Marcoul (2012b) propose an alternative that would be to write an explicit contract that includes a proxy on quality (e.g., number of citations made by the examiner).[21]

The effectiveness of the incentive system within EPO has been analyzed in Friebel et al. (2006), who provide a survey of EPO examiners and an overview of the literature on incentives. The authors apply this literature to the behavior of examiners, and provide a list of "tests" to be considered in determining whether explicit incentives should be adopted. They warn against putting too much emphasis upon rewarding examiners according to quantitative measures. In particular, their survey of EPO staff shows that examiners perceive their work as being highly interdependent. Incentives to improve individual performance through quantity measurement may be detrimental to team work if individual examiners neglect their team contribution in favor of their highly rewarded individual contribution. The literature on incentive theory shows that in presence of asymmetric information between managers and workers, explicit incentive mechanisms can be a powerful tool. However, if the work is complex and subject to uncertainty, these mechanisms can induce workers to behave in a detrimental way, as workers will work toward achieving the goal set in the incentive scheme, which might have a negative impact on the desired performance outcomes (Friebel et al., 2006). Explicit incentives based on quantity will likely push examiners to process more patent applications.

Examination quality may also be driven by incentives coming from outside of the patent

[21] Imprecise quality standards not tied to quantitative proxies may allow the patent office more flexibility in evaluating examiners.

office. A high attrition rate of examiners at the USPTO[22] has resulted in a lower overall level of examiner experience (van Pottelsberghe, 2011). One possible explanation for this turnover is career concerns; examiners may be leaving the patent office to work at firms on the other side of the patent process that might value their experience and their understanding of the patent system.

Examiners might behave strategically in order to enhance their ability to move to the private sector. In managerial career contexts, Holmstrom (1999) shows that career motives can be either beneficial or detrimental to organizations depending on the context. While Fama (1980) argues that career concerns will induce efficient behavior and discipline manager's behavior, Holmstrom (1999) shows that labor market forces may induce suboptimal behavior. More precisely, a manager will, in equilibrium, make decisions in order to manipulate labor market inference about his talent rather than to maximizing profit. In the context of the patenting process, examiners might send signals (such as systematically granting patents with many claims) through their patenting decisions to potential employers in order to accelerate their career track. However, it is unclear whether career motives of patent examiners will negatively impact the patenting process (Langinier and Marcoul, 2011), even though examiners seem to be more careful about making the right decision when they stay longer at the USPTO (Schuett, 2010).

To date, mobility motives of patent examiners have received only limited empirical attention. Conditional on experience, Lemley and Sampat (2012) test whether examiners who leave within 5 years have more citations or higher grant rates. They do not find any significant effect. However, their analysis is based on a cross section, and does not consider changes in the behavior of examiners over their careers.

Langinier and Lluis (2012) use data on U.S. examiners over the period 1976-2006 to

[22] During the period 1992-2004, although the attrition rate at the USPTO was only 7 percent (which is just above the average attrition rate at federal agencies), for every 10 examiners hired during that period, five left (NAPA, 2005).

analyze the determinants of examiners' mobility at the USPTO. A comparison of their random sample of examiners with the entire data of Hall et al. (2001) shows evidence of differences between the examiners who have not left the USPTO in their sample, and the entire data. This suggests that a selection bias might exist in the way examiners process patents. They also examine the factors that may impact mobility outcomes within the institution (promotion or lateral move) or outside of the institution (leaving the USPTO). The main findings of this preliminary analysis are that the determinants of mobility have different effects on mobility. For instance, the technological field and the tenure as assistant examiner have significant effects on promotion. By using longitudinal data, the authors show that switching Art Units has a positive impact on mobility (examiners who switch Art Unit more often are more likely to get promoted), and that the longer an examiner stays at the USPTO, the lower his chances of leaving. These findings are consistent with those in the labor economics literature where it has been established that long-term employment relationships are common and the probability of job changes in the U.S. declines with tenure (Farber, 1999), and individuals hold on average seven jobs over the first ten years of their career (Topel and Ward, 1992).

3.2. Patent Applicant Behavior

A discussion of applicant behavior within the patent system can be divided into two issues: the specific filing strategies that applicants can employ (e.g., where to apply, how to draft the patent application), and the effect of examination rules and procedures on broader decisions such as whether to innovate and whether to apply for patents on innovations of given quality. [23]

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[23] The traditional patent literature has already dealt with issues on whether to patent or keep the innovation secret (see, for instance, Hortstman et al., 1985; Gallini, 1992).

3.2 (a) Filing Strategies

Once the decision has been made to apply for a patent, an applicant faces a large range of decisions that can impact the patenting outcome.[24] The applicant must decide to which agencies to apply, and in what order. This includes a decision of whether to apply first to a national agency, to the EPO, or through the Patent Co-operation Treaty (PCT). There are 142 contracting countries of the PCT (including the USPTO, JPO, EPO and CIPO), under which an applicant can pursue protection simultaneously in many countries through the submission of an international application. The application first passes through an international phase, in which an International Searching Authority conducts a search for prior art and provides a preliminary. The applicant may then proceed to the national phase, in which the application is examined by individual national offices, which may reach different decisions.[25] Likewise, the applicant may be able to make use of Patent Prosecution Highway (PPH) agreements intended to speed up examination. As an example, since January 2008, USPTO and CIPO have been participating in a PPH Pilot Program, under which accelerated examination in one country can be requested for an application for which at least some claims have been allowed in the other country.

Several strategic decisions are also involved in the drafting of the application, including the number of claims, the inclusion or exclusion of relevant prior art, and the length and readability of the application. Once an application is submitted, the applicant potentially faces another series of decisions: whether and when to apply for examination, how to respond to feedback, whether to amend the application, and whether to withdraw the application.

Two basic implications of these different decisions have been identified in the literature: the length of time taken by the examination process, and the revelation and concealment of

[24] Stevnsborg and van Pottelsberghe (2007) discuss the decisions faced by an applicant in the European context.
[25] See http://www.ic.gc.ca/eic/site/cipointernet-internetopic.nsf/eng/h_wr02598.html (last accessed Oct. 8, 2010).

private information by applicants. Stevnsborg and van Pottelsberghe (2007) divide application filing strategies into four broad categories, based largely on the considerations of duration and information revelation: good will and fast track, good will and slow track, bad will and slow track, and deliberate abuse of the system. A longer filing duration can be encouraged through application under the PCT, and through the drafting of a complicated application with too many claims. Shorter durations can be achieved through national applications, drafting of a clear and accurate document, early requests for examination and quick responses to agency feedback. These decisions also influence the information revealed by the applicant and the timing of the revelation. Complicated applications with many claims can conceal the true invention. The nature of the invention or limits of the scope of innovation can be concealed by not reporting relevant prior art, or indeed not searching adequately for it. Uncertainty regarding whether the patent will be granted and the scope of the patent can be extended in time through drafting and other strategies described above that lengthen the duration required for the patenting procedure.

The motivations for delaying the outcome of the patent process, and how the decision to delay may be related to the value of the innovation, have received both theoretical and empirical attention. In a theoretical model, Régibeau and Rockett (2010) consider the delay as a function of applicant effort. Applicants with good applications have stronger incentives for such effort. In equilibrium, more important applications are ultimately approved faster. The intuition is that the monetary patent benefit to an innovator is greater when the innovation is good and important, creating a stronger incentive to achieve that payoff increase early.

Delaying the granting of a patent may be attractive to an applicant because it allows further time to study the commercial value of the patent, it extends the uncertainty of rivals regarding the patent, and it delays certain fees associated with its granting. Incentives to delay may differ across industries and may be associated with the expected lifespan of innovations in the industry (Harhoff and Wagner, 2009).

Much of the empirical literature examining the time lag between application and patent process outcome has focused on the determinants of delay, and on whether more valuable patents experience more (or less) delay than less valuable patents. Regarding the latter question, results have been mixed. In a study of applications at the EPO over the 1982-1998 period, Harhoff and Wagner (2009) find that more valuable patents are granted earlier than those of lower quality, and that examination duration communicates information on the patent to rivals. Régibeau and Rockett (2010), using data on U.S. patents for genetically modified crops from 1983 to 1999, find that once the filing date is controlled for, delay is shorter for more important patents. They suggest (p. 244) that "more important patents are pushed through the approval process more eagerly…" In contrast, Johnson and Popp (2003), in an study of U.S. patents from 1976 to 1996, find that patents that take longer to go through the patent process are more cited.

Studies of the relationship between patent value (somehow measured) and process duration often face several empirical issues, including a frequent reliance on data only for granted patents, and the fact that delays in the patent process can be caused by both applicants and examiners. One branch of the literature attempts to deal with this second issue by exploiting the fact that, at several patent offices, applicants must submit a separate request for their application to be examined, along with an examination fee (this is not the case in the U.S.). The primary reasons for an examination request are that it reduces the number of examinations since many applications never request examination, and that it allows applicants additional time to assess the marketability of the innovation (Nikzad and Collette, 2008; van Pottelsberghe, 2011).

Recent empirical studies have analyzed the determinants of the length of time between application and request for examination, and the decision of whether or not to request examination, with the justification that this time lag is less likely to be influenced by patent office behavior. In a study of the decisions of electronics and electrical manufacturers in Japan regarding the request for examination, Nakata and Zhang (2012) find that variables designed to measure patent value were positively associated with early examination requests. Palangkaraya et al. (2008) draw similar conclusions using data for applications submitted to four different patent offices. Henkel and Jell (2010) combine data on German applications with data from a survey of German inventors to examine how the justifications given by inventors for applying for a patent are associated with the extent to which they delay the application process. The authors find that applicants who list “create uncertainty” and “gain time for evaluations” as reasons for filing an application are more likely to delay the application process.

Beyond the impact of patent value on delay, the empirical literature has identified other patent, industry and applicant features statistically associated with the duration of the patent process. Analyzing the time to granting at the EPO, Harhoff and Wagner (2009) find that application complexity and the inclusion of questionable claims delay approval. Further evidence on the impact of drafting and procedural strategies on patent lifespan (including the process period) is given in van Zeebroeck (2009). Popp et al. (2004), using USPTO data, find that duration is most strongly related to an application’s technological field, and suggest that duration is greater in complex areas that require frequent communications between examiners and applicants. In applying survival analysis techniques to a similar data set of patents granted by the USPTO, Xie and Giles (2011) show that delay is associated with technological category, the number of claims and citations, and applicant type. Survival analysis techniques applied to CIPO data demonstrate that more complex applications lead to longer delays, and that non-PCT applications experience longer time lags to granting (Nikzad, 2011).

Much of the empirical literature studying patent process delay is descriptive, as it is primarily aimed at measuring the degree of association between delay and value, and other components of a firm's strategy. A parallel empirical literature puts measures of patent value on the left-hand side of the equation, and lists on the right-hand side variables intended to capture certain aspects of filing strategy, including aspects of the strategy that delay the patent process (Guellec and van Pottelsberghe, 2000; van Zeebroeck and van Pottelsberghe, 2011a). [26]

Some attention has been given to the impact of delay on other aspects of a innovator's patenting strategy. Gans et al. (2008) examine the impact of the announcement of the granting of a patent on the timing of the licensing decision.[27] They find that the licensing hazard rate increases by approximately 70% upon announcement of granting. This highlights the importance of market imperfections, and particularly asymmetric information, in licensing markets.

Apart from achieving delay, an applicant's filing strategy may be aimed at creating or eliminating uncertainty on the part of other firms or examiners.[28] Regarding the uncertainty of other firms, Gans et al. (2008) identify five different forms of uncertainty that arise during the patenting process: uncertainty regarding whether a patent will be granted, what the scope of the patent will be, the length of time of the patent process, whether the patent will be enforced, and its market value. Their findings regarding the granting of a patent on licensing decisions suggest that the granting of a patent resolves uncertainty, reducing market imperfections.

Much of the literature regarding examiner uncertainty has focused on the innovators' incentives to discover or reveal prior art. If applicants always disclose the prior art information

[26] van Zeebroeck and van Pottlesberghe (2011b) provide a literature survey on the determinants of patent value.
[27] Note that, as per the literature discussed above, the timing of the patenting decision can be partly determined by a firm's strategic decisions as well.
[28] Note that as mentioned earlier, increased uncertainty may also arise from delay tactics.

they possess (as stipulated by the duty to disclose in the U.S.), Atal and Bar (2010) show that they might have an incentive not to search for prior art. This finding is consistent with evidence that, in some industries, firms ignore patents (Lemley, 2008; Mulligan and Lee, 2012). In Atal and Bar (2010)'s model, when innovators search for prior art, their search intensity increases with R&D cost, and with the examiners' expected search effort. Furthermore, since it is difficult for a patent office to prove that an applicant did not disclose all relevant information, applicants have an incentive to conceal information on prior art. Langinier and Marcoul (2012a) show that applicants endowed with innovations that should not be issued a patent have an incentive not to reveal all prior art information. Because of this incentive, examiners should undertake identical scrutiny effort, irrespective of the amount of information provided by the applicant.

Empirical studies have begun to consider the information provided by applicants, exploiting the recent availability of data sets that distinguish between citations provided by applicants and examiners. Evidence suggests that, even though they add many citations, examiners face challenges in identifying prior art in some fields (Sampat, 2010). In addition, based on U.S. patent data from 2001 to 2003, Alcacer and Gittelman (2006) show that two thirds of citations are added by examiners. Schneider (2007), using data on patents applied for by Danish firms at the EPO from 1978 to 1998, finds behavioral differences between experienced and inexperienced applicants; applicants with large patent portfolios apply for more patents and do not withdraw their application when the expected probability of granting is high. In a study of U.S. patents over the period 2001-2003, Alcacer et al. (2009) find that firm-level effects (experience of applicants, nationality) explain most of the variance of examiner citation shares. More experienced applicants (with a high number of patents) received higher shares of examiner citations than less experienced ones. There exists empirical evidence that innovators conceal information about prior art in the U.S. (Lampe, 2012).

Beyond the inclusion of prior art, limited attention has been given to other drafting strategies. The size of an application (in terms of pages and number of claims) has been studied by van Zeebroeck et al. (2009), using EPO data for applications from 1982 to 2004. The authors study the determinants of application size, using variables derived from four different hypotheses regarding the causes of the increased length in applications; national practices and internationalization of procedures, increased technical complexity, emerging sectors, and patenting strategies such as concealment of information.[29] While the authors find evidence in support of all four sets of explanations, they find that the most important determinants of application size are the geographic origin of the application and the procedural route chosen by applicants. These findings are taken to suggest that one impact of the PCT is the harmonization of drafting practices along those of the U.S., and that harmonization can lead to the importation by other offices of U.S. drafting approaches.

Recent attention has turned to the appropriate policy responses to the problem of "notice failure:" the divergence of private and public incentives for patent holders to reveal information regarding the boundaries of their property rights. This problem has been particularly associated with software and business methods patents (Mulligan and Lee, 2012). Reitzig et al. (2007) argue that the incentive to deliberately conceal their patents and patent boundaries in order to engage in subsequent patent trolling by litigating infringing firms is greater for small firms in complex technology fields where monitoring the state of the art is difficult. Furthermore, the existence of patent trolls might partly be the result of the practices of the court in assessing damages. A large number of policy responses have been promoted (Menell and Meurer, 2012).

[29] A descriptive analysis using the same data set is given in Archontopoulos et al. (2007).

3.2 (b) The impact of the patenting system on applicant behavior

Several patent policies that could influence the strategic decisions of applicants have been subject to theoretical and empirical attention. Changes in patenting fees will likely change the applicants' behavior, which, in turn, will affect the examination process.[30] It has been empirically shown that there exists a negative relationship between patent cost per claim per capita and the number of claims filed (van Pottelsberghe and François, 2009). This supports the idea that differences in fees might partly explain difference in patenting rates in different countries.

Surveys have also emphasized the importance of fees for patent applicants (Cohen et al., 2000; Graham et al., 2009). It has been argued that lower fees in Europe have contributed to the increase propensity to patent (de Rassenfosse and van Pottelsberghe, 2011). A few theoretical contributions have studied the optimal fee schemes. When there is *ex ante* uncertainty on the R&D effort, and the inventor has more information about the *ex post* value of the innovation, it might be optimal for the patent office to offer a menu of patent durations and associated lump-sum fees. In fact, the current renewal fee system rises at too slow a path (Cornelli and Schankerman, 1999). In a framework where costs and benefits are both unobservable, Scotchmer (1999) shows that the patent renewal system is equivalent to a direct mechanism where higher value inventions should get longer patents.

Other theoretical contributions have considered the efficiency impact of increased patent fees. Atal and Bar (2010) show that increasing patenting fees will lower the net expected benefit of bad patents and will likely increase the prior art search intensity of applicants, which might also be welfare enhancing. Caillaud and Duchêne (2011) find that the impact of patent fees on R&D investment and on the incentive to apply for a patent might be very limited.

[30] Rassenfosse and van Pottelsberghe (2012) provide a survey of theoretical and empirical analyses of patent fees.

Another way of altering the fee structure could be to make the applicant choose between two types of examinations (more expensive and more thorough examination or normal and cheaper). The introduction of a two speed system (or gold-plate system), which will affect the quality of ~~patent~~ examination through the behavior of the applicant, has been under consideration at the USPTO (Lemley and al., 2005). Such a policy could reduce the total number of applications as, in equilibrium, only good applicants will apply for the gold-plate whereas those who apply in the regular system will signal that it is more likely they have bad applications (Atal and Bar, 2011).

As indicated in Section 2, until recently the U.S. has stood largely alone in granting patents to the first to invent, while most of the other countries used a first-to-file rule. A switch of system might impact the behavior of examiners as they might have to search for more evidence in a first-to-file system. According to Scotchmer and Green (1990), the novelty requirement and the existence of a “first-to-file” system affect the speed of innovation. One of their findings is that that first-to-file accelerates discovery of the final innovation relative to first-to-invent. In contrast, Miyagiwa (2012) examines the tradeoff for an inventor between losing a patent because a rival receives the patent first, and duplicating rival research effort when the rival has already invented. The author develops a model of a patent race with private information, and finds that a first-to-invent standard induces as least as much R&D effort as first-to-file.

The impact of the 1987 switch in Canada from first-to-invent to first-to-file on R&D effort has been empirically analyzed by Lo and Sutthiphisal (2009). They find that the switch did not change R&D efforts by Canadian inventors and had a small negative impact on patenting of Canadian industries in Canada, U.S. and Europe, and that the first-to-file system seems unfavorable to individual inventors and small businesses. Overall, they suggest that a switch from first-to-invent to first-to-file may harm the inventive activity of a country.

Shortening the period of examination request may have an impact on the examination quality through the behavior of applicants. Yamauchi and Nagaoka (2009) study the effect of the recent reduction in Japan of the maximum time lag between application and examination request (from 7 to 3 years). They conclude that this change increased the rates of early examination, and had a larger effect on firms facing the greatest uncertainty regarding patent value.

Other policies designed to address issues of patent quality could have unintended consequences because of their impact on applicant decisions. For example, it has been suggested that quality could be enhanced by having more examiners processing the same patent application.[31] In 2000, the USPTO implemented a Second Pair of Eyes Review (SPER) in the class of business method innovations. The expected effect of this initiative is ambiguous. If patent applications are more thoroughly examined in a particular field, the average patent quality in this field should increase by deterring low-quality applicants. However, this quality increase in the targeted field could be at the expense of other fields as applicants attempt to steer low quality applications toward fields with lower scrutiny. As a result, patents in the field in which the SPER is implemented will be expected to be of higher quality, on average, while quality in other fields may fall (Allison and Hunter, 2006; Langinier and Marcoul, 2012a). In addition, increasing the number of examiners would also increase the cost of the patent office.

3.3. Third Party Behavior

Due to the uncertain nature of the validity of any patent, particularly in new technological fields, third parties can intervene in the patenting process and their behavior will likely affect the

[31] In Europe, each application is evaluated by three examiners compared to one examiner in the U.S. As well, the quality standards seem to be higher in Europe. EPO is also the costlier system (van Pottelsberghe, 2011).

patent outcome. Third parties are typically competitors who may have information regarding the novelty, obviousness and technological development of an innovation (Graham and Harhoff, 2006). Competitors may be aware of prior art that is not easily accessible to the examiner and can provide useful information against the patentability of the innovation. However, once they decide to get involved in the patenting process, competitors reveal information about the state of their own knowledge.[32]

Different channels for challenging a patent exist. In certain jurisdictions (e.g., EPO) a patent may be challenged within patent offices through a post-grant review mechanism. Alternatively, in the U.S., the primary approach to challenging a patent is through litigation.

Following the granting of a patent by the EPO, any third party can file an opposition. The opposing party must provide evidence that the patentability requirements were not fulfilled. The outcome of the opposition system can be to revoke the patent, amend it or do nothing. On average, 8.2% of European patents are subject to opposition, among which one third are revoked (Harhoff and Reitzig, 2004). One feature of the opposition system that makes it different from litigation is that, even though the third party has decided to abandon the opposition, the EPO may continue the case. This makes settlement more difficult to reach once opposition has been filed. If the outcome of the opposition is not satisfactory, both parties can appeal within two months of the decision. One third of the cases are appealed (Hall and Harhoff, 2004). Once the appeal process is over, both parties have still the option to litigate in case of a non-satisfactory outcome.

In a model of opposition in which the patent holder and opponent have differing assessments of the probability of opposition being successful, Harhoff and Reitzig (2004)

[32] However, third parties may have limited scope for intervention during the examination by submitting prior art. For example, in the U.S. third parties are permitted to provide prior art information within 6 months after the patent application has been filed. However, we are unaware of studies of third party decisions to contribute prior art during the examination process, and therefore do not discuss this avenue further.

determine when opposition proceedings are expected and when the parties will negotiate a settlement. They consider two cases; in the first case, successful opposition allows the opponent to enter the patent holder's monopoly, while in the second case, opposition protects the opponent's monopoly from entry. Opposition proceedings are expected when the total profit from settlement net of settlement costs is less than the combined expected profits from the opposition proceedings. Based on this model and on the related theoretical literature, the authors conclude that opposition proceedings are more likely to be observed when: (1) the beliefs of the parties regarding the likely success of opposition diverge; (2) the asymmetry of information across the parties increases; (3) the overall stakes (in terms of profits) increases; and (4) opposition costs fall relative to settlement costs.

Using data on patents granted by the EPO from 1978 to 1996 in the biotechnology and pharmaceutical areas, Haroff and Reitzig (2004) then examine empirically the association between whether a patent is opposed and variables expected to influence the likelihood of opposition. They find, in support of predictions (1) to (3), that the probability of opposition is increasing in variables expected to be positively associated with patent value, and variables associated with increased uncertainty and information asymmetry.

In the U.S., litigation is the most common avenue for challenging the validity of a patent, even though an *ex parte* reexamination process exists. During the opposition, the opponent does not actively participate and the patent holder has exclusive rights to communicate with the examiner. Nevertheless, reexaminations are extremely rare; according to Graham and Harhoff (2006) only 0.3% of U.S. patents granted between 1991 and 1998 were reexamined, and more than half of these reexamination requests were initiated by the patent holders.[33]

[33] This strategy, which allows patent holders to make changes to granted patents, is not possible in the European opposition system.

The threat of litigation can influence the behavior of rival firms. In some technological fields (e.g., biotechnology) it is sufficient to deter firms from innovating (Lerner, 1995). This has a negative impact on the overall level of R&D investment as it reduces the incentive of competitors to pursue some lines of research.

Litigation has been increasing in the U.S. since the 1990s. This increase does not seem to be only explained by the increase in patent applications and grants. Mulligan and Lee (2012) associate the "explosion of patent litigation" with software patents, an area where infringement is difficult to avoid. To analyze the causes of the increase in litigation and its likely impact, Bessen and Meurer (2005) conduct an empirical analysis of litigation hazards faced by firms. They conclude that legal changes, such as the creation of a unified appeal court (the U.S. Court of Appeals for the Federal Circuit) in 1982, have been a driver of the rapid growth in litigation. According to their findings, plaintiffs are not necessarily pure imitators, but they do spend substantial amount on R&D investments, as do defendants. The higher the investment in R&D, the more likely the firm will be sued. Furthermore, there are differences across patents in their exposure to litigation risk, and small firms are more at risk to be challenged in court (Lanjouw and Schankerman, 2004). Litigated patents tend to be valuable patents and software patents are more likely to be litigated (Allison et al., 2011). However, both large and small firms face lawsuits by "non-practicing entities," also called patent trolls (Bessen and Meurer, 2012).

Patent litigation reveals information about the validity of a patent to other potential entrants or infringers. It also creates informational externalities: entry decisions of potential entrants can be conditioned on the information revealed during litigation with a first infringer. As a result, infringers might have an incentive to wait, leading to a free riding problem. This can also impact the behavior of the patentee who might decide not to sue the first imitator to avoid this informational externality. However, it has been shown in the theoretical model of Choi (1998) that the threat of litigation can prevent the second innovator from entering.

Most patent litigations do not end up in court. Indeed, many patent disputes (for validity or infringement) are settled out of court, and the settlement agreements typically are confidential. The basic predictions regarding when litigation will result in settlement are similar to those regarding opposition systems; see Lanjouw and Lerner (1998) for a simple model. In a theoretical contribution where patent holders must monitor their market, Crampes and Langinier (2002) show that patent holders may prefer a settlement to a trial even if the penalty paid by the infringer is relatively high. According to Chiou (2008) in a theoretical contribution, when the patent holder has private information concerning the patent validity a weak patent is more likely to be settled out of court than a strong patent.

The adoption of an opposition system in the U.S. has been considered for years and is strongly supported by many scholars (e.g., Merges, 1999; Hall and Harhoff, 2004; Graham and Harhoff, 2006; Farrell and Shapiro, 2008). The perceived benefits of a post-grant opposition mechanism are reduced uncertainty regarding the validity of a patent, or at least a more rapid resolution of uncertainty, and a reduction in the costs of opposition.[34] On the other hand, it might impose additional costs on the USPTO and the patent holder. Moreover, if it is more common to challenge through the opposition system, increasing the patenting cost of patent holders will likely affect their incentive to innovate. Overall, the social welfare impact of an opposition system is uncertain. A system that requires the participation of third parties can be subject to free riding because of weak incentives for third parties to challenge the patent. Indeed, the competitor who initiates the post-grant opposition will only get a fraction of the value created by the

[34] The estimated average cost for each party involved in an opposition mechanism is about $20,000, which is much lower than U.S. litigation costs that can range between $0.5 to 4 million per party (Hall and Harhoff, 2004).

opposition procedure. Furthermore, the rival firm who challenges the patent will signal to the patent holder that it might be infringing the patent (Lemley and Shapiro, 2005).

Graham and Harhoff (2006) use a data set of “equivalent” patents in the U.S. and Europe from 1963 to 2003 to compare outcomes under an opposition system and litigation. Patents are considered “equivalent” when they share the same set of priority documents. The authors find a higher EPO grant rate for the equivalents of patents litigated in the U.S. than for those not litigated. Equivalents of U.S. litigated patents are three times as likely to be opposed as control group patents. As well, EPO equivalents of U.S. non-litigated patents that are opposed in Europe are revoked in 28 to 40 percent of cases. The authors conclude that U.S. adoption of a post-grant review mechanism would increase welfare, and that the main benefit would derive from revoking invalid patents that currently do not proceed to litigation in the U.S.

Similar conclusions regarding the impact of the European post-grant review mechanism are reached by Hall and Harhoff (2004) using European data on patents that were opposed between 1980 and 1995: they find that one third of the opposed patents are revoked, which suggests that a large number of examination errors are corrected during the opposition process. By combining German patent data and a survey conducted in 1996 with German patent holders who were asked to provide a value range of their patents, Harhoff et al. (2003) find that the European opposition system is effective in identifying important patents. In a study of matched EPO and U.S. patents, Graham et al. (2002) find that opposition leads to a 41 percent of opposed patents being revoked, in comparison to the 12 percent of U.S. patents subjected to re-examination that were cancelled.

4. Concluding Remarks and Policy Implications

Increases over the last decades in patenting activity in many countries, and the recognition that further increases may be realized in certain jurisdictions, motivate an overview of the recent economic literature aimed at opening the “black box” of the patent process. This literature has made advances in developing the economic theory of patent systems, and in assembling data sets that may be used to answer questions about examiner and applicant behaviors. Recent developments of patent data have permitted new studies of patenting behavior. Furthermore, some patent offices have recently begun to encourage research into these areas by increasing data access and commissioning new studies. However, much remains to be done, and many interesting questions are currently unresolved.

The outcomes of the patent system are affected by the behavior of several different types of agents who are likely to have their own objectives, incentives and information. Empirical work confirms the importance of individual examiner conduct to the output of patent offices, and economic theory outlines how examiners are expected to respond to different managerial incentives that may be set by a patent office. Likewise, applicants can be seen as behaving strategically along multiple dimensions, including decisions regarding whether to reveal private information on the value of their innovations. Empirical evidence highlights the strategic motives of applicants, the importance of individual applicant behavior, and the role of asymmetric information. Strategic motives can also influence the behavior of third parties when providing information during the patenting process.

Much of the focus of the recent literature on patent systems has been on policy issues of patent quality and backlogs, and on whether differences in patent systems across countries may contribute to differences in the observed outcomes. However, as it has been emphasized, cross-country differences in these outcomes can be difficult to interpret. Several policies might be considered by a patent office anticipating a surge in applications in a particular field. In order to maintain patent quality and to minimize the increase of backlogs, a patent office may revisit its examiner incentive system to place more direct incentives on quality or, at least, on measurable proxies for quality. The economic literature to date urges caution in this regard, since quality is difficult to measure, and the work of a patent examiner is complicated and involves teamwork.

Other policies aimed at promoting examination quality and reducing pendency times may target certain technological areas or firms. Applications in certain fields could be examined faster, or could be subject to consideration by multiple examiners. Indeed, such targeted policies have already been adopted or considered in different countries; for instance, the U.S. offers reduced fees to small entities, and considers expedited examinations for applications regarding "green technology." Likewise, there is some experience in the U.S. with patent examination policies (such as the Second Pair of Eyes review) that treat examinations of applications in certain technological areas differently. However, it is important with any such policy to consider its impact on agent behavior. Subjecting a particular field to increased examination scrutiny, for example, may provide incentives for applicants to misreport the field of the innovation, increasing backlogs and complicating quality judgments in other technological areas.

The suggestion has also been made that increased international harmonization of patent systems, through shared examination effort and mutual recognition, can reduce examiner workloads and backlogs. Indeed, many countries are already engaged in some form of cooperation through the Patent Co-operation Treaty and participation in Patent Prosecution Highway projects. London Economics (2010, p. ix) concludes that a system of "mutual recognition" that reduced the time spent on duplicate applications by 25% could reduce backlogs by 19% within five years. In contrast, van Pottelsberghe (2011) warns of the impact of increased harmonization on patent quality. By participating in such projects, countries run the risk of importing lower quality from elsewhere (particularly the U.S.). The transmission of patent quality from country to country, and the impact of such transmission, remains an area of research that could benefit from further study.

Several important directions for future research remain. The focus of existing research has been on the major patent offices (USPTO, EPO and the JPO). However, because of differences in patent systems, findings from one patent office may be difficult to apply to another. In particular, important lessons could be learned from research on patenting at smaller offices. Basic descriptive work could verify claims made about smaller offices, such as their roles as offices of second filing. Furthermore, smaller offices may face unique policy questions that could be addressed with empirical research. The claim that harmonization of examination procedure could harm countries by importing lower standards could be particularly important to smaller offices, if they rely on the examination efforts of larger offices. Policy changes in smaller countries, such as the 1996 change to the Canadian request for examination deadline, present the opportunity for useful research.

More work also remains to be done to understand the interaction between examiners and applicants. Data sets that allow research into the role of individual examiners and the strategic behavior of applicants have only recently been developed and face continued technical challenges. Little empirical evidence currently exists, for example, regarding how examiners respond to patent office incentives and the relative roles of examiners and applicants in affecting pendency time and overall patent quality. However, because both applicants and examiners play a key role in the patenting process it is important to explore their behavior and their interactions. In evaluating the effectiveness of any policy aimed at improving patent quality the impact the main actors of the patenting process should be considered.

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