# THE QUEST FOR EXPANSIVE INTELLECTUAL PROPERTY RIGHTS AND THE FAILURE TO DISCLOSE KNOWN RELEVANT PRIOR ART

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*Expansive patent portfolios may be used by firms to fence off technological space for commercialization, impede the commercialization efforts of competitors, and enhance bargaining power in cross-licensing negotiations. Low quality patents with claims that overlap those of other patents contribute to these portfolios and patent strategies. By failing to disclose known relevant prior art during the patenting process, inventors and their firms may be granted low quality patents with intellectual property claims which would not otherwise have been granted. We find that the failure of inventors to disclose known relevant prior art increases as they gain experience with the patenting process. Such failure is also greater among inventors employed by relatively small, poorly performing firms that rely on outsourced legal counsel during the application process.* Copyright © 2014 John Wiley & Sons, Ltd.

## INTRODUCTION

Attaining patent rights to technological advances is a valuable means of creating barriers to imitation and generating monopoly rents (Mahoney and Pandian, 1992). However, unlike tangible assets such as land, where boundaries and ownership are clearly defined, establishing the confines of a patent is an inherently subjective process that can lead to ambiguous boundaries (Linden and Somaya, 2003). As a result, patents may lay claim to intellectual property which overlaps the claims of other patents.

Ambiguous patent boundaries and the potential for firms to infringe on the intellectual property of others when commercializing their own patented intellectual property have led to a vicious cycle where firms develop expansive portfolios of patents of marginal novelty as part of their competitive strategy (Somaya, 2012). These patent portfolios can be used to assert infringement against competitors to block their commercialization efforts or extract licensing fees. In return, competing firms develop expansive portfolios of patents that create countervailing litigation threats and fence off their own technological space for commercialization (Ceccagnoli, 2009). Bargaining power in cross-licensing negotiations may rest on the sheer number of patents that firms own, rather than their true novelty. To avoid litigation, some competitors have resorted to settling infringement cases by measuring whose stack of patents is taller (Krajec, 2013).

Whether firms intend to use an offensive patent strategy (blocking others from commercializing), a defensive patent strategy (securing technology space by establishing countervailing litigation

threats), or a leveraging strategy (patents as bargaining chips for licensing), accumulating a vast trove of patents can provide strategic value for firms in their patent wars against others (Somaya, 2012). In 2011, Apple and Google spent more on patent purchases and patent litigation than on R&D (Duhigg and Lohr, 2012). Because of their presumed validity in a court of law, even low quality patents that are not truly novel can play an integral role in patent strategies supporting a firm's competitive positioning (Somaya, 2012).[1]

Because of the strategic relevance of patent portfolios, scholars have explored firm differences in patenting rates due to critical inputs such as R&D expenditures or external knowledge (e.g., Somaya, Williamson, and Zhang, 2007). Though insightful, such research places substantial confidence in the veracity of the patenting process. Relatively little work has considered when firms and their inventors are likely to exploit the inherent ambiguity of patent boundaries by attempting to attain low quality and unjustifiably broad patents to supplement strategically valuable patent portfolios (e.g., Lampe, 2012).

To gain insight, we delve deeper into the subjective process by which patent rights are attained. Patents are only granted if the claims made within them are *judged* to be novel. Determining invention novelty is a process that is negotiated on one side by inventors and their legal counsel, and government patent examiners on the other. Ambiguous patent boundaries and overlapping claims occur when relevant prior art (e.g., previously granted patents, publications) is not sufficiently vetted during the examination process (Bessen and Meurer, 2008). Inventors have unique insights distinct from those of patent examiners on the prior art relevant to their inventions, and are legally bound to disclose any prior art known to them that is relevant to their inventions being considered for patent protection. However, full disclosure may result in certain claims, or even the entire patent being rejected. Thus, by *not* disclosing known relevant prior art, inventors and their firms may be granted patents and claims they would not have otherwise been awarded. Nonetheless, by doing so, inventors and their firms risk having their patents invalidated at

some point in the future when defending them against infringement by other firms.

Knowing when inventors are less likely to disclose known relevant prior art holds significant implications for firms competing through their patented property rights and limiting those of others. The *America Invents Act* of 2012 makes it easier for firms to oppose the patent applications of competitors. For a price, firms can anonymously submit any prior art they believe is relevant to their competitors' patent applications in hopes of preventing competitors from obtaining overly broad patents to support their claims. Recent changes to the law also enable firms to lodge post-grant opposition to recently granted patents. In response to such regulatory changes, firms benefit by developing competitive intelligence capabilities for tracking the patenting pursuits of their competitors (Kravets, 2012). A budding industry of prior art crowdsourcing services (e.g., Article One Partners) identifies relevant prior art for clients hoping to invalidate competitor patents. The emergence of such services is indicative of a growing desire to monitor the patent quality of competitors and diminish the strategic value of their patent portfolios. Understanding when competitors inadequately disclose known relevant prior art will add precision to this monitoring process and enhance the efficiency of resources allocated to identifying low quality patents.

We consider when applicants (i.e., inventors and their legal counsel) are less likely to disclose relevant prior art known to them during the application process. To do so, we adopt a behavioral approach that considers both the potential biases of inventors as well as the extent to which legal counsel may curb the effects of such biases. First, inventors are potentially biased when assessing their risk of being penalized for not disclosing relevant prior art. In general, prior experience making similar repeated decisions influences how individuals assess the likelihood of rare outcomes from a current decision (Hertwig *et al.,* 2004). Inventors who have had extensive experience developing and patenting inventions over the course of their careers may discount the risk of a patent's invalidation from not disclosing relevant prior art.

Second, the unmet aspirations of the inventor's employer can impinge on the obligation to reveal relevant prior art. Performing below aspiration levels is typically viewed by individuals as a loss situation (Kahneman and Tversky, 1979). In order

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[1] For example, Apple's Siri patent was granted only after being rejected nine times by the USPTO. Although many believe this patent to be low quality because its underlying technology is a commonplace variation on existing ideas, it is essential to Apple's strategy and ongoing battle with Samsung in the smartphone market (Duhigg and Lohr, 2012).

to mitigate this situation, people tend to take more risks. We suggest that the incentives to not disclose relevant prior art are particularly tempting for inventors employed by firms performing below their financial aspirations where risk-taking is likely to be encouraged.

The effects of these biases may be mitigated by legal counsel who work on behalf of inventors and their firms, and help ensure that legal obligations are met. Their ability to do so depends on their familiarity with the knowledge possessed by the inventors they represent. Compared to outsourced legal counsel, in-house lawyers tend to have a better sense of the knowledge within the applicant firm due to their close interaction with inventors (i.e., fellow employees) and history of processing their employer's previous patent applications. Because of this knowledge specificity and the professional obligations that come with such knowledge, the use of in-house legal counsel will limit the effects of inventor biases and their failure to disclose known relevant prior art to a greater degree than using outsourced legal counsel.

To assess our hypotheses, we tracked the disclosure of prior art on over 5,000 patents from 1,217 serial inventors, and whether the prior art known by the inventor was either disclosed by inventors or added by the examiner. We relied on a conservative representation of inventor knowledge, assuming only that inventors must be aware of their own previous patents, and used a conservative within-subject design. We begin with a description of the patenting process, followed by the development of our hypotheses and explanation of our data and analyses.

## THE PATENTING PROCESS

In order to establish the right to exclusively exploit an invention, an inventor submits a patent application with the USPTO, normally through legal counsel. This application contains a set of claims that defines the scope of the patent and the specific technology the inventor wishes to protect (Lemley and Shapiro, 2005). Patent protection is granted only to those claims that are deemed novel, nonobvious, and useful. Once a patent is granted, it can be used to deny others the right to exploit the protected claims. To determine the novelty (and thus the validity) of a claim, a patent examiner reviews related prior art as found in previously granted patents

or publications. The USPTO patent examiner then compares this prior art to claims in a new patent application in order to assess whether the invention is indeed novel (Cotropia, 2009).

The gatekeeper role of patent examiners is analogous to journal editors who ensure the articles they accept for publication will constitute a worthy contribution to the literature. Similarly, patent examiners are responsible for ensuring that inventors and their firms are granted patent rights only for ideas that are truly novel. Access to relatively complete information regarding relevant prior art is essential to this process. However, substantial information asymmetry exists between inventors and examiners (Mack, 2006). Although patent examiners specialize in a particular realm of technology, they lack the tacit knowledge and prior art links associated with an invention that can be developed only through actual invention (Kesan, 2002).

To reduce this information asymmetry, patent applicants are legally bound to disclose prior art known to them which is relevant to the invention they are seeking to protect. Section 1.56 of Title 37 of the Code of Federal regulations requires a duty of candor and good faith in dealing with the USPTO during the period of examination. All individuals associated with the patent application, including inventors and legal counsel substantively involved in the preparation of the patent application, are bound by this duty. Although there is no obligation to search for relevant prior art beyond what the inventor and legal counsel are already aware of, any relevant prior art that is known to them must be submitted in an Information Disclosure Statement.[2] Legal counsel is responsible for educating inventors about their legal obligations and the potential consequences of not abiding by them, as well as facilitating any communication with the USPTO (Flores and Warren, 1999).

In accordance with the duty of candor, at the time of application, applicants (i.e., inventors and legal counsel) disclose known relevant prior art

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[2] There are perverse incentives for inventors and their legal agents to remain ignorant of relevant art; the more they know, the greater their exposure under the duty of candor (Cotropia, 2009). Because of the potential benefits from securing low quality patents, strong incentives exist for inventors and lawyers not to do outside searches (Atal and Bar, 2010). In our own private conversations, several inventors indicated that counsel dissuaded them from searching for prior art. Some companies even block employees' access to patent office databases to prevent them from finding prior art and thus risk allegations of inequitable conduct (Atal and Bar, 2010).

and put forth claims to intellectual property that are distinct from the prior art they disclose. Patent examiners begin their assessment by reviewing the prior art and claims submitted by the applicants. They typically conduct their own search for relevant prior art and, based on what they uncover, they may either reject the application or narrow the initial claims (Lemley and Sampat, 2012). Following the examiner's preliminary report, the patent applicant may file a response to rebut the examiner's analysis or amend the application and its claims. Through this iterative process, a record of relevant prior art is developed for those patents that are eventually granted (Mack, 2006). Some of the prior art may be submitted by the applicant and the remainder added by the examiner as a result of his or her own search.

By adhering to the duty of candor and disclosing known relevant prior art, inventors help ensure that only novel claims are granted patent protection. Even so, there are clear disincentives for patent applicants to do so. By refraining from disclosing known relevant prior art, patent applicants can attain broader claims than they might otherwise, should an examiner fail to uncover such prior art during his or her own search (Alcacer, Gittelman, and Sampat, 2009). A patent's scope and the applicant's exclusivity over technology subsumed in the patent are often reduced by any relevant prior art uncovered through the patenting process (Wagner, 2002). Patents entailing a broad scope of protected technology are more economically valuable than those with a narrow scope (Merges and Nelson, 1990). If the claims, justified or otherwise, are granted, their presumed validity can generally only be overturned with convincing evidence (Sampat, 2010). Courts are often reluctant to second-guess the judgment of examiners, who are perceived to be experts at what they do (Cotropia, Lemley, and Sampat, 2012). Prior art disclosed in a patent can also provide an unintended roadmap for competitors on how to work around the patent (Conigliaro, Greengberg, and Lemley, 2001). Ultimately, the incentives to not disclose relevant prior art can lead to low quality patents that incorrectly represent the true novelty of the underlying technology. Though their true novelty may be dubious, such patents can hamper the commercialization efforts of competitors, and serve as bargaining chips for cross-licensing agreements.

Countering these incentives to hold back known relevant prior art is the possibility that accused infringers will assert that inequitable conduct occurred at the time of patenting. Inequitable conduct occurs when inventors and legal counsel *intentionally* misrepresent or fail to disclose known prior art during the patent application process. In this case, the entire patent can be rendered unenforceable, costing patent owners their investment and the opportunity to exclusively exploit the technology. Any efforts spent developing products based on these patents may be wasted. Findings of inequitable conduct damage the reputation of the firm and adversely affect the value of related patents. Inequitable conduct can be asserted only by those accused of infringing on a patent after the patent has been granted, and not by the USPTO during the patent examination process.

An inequitable conduct defense is proffered in a quarter of all patent infringement litigation filed (Mack, 2006). However, determining inequitable conduct is relatively difficult (Cotropia, 2009). Whether an accused infringer will be able to legally establish that the omitted prior art is in fact relevant and that the inventor intentionally omitted it is highly uncertain. Given that only 1.5 percent of all patents are ever litigated (Lemley, 2001), a finding of inequitable conduct is a relatively rare outcome.

## A BEHAVIORAL PERSPECTIVE ON DISCLOSING RELEVANT PRIOR ART

To some degree, decisions regarding the disclosure of prior art balance risk (the rare occurrence of an inequitable conduct ruling) against reward (greater economic returns) (Cotropia, 2009).[3] We contend that the failure of inventors to disclose relevant prior art known to them is influenced by their patenting experience and the performance of their employers. Such influence may be somewhat mitigated by legal

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[3] Not all examiner-added prior art necessarily leads to the rejection of claims, reducing the scope of a patent (Cotropia *et al.*, 2012). Some examiner-added prior art lead to modifications of existing claims or are deemed "pertinent" to the patent without claim modification (http://www.bitlaw.com/source/mpep/707_05.html). However, from an applicant's perspective, it is highly uncertain whether an examiner will interpret disclosed prior art as reason to reject or modify a claim, or merely pertinent. Thus, for those applicants inclined to maximize patent scope, possibly at the risk of having the patent later deemed not enforceable due to a finding of inequitable conduct, there remains incentive to not disclose relevant prior art in hopes that the examiner will also not uncover it and then use it to reduce patent scope (Wagner and Parchomovsky, 2005).

counsel's familiarity with the knowledge possessed by inventors.

## Inventor patenting experience

Through repeated interactions, inventors gain experience with the patenting process. Such experience can influence the decision calculus of inventors during the patent application process and the probabilities they place on possible outcomes. Prolific inventors garner extensive experience with the patenting process by developing patentable inventions on a regular basis. For others, novel ideas are few and far between, and experience accrues much more slowly.

Most individuals have a difficult time accurately accounting for rare outcomes when making decisions under uncertainty. Kahneman and Tversky (1979) found that the prospect of rare outcomes are either completely neglected or given too much emphasis. Recent studies have shown that the experience of the decision maker determines the direction of these errors. When individuals have limited prior experience making a particular decision, and thus little direct feedback, decisions tend to be made based on salient descriptions of the possible outcomes (Hertwig *et al.*, 2004). As prescribed by prospect theory (e.g., Fox and Tversky, 1998), individuals often *overweight* the probability of adverse rare outcomes. However, as decision makers gain experience through their repeated decisions, they tend to rely on their own limited sample of outcomes as opposed to a more accurate distribution of outcomes from the broader population. This reliance on an inadequately small sample of outcomes, along with a tendency to rely on most recent experience, can cause decision makers to *underweight* the probability of adverse rare outcomes (Hertwig *et al.,* 2004). In essence, rare outcomes have less influence on experienced decision makers than they deserve because they have either not directly encountered them from their own experience, or have not encountered them recently.

In sum, confidence gained through experience can create a tendency to underweight the probability of rare adverse outcomes. Such a tendency can influence inventors' disclosure of prior art. Experienced inventors will discount the risk of being found to have acted inequitably for not disclosing known relevant prior art. Findings of inequitable conduct are rare events relative to the population of patents granted. When inventors have little patenting experience, the description from legal counsel of the adverse consequences of failing to disclose relevant prior art will be particularly salient. These inexperienced inventors will be highly sensitive to the potential consequences from this rare outcome and will diligently disclose the relevant prior art known to them. However, as inventors gain proficiency with the patenting process over the course of their careers, they will rely on their personal experience and record of outcomes to guide their decisions. Ultimately, experienced inventors are likely to grow complacent regarding the risks associated with not disclosing known relevant prior art, and discount the likelihood of being found to have acted inequitably.

Because of the tendency of experienced inventors to underestimate the likelihood of subsequent patent invalidation due to inequitable conduct on their part, the failure of inventors to disclose relevant prior art known to them will increase as they accrue experience with the patenting process over the course of their careers.

> *Hypothesis 1: Increased patenting experience of inventors leads to greater failure in their disclosing relevant prior art known to them.*

## Organizational performance

Financial performance is the *raison d'etre* of profit-seeking organizations. If management is unable to deliver acceptable yearly or even quarterly financial returns, their positions can become precarious. This pressure for financial performance permeates the organization and can influence all levels and functions. The attitudes and values of upper management, either positive or negative, trickle down to the lower rungs of the organization (Aryee *et al.,* 2007; Mayer *et al.,* 2009). Supervisors' bottom line mentality has been shown to influence the mentality of their underlings (Greenbaum, Mawritz, and Eissa, 2012).

The behavioral theory of the firm addresses how performance relative to aspirations influences risk taking and decision making (March, 1994). The performance aspirations of profit-seeking firms are generally established through a comparison with competitors in the same industry (Harris and Bromiley, 2007). The extent to which a firm is performing below the industry average signifies underperformance relative to reasonable aspirations (Mishina

*et al.,* 2010). Performing below aspirations is typically viewed by individuals as a loss situation (Kahneman and Tversky, 1979). In order to mitigate this situation, individuals are willing to take more risks. Indeed, subpar performance has been shown to increase the level of risky R&D (Greve, 2003). Past work has also shown that performance relative to aspirations can influence the accuracy of reporting. Harris and Bromiley (2007) found that the farther firms performed below industry average, the more likely their managers would be to misrepresent subsequent financial performance. Although there is the risk that such misrepresentation is detected, managers are more willing to accept these risks and associated consequences when the performance of their firm is subpar.

Firm performance below aspirations may influence the disclosure of prior art as well. Performance shortfalls can be remedied by developing commercially viable products and services, or by preventing competitors from commercializing their own innovations. However, the extent to which firms can do so depends on the number and scope of patents in their patent portfolios, granting them the exclusivity needed for commercialization, and the ability to keep competitor commercialization in check. The incentive to not disclose relevant prior art in order to gain a competitive advantage will be particularly influential within firms that are not meeting their financial aspirations. Patent scope and their potential economic value are enhanced when inventors hold back relevant prior art known to them during the patenting process. Although doing so increases the risk of patent invalidation, that risk will be more acceptable to inventors when their firms are performing below aspirations. Thus, the failure to disclose relevant prior art known to them will be greater for those inventors employed by firms that are performing below their financial aspirations.

*Hypothesis 2: Firm performance below aspirations leads to greater failure of inventors in revealing relevant prior art known to them.*

### The mitigating effects of legal counsel

When pursuing patent protection for intellectual property, legal counsel provides guidance about claims that can be made in light of existing prior art, and monitors the process to ensure that all legal obligations are met, including the duty of candor. In essence, patent attorneys facilitate information flow from inventors to patent examiners (Cotropia, 2009). Like inventors, legal counsel may be held liable for inequitable conduct if they intentionally fail to disclose any relevant prior art known to them in the patent applications that they represent. The penalties for such conduct are severe and can lead to either temporary or permanent disbarment depending on the seriousness of the infraction (Flores and Warren, 1999).

While some patent applications are represented by in-house legal counsel, others are done so through outside legal counsel. The benefits of outsourcing activities such as manufacturing and marketing support are well known. Firms can access specialized capabilities which would be prohibitively expensive to maintain internally (Mowery, Oxley, and Silverman, 1996). Large suppliers also can service the pooled demand of a broad array of clients more efficiently than what a single client could provide for itself (Liebeskind *et al.,* 1996). However, these benefits come at the cost of close integration and coordination. There is generally a greater flow of information between value chain activities that reside within an organization than between value chain activities that are linked through outsourcing agreements (Teece, 1996).

These tradeoffs apply to legal services as well. When inventors and legal counsel reside within the same organization, their levels of interaction are greater than if they were employed by separate organizations linked by an outsourcing agreement. In-house legal counsel typically represents numerous patents involving their employer's inventors. Through this process, they become deeply familiar with inventions developed by their firm and the knowledge underlying these inventions. In this way, in-house counsel acquires technical knowledge that is highly specific to their employer and its inventors.

Somaya *et al.* (2007: 931–932) considered the difference in knowledge specificity between in-house and outsourced patent attorneys, and interviewed retired in-house patent counsel from several firms. One explained that when outsourced legal counsel was used, they had to "educate them from the beginning [on] the concept of what you do and the prior art" whereas in-house lawyers "could begin discussing things at a much different level than if you come [in] from the cold." Others described the in-house patent attorney-inventor relationship involving "a good deal of interchange of information" and that the lawyers "have a close relationship with the scientists." Although

outsourced legal counsel may have expertise over a broad technological domain, they do not enjoy the same level of specialization as comparable in-house counsel regarding their client's inventive pursuits.

Familiarity with the technical domain and patenting history of inventors they represent determines the responsibilities and liabilities of legal counsel. Patent attorneys are legally responsible for disclosing relevant prior art that is known to them without actively searching (Hricik, 2000). As they process patent applications, attorneys become exposed to a broader array of prior art (Cotropia, 2009). Thus, the liability of counsel increases substantially the more familiar they become with the technological domain and patenting history of the inventors they represent. Flores and Warren (1999) point out that patent attorneys are particularly liable for not disclosing the relevant prior art that is in their files from previous work developing patent applications. A strong inference can be made by the court that withholding such art was intentional. Any ability of the patent attorney to plausibly deny awareness in the face of claims of inequitable conduct becomes highly untenable. By contrast, outsourced legal counsel will not only be less familiar with the patenting history of the applicant firm, their limited familiarity decreases their professional responsibilities and legal liabilities. As pointed out in a recent law review of patent attorney responsibilities, "Clearly, a patent representative who knows of relevant prior art must disclose it, but one who does not know can *rest on that ignorance* (italics added)" (Clifford, 2013: 360). With ignorance comes plausible deniability and a reduced threat of professional sanctions.

The differences between in-house and outsourced legal counsel can influence their ability to ensure that inventors disclose the relevant prior art that is known to them. Because in-house counsel is relatively familiar with the patenting history and the prior art known to the inventors they represent, they are potentially more effective at curbing inventors' tendencies not to disclose relevant prior art known to them. Biases due to inventor patenting experience and lackluster financial performance may have less influence on the disclosure of relevant prior art known to the inventor. In contrast, because outsourced counsel has relatively less familiarity with their clients' patenting history and associated prior art, inventors may have greater discretion to act on their biases and fail to disclose relevant prior art known to them.

Not only does in-house legal counsel have the ability to keep inventor biases in check, they have the incentive. Although in-house counsel and the inventors they represent are employed by the same organization, their motivations differ. Attorneys belong to a professional community that provides them a sense of identity and legitimacy (Larson, 1977). In order to maintain a sense of prestige and distinction from their nonprofessional coworkers, those employed by nonprofessional organizations (e.g., lawyers employed by corporations as opposed to law firms) tend to identify with their profession more than their employer (Johnson *et al.,* 2006). This strong affinity to the profession is understandable, given that an attorney's livelihood depends on maintaining professional standing. Allegations of inequitable conduct implicate patent attorneys' reputations (Flores and Warren, 1999). Attorneys found to have acted inequitably may be disbarred and unable to practice law or maintain good standing in a professional community critical to their identity. By contrast, the consequences for inventors found to have acted inequitably are not as egregious. All claims within the respective patent may be rendered unenforceable and the reputation of the inventor tarnished somewhat, but there is no loss of license and they maintain the right to submit future patent applications.

In sum, familiarity with their firm's previous patenting activity *enables* in-house legal counsel to keep inventor biases in check, and ensure that relevant prior art known by the inventor is disclosed. The threat of professional sanctions provides *incentive* to in-house legal counsel to act on their added familiarity. In contrast, outsourced legal counsel may actually benefit from their lack of familiarity with the prior art known to the client inventors they represent. Because outsourced legal counsel can avoid disclosing unfamiliar relevant prior art without risking professional sanctions, their clients may gain additional and more broadly scoped patents; outcomes that can lead to future business and additional client fees for the attorney and law firm. Indeed, many corporate clients specifically request that outside legal counsel *not* search for prior art beyond their often limited existing knowledge of prior art (Clifford, 2013). Law firms are known to establish "Chinese walls" to curb the flow of discussion and information between attorneys in their practice, in order to decrease their liability under the duty of candor (Hricik, 2000). Thus, maintaining a level of ignorance regarding relevant prior art

may be strategically beneficial to outsourced legal counsel.[4]

*Hypothesis 3: The relationship between inventor patenting experience and the failure to disclose relevant prior art known to them will be stronger when outsourced counsel is used to represent the patent application.*

*Hypothesis 4: The relationship between firm performance below aspirations and the failure of inventors to disclose relevant prior art known to them will be stronger when outsourced counsel is used to represent the patent application.*

## METHODS

### Data and design

We began our data construction using the inventor disambiguated database from Patent Network Dataverse (Lai *et al.,* 2011). We identified all 123,363 utility patents attributed to solo inventors employed by publicly traded firms that were applied for in years 1997 and beyond, and granted from 2001 to 2006. In 2001, the USPTO began to distinguish prior art citations added by the examiner from those disclosed by the applicant for all patents granted. Because this distinction is critical for our dependent variable, our sample begins in 2001, based on grant date. Our sample ends in 2006 (based on grant date) to provide a five year window from 2006 to gather forward citations data necessary for purposes of control. We restricted our sample to patents attributed to a solo inventor in order to avoid the confounding effects that occur when inventions are developed by a team, and to patents from publicly traded firms in order to have access to firm performance data. We used the NBER patent project database[5] to ascertain the identity of the parent firm for each patent. Key financial information on those firms that were public was collected from the COMPUSTAT database.

Because inventors are only responsible for disclosing relevant prior that is known to them, we narrowed our sample to patents where we could accurately detect a failure of inventors to disclose such art. We relied on a conservative representation of what inventors knew, assuming only that inventors were aware of their own previous patents. This conservative representation has two attractive features: (1) we can justifiably assert that inventors can recall their own work with little difficulty; and (2) because recall of such prior art is essentially free in terms of time and effort, we control for variability in the resources put forth by the applicant firm toward patent application preparation (Sampat, 2010). We identified sample patents where the inventor had a history of patenting within the 10 years prior to the application of the sample patent. For those sample patents where the inventors had previously granted patents, we identified those where the prior art associated with the sample patent contained some of the inventor's previous patents. These sample patents were initially viable for our analyses, as we were able to compute the failure of the inventor to disclose known relevant prior art.

To further enhance the internal validity of our analysis, we relied on inventor-level fixed effects empirical models to control for any unobserved time invariant heterogeneity associated with inventors. Over 95 percent of the inventors in our sample remained with one firm throughout the window of our sample (2001–2006). Thus, by using inventor-level fixed effects, we control, for the most part, firm-level unobserved heterogeneity as well. This approach provides a conservative test of our hypotheses. Inventors with only one viable solo patent during the 2001–2006 time frame were dropped from our analysis as a function of the fixed effects models and within-subject design. At the completion of this process, 5,484 patents from 1,217 serial inventors remained viable for analysis. We compared our final sample of 5,484 solo-authored patents to the population of 123,363 solo-authored patents granted to public firms in terms of technology representation based on the NBER subcategory classification (Hall, Jaffe, and Trajtenberg, 2001). In 29 out of the 36 subcategories, the difference between sample and population in percent representation was less than one percent.[6]

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[4] We thank an anonymous reviewer for bringing to our attention the potential incentives of outsourced legal counsel.

[5] https://sites.google.com/site/patentdataproject/Home

[6] The primary difference between the population of solo-authored patents and the sample that we used to test our hypotheses was that the sample was limited to patents that referenced inventors' previous patents as prior art. This restriction occurred because our dependent variable is based on known relevant prior art

USPTO data made available through Google[7] was used to supplement the Patent Network Dataverse data to distinguish prior art citations added by examiners from those added by applicants, attain the name of the patent examiner, and to identify the use of outsourced counsel.

## Key variables

### *Failure to disclose known relevant prior art*

We measured the extent to which an inventor failed to disclose relevant prior art known to them by counting the inventor's previously granted patents listed as prior art of the focal patent, and added by the patent examiner. We limited the inventor's inventory of previously granted patents to those *granted* during the 10-year window prior to the focal patent's *application* year.[8] These prior art citations added by examiners were clearly known to the inventor in that they were the inventor's previously granted patents, and *not* subsequently disclosed by the inventor to the examiner. Notably, this measure does not account for relevant prior art known to the inventor which may have been withheld by the inventor but *not* discovered by the examiner. Thus, our measure is a conservative estimate of failure to disclose known prior art (Lampe, 2012). On average, examiners contributed 36 percent of the relevant prior art known to the inventor referenced by the sample patents. Although the inventors were aware of this prior art given that it entails their own prior patents, examiners were still left to uncover over a third of such art.[9]

### *Inventor patenting experience*

To measure the experience of the inventor at the time of the application for the sample patent, going back to 1975, we counted the total number of patents that had been granted to the inventor before the application year of the sample patent.

### *Performance below aspirations*

Consistent with those who have measured firm performance below aspirational levels (e.g., Greve, 2003; Harris and Bromiley, 2007), we used return on assets (ROA) as our measure of performance. For each applicant firm connected to a sample patent, we subtracted firm ROA for the year prior to the application year of the focal patent from the industry average ROA (based on four-digit primary SIC) if firm ROA was below the industry average. If firm ROA was greater than industry average, performance below aspirations was coded as 0. A more positive value indicates greater underperformance relative to aspirations.

### *Outsourced legal counsel*

We determined whether counsel used to represent each sample patent was outsourced by examining the "law firm" field within the "Agents" section of the Google database. If a name of a law firm appeared in this field, this was deemed to be outsourced legal counsel. To measure whether outsourced legal counsel was used during the patent application process, we used a dummy variable set to 1, if outside legal counsel was used, and 0 otherwise.

(i.e., the inventor's prior patents) at risk of not being disclosed. Our restricted sample does limit the generalizability of our results. However, we felt that the enhanced internal validity lent greater confidence in our inferences and outweighed the loss of generalizability. By assuming only that inventors are aware of their own previous patents, and restricting sample patents to those that reference the inventor's prior work, we assured that our results were not driven by limited awareness of relevant prior art.

[7] http://www.google.com/googlebooks/uspto-patents-grants-biblio.html

[8] Thus all of the patent numbers of the known relevant prior art at risk of not being disclosed are available to applicants at the time the focal patent is applied for. One limitation of our design is that any relevant prior art known to the inventor that is still in the application process at the time that the focal patent is applied for is not considered. We chose to forego consideration of such prior art in order to avoid situations where applicants disclosed application numbers that are then converted to granted patent numbers by examiners, which would introduce significant error in our measure.

[9] Similarly, using a broader sample of over 150,000 patents (solo and multiple authored) from 2001 to 2003, Sampat (2010) found

that examiners added 41 percent of all citations to inventors' own prior art. We have seen no evidence that examiners have any incentive to add irrelevant prior art citations. They work under a production quota system where they need to examine a set number of applications every two weeks (Wang, 2010). Depending on experience, examiners are allowed 10–18 hours for each patent application and are rewarded if they outperform their production quota. Lemley and Sampat (2012) observe that examiners are not directly rewarded for extensively searching for or adding prior art under this system. Moreover, there is a real time cost for the examiner in adding prior art. According to the Manual of Patent Examining Procedure, section 707.5, "…the examiner should cite appropriate prior art which is nearest to the subject matter defined in the claims. When such prior art is cited, *its pertinence should be explained* (italics added)." Given the need to explain the pertinence of the added prior art and their already tight time constraints, we believe that examiners will be disinclined to add irrelevant prior art.

## Control variables

### Prior art at risk of not being disclosed

Because our dependent variable is the total prior art associated with the focal patent known to the inventor (i.e., his or her previously granted patents) and added by the examiner, we needed to control for the risk set of such occurrences. The prior art at risk for not being disclosed by the inventor is the total count of prior art associated with the focal patent and known to the inventor. Some prior art may have been disclosed by the inventor and some added by the examiner. The grand total constitutes the risk set for the focal patent.

### Average age of prior art at risk

It is possible that inventors may have a harder time recalling their older patents as potentially relevant prior art when they are applying for a subsequent patent. We control for the average age of the relevant prior art known by the inventor at risk of not being disclosed by the inventor (i.e., that which was provided by either the inventor or examiner) in all of our models.[10] Age was computed as the difference between the application year of the focal patent and grant year of the prior art.

### Performance above aspirations

We computed a measure of performance above aspirations similar to our measure of *performance below aspirations*. For each applicant firm connected to a sample patent, we subtracted industry average ROA from firm ROA for the year prior to the application year of the focal patent, if firm ROA was above the industry average. If firm ROA was less than industry average, performance above aspirations was coded as 0. Thus, a more positive value indicates greater performance relative to aspirations.

### Forward citations

A forward citation occurs when a future patent cites a focal patent as relevant prior art. The count of forward citations received by a patent is an indicator of its value (Lampe, 2012; Sampat, 2010). If the patent is valuable in its own right, there may be more incentive for full disclosure of prior art to ensure its defensibility. For each of our sample patents, we counted the number of forward citations within a five-year window subsequent to the grant date of the sample patent.

### Examiner technology class-specific experience

The ability of patent examiners to develop a thorough record of relevant prior art for a given patent may depend in part on their experience (Wang, 2010). Examiners with more experience granting patents in a particular class of technology are likely to have greater knowledge of potentially relevant prior art. Thus, we controlled for examiner experience in assessing patents of the same class as the focal patent.

The USPTO does not assign its examiners unique identifiers, and the names listed for various examiners are not standardized. The Google patent database for 1976–2011 showed 3,710,621 patents with 53,693 unique names listed in either the primary or secondary examiner field. Many of those names listed are permutations of the same name. Using a multiple-step disambiguation process, we clustered names from the examiner fields of the Google database that could be considered permutations associated with the same name. First, we applied a matching algorithm to the full inventory of 53,693 unique names. This algorithm generates different ways in which a given name can be represented. The algorithm then looks for matches with other names in the full inventory. If a match is found, the given name is linked to the obtained match. Once the algorithm processes the entire inventory of names, a unique identification number is assigned to each set of names that have been linked.

We then manually examined the results of this algorithm, sorting iteratively by surname and first name and adjusting the clusters accordingly based on the judgment of the authors. Although ad hoc, we are confident that this process improved the accuracy of our disambiguation algorithm by reducing Type II error where a given examiner's true body of work is incorrectly assigned to multiple unique identifiers.

Finally, we examined the distribution of granted patents associated with each newly assigned unique identifier over time. Substantial time gaps in the distribution, where no examination activity (i.e., granted patents) is interspersed between years of

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[10] Note that this is not the average age of all of the inventor's previous patents, but rather is restricted to the known relevant prior art at risk of not being disclosed for each focal patent.

extensive activity, indicate a possible clustering Type I error where the work of multiple examiners was incorrectly assigned to one unique identifier. In such cases, the names of the original examiners listed on the patents were closely examined and a judgment made whether to assign multiple unique identifiers. At the conclusion of this process, 1,326 primary and secondary examiners were represented in the full sample of 5,484 patents.

In our sample of patents, 42 percent had only a primary examiner while the remainder had both primary and secondary examiners. When used, secondary examiners tend to do the bulk of the examination which is then reviewed by the primary examiner (Lemley and Sampat, 2012). Examiner experience for each focal patent is based on secondary examiner when such an examiner is listed on the patent. The primary examiner is used when there is no secondary examiner. For each focal patent within our sample, we counted the number of patents granted by the examiner acting as either a primary or secondary examiner, from 1976 to the year prior to the grant date of the focal patent, falling within the same three-digit technology class as the focal patent. The potential for Type I error from our disambiguation process introducing error into our measure of examiner experience was limited by our focus on technology class-specific experience. Patent examiners specialize in patent applications for a limited set of distinct technology classes (e.g., organic chemistry, electronics) taken from over 400 technology classes defined by the USPTO. The likelihood that two examiners would be incorrectly assigned to one unique identifier *and* overlap in terms of patent class specialization seemed relatively remote.[11]

### Examiner diligence

Patent examiners work under a quota system and time pressure, and may vary the effort they put forth toward reviewing a given patent application (Wang, 2010). To partially account for the variability in the diligence of the examiner across our sample of patents, we controlled for the percentage of all prior art citations added by the examiner to the sample

patent, relative to the total count of prior art citations associated with the patent.

It is highly recommended that when a ratio is included in an empirical model, the components of the ratio should be included in order to control for their main effects as well (Bradshaw and Radbill, 1987). Thus, we included the count of *examiner-added prior art citations* and the count of *total prior art citations* for each sample patent.

### Technological subcategory

There is some evidence of differences in the rate of examiner-added prior art citations across technological categories (Sampat, 2010). Patent profitability varies across technological categories (Bessen and Meurer, 2008) which may influence the general propensity to reveal relevant prior art (Lampe, 2012). Our sample patents were delineated into 36 distinct technological subcategories based on the primary technology class assigned by the USPTO and the concordance developed by Hall *et al.* (2001).

## ANALYSIS AND RESULTS

Our dependent variable is a count variable that can take on only nonnegative integer values. The use of linear regression to model such data may result in inefficient, inconsistent, and biased coefficient estimates (Long, 1997). Poisson Quasi-Maximum Likelihood (PQML) fixed effects controls for all stable covariates, and effectively contends with both over- and under-dispersion in the dependent variable and the prevalence of zero values (Woolridge, 2002). Thus, we use PQML fixed effects with robust standard errors as our primary means of estimation for all of our models.[12] We control for inventor-level fixed effects, which means that the variance *within* each inventor is the basis for our results.

Because of the exponential specification, the established practice (e.g., Somaya *et al.,* 2007) is to transform all nondummy variables by computing their logs such that both dependent and independent

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[11] This is the most comprehensive disambiguated inventory of primary and secondary examiners that we are aware of. This file of disambiguated examiner names is available from the authors on request.

[12] The PQML fixed effects estimator is implemented by the xtpqml module using STATA v12.1. The xtpqml module computes robust standard errors as described by Woolridge (1999). This module can be downloaded from http://ideas.repec.org/c/boc/bocode/s456821.html

variables are scaled in a similar fashion.[13] The coefficients of logged variables can be interpreted as elasticities. Summary statistics for our variables are shown in Table 1. Table 2 presents our empirical models.

Model 1 only contains the control variables. Model 2 includes the first order terms. Model 3 adds the *inventor patenting experience × outsourced legal counsel* interaction term. Model 4 adds the *performance below aspirations × outsourced legal counsel* interaction term. Model 5 is the full model comprising all first and second order terms. The first order term for *inventor patenting experience* is notably positive and significant across Models 2–5 ($p < 0.01$) and provides initial evidence for the notion that greater *inventor patenting experience* leads to greater failure to disclose known relevant prior art (Hypothesis 1). The first order term for *performance below aspirations* is insignificant across Models 2–5. Because the interaction terms are consistently significant across Models 3–5 and suggest that our first order relationships are contingent on whether in-house or outsourced counsel is used, we relied on Model 5 to assess our hypotheses and interpret results.

Hypothesis 3 proposes that the relationship between inventor patenting experience and the failure to disclose relevant prior art known to them will be stronger when outsourced counsel is used. The interaction between *inventor patent experience* and the use of *outsourced legal counsel* is both positive and significant ($p < 0.05$) providing support for Hypothesis 3. The effect size of *inventor patenting experience* when there is in-house legal counsel (i.e., outsourced legal counsel variable $= 0$) may be calculated at the mean of all the other covariates as the exponent of a standard deviation change in *inventor patenting experience* (s.d. $= 1.12$) multiplied by the first order coefficient for prior inventor experience (B $= 0.169$), or $e^{(1.12 \times 0.169)} = 1.21$. $1.21 - 1 = 0.21$, or 21 percent.[14] Thus, when internal legal counsel is used, an increase of one standard deviation in *inventor patenting experience* leads to a 21 percent increase in failure to disclose relevant prior art known to the

inventor. The effect size of *inventor patenting experience* in the presence of *outsourced legal counsel* (i.e., *outsourced legal counsel* variable $= 1$) may be calculated as the exponent of a standard deviation change in *inventor patenting experience* multiplied by the sum of the first order coefficient for *inventor patenting experience* and the coefficient associated with the interaction term (B $= 0.111$), or $e^{(1.12 \times (0.169 + 0.111))} = 1.37$. $1.37 - 1 = 0.37$, or 37 percent. Thus, when *outsourced legal counsel* is used, an increase of one standard deviation in *inventor patenting experience* leads to a 37 percent increase in the failure to disclose relevant prior art known to the inventor. Hypothesis 3 is supported.

Hypothesis 4 proposes that the relationship between firm performance below aspirations and the failure of inventors to disclose relevant prior art known to them will be stronger when outsourced counsel is used. The interaction between *performance below aspirations* and the use of *outsourced legal counsel* is both positive and significant ($p < 0.05$) in Model 5 and provides support for Hypothesis 4. Because *performance below aspirations* has a truncated distribution (52.59% of our observations are 0) where standard deviation has limited meaning, we considered the influence of moving from 0 to the 50th and 75th percentile level of those observations where the firm is performing below aspirations (i.e., values greater than 0). When *outsourced legal counsel* is used, a change in *performance below aspirations* to the 50th percentile level leads to a three percent increase in the *failure to disclose relevant prior art*. A change in *performance below aspirations* to the 75th percentile level leads to a seven percent increase in the *failure to disclose relevant prior art*.

### Post hoc analyses

One assumption of our theoretical development is that the prior art known by the inventor and uncovered by the examiner is related to the rejection of claims and patent scope. To further verify that there is a relationship between our dependent measure (i.e., the relevant prior art known to the inventor and added by the examiner) and rejection of patent claims, we conducted a post hoc test where we randomly selected two groups of 40 patents each from our sample of 5,484 patents using a matched pair design. Pairs of patents were matched based on the variable *relevant prior art at risk* for being disclosed and the level of disclosure. In Group 1, none of the

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[13] For those variables that had observations less than 1, we added a constant such that minimum was 1 and the natural log was, at minimum, 0.

[14] Predicted failure to reveal prior art is $e^y$ where y is the linear outcome of the estimated model. The interaction term drops out of the effect size calculation when outsourced legal counsel $= 0$.

Table 1.    Summary statistics

| Variable | Type | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|---|
| Failure to disclose known relevant prior art | Count | 5,484 | 0.69 | 1.02 | 0 | 14 |
| Inventor patenting experience[a] | Count | 5,484 | 3.05 | 1.12 | 0 | 6.08 |
| Performance below aspirations[a] | Continuous | 5,484 | 0.04 | 0.09 | 0 | 1.01 |
| Outsourced legal counsel | Dummy | 5,484 | 0.60 | 0.49 | 0 | 1 |
| Relevant prior art at risk[a] | Count | 5,484 | 1.17 | 0.56 | 0.69 | 3.58 |
| Average age of relevant prior art at risk[a] | Years | 5,484 | 1.30 | 0.45 | 0.69 | 2.40 |
| Performance above aspirations[a] | Continuous | 5,484 | 0.03 | 0.04 | 0 | 0.31 |
| Forward citations[a] | Count | 5,484 | 1.33 | 0.96 | 0 | 5.16 |
| Class-specific examiner experience[a] | Count | 5,484 | 4.96 | 1.82 | 0 | 8.06 |
| Examiner diligence[a] | % | 5,484 | 2.98 | 1.37 | 0 | 4.62 |
| Examiner-add prior art citations[a] | Count | 5,484 | 1.57 | 0.79 | 0 | 5.16 |
| Total prior art citations[a] | Count | 5,484 | 1.51 | 0.77 | 0 | 4.42 |

[a] log transformed.

Table 2.    Failure to disclose known relevant prior art: Poisson Quasi-Maximum Likelihood estimates

| Independent variables | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Inventor patent experience | | 0.246*** | 0.174** | 0.241*** | 0.169** |
| | | (0.056) | (0.066) | (0.055) | (0.065) |
| Performance below aspirations | | 0.165 | 0.172 | −0.568 | −0.555 |
| | | (0.458) | (0.458) | (0.483) | (0.481) |
| Inventor patenting experience × Outsourced legal counsel | | | 0.112* | | 0.111* |
| | | | (0.044) | | (0.0442) |
| Performance below aspirations × Outsourced legal counsel | | | | 1.075* | 1.066* |
| | | | | (0.421) | (0.423) |
| Outsourced legal counsel | −0.014 | −0.043 | −0.393** | −0.096+ | −0.441** |
| | (0.052) | (0.053) | (0.147) | (0.0567) | (0.147) |
| Known relevant prior art at risk | 0.980*** | 0.929*** | 0.927*** | 0.930*** | 0.929*** |
| | (0.060) | (0.060) | (0.059) | (0.060) | (0.060) |
| Average age of known prior art at risk | −0.134* | −0.188** | −0.189** | −0.188** | −0.189** |
| | (0.060) | (0.065) | (0.066) | (0.065) | (0.066) |
| Performance above aspirations | 0.257 | 0.484 | 0.559 | 0.526 | 0.602 |
| | (0.655) | (0.659) | (0.662) | (0.656) | (0.658) |
| Forward citations | −0.029 | 0.001 | 0.002 | −0.000 | 0.001 |
| | (0.026) | (0.026) | (0.026) | (0.026) | (0.026) |
| Class-specific examiner experience | 0.009 | 0.006 | 0.006 | 0.006 | 0.006 |
| | (0.012) | (0.012) | (0.012) | (0.012) | (0.011) |
| Examiner diligence | 1.522*** | 1.521*** | 1.506*** | 1.512*** | 1.497*** |
| | (0.171) | (0.171) | (0.171) | (0.171) | (0.171) |
| Examiner-added prior art citations | −0.597** | −0.585** | −0.565** | −0.573** | −0.553** |
| | (0.200) | (0.200) | (0.201) | (0.201) | (0.201) |
| Total prior art citations | 0.775*** | 0.764*** | 0.747*** | 0.757*** | 0.740*** |
| | (0.186) | (0.187) | (0.187) | (0.187) | (0.187) |
| Inventor fixed effects | Yes | Yes | Yes | Yes | Yes |
| Technology subcategory fixed effects | Yes | Yes | Yes | Yes | Yes |
| Log-likelihood | −2,859 | −2,850 | −2,848 | −2,848 | −2,846 |
| Likelihood-ratio test[a] | | 18.12*** | 4.80* | 4.01* | 8.71* |

[a] Model 2 is compared to Model 1. All other models are compared to Model 2.
$n = 5,484$.
Robust standard errors in parentheses.
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; +$p < 0.10$; two-tailed tests

prior art at risk in each patent was disclosed by the inventor (i.e., all was uncovered by examiner). In Group 2, all of the prior art at risk was disclosed by the applicant. For each of these patents, we examined the Conditional Acceptance letter, issued at the end of the patent prosecution process by the USPTO. The average number of claims rejected for Group 1 (15.80) was more than double that of group 2 (7.67). After controlling for the number of claims originally applied for, this difference between group 1 and group 2 was significant at the 0.01 level. Thus, there appears to be a strong relationship between our dependent variable and claim rejection.

Although our initial results indicated that inventors employed by firms performing below aspirations and represented by outsourced legal counsel fail to disclose relevant prior art known to them to a greater extent than others, the effect size was relatively small. An underlying assumption is that inventors have a stake in the performance of their employers and adjust their behavior accordingly. This may depend on the size of the employing firm. All else being equal, the contributions that individual employees make to smaller employers are greater than those made to larger ones (Zenger and Hesterly, 1997). Because of the closer link between employee behavior and firm performance within smaller firms, such firms can strongly tie individual rewards to firm performance (Zenger, 1994). Overall, high powered incentives are easier to maintain in small firms. Thus, the incentive to not disclose known relevant prior art may be greater for inventors in *smaller* underperforming firms where there are tight links between employee behavior, firm performance, and employee rewards.

To test whether results differ by firm size, we split our sample of focal patents into two subsamples based on the median number of employees of the patent owning firm (those less than 19,000 employees vs. those greater). Our small-firm subsample model indicated that moving from 0 to the 75th percentile level of *performance below aspirations* will increase inventors' failure to disclose known prior art by 11 percent when using outsourced legal counsel. In contrast, based on the large-firm subsample model, *performance below aspirations* had no statistically significant influence on whether inventors failed to disclose known relevant prior art, regardless of the type of counsel used. This analysis provides some evidence that our initial results from our full sample were driven by the behavior of inventors from smaller firms where there is a

tighter link between employee behavior and firm performance.

In our analyses, the control variable, average age of prior art at risk, was found to be negatively related to our dependent variable. In other words, the failure to disclose known prior art decreased when the prior art at risk was older. To dig a bit deeper, we created a separate sample where the unit of analysis was the known relevant prior art (i.e., focal inventor's previous patents listed as prior art) nested within each focal patent. We used age of the prior art as our dependent variable and a dummy variable (inventor-added vs. examiner-added) as our independent variable. Using a patent-level fixed effects PQML model, we find that the known relevant prior art disclosed by the inventor was on average 22 percent older than that added by examiners. Inventors appear to be more forthcoming with their older previous patents than more recent ones. One explanation may be that inventors' current patent applications are often extensions of their most recent work. To increase the likelihood of the patent application being deemed novel and patent-worthy, inventors may avoid disclosing their recent patents; those that represent intellectual property particularly close to their current work. Though speculative, this possibility may be worthy of future consideration and research.

We also considered the possibility that co-invented patents may be more difficult for inventors to recall than their solo patents. However, in our sample, 54.5 percent of the known prior art not disclosed by the inventor but added by the examiner were solo patents, 75 percent were either solo or had two authors, and 87 percent had three or fewer authors. Thus, failure to disclose known relevant prior art in our sample does not appear to be driven by inventors' inability to recall patents in which they played a small and insignificant role (e.g., a team of 10 inventors).[15]

Previous research suggests that the overall share of examiner-provided prior art relative to that which is provided by the applicant may vary across broad

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[15] To explore whether inventors are less able to recall their prior patents in which they are part of a larger team, we turned to our sample of known relevant prior art nested within each sample patent. We used the number of inventors of the prior art as our dependent variable and the dummy variable (inventor-added vs. examiner added) as our independent variable. Based on the patent-level fixed effects PQML model, we found no evidence that inventors were more forthcoming with known relevant prior art involving fewer inventors than that added by examiners.

industry sectors (Sampat, 2010). Some sectors such as chemicals and pharmaceuticals tend to rely on discrete technologies where one or a few patents provide strong monopoly rents for product development. In other sectors such as electronics and telecommunications, technologies are more complex and hundreds of patents may be required to commercialize a product. Each patent may be less valuable independently in terms of protecting rents, and are more likely to be used as bargaining chips in cross-licensing or to deter infringement claims from others. Because of their individual importance, perhaps firms and their inventors will be more concerned about bullet-proofing patents associated with discrete technologies by disclosing all relevant prior art available in order to ensure they remain valid in the future (Sampat, 2010). Our primary analyses controlled for broad sector differences through inventor-level fixed effects. When we remove these fixed effects, our viable sample increased to 11,723 patents. For each patent, we computed the share of prior art added by the examiner, yet known by the inventor (i.e., inventor's prior patents) relative to all known prior art at risk of not being disclosed by inventor (i.e., known prior art added by either examiner or applicant). Based on the six NBER patent technology sector categories (Hall *et al.*, 2001), an ANOVA model comparing the average shares across the six categories was significant ($p < 0.001$). We drilled down further to find that the average share of examiner-added prior art known to the inventor for patents in the Computers and Communications sector (complex) was six percentage points higher than for Drugs and Medical (discrete)—a pattern consistent with the notion of the desire to bullet-proof discrete technologies relative to complex technologies. However, we did not find a difference between Drugs and Medical (discrete) vs. Electrical and Electronics (complex). We also found that the average share for Computers and Communications (complex) was five percentage points higher than for Electrical and Electronics (complex). In sum, while there is some evidence for the bullet-proofing of discrete technologies, sector differences in disclosure behavior cannot be attributed solely to the notion of complex vs. simple technologies.

## DISCUSSION

Expansive portfolios of patents can be used by firms to fence off technological space for commercialization, block the commercialization efforts of competitors, or enhance bargaining power in cross-licensing negotiations. Because of their presumed validity, patents do not always have to be truly novel to contribute to these patent strategies, only *judged* to be novel at the time of their examination (Somaya, 2012). Low quality patents lay claim to intellectual property that overlaps the claims made in other patents. By failing to disclose known relevant prior art during the patenting process, inventors and their firms may be granted patents and claims that they would not otherwise be granted, further supplementing their patent portfolios.

We have explored when inventors are more likely to fail to disclose known relevant prior art when pursuing patent protection. We find that such failure tends to increase as inventors acquire experience with the patenting process. Confidence gained through experience creates a tendency to underweight the probability of rare adverse events occurring. Experienced inventors grow complacent and discount the risk of being found to have acted inequitably by not disclosing known relevant prior art. We find that these effects are stronger when outsourced legal counsel is used to facilitate patent applications. As compared to in-house counsel who has closer interaction with the inventors (i.e., fellow employees) residing within their firms, outsourced counsel has less knowledge that is specific to the inventor and applicant firm. As a result, outsourced counsel will be less able to ensure that inventors disclose relevant prior art known to them, allowing inventors greater discretion to act on their biases.

We also found the failure to disclose known relevant prior art to be more prevalent in firms that are performing below their aspirations, and relying on outsourced legal counsel to facilitate patent applications. As performance weakens, the enhanced potential for having a patent granted, broadening patent scope, and increasing economic benefit is valued more highly, and there is greater willingness to risk future patent invalidation by not disclosing relevant prior art. This nondisclosure is borne out when outsourced legal counsel is used. Post hoc analysis suggests that the influence of firms performing below aspirations on nondisclosure is greater in smaller firms where there are tight links

between employee behavior, firm performance, and employee rewards.

Our research efforts align with others who have explored the strategic implications of the patenting process, including patent re-examinations (Clarkson and Toh, 2010) and the speed with which patent protection is obtained (Reitzig and Puranam, 2009). Our work also supplements current efforts which suggest that the strategy used for disclosing prior art may vary across technology sector and firms (e.g., Alcacer *et al.,* 2009; Lampe, 2012; Sampat, 2010). Contrary to their expectation, Alcacer *et al.* (2009) found a positive relationship between the number of patents held by a firm, and the extent to which examiners were left to find relevant prior art (including the firm's own previous patents) in the firm's subsequent patent applications. Although firms that were highly experienced with patenting were expected to have enhanced capabilities for identifying and disclosing relevant prior art, leading to greater disclosure, the opposite was found. They concluded that differences in disclosure due to experience may have less to do with capability and more to do with incentives and motivation. By probing the behavior of individual inventors and legal counsel, the fine-grained analysis we adopt continued where theirs left off. Our work is also in line with the recent efforts of strategy scholars that employ insights from psychology to explore micro-level phenomena with substantial strategic implications for firm performance (e.g., Larkin, Pierce, and Gino, 2012; Markle, 2011).

We provide insight on behavioral risk-taking more generally by showing that the extent to which biases are tempered by monitoring agents such as legal counsel depend on their proximity (in-house vs. outsourced). Without fully understanding the relevant prior art known to the inventor, outside counsel may support low quality patent applications which are subsequently granted.

### Implications, limitations, and future research

Our results suggest that competitors may wish to keep a watchful eye on the patent applications of poorly performing smaller competitors, particularly when outsourced counsel is used. The influence of inventor experience in conjunction with the use of outsourced legal counsel on the failure to disclose relevant prior art was particularly substantial. Tracking patent applications of especially prolific competing inventors may therefore be a worthwhile pursuit.

The addition of prior art is in part a subjective process. Some failure to disclose prior art may be due to differing opinions between inventors and examiners regarding its true relevance. The set of "true" relevant prior art is inherently unobservable. Our dependent variable does not distinguish between prior art undisclosed by inventors due to their attempt to strategically conceal prior art, and that which is undisclosed due to their belief that it is not relevant. When there are greater amounts of known relevant prior art at risk of not being disclosed, subjectivity and differences in opinion may play a greater role in nondisclosure. Although we cannot directly control for the effect of this subjectivity, our post hoc tests affirm a strong strategic motivation behind the nondisclosure of known relevant prior art. We find that inventors tend to disclose their older relevant patents more so than their recent ones which could more severely discredit the novelty of the current application. We also showed that examiner-added prior art was correlated with claim rejections suggesting the cost of full disclosure by the inventor. Furthermore, the pattern of results associated with the interaction between inventor experience and the use of outside legal counsel cannot be accounted for by the subjectivity of the process. If subjectivity is an influential omitted variable, it would need to influence the relationship between inventor experience and nondisclosure differently for when internal counsel is used than when outsourced counsel is used. Although possible, this seems unlikely. Nonetheless, future efforts developing a less noisy measure of the strategic concealment of known relevant prior art would be worthwhile.

Although our design controls for inventor-level fixed effects, which accounts for all time invariant heterogeneity across inventors (and, for all intents and purposes, firms), endogeneity remains a possible limitation, particularly with regard to the use of in-house or outsourced counsel.[16] Relying on

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[16] Because we are employing non-linear modeling, the typical two-stage Heckman correction is not applicable because of its assumptions of normality (Boehmke, Morey, and Shannon, 2006). Hamilton and Nickerson (2003) suggest that when one is unable to find strong instruments, or unable to conduct a two-stage correction model, the best alternative for researchers is to account for as much of the observable differences between observations that exhibit one option over the other (in this case, in-house versus outsourced legal counsel).

outsourced legal counsel for patent filing has been shown to hamper a firm's knowledge of, and defense against, competitor patents (Reitzig and Wagner, 2010). Based on our results, an additional implication of relying on outsourced counsel is that it may lead to lower quality, yet higher levels of patenting. One motivation for employing outsourced legal counsel could be to exploit their lack of familiarity (i.e., strategic ignorance) with prior art known to the inventors (relative to in-house counsel), thereby maximizing patent rates and scope. Firms also favor outside legal counsel to process patents that may be subject to litigation (Mayer, Somaya, and Williamson, 2012). Additional research exploring the role of legal counsel, and the strategic motivations in play would be valuable.

Knowing when inventors are less forthcoming about known relevant prior art has implications for public policy as well. Granting patents whose novelty has been incorrectly assessed can lead to wasteful litigation (Allison and Lemley, 1998), a proliferation of patenting for the sole purpose of deterring litigation (Hall and Ziedonis, 2001), and reduced overall investment in R&D (Cockburn and MacGarvie, 2006). If inventors and their firms are granted levels of exclusivity beyond what is warranted, competing firms may be deterred from devising socially beneficial inventions. As Robert Stoll (2013), former USPTO commissioner for patents, notes, "It is the improvidently granted patent that is causing the bulk of our problems, not just in emerging technologies, but in all areas. Those patents that are not well searched and those claims that mask the true invention with vague language and overly broad scope are the biggest threat to our system." Our results suggest that examiners may want to dedicate more time to patent applications from highly experienced inventors and those from poorly performing firms, particularly when they are represented by outsourced legal counsel.

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