EXAMINING PATENT EXAMINATION: AN ANALYSIS OF EXAMINER AND APPLICANT GENERATED PRIOR ART[*]

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1. Introduction

In an 1813 letter discussing the originality of Oliver Evans' patent on "Elevators, Conveyers, and Hopper-boys" in light of previously known inventions and ideas[1], Thomas Jefferson, the first Commissioner of the U.S. Patent System and the nation's first patent examiner, pointed to the "the difficulty of drawing a line between the things which are worth to the public the embarrassment of an exclusive patent, and those which are not" (Lipscomb 1904, 355).

Though in the years immediately following Jefferson's tenure the patent office operated primarily as a registration system (Walterscheid, 1998), today patent examiners draw the line between what is and is not patentable by comparing applications to related information already in the public domain, or the "prior art." And there is growing concern that difficulties examiners face obtaining access to the relevant prior art are contributing to the issuance of patents of questionable validity. These concerns about diminished patent "quality" have prompted a range of calls for patent system reform (Cohen et al. 2003; FTC 2003).[2]

While central to contemporary debates about patent quality and patent system reform, issues relating to the identification of prior art have received little empirical attention from economists. In large part, this is because scholars have lacked useful data

[1] The prior references he discussed included Mortimer's *Husbandry*, Perrault's *Vitruvius*, Bossuet's *Historie de Mathematiques*, Wolf's *Cours de Mathematiques*, and Desagulier's *Experimental Philosophy,* among others.

[2] Indeed Jefferson himself anticipated some of these concerns, once writing that "the abuse of the frivolous patents is likely to cause more inconvenience than is countervailed by those really useful" (Letter to Thomas Cooper, in Lipscomb 1904).

on the identification of prior art, or the role of patent examiners and applicants in generating prior art against which patents are evaluated.

In this paper, I attempt to shed light on the prior art disclosure and search processes using a novel dataset of examiner and applicant inserted references to the prior art in the 502,687 utility patents issued between January 1, 2001 and December 31, 2003 to. In particular, I use these data to examine field-, applicant-, examiner-, and invention-specific factors influencing the identification of prior art.

The remainder of the paper is organized as follows. Part 2 provides an overview of the prior art search, discusses its centrality to contemporary debates about patent quality and patent system reform, and lays out the unresolved empirical issues in those debates. Part 3 describes the data used in this analysis, uses these data to assess whether patent examiners have differential (relative) access to different types of prior art, and explores differences across technological fields. Part 4 investigates how a range of applicant and examiner specific variables affect the distribution of prior art used to evaluate patentability. Part 5 examines whether patent examiners are disadvantaged in emerging technological fields, focusing on nanotechnology. Part 6 tests the effects of invention specific variables, including the "importance" of an invention, on the prior art search. Finally, Part 7 concludes.

2. The Prior Art Search and Patent Quality

In order to be patentable, a patent eligible invention must be shown to be both novel and non-obvious. Under the novelty bar, an invention cannot be patented if it

previously was known or used. Under the non-obviousness bar, an invention cannot be patented if "the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter pertains" (35 USC § 103a).

In order to assess whether an invention disclosed in a patent application satisfies these requirements, a patent examiner compares a claimed invention to the prior art, or "knowledge that is available, including what would be obvious from it, at given time, to a person of ordinary skill in the art" (Rosenberg 2000). Like the patent system itself, the novelty and non-obviousness requirements were designed with a utilitarian purpose in mind, to ensure that society only incurs the social costs of patents for inventions that are significant departures from what is already in the public domain (Barton 2001; Walterschneid 1998).

In particular, the examiner compares the claimed invention to prior art embodied in references to patents and printed publications. If the patent examiner deems that an invention is novel and non-obvious (and satisfies various other criteria for patentability), a patent is granted. Since 1947, the Patent Office has listed the prior art references against which the patentability of an invention was judged on the front-page of issued patents.[3]

Though examiners are officially responsible for constructing the list of prior art references against which patentability is judged, they rely in part on applicant disclosure

[3] Printing of prior art references on the actual patent followed from a Patent Office Order issued on December 19, 1946. The first patent to include prior art references was issued on February 4, 1947, and all patents since that date include a "references" section. This is not to say that claimed inventions were not evaluated against the prior art before this date: prior art searching became common practice with the passage of the Patent Act of 1836. Prior to 1947, however, the prior art against which the claimed invention was evaluated was available only from the "file history" of the issued patent, stored at the Patent Office.

of the prior art submitted with the patent application, on Information Disclosure Statements. In the United States, applicants (and their attorneys) have a "duty of candor" to disclose any prior art "material to patentability" of an invention, i.e. any prior patent or publication for which there is "a substantial likelihood that a reasonable examiner would consider it important in deciding whether to allow the application to issue as a patent" (USPTO 1998, Section 2242). If an applicant knowingly fails to disclose material prior art, an accused infringer can raise an "inequitable conduct" defense in court, and if the court agrees the patent will be rendered enforceable. Even absent inequitable conduct, some or all of the claims of a patent can be rendered invalid in post-issuance lawsuits or re-examination, if it is subsequently shown that prior art material to patentability was not considered by the patent examiner (Allison and Lemley 1998).

In this context, one may believe that complete revelation by patent applicants is incentive compatible, i.e. that patentees have incentives to disclose all known relevant prior art. On the other hand, a number of legal scholars persuasively argue that as a result of various rulings by the Court of Appeals for the Federal Circuit (CAFC) and decisions by the USPTO, the level of proof required to make determinations of inequitable conduct is sufficiently high to render it moot (Kesan 2002; Merges 1999). Moreover, re-examination proceedings are extremely rare (Graham et al. 2002), and the costs to competitors to invalidate issued patents can be high. In this setting, according to Kesan (2002), "[p]rivate information regarding the relevant prior art is often not adequately disclosed because there is no significant incentives for the patentee to do so" (9).

However, Thomas (2001) suggests that the threat of inequitable conduct may in fact have another effect, creating disincentives for applicants to search for relevant prior

art. In other words, applicants may be wary of discovering new information material to patentability, for fear that (intentional or inadvertent) failure to disclose references which are later deemed relevant may result in a charge of inequitable conduct.

There is surprisingly little empirical evidence on the extent to which patent applicants themselves conduct prior art searches, or the applicant, field, or invention specific effects that may affect prior art search or disclosure by applicants (USPTO 1999a, 1999b, 1999c). Some have suggested that firm resources and/or patenting experience may matter, with larger and experienced firms more likely to be able to afford to conduct prior art searches and/or know the relevant prior art (Mossinghoff in USPTO 1999a). However, there may also be diseconomies of scale, i.e. smaller "niche" firms may be more likely to know the universe relevant prior art, even without a formal patent search (Mossinghoff in USPTO 1999a, 22). Still others suggest that prior art searching and disclosure by applicants may be less likely in fields, or for firms, where the "quantity" of issued patents matters more than "quality" (Aharonian in USPTO 1999b).

Notwithstanding disagreement about the extent of prior art disclosure by applicants and the factors affecting it, there is widespread agreement that applicants' disclosures are unlikely to identify the universe of relevant prior art. In recognition of this, patent examiners conduct their own prior art searches, primarily via full-text or bibliographic databases of patent documents and the scientific and technical journal literature (see Cockburn et al. 2003 for an excellent discussion of this process).

If these databases spanned the universe of relevant prior art, and if examiners could search them (and evaluate the results of these searches) without cost, in principle no anticipatory prior art references would be missed. Of course, in a world of limited

resources, the finite corps of patent examiners faces strict time allocation guidelines per application (Thomas, 2001; Cockburn et al. 2002). Indeed, examiner time constraints have tightened in recent years, with growth in patent applications outpacing growth in the number of examiners (Merrill et al. 2004). These time and resource constraints necessarily limit the comprehensiveness of examiners' prior art searches.

Moreover, searching prior art databases is difficult. Many observers believe that these difficulties are most pronounced in searching for non-patent prior art. For example, Thomas (2001) argues that "[i]n comparison to much of the secondary literature [non-patent art], patents are readily accessible conveniently classified, and printed in a common format. Identification of a promising secondary reference, and full comprehension of its contents, often prove to be more difficult tasks" (318).

New technological fields (or old fields that are newly patent eligible, like software) may present their own challenges. Former USPTO Commissioner Dickinson recently suggested that "rapid progress in emerging technologies continues to challenge the USPTO's ability to access the most current information that demonstrates the state of that art" (USPTO 1999a, 3). One reason for this is that much of the prior art in such fields tends to be in the non-patent literature, which, as suggested above, tends to be more difficult to search (Merges 1999). Indeed, the USPTO may not even have access to the relevant non-patent databases in some new fields. Compounding this, anecdotal evidence suggests that there are learning curves in patent searching, and patent examiners may simply lack the experience to inexperienced to conduct proper searches in new fields (Thomas 2001, Jenckes in USPTO 1999a).

Several commentators have pointed to the difficulty the Patent Office faces in recruiting and retaining examiners in new technological areas (Popp and Johnson 2001; Thomas 2001). More generally, a high rate of examiner attrition (Bawa 2004) may limit any benefits realized from "learning by doing" in prior art searching. Thus Jennings (in USPTO 1999a, 34) suggests that "turnover of patent examiners" may diminish the quality of prior art searching at the USPTO, since "they leave before they gain real experience and knowledge of the pertinent art."

There is growing concern that these various constraints on effective prior art searching are increasingly binding, and that the USPTO is issuing more and more "low quality" patents, i.e. patents that would not have been issued had the examiner considered the entire universe of relevant prior art.[4] Issuance of such patents can impose a range of social costs, including, inter alia, standard deadweight losses from monopoly pricing, encouragement of predatory and/or rent-seeking behavior, and, in the context of cumulative invention, taxes on subsequent innovators (cf. Lemley 2001). In response to these concerns, a number of reforms to the US Patent System have been proposed by groups as diverse as the National Academy of Sciences (Merrill et al. 2004) and the Federal Trade Commission (2003).

Though prior art search and disclosure are central to current discussions of patent system reform, there is remarkably little systematic empirical evidence on the efficiency and effectiveness of prior art searching at the USPTO, or on applicants' searching or disclosure activities. As a 1999 *Federal Register* "Notice of Public Hearing and Request for Comments on Issues Related to the Identification of Prior Art During the Examination

[4] See Hall and Harhoff (2004) for a useful discussion of definitional issues related to the term "patent quality." My use of the term here is broadly similar to theirs.

of a Patent Application" made clear, a number of the issues discussed above remain open empirical questions, including (1) The extent to which patent applicants contribute prior art used to make the patentability decision; (2) The extent to which applicants search for and/or disclose relevant prior art; (3) Whether examiners face particular difficulties in identifying certain types of prior art; (4) Whether examiners are particularly disadvantaged in emerging technological fields; and (5) The "returns to experience" in prior art searching. In the following sections, I use data on applicant and examiner inserted prior art references in U.S. patents to examine these (and related) issues bearing on current deliberations about whether and how to reform the patent system.

3. Applicant and Examiner Citations: A First Look

3.1 The Dataset: An Overview

Since a January 1, 2001 change in procedure at the USPTO, the front pages of issued U.S. patents have indicated with asterisks all prior art references cited by an examiner during patent prosecution, thus distinguishing them from references taken from applicant Information Disclosure Statements. This USPTO instituted this change in hopes that indications of the sources of citations would "be helpful in compiling statistical data related to prior art submissions so that the USPTO can better consider whether changes are required to the rules governing prior art statements."[5] In part, the change was

[5] http://www.micropat.com/og/ogn20001226/patrefr.html

responsive to concerns that foreign applicants are particularly lax in submitting prior art (personal communication, Karin Tyson, USPTO).[6]

This policy change allows for analysis of the extent to the prior art used by the examiners to make patentability decisions originates from applicants and their attorneys, or from examiners' own prior art searches. Moreover, it facilitates testing of hypotheses about field, applicant, invention, and examiner effects on the identification of prior art used to make patentability decisions.

The main dataset consists of the 502,687 utility patents issued by the USPTO between January 2001 and December 2003, the 6,324,381 references in these patents to earlier U.S. patents, the 1,382,430 references to foreign patents, and the 1,655,166 references to non- patent literature. As Table 3.1 shows, the vast majority of citations in these patents are to previous U.S. patents, a finding which holds both at the citation and patent levels. Perhaps not surprisingly, U.S. patents are the main source of information bearing on the patentability of subsequent U.S. applications.

Table 3.2 shows the basic numbers on examiner and applicant inserted references in these 502, 687 patents. As the first row indicates, patent examiners insert 41% of the citations to previous U.S. patents. At the patent level, the average share of citations to U.S. patents inserted by examiners is 62%.[7] Note that this non-trivial discrepancy

[6] To verify that these citations in fact originated from examiners, I examined the file wrappers for 10 randomly chosen patents. In each case, the "applicant" citations in my dataset were in fact from applicants' Information Disclosure Statements, and the "examiner" citations from patent examiners' Office Actions.

[7] These figures are broadly consistent with results from Jaffe et al. (2000), who surveyed 600 inventors listed on patents in 1993 and asked them (among other things) how they learned about specific inventions cited in their patents. The 166 respondents reported that they learned about 40% of the cited patents only during the patent application process, and were not even aware of 24% of the cited patents until receipt of the Jaffe et al. survey. It is likely that many of these citations were inserted by examiners. Some observers suggest that this fact undermines the recent literature (see e.g. Jaffe and Trajtenberg 2003) using citations as proxies for spillovers or knowledge flows. Thus Gregory Aharonian, editor of the Internet Patent Newsletter and a well-known commentator on the patent system, recently noted that "One of the problems

between the shares at the citation and patent levels suggests that there is significant variation across patents in both the number of citations in patents and the share of citations inserted by examiners, which I explore in more detail below.

At both the citation and the patent levels, examiners account for a much smaller share of references to the non-patent literature and to foreign patents than to U.S. patents. This provides some support for the claim, discussed in Section 2 above, that patent examiners' ability to locate prior art embodied in U.S. patents far exceeds their ability to locate other types of prior art, in particular prior art embodied in the scientific and technical literature. To examine this more systematically, and to control for any technological field effects on type of prior art and examiner citations, I estimated a simple linear probability regression of whether a citation was examiner-inserted on dummy variables indicating the type of prior art cited and citing patent class fixed effects. The regression was estimated over all 9,361,977 citations in the 2001-2003 patents. Table 3.3 shows the results. The left out prior art category is U.S. patents, suggesting that references to foreign patents and to non-patent literature are respectively 27 and 26 percentage points less likely to be inserted by examiners rather than applicants, broadly similar to the unconditional differences in probability reported in Table 3.2.

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with many of these papers is that the economists who write about patent citation analysis have little experience with patent searching, and don't realize how worthless most patent citations are for measuring anything. For example, many of them assume that the citations that appear on the front of the patent were all used and discovered by the inventor. They then use that assumption to measure flows of information between companies and inventors ... What they don't realize is that many citations are found either by the examiner or by professional searches ... so that such citations do not measure anything about information flow or patent importance. And without detailed analysis of many file wrappers, no one knows what percentage of citations are due to inventors, and those due to others" (posting to PIUG-L listserv, April 29, 2001). The extent of bias created by examiner citations depends on whether they are essentially random or systematically related to variables of interest (see e.g. Griliches 1986, Krasker and Pratt 1986). Ultimately, this is an empirical question, explored recently in excellent papers by Thompson (2004) and Alcacer and Gittleman (2004). Note that it is less clear that examiner citations would bias citation-based measures of patent "importance" or "value" (cf. Sampat and Ziedonis 2004 and the references cited therein).

This is also evident in Figure 3.1, which shows the distribution of the share of examiner inserted citations, at the patent level, by types of prior art. The first panel shows that in 38% of all patents issued between 2001 and 2003 (that cite U.S. patents) patent applicants contributed *no* patented prior art used in the patentability decision. Moreover, the distribution is bimodal. In 9% of these patents, *all* citations to U.S. patents came from the applicant's Information Disclosure Statement, rather than from the examiner. The second and third panels of Figure 3.1 show that the distributions of citations to non-patent prior art and foreign patents are also bimodal. Strikingly, in 69% of the patents citing non-patent prior art, *all* citations to non-patent prior art come from applicants; the corresponding figure for patents citing foreign patents is 70%. However, examiners accounts for all of the citations to non-patent prior art in 12% of the patents citing non-patent literature, and all of the citations to foreign patents in 13% of the patents citing foreign patents.

Taken together, these figures support the argument that examiner capabilities for searching U.S. patents far exceed their capabilities for searching other sources. In addition, the shapes of the distributions suggest that at the patent level, the average share of examiner-inserted citations may be a less informative statistic than whether this share is zero or one, which I take into account in the analyses in subsequent sections.

3.2 Differences Across Technological Fields

Distributions of types of citations, and applicant-examiner differences in types of citation, may also vary across technological fields. To examine this, I mapped each of the patents in my sample to one of six broad technological categories, using the concordance

developed and described in Jaffe and Trajtenberg (2002). Tables 3.4 and 3.5 show the basic tabulations.

Table 3.4 shows that the proportion of citations to non-patent prior art is much larger in the biomedical arena (drugs and medical patents) than in other fields, broadly consistent with results from previous survey research suggesting that linkages between academic science and industrial innovation are particularly strong and direct in this field (Cohen et al. 2001, Mansfield 1995).

Table 3.5 shows the distribution of examiner and other citations, by type of prior art, across technological fields. Two facts stand out. First, both at the patent and citation levels, examiners insert a higher share of citations to U.S. patents than other types of prior art across all technological fields. In fact, the examiner share of citations to U.S. patents is at least twice the examiner share of citations to either of the other forms of prior art, in all fields. Second, the share of applicant inserted citations to U.S. patents is significantly higher for chemical and biomedical patents than for patents in other technological fields. This is an intriguing result, especially in light of empirical research suggesting that patents are more important as mechanisms for appropriating returns to R&D in chemicals and pharmaceuticals than in other fields (Levin et al. 1988; Cohen et al. 2002).

These differences across fields are also evident in the share of patents where the examiner inserts 0% or 100% of citations, plotted in Figures 3.2, 3.3, and 3.4 for citations to U.S. patents, non-patent prior art, and foreign patents respectively. Across all fields, the share of patents where examiner citations account for “all or nothing at all” exceeds 40% for citations to U.S. patents, 60% for non-patent references, and 70% for foreign

patents, again illustrating to the bimodal distribution of the share of examiner inserted citations. Figure 3.2 shows that the share of patents where applicants insert all citations to U.S. patents is less than 10% in most technological fields, with the notable exceptions of chemicals and biomedical patents, where the shares are 17% and 27% respectively. In fact, for biomedical patents, the share of patents where applicants account for all citations to prior U.S. patents exceeds the share of patents where examiners account for all such citations, which is not true in another other technological field. By contrast, Figures 3.3 and 3.4 show that for citations to non-patent literature and foreign patents, applicants insert all citations in the vast majority of cases, and there are few notable differences across fields.

As discussed in Section 2, a persistent question in discussions about patent system reform is the extent to which applicants (or their agents) actually conduct their own prior art searches and/or disclose known prior art. Though hardly definitive, one interpretation of these basic findings is that applicants are more likely to search for prior art in fields where patents are more important—the chemical and pharmaceutical industries--since having valid "high quality" patents (i.e. those defensible upon litigation) is more important in such fields. By contrast, in fields where patents primarily are used for purposes other than appropriability (see Hall and Ziedonis 2001, Cohen et al. 2002 for discussions), simply getting a patent may be more important than getting a high quality patent. Similarly, full disclosure of known prior art may be more incentive compatible in fields where patents are important, since the costs of inequitable conduct findings—having a patent declared invalid--are likely higher in such fields.

The fact that these cross field differences are only evident in citations to U.S. patents, and not in other types of citations, casts some doubt on this interpretation. However, the results in Section 3.1 suggest that patent examiners have a comparative advantage (and perhaps absolute advantage) vis-à-vis applicants at identifying prior art embodied in U.S. patents, rather than other types of prior art. This could mean that examiners are more likely to discover relevant prior art that applicants miss (or fail to disclose) when that prior art is embodied in U.S. patents, rather than other sources. From this perspective, cross-field differences in applicant versus examiner inserted citations to U.S. patents provide an even more meaningful signal (of differences in applicants' incentives to search for and/or disclose relevant prior art) than cross-field differences observed in other types of prior art. But this is a complicated question, and warrants further research.

4. Applicant and Examiner Characteristics

4.1 The effects of applicant and examiner characteristics on the share of examiner-inserted references

In addition to field specific characteristics, firm specific and examiner specific characteristics may also affect applicants' incentives to search for and/or disclose relevant prior art, and examiners' incentives and ability to search for relevant prior art. As suggested in Section 2, firm size and/or patenting experience may affect applicants' prior art search and/or disclosure strategies. To examine this, for all patents issued from 2001-2003 which were assigned to a firm, I constructed a variable *ASSIGNEE PATENT*

VOLUME measuring the number of patents issued to that assignee over the previous five years. Limiting the analysis to assigned patents reduced the sample size from 502,687 to 440,473.

Recall from Section 3 that one of the reasons the USPTO began to include indications of examiner citations on issued patents in 2001 was to assess whether foreign applicants were less likely to disclose prior art. In most foreign countries, applicants face no "duty of candor" similar to that in the U.S., and may be less accustomed to submitting relevant prior art. To examine this formally, I constructed a dummy variable for *FOREIGN PATENT ASSIGNEE* for each patent in the sample.

Another unresolved issue is the effect of examiner experience on examiners' prior art searches. Previous research by Cockburn et al. (2002) and Lichtman (2004) suggests that examiner heterogeneity affects patent characteristics, and as discussed in Section 2, many observers believe that keeping experienced examiners is a central issue facing the USPTO today.

Two natural measures of examiner experience are the number of patents issued by the examiner, and examiner tenure, i.e. years on the job. In principle, each can be constructed using examiner data listed on the front-page of issued U.S. patents. One problem with this approach is that the experience and age measures are right-truncated for examiners who were employed by the USPTO before 1976; it is difficult to obtain examiner name data from earlier patents. More important, as Cockburn et al. (2002) point out, patent examiner names are transcribed onto the front-pages of U.S. patents with

considerable error. For example, the name of Ponnathapura N. Achutamurthy, an examiner in Art Unit 1652, appears on the text of patents from 2001-2003 in 20 variants.[8]

To facilitate construction of meaningful examiner experience measures, I hand-matched each of the 6,172 primary patent examiner names in the 2001-2003 data to a "standardized" patent examiner name from the 1999 and 2004 USPTO Employee Directories.[9] I matched these names to corresponding examiner name variants on the 1976-2000 patents by assuming that if a name was misspelled on the later patents, it was misspelled in the same way on the earlier patents, and matched the standardized names to incorrectly spelled variants accordingly.[10] Not surprisingly, the measure of examiner experience based on number of patents was highly correlated with the measure based on years since first patent: the bivariate correlation coefficient is .71, even before controlling for patent class. Accordingly, in the analysis below I included only the tenure variable, *EXAMINER EXPERIENCE IN YEARS*.[11]

Finally, the number of patent examiners on a case may affect examiners' ability (or incentives) to locate relevant prior art. The patent office has a training/mentoring

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[8] Achutamurthy Donnathapu, Achutamurthy P., Achutamurthy Ponnathapau, Achutamurthy Ponnathapu, Achutamurthy Ponnathapua, Achutamurthy Ponnathapuea, Achutamurthy Ponnathapur, Achutamurthy Ponnathapura, Achutamurthy Ponnathaput, Achutamurthy Ponnathupura, Achutamurthy Punnathapu, Achutamurtry Ponnathapu, Achutamurty Ponnathapu, Achuthamurthy Ponnathapu, Achutmurthy Ponnathapu, Achutyamurthy Ponnathapu, Murthy Ponnathapu, Murthy Ponnathapu Achuta, Murthy Ponnathapuachut Murthy, and last but not least, Ponnathapuachuta.

[9] I occasionally relied on patent class to Art Unit concordances to verify the match. I was able to match the primary examiner names for all but 86 of the 502,687 patents issued over this period.

[10] There were 17,333 name variants for primary examiners on the 1976-2000 patents. I also experimented with matching the names using proprietary fuzzy name matching software developed by Language Analysis Systems, Inc. (http://las-inc.com/) which was designed to "meet the challenges posed by large, multi-cultural databases in which both predictable and random name-spelling variations are present in a significant number of records." Jim Basara of Language Analysis Systems generously ran this analysis for me. In practice, these approaches yielded qualitatively similar results, and the reported results are based on the first, more conservative, approach. However, the "fuzzy matching" approach could prove valuable to researchers attempting to "de-dupe" inventor names in the patent data (see e.g. Trajtenberg 2004).

[11] Note that this variable measures the experience of the primary (or senior) examiner.

program whereby "assistant" examiners, those with less than six years of experience on the job, are assigned to work with primary examiners to assist with examination and to learn the trade. Approximately 45% of the patents issued over this period were examined by both a primary and assistant examiner. To estimate the impact of this on the prior art search, I created a *TWO EXAMINERS* dummy variable.

To assess the impact of these variables on applicants' and examiners' roles in generating prior art, I examined three main patent-level dependent variables: *SHARE OF CITATIONS TO U.S. PATENTS INSERTED BY EXAMINER*, (computed only for patents citing U.S. patents), *SHARE OF CITATIONS TO NON-PATENT LITERATURE INSERTED BY EXAMINER* (computed only for patents citing non-patent literature), and *SHARE OF CITATIONS TO FOREIGN PATENTS INSERTED BY EXAMINER* (computed only for patents citing foreign patents). In addition, given the bimodal distribution of these "share" variables, I constructed at two sets of dummy variables for each type of prior art, one set indicating whether each of the shares above is zero (i.e. whether the examiner inserted none of the citations), and one set indicating whether the share is one (i.e. whether the examiner inserted all of the citations).

Table 4.1 shows descriptive statistics for each of the independent and dependent variables. Tables 4.2 to 4.4 show the results of OLS regressions of each of the dependent variables on the independent variables listed above, entered into the models serially. Each of the models also includes a full set of 3-digit patent class fixed effects, so identification of the coefficients comes off of within-class variation. Finally, I allow for flexibility in the functional form of the assignee-experience and examiner-experience variables, breaking them into categorical variables based on quartiles of patenting and years of

experience respectively. In each regression, the dummies for the first quartile in patenting volume and 0-1 years of examining experience are omitted, to avoid perfect multicollinearity.

For each set of dependent variables, I first estimated a model with only the assignee experience and class effects (Columns 1-3), then added examiner experience (Columns 4-6), then the foreign assignee dummy (Columns 7-9) and finally the two examiners dummy (Columns 10-12).

The first set of results, in Table 4.2, show that for citations to U.S. patents and non-patent literature, the coefficients on the assignee experience dummies suggest a U-shaped relationship between patenting volume and the share of examiner inserted citations. Examiners account for a lower share of citations to these types of prior art in patents from assignees in the second quartile of patenting than in patents from the most inexperienced patentees, but a significantly higher share of the citations in patents from assignees in the third and fourth quartiles of cumulative patenting. The magnitude of the difference between the bottom and top quartile of assignees varies slightly across the models, between 1 and 2 percentage points for non-patent prior art, and between 4 and 6 percentage points for citations to U.S. patents. The form of the relationship between assignee experience and share of examiner inserted citations to foreign patents is less stable across the models, but in all cases examiners insert the highest share of citations to foreign patents for the most inexperienced assignees.

The results on examiner experience are almost identical whether or not we include the foreign assignee dummy (compare Models 4-6 to Models 7-9). For citations to U.S. patents, more experienced examiners do insert a greater share of citations, but the

magnitudes of the effects are extremely small. Intriguingly, for citations to the non-patent literature and foreign patents, more experienced examiners actually insert a lower share of citations, suggesting that newer examiners may be better at (or more willing to) search these sources.

The coefficients on the foreign assignee dummies lend credence to the concern that foreign applicants present less (or less relevant) prior art than domestic applicants. For citations to patents and non-patent literature, the examiner share of citations is 21 percentage points and 5 percentage points higher, respectively, for foreign applicants. However (and perhaps not surprising), in each of the models the examiner's share of citations to foreign prior art is lower when the applicant is a foreign firm.

Models 10-12 show the effects of including the dummy variable for two examiners. In all cases, the two examiner teams consist of a primary examiner and a junior examiner, who has typically been at the USPTO less than 6 years (Lichtman 2004). For each type of prior art, adding a junior examiner results in a statistically and qualitatively significant change in the proportion of examiner inserted citations: a 5 percentage point increase for citations to U.S. patents, a 4 percentage point increase for citations to non-patent literature, and a 1 percentage point increase for citations to foreign patents. The reason for this intriguing finding is unclear, and warrants more research. It is plausible that, simply, "two sets of eyes are better than one." On the other hand, the primary-assistant examiner relationship is often described as a mentor-apprentice training

system, and there may be incentives for both mentors and apprentices to be more thorough in the context of this relationship.[12]

Interestingly, inclusion of the two examiners dummy has a downward effect on the coefficients of the examiner experience dummies, and indeed "flips" the coefficient on these variables in all cases where they were positive. One possible explanation for this is that more experienced primary examiners are more likely to be assigned as mentors to junior examiners, i.e. more likely to be part of a team. The data support this: the share of patents with an assistant examiner is 17% for primary examiners with 0-1 years of experience (as primary examiners), 46% for examiners with 4-5 years experience, 49% for examiners with 8-9 years experience, and 58% for examiners with 12-13 years experience. From this point of view, one important "return to experience" for primary patent examiners could be increased likelihood of being assigned to work with a junior examiner on an application, which itself appears to increase the depth of examiners' prior art searches.[13] Notwithstanding whether one accepts this particular interpretation, the evidence of any "learning curve" in prior art searching disappears upon controlling for the number of examiners.

The estimates of how these variables affect the probability that all or none of the citations in a patent are inserted by examiners, in Tables 4.3 and 4.4 respectively, show similar results. Two points stand out, however. First, in the full model (Columns 10-12) the probability that examiners inserted all citations to U.S. patents for is 5.4 percentage points greater for the most experienced assignees than the least experienced assignees.

[12] Douglas Lichtman (2004) also finds differences in the characteristics of patents issued by "teams" of examiners and those examined by primary examiners alone. We are currently collaborating on a project exploring the causes and consequences of these differences in detail.
[13] That is to say, teaching and search may be complementary.

Second, experienced examiners are much less likely to insert all citations to non-patent literature, and much more likely to issue patents where the applicant accounts for all citations to the non-patent literature. Finally, having two examiners significantly increases the probability that examiners insert all citations in a patent, and significantly decreases the probably that they insert none, a result which holds for all types of prior art citations.

Taken together, the results from these analyses provide fairly consistent evidence that the most experienced applicants are least likely to search for and/or disclose relevant prior art, that foreign applicants disclose less prior art than domestic applicants, and that "teams" of primary/junior examiners conduct more thorough searches than individual primary examiners alone. There is limited evidence of any direct "returns to experience" in prior art searching (cf. Cockburn et al. 2002). Indeed, more experienced examiners appear to have a disadvantage at searching non-patent prior art.

These results must be interpreted with caution, since a number of omitted invention-specific variables may be confounding the results. Accordingly, in Section 6 below, I run similar analyses including a number of invention-level controls.

4.2 "Self" Citations

Previous research (Jaffe and Trajtenberg 2002; Cockburn et al 2002) suggests that "self" citations at the firm level (an assignee citing its own earlier patents) and at the examiner level (examiners citing patents they previously issued) may have unique properties different from the broader universe of patent-patent citations. In this section, I explore the extent to which these self-citations are inserted by applicants and examiners.

Table 4.5 tabulates the share of assignee-assignee self citations and examiner-examiner self citations in patents issued between 2001 and 2003.[14] The final row shows that 6% of the citations in these patents are to patents previously examined by the same examiner, and 11% to the assignee's own patents. Though these shares undoubtedly reflect technological field effects, they also suggest that a significant portion of the patented prior art used to evaluate patentability is based on information that is "local" to either assignees or examiners.[15]

Column 1 shows that examiners account for 55% of all examiner-examiner self citations, and applicants 45%. Citations to an examiner's previous patents account for 8% of all examiner inserted citations, and 4% of all applicant inserted citations.

More surprisingly, Column 2 indicates that citations to an assignee's earlier patents represent the same proportion (11%) of all examiner citations as applicant citations. Indeed, examiners are as likely to be responsible for a self-citation as they are other citations, accounting for 41% of each.

The fact that examiners insert a significant share of self-citations provides prima facie evidence that a significant share of applicants do not search for, or fail to disclose, material prior art. It is plausible that even with an extensive search, applicants may not discover other firms' patents that are related to their inventions. It is less plausible that they are unable to discover their own relevant patents that the examiner later discovers.

Accordingly, the share of assignee-assignee "self" citations inserted by examiners may be a useful indicator of whether applicants' incentives to search for and/or disclose

[14] Note that the total number of patent-patent citations is smaller than that reported in Section 3 above, since I had to drop unassigned citing and cited patents, as well as pre-1976 cited patents for which assignee and applicant information is unavailable.

[15] However, the raw figures mask some double-counting. Approximately 1% of all cited patents have the same assignee and examiner as the citing patent.

prior art vary across fields. Figure 4.1 shows the share of assignee-assignee self-citations inserted by examiners, by broad technological category. Note that the shares are lowest for biomedical and chemical patents, 29% and 32% respectively. This again is consistent with the hypothesis that applicants' incentives to contribute to the issuance of "high quality" patents are greatest in fields where patents are important for appropriating returns to R&D, though here again more systematic work is needed.

5. Is Prior Art Searching More Difficult in Emerging Fields? The Case of Nanotechnology

As discussed in Section 3, some observers have argued that patent examiners are particularly disadvantaged in emerging technological fields. Testing this systematically would require a useful measure of the "newness" of a technological field, which to my knowledge does not exist.[16] Instead, in this section I explore prior art searching in a field which is widely characterized as "new" and "emerging": nanotechnology.

According to a recent *Wall Street Journal* article, nanotechnology inventions include "man-made structures less than 100 nanometers in size" (Regaldo 2004, A1). Growth in nanotechnology patenting has surged over the past half-decade (Huang et al. 2003), presenting particular problems for the USPTO. Bawa (2004) suggests that the lack of nanotechnology related expertise at the Patent Office, the lack of a formal Art Unit or classification system for nanotechnology patents (which would be difficult to establish, given its cross-disciplinary nature), and limited access to relevant prior art databases, all are contributing the issuance of patents which should not have been granted in light of

[16] However, I am exploring the possibility of using information from Classification Orders, which create new USPTO technology classes and re-map old ones, to construct proxies for the age of a patent class.

previous prior art. These sentiments were echoed by the recent testimony before the Senate Commerce Committee by Mark Modzelewski, Executive Director of NanoBusiness Alliance:

> "The Patent Office is in desperate need of training programs to ensure its examiners understand nanotechnology. At USPTO, nanotech patent applications – understandably due to the wide breadth of application areas the technology covers – go down many different review silos at USPTO. Also, several early nanotech patents are given such broad coverage, the industry is potentially in real danger of experiencing unnecessary legal slowdowns" (http://commerce.senate.gov/hearings/testimony.cfm?id=845&wit_id=2323).

In order to assess whether identification of prior art in this new technological field in fact poses particular challenges, in this section I compare applicant and examiner generated prior art in nanotechnology patents and a comparison sample.

Based on the definition in Huang et al. (2003), I define "nanotechnology" patents as all patents with one or more of the following keywords in their claims: *selfassembl*, self assembl*, atomic force microscop*, scanning tunneling microscop*, atomistic simulation*, *biomotor*, *molecular device*, *molecular electronics*, *molecular modeling*, *molecular motor*, *molecular sensor*, *molecular simulation*, *quantum computing*, *quantum dot*, quantum effect*,* and *nano** (excluding *nanosecond* and *nanoliter*). Over the 2001-2003 period, the USPTO granted 3,748 such patents.[17]

[17] This figure is lower than that reported in other studies (e.g. Huang et al. 2003) because I searched only claims, and not the entire patent document, for these keywords. Over the 2001-3 period, the ten largest recipients of nanotechnology patents using this definition were IBM, Micron Technology, Advanced Micro Devices, Xerox, L'Oreal, the University of California, Motorola, Eastman Kodak, General Electric, and 3M, broadly consistent with the top ten lists based on less conservative definitions of "nanotechnology patents."

Strikingly, these nanotechnology patents span 200 primary U.S. patent classes (at the 3-digit level) and 253 primary international patent classes (at the 4-digit level). Moreover, these patents were examined by 794 unique primary patent examiners, approximately one-fourth of the primary patent examiners employed by the USPTO over this period. These facts broadly support Darby and Zucker's (2003) characterization of nanotechnology as a "Grilichesian breakthrough" -- creating technological opportunities across a range of fields. However, they also are consistent with the concern that nanotechnology patents are too broadly distributed across the patent office, possibly to examiners lacking expertise in the field.

To compare prior art searches in nanotechnology with those in other technological fields, I constructed a comparison sample of all patents issued between 2001 and 2003 with the same primary patent examiners as those on the nanotechnology patents, yielding a sample of 285,807 comparison patents.

Table 5.1 shows the distribution of prior art references for the nanotechnology and comparison sample. Note that nanotechnology patents are comparatively less reliant on patented prior art. Slightly less than 30% of the references in nanotechnology patents are to non-patent prior art, almost ten percentage points greater than for other patents. Since nanotechnology is an emerging technological (and indeed, scientific) field, it is not surprising that much of the prior knowledge material to patentability is codified in the journal rather than the patent literature. Data at the patent (rather than citation) level paint a similar portrait: the average share of non-patent references in all references is 21% in nanotechnology patents, compared to 12% for the comparison patents (the difference in means is significant at the 1% level).

Results from previous sections suggested that applicants have better access to the non-patent literature than examiners. Combined with the results in the previous paragraph, this suggests that applicants will account for a larger share of citations for nanotechnology patents than examiners. Indeed, at the citation level, examiners account for 28% of all references in the comparison sample of non-nanotechnology patents, but only 20% of references in the nanotechnology patents. At the patent level, the analogous shares are 49% and 40%.

Perhaps more surprising, these differences hold even after controlling for differences in the composition of prior art cited. Column 1 of Table 5.2 shows results from a linear probability regression of the probability that a citation is examiner inserted, as a function of the type of citation (*FOREIGN or SCIENCE*, with patent-to-patent citations as the reference category), a dummy variable indicating whether the patent is a nanotechnology invention (*NANOTECHNOLOGY*), and patent class fixed effects. The coefficient on the *NANOTECHNOLOGY* dummy implies that even after controlling for the different types of prior art cited in nanotechnology and other patents, any given reference in a nanotechnology patent is approximately 5 percentage points less likely to be inserted by an examiner than in other fields. This provides strong evidence that examiners are less informed (relative to applicants) about the relevant prior art in nanotechnology than in other fields.

To analyze whether this information asymmetry is more pronounced for certain types of prior art, I interacted the *NANOTECHNOLOGY* variable with the variables indicating type of citation. The results, in Column 2, are somewhat surprising. The biggest applicant-examiner difference between nanotechnology and other fields is for

U.S. patents, rather than non-patent prior art or foreign patents.[18] Even in their searches of U.S. patents, where they have the most complete databases and well-developed routines, examiners appear to have a more difficult job in identifying relevant prior art in nanotechnology than in other fields.

One concern may be that nanotechnology inventions may be more likely to be assigned to certain types of patent examiners, and that these results are capturing examiner rather than field differences in citation patterns. To examine this, I added a full set of examiner-specific fixed effects to the models above. With the class and examiner fixed effects, identification of the difference between citation patterns in nanotechnology and other patents is based on variation within classes, within examiners. Estimates from these regressions are reported in Columns 3 and 4, and do not differ markedly from those with class effects alone.

Finally, I estimated analogous regressions at the patent level, regressing the share of prior art references inserted by examiners for different types of prior art on the nanotechnology dummy and class fixed effects (reported in Columns 5, 6, and 7), and examiner fixed effects (reported in Columns 8, 9, and 10), yielding results that are broadly consistent with those from the citation-level regressions discussed above.

Overall, these results provide strong evidence that patent examiners face particular challenges in searching for prior art in nanotechnology, compared to other technological fields. Of course, it is difficult to know the extent to which these findings reflect general characteristics of "new" technological fields, or factors specific to nanotechnology.

[18] In fact, examiners insert a qualitatively small but statistically significant greater proportion of references to foreign patents in nanotechnology than other fields.

6. The Importance of Invention-Specific Characteristics

The analyses in previous sections examined how the share of examiner citations relate to several assignee and examiner characteristics, after controlling for technology class. However, it is possible that the coefficients from these analyses are biased, due to failure to include invention-level characteristics that are correlated with the examiner/applicant variables and affect the share of examiner inserted citations.

Moreover, the impact of invention level characteristics on generation of prior art by applicants and examiners is interesting in its own right. Most advocates of patent system reform concede since the vast majority of issued patents have little social cost, "sorting"--conducting more thorough prior art searches for patent applications with greatest potential social cost, i.e. those which would impinge on many future inventive efforts—would be a first best solution (Lemley 2001, Merges 1999). The official policy of the patent office, however, is that "all applications are created equal," suggesting little conscious allocation of different levels of effort (e.g. in the prior art search) to different applications.[19] However, there is some empirical evidence that more "important" inventions have longer approval times (Popp et al. 2003), though the reasons for this empirical relationship are unclear.[20]

Another possibility is sorting among examiners. Obviously, giving more complicated or more important inventions to certain types of examiners (or teams of examiners) could bias the effects of the examiner variables in the earlier analyses.

[19] See Iain Cockburn's presentation at the 2001 NAS conference on the operation of the patent system: http://www7.nationalacademies.org/step/transcript1022_PDF.pdf

[20] There are interesting parallels between this literature and the literature on whether more "important" drugs are approved more quickly by the FDA, e.g. Dranove and Meltzer (1994).

However as Lichtman (2004) points out, the feasibility of such sorting is unclear, since "at first blush, it is not so easy to predict which applications will prove difficult and which straightforward" (168).

It also is possible that applicants' incentives are shaped by invention specific characteristics. Above, I suggested that applicants may face stronger incentives for prior art searching and/or disclosure in fields where patents are relatively more important. It is also possible that within fields, applicants have stronger search and/or disclosure incentives for more technologically or commercially important inventions.

To investigate these hypotheses, for each of the 24,522 (assigned) utility patents issued in January 2001 and February 2001, I constructed a variable *IMPORTANCE*, measuring the number of "forward" citations these citations received between their issue dates and February 2004. Previous research suggests that forward citation counts are useful proxies for the value of patents (see Jaffe and Trajtenberg 2002; Lanjouw and Schankerman 1998; Harhoff et al. 1999; Sampat and Ziedonis 2004).

One concern in the present context is that the window of forward citations is short, 3 years from date of issue, and "truncation bias" could affect results (cf. Sampat et al. 2003).[21] Accordingly, I also defined a "time zero" measure of value, *FAMILY SIZE*, a count of the number of countries in which applicants filed patent applications on an invention. Several scholars (Lanjouw et al. 1998, Putnam 1996) have argued that family size is a useful indicator of the quality of an invention.[22]

[21] However, Lanjouw and Schankerman (1999) suggest that even early citations (which they define as citations occurring within 5 years of application date) provide an informative signal of patent value.

[22] Lanjouw and Schankerman (1999) note that "International agreements give inventors at most two and a half years to file all worldwide applications, so family size is established early," i.e. it is unlikely to be right-censored.

However, family size may also pick up the effects on citations of having a foreign patent office examine an invention. In cases where applications are field in multiple countries, examiners may "piggyback" on foreign search reports (prepared either by the patent offices or professional search firms). To control for this, and to assess the impact of foreign search reports on applicant and examiner generated prior art, I created a dummy variable *U.S. PRIORITY* indicating if the first application was filed in the United States. The likelihood that examiners are drawing on foreign search reports is lower in cases where the U.S. is the priority country, since foreign searches take time to complete and reports may not be available in time to be useful to U.S. examiners.

To examine the effects of these variables on applicant and examiner inserted references to U.S. patents and non-patent prior art, I estimated regressions similar to those in Section 4 above, adding these additional variables. Table 6.1 shows basic descriptive statistics for each of the variables used in the analyses. Tables 6.2 to 6.4 show results from these regressions.

Table 6.2 shows that the importance measure based on forward citations has a negative and statistically significant effect on the share of examiner inserted citations for both references to patent and non-patent prior art. In the full model (Columns 13-14), a one standard deviation increase in the number of citations a patent receives leads to approximately a 1.7 percentage point decrease in the share of examiner inserted citations to U.S. patents, and slightly less than a 1 percentage point reduction in the share of examiner inserted citations to non-patent literature. These results suggest that examiners are responsible for a slightly lower share of prior art for more "important" patents, a

finding which is also seen in the "all or nothing at all" regressions reported in Tables 6.3 and 6.4.

However, it is difficult to determine whether importance is acting via affects on applicant or examiners. (As the discussion above suggests, either are conceptually plausible.) Accordingly, I estimated separate regressions of (1) the *number* of references inserted by applicants, and (2) the *number* of references inserted by examiners on class dummies and *IMPORTANCE*, for references to both U.S. patents and non-patent prior art. Table 6.5 shows the results from these simple regressions. Both applicants and examiners cite more prior art for more important inventions, but the magnitude of the effect is between 6 and 10 times larger for applicants than examiners, depending on the specification and the type of prior art. These results suggest that the overall effect on of importance in the analyses reported in Tables 6.2-6.4 is working primarily via effects on applicants' behaviors, providing some evidence that more thorough searching and/or disclosure by applicants is more incentive compatible in the case of more important inventions.

In each of the models, the patent family size variable also has a negative effect on the share of examiner inserted citations. In the full model, increasing this variable by one standard deviation decreases the examiner share of citations to U.S. prior art by about 5 percentage points, and the share of citations to non-patent prior art by about 2 percentage points. All else equal, examiners account for fewer citations in cases where patent families are larger. The linear probability regressions in Tables 6.3 and 6.4 show similar results. This again provides some evidence that applicants are responsible for relatively more prior art for more "important" inventions.

The effects of the *US PRIORITY* dummy are striking. Conditional on family size, importance, and class effects, patent examiners account for a significantly lower share of citations in cases where the U.S. application was filed first. Conversely, they are much more likely to insert citations in patents with foreign priority. This provides some evidence that examiners rely upon information from foreign search reports, in cases where foreign applications are filed before the U.S. application.

However, upon inclusion of the foreign assignee dummy, the magnitude of this effect drops considerably. Foreign assignees are more likely to have filed earlier applications abroad (typically their home countries). And, as we have seen above, examiners are more likely to insert citations for foreign applicants. Omitting the foreign applicant control thus leads to negative bias in the estimated coefficient on *USPRIORITY*. Nonetheless, even after controlling for whether the applicant is a foreign or domestic assignee, examiners insert an 11 percentage point greater share of citations to earlier patents in cases where the priority country is not the U.S. In other words, examiners insert a higher share of citations for both foreign and domestic applicants who file outside of the U.S. first, even after controlling for the importance of an invention, patent family size, and detailed technology class effects. (Note also that the coefficient on the foreign assignee dummy remains statistically and qualitatively significant, even after including the priority country control.)

Inclusion of a battery of invention level variables had only modest effects on the results relating to assignee and examiner experience reported in Section 4. The effects of assignee experience on citations to U.S. prior art remain roughly similar, though the effects on citations to non-patent prior art become statistically insignificant. There is little

strong evidence of "returns to experience" in these models. Indeed, upon conditioning on invention-level characteristics, the negative impact of examiner experience on the probability that an examiner will insert no citations to non-patent prior art becomes more pronounced. Finally, even after inclusion of the invention-level controls, junior-primary examiner teams include a higher share of citations to prior art, are more likely to insert all the references in a patent, and less likely to insert none of the references. These results are statistically and practically significant, and hold for citations to both patent and non-patent prior art.

7. Conclusions

Despite their general aversion towards monopolies, in Article I, Section 8 of the U.S. Constitution the framers sanctioned the creation of a patent system in order to "Promote the Progress of Science and the Useful Arts." Today, there is widespread recognition that the extent to which the patent system performs achieves this lofty goal is directly proportional to the ability of the USPTO to evaluate patent applications against the prior art. Despite the centrality of issues relating to the identification of prior art in contemporary discussions of patent quality and patent system reform, these issues have been subject to limited empirical scrutiny by economists (Cockburn et al. 2002 and Graham et al. 2002 are two notable exceptions). In this paper, I explored factors affecting the identification of prior art using a novel dataset of applicant and examiners citations.

The results from the analyses above show strong evidence that patent examiners' capabilities for identifying prior art in U.S. patents far exceeds their capabilities for searching non-patent prior art or foreign patents. This suggests that, all else equal, the

quality of prior art identification, and the consequently the quality of issued patents, is likely to be worse in fields where a substantial portion of the relevant prior art is embodied in sources other than U.S. patents, including the scientific and technical literature. Moreover, I found some evidence that patent examiners face particular challenges in identifying prior art in emerging technological fields, based on a case study of nanotechnology. One implication of these findings is that, paradoxically, the quality of issued patents is likely to be worst in industries near the scientific and technological frontier, arguably those where the costs of low-quality patents are greatest.

I found more suggestive evidence that applicants themselves are more likely to contribute to the identification of relevant prior art in fields where patents are particularly important for appropriating returns to R&D, and that within fields applicants are more likely to search for and/or disclose prior art for more important inventions. Though preliminary, these findings do suggest that applicants do respond to incentives, which could point to possible mechanisms to compel more widespread contribution by applicants to the identification of relevant prior art.

Overall, the results on applicant experience are mixed. However, I found consistent evidence that examiners inserted a higher share of citations for firms in the far right tail of the distribution, those with the highest levels of cumulative patenting over the previous 5 years. The reasons for this are unclear, and warrant further research.

Despite widespread claims about the importance of examiner experience, I found little consistent evidence that experience contributes to examiners' share of citations, and even where it did the impact was small. Indeed, more experienced examiners tend to insert a lower share of citations non-patent prior art, a finding which is consistent across

models. Though intriguing, it is important to emphasize that I have no direct information on the quality of the prior art being identified (or not), or the quality of the resulting patents. In related research, I am exploring the impact of examiner experience on patent re-examination, and outcomes conditional on re-examination. Despite the fact that it is rare (Graham et al 2002), re-examination provides a useful lens on factors affecting the identification of prior art, since the primary catalyst for re-examination is prior art not considered during patent prosecution.

On the other hand, teams of junior-senior examiners do appear to identify larger shares of prior art, a result which is robust across all types of prior art. This phenomenon is almost certainly unintentional, and the mechanisms underlying it unclear. As suggested above, it could reflect dynamics of the apprentice-mentor relationship. Alternatively, it could simply reflect the fact that increasing examiner resources allocated to a given patent increases the comprehensiveness of the prior art search. This issue is highly relevant to the USPTO today, as it considers extending the "two sets of eyes" review of business method patents (Class 705) to other classes.[23]

Finally, the results on foreign applicants, and on applications with foreign priority, are intriguing. First, foreigners are much less likely to contribute prior art than domestic assignees. If this is a problem it is a non-trivial one, since foreign applicants account for nearly half of the applications handled by the USPTO. On the other hand, and independent of this effect, examiners are much more likely to insert prior art for applications previously vetted by a foreign patent office, suggesting that may be relying on prior art listed in foreign search reports. To the extent that this is true, it undercuts one the most common objection to the Patent Office's plan to "outsource" the prior art search

[23] http://www.uspto.gov/web/offices/com/strat21/action/q3p17a.htm

to specialized firms (USPTO 2003), that the search and examination duties of patent examiners cannot be decoupled.

While these findings provide empirical grounding for a number of important issues in current deliberations about reforming the patent system, they raise as many questions, and perhaps more, than they answer. As usual, much remains for future research.

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Table 3.1: Prior Art References in 2001-2003 Patents

	Share of All Citations in Patents, at Citation Level	Mean Number of References, At Patent Level
US Patents	67%	12.58
Non-Patent Literature	18%	3.29
Foreign Patents	15%	2.75

Table 3.2 : Examiner Inserted Citations in 2001-2003 Patents By Type of Prior Art

	Share of Citations Inserted By Examiner	Share Inserted By Examiners, Average Across Patents
US Patents	41%	62%
Non-Patent Literature	10%	17%
Foreign Patents	12%	21%

Data based on 502,687 Patents Issued from 1/1/01 to 12/31/03, and the 9,361,977 references in these patents

Table 3.3: Probability A Reference Is Inserted By Examiner, By Type of Prior Art

	Examiner Citation: (Yes=1)
Citation to Foreign Patent	-.267***
	[.000]
Citation to Non-Patent Literature	-.259***
	[.000]
Constant	.401***
	[.000]
Class Effects	Yes
	Sig.
Observations	9361977
R-squared	0.1397

Notes:

Robust standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3.4: Distribution of Prior Art Citations, By Field

	Chemical	Computers	Drugs and Medical	Electric and Electronic	Mechanical	Other	Total
Citations to U.S. Patents	839,663	1230755	844,863	1123372	1044873	1240855	6324381
(*Column Percenatage)*	*59.68*	*72.04*	*46.01*	*74.38*	*77.89*	*79.61*	*67.55*
Citations to Non-Patent Literature	290,110	276,795	719,524	166,531	79,500	122,706	1655166
(*Column Percenatage)*	*20.62*	*16.2*	*39.19*	*11.03*	*5.93*	*7.87*	*17.68*
Citations to Foreign Patents	277,212	200,808	271,686	220,406	217,159	195,159	1382430
(*Column Percenatage)*	*19.7*	*11.8*	*14.8*	*14.6*	*16.2*	*12.5*	*14.8*
All Citations	1406985	1708358	1836073	1510309	1341532	1558720	9361977

Table 3.3: Probability A Reference Is Inserted By Examiner, By Type of Prior Art

	Examiner Citation: (Yes=1)
Citation to Foreign Patent	-.267***
	[.000]
Citation to Non-Patent Literature	-.259***
	[.000]
Constant	.401***
	[.000]
Class Effects	Yes
	Sig.
Observations	9361977
R-squared	0.1397

Notes:

Robust standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3.5: Examiner Inserted Citations, By Type of Prior Art and Field

Type of Citation	Chemical	Computers and Comm.	Drugs and Medical	Electric and Electronic	Mechanical	Other
Citations to U.S. Patents						
Share of Examiner Citations (Citation Level)	32.64%	46.28%	20.77%	46.58%	48.70%	45.57%
Share Inserted by Examiner (Average Across Patents)	51.35%	69.32%	40.93%	68.47%	67.03%	64.24%
Citation to Non-Patent Literature						
Share of Examiner Citations (Citation Level)	10.20%	13.12%	8.47%	7.59%	8.18%	15.38%
Share Inserted by Examiner (Average Across Patents)	18.71%	21.44%	17.70%	13.65%	13.71%	15.79%
Citation to Foreign Patents						
Share of Examiner Citations (Citation Level)	10.84%	9.59%	5.85%	12.81%	19.66%	17.55%
Share Inserted by Examiner (Average Across Patents)	18.88%	16.14%	13.13%	20.40%	28.25%	29.82%

Table 4.1: Descriptive Statistics: Patents Issued from 2001-2003

Variable	Obs	Mean	Std. Dev.	Min	Max
Assignee Patent Volume, Previous 5 Years	440473	1451.699	2781.17	0	14998
Examiner Experience, Number of Years	440473	9.059715	7.15299	0	27
Foreign Assignee (1=Yes)	440473	0.4857278	0.4997968	0	1
Two Patent Examiners (1=Yes)	440473	0.4663668	0.4988681	0	1
Share of Examiner Inserted Citations, for Citations to U.S. Patents	433800	0.6181277	0.3773138	0	1
Share of Examiner Inserted Citations, for Citations to Non-Patent Literature	170898	0.1779558	0.3414054	0	1
Share of Examiner Inserted Citations, for Citations to Foreign Patents	248828	0.191163	0.3525581	0	1
Examiner Share of Citations to U.S. Patents=100% (1=Yes)	433800	0.3774003	0.4847369	0	1
Examiner Share of Citations to Non-Patent Literature=100% (1=Yes)	170898	0.1206158	0.3256812	0	1
Examiner Share of Citations to Foreign Patents=100% (1=Yes)	248828	0.1348683	0.3415835	0	1
Examiner Share of Citations to U.S. Patents=0% (1=Yes)	433800	0.0884897	0.2840061	0	1
Examiner Share of Citations to Non-Patent Literature=0% (1=Yes)	170898	0.6918688	0.4617224	0	1
Examiner Share of Citations to Foreign Patents=0% (1=Yes)	248828	0.7013961	0.4576466	0	1

Table 4.2	Dependent Variable: Share of Examiner Inserted Citations in Patent, By Type of Prior Art Cited											
	1	2	3	4	5	6	7	8	9	10	11	12
	US Patents	Non Patent Lit.	Foreign Patents	US Patents	Non Patent Lit.	Foreign Patents	US Patents	Non Patent Lit.	Foreign Patents	US Patents	Non Patent Lit.	Foreign Patents
Assignee Patent Volume, Second Quartile	-0.013***	-0.005*	-0.026***	-0.013***	-0.005*	-0.026***	-0.019***	-0.005**	-0.025***	-0.018***	-0.004	-0.025***
	[0.002]	[0.003]	[0.002]	[0.002]	[0.003]	[0.002]	[0.002]	[0.003]	[0.002]	[0.002]	[0.003]	[0.002]
Assignee Patent Volume, Third Quartile	0.026***	0.001	-0.013***	0.026***	0.001	-0.013***	0.020***	0.002	-0.013***	0.020***	0.002	-0.013***
	[0.001]	[0.002]	[0.002]	[0.001]	[0.002]	[0.002]	[0.001]	[0.002]	[0.002]	[0.001]	[0.002]	[0.002]
Assignee Patent Volume, Top Quartile	0.061***	0.019***	-0.022***	0.061***	0.019***	-0.022***	0.041***	0.014***	-0.014***	0.041***	0.014***	-0.014***
	[0.001]	[0.002]	[0.002]	[0.001]	[0.002]	[0.002]	[0.001]	[0.002]	[0.002]	[0.001]	[0.002]	[0.002]
Examiner Experience, 2-3 Years				-0.004	-0.015***	-0.020***	-0.004*	-0.015***	-0.019***	-0.015***	-0.023***	-0.022***
				[0.002]	[0.004]	[0.003]	[0.002]	[0.003]	[0.003]	[0.002]	[0.004]	[0.003]
Examiner Experience, 4-5 Years				0	-0.020***	-0.015***	-0.002	-0.020***	-0.014***	-0.020***	-0.033***	-0.019***
				[0.002]	[0.003]	[0.003]	[0.002]	[0.003]	[0.003]	[0.002]	[0.004]	[0.003]
Examiner Experience, 6-7 Years				0.007***	-0.021***	-0.012***	0.004*	-0.021***	-0.011***	-0.017***	-0.038***	-0.016***
				[0.002]	[0.003]	[0.003]	[0.002]	[0.003]	[0.003]	[0.002]	[0.003]	[0.003]
Examiner Experience, 8-9 Years				0.012***	-0.017***	-0.005	0.009***	-0.017***	-0.004	-0.011***	-0.033***	-0.009***
				[0.003]	[0.004]	[0.003]	[0.002]	[0.004]	[0.003]	[0.003]	[0.004]	[0.003]
Examiner Experience, 10-11 Years				0.011***	-0.002	-0.006	0.009***	-0.003	-0.005	-0.014***	-0.019***	-0.011***
				[0.003]	[0.004]	[0.004]	[0.003]	[0.004]	[0.004]	[0.003]	[0.004]	[0.004]
Examiner Experience, 12-13 Years				0.014***	-0.009**	-0.007*	0.012***	-0.009**	-0.006	-0.015***	-0.030***	-0.012***
				[0.003]	[0.004]	[0.004]	[0.003]	[0.004]	[0.004]	[0.003]	[0.005]	[0.004]
Examiner Experience, 14+ Years				0.007***	-0.014***	-0.021***	0.004*	-0.014***	-0.020***	-0.021***	-0.034***	-0.026***
				[0.002]	[0.003]	[0.003]	[0.002]	[0.003]	[0.003]	[0.002]	[0.004]	[0.003]
Foreign Assignee							0.209***	0.050***	-0.060***	0.209***	0.049***	-0.061***
							[0.001]	[0.002]	[0.002]	[0.001]	[0.002]	[0.002]
Two Examiners										0.054***	0.041***	0.014***
										[0.001]	[0.002]	[0.002]
Constant	0.598***	0.174***	0.203***	0.593***	0.188***	0.216***	0.501***	0.170***	0.249***	0.495***	0.165***	0.248***
	[0.001]	[0.001]	[0.001]	[0.002]	[0.003]	[0.003]	[0.002]	[0.003]	[0.003]	[0.002]	[0.003]	[0.003]
Class Effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Observations	433800	170898	248827	433800	170898	248827	433800	170898	248827	433800	170898	248827
R-squared	0.11	0.08	0.07	0.11	0.08	0.07	0.18	0.09	0.08	0.19	0.09	0.08

Notes:

Robust standard errors in brackets

All models include patent class fixed effects

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4.3	Dependent Variable: Did Examiner Insert *All* Citations in Patent? (Yes=1) By Type of Prior Art											
	1	2	3	4	5	6	7	8	9	10	11	12
	US Patents	Non Patent Lit.	Foreign Patents	US Patents	Non Patent Lit.	Foreign Patents	US Patents	Non Patent Lit.	Foreign Patents	US Patents	Non Patent Lit.	Foreign Patents
Assignee Patent Volume, Second Quartile	-0.007***	-0.005**	-0.029***	-0.007***	-0.005**	-0.029***	-0.012***	-0.005**	-0.028***	-0.012***	-0.005*	-0.027***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Assignee Patent Volume, Third Quartile	0.027***	-0.001	-0.018***	0.027***	-0.001	-0.018***	0.021***	0	-0.018***	0.021***	0	-0.018***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Assignee Patent Volume, Top Quartile	0.072***	0.018***	-0.029***	0.072***	0.018***	-0.029***	0.054***	0.014***	-0.018***	0.054***	0.013***	-0.018***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Examiner Experience, 2-3 Years				0.003	-0.013***	-0.013***	0.003	-0.013***	-0.012***	-0.002	-0.018***	-0.013***
				[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Examiner Experience, 4-5 Years				0.004	-0.016***	-0.012***	0.003	-0.016***	-0.011***	-0.005	-0.024***	-0.013***
				[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Examiner Experience, 6-7 Years				0.009***	-0.017***	-0.009***	0.007**	-0.017***	-0.007**	-0.002	-0.028***	-0.010***
				[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Examiner Experience, 8-9 Years				0.006*	-0.012***	-0.003	0.004	-0.012***	-0.002	-0.004	-0.022***	-0.004
				[0.003]	[0.004]	[0.003]	[0.003]	[0.004]	[0.003]	[0.003]	[0.004]	[0.003]
Examiner Experience, 10-11 Years				0.008**	0.002	-0.005	0.006	0.002	-0.005	-0.003	-0.009**	-0.007*
				[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
Examiner Experience, 12-13 Years				0.010***	-0.006	-0.004	0.009**	-0.006	-0.003	-0.002	-0.019***	-0.006
				[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
Examiner Experience, 14+ Years				0.009***	-0.006*	-0.015***	0.007**	-0.006*	-0.014***	-0.003	-0.019***	-0.016***
				[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Foreign Assignee							0.194***	0.042***	-0.083***	0.194***	0.041***	-0.083***
							[0.001]	[0.002]	[0.002]	[0.001]	[0.002]	[0.002]
Two Examiners										0.022***	0.027***	0.006***
										[0.002]	[0.002]	[0.001]
Constant	0.353***	0.117***	0.150***	0.347***	0.127***	0.160***	0.262***	0.112***	0.205***	0.259***	0.108***	0.205***
	[0.001]	[0.001]	[0.001]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Class Effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Observations	433800	170898	248827	433800	170898	248827	433800	170898	248827	433800	170898	248827
R-squared	0.05	0.05	0.05	0.05	0.05	0.05	0.08	0.05	0.06	0.08	0.05	0.06

Notes:

Robust standard errors in brackets

All models include patent class fixed effects

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4.4	Dependent Variable: Did Examiner Insert *No* Citations in Patent? (Yes=1) By Type of Prior Art											
	1	2	3	4	5	6	7	8	9	10	11	12
	US Patents	Non Patent Lit.	Foreign Patents	US Patents	Non Patent Lit.	Foreign Patents	US Patents	Non Patent Lit.	Foreign Patents	US Patents	Non Patent Lit.	Foreign Patents
Assignee Patent Volume, Second Quartile	0.004***	-0.004	0.019***	0.004***	-0.004	0.019***	0.005***	-0.004	0.019***	0.004***	-0.005	0.018***
	[0.001]	[0.003]	[0.003]	[0.001]	[0.003]	[0.003]	[0.001]	[0.003]	[0.003]	[0.001]	[0.003]	[0.003]
Assignee Patent Volume, Third Quartile	0	-0.004*	0.008***	0	-0.004	0.007***	0	-0.005*	0.007***	0	-0.004*	0.007***
	[0.001]	[0.003]	[0.002]	[0.001]	[0.003]	[0.002]	[0.001]	[0.003]	[0.002]	[0.001]	[0.003]	[0.002]
Assignee Patent Volume, Top Quartile	-0.003***	-0.010***	0.014***	-0.003***	-0.010***	0.014***	0	-0.008***	0.011***	0	-0.008**	0.011***
	[0.001]	[0.003]	[0.003]	[0.001]	[0.003]	[0.003]	[0.001]	[0.003]	[0.003]	[0.001]	[0.003]	[0.003]
Examiner Experience, 2-3 Years				0.006***	0.021***	0.028***	0.006***	0.021***	0.027***	0.013***	0.035***	0.034***
				[0.002]	[0.005]	[0.004]	[0.002]	[0.005]	[0.004]	[0.002]	[0.005]	[0.004]
Examiner Experience, 4-5 Years				0.007***	0.028***	0.020***	0.007***	0.028***	0.019***	0.019***	0.050***	0.030***
				[0.002]	[0.005]	[0.004]	[0.002]	[0.005]	[0.004]	[0.002]	[0.005]	[0.004]
Examiner Experience, 6-7 Years				-0.002	0.038***	0.017***	-0.002	0.038***	0.017***	0.012***	0.066***	0.030***
				[0.002]	[0.004]	[0.004]	[0.002]	[0.004]	[0.004]	[0.002]	[0.005]	[0.004]
Examiner Experience, 8-9 Years				-0.011***	0.038***	0.009**	-0.011***	0.038***	0.008**	0.002	0.065***	0.020***
				[0.002]	[0.005]	[0.004]	[0.002]	[0.005]	[0.004]	[0.002]	[0.005]	[0.004]
Examiner Experience, 10-11 Years				-0.008***	0.020***	0.008	-0.008***	0.020***	0.008	0.007***	0.048***	0.021***
				[0.002]	[0.005]	[0.005]	[0.002]	[0.005]	[0.005]	[0.002]	[0.005]	[0.005]
Examiner Experience, 12-13 Years				-0.009***	0.023***	0.009*	-0.009***	0.023***	0.009*	0.009***	0.059***	0.025***
				[0.002]	[0.006]	[0.005]	[0.002]	[0.006]	[0.005]	[0.002]	[0.006]	[0.005]
Examiner Experience, 14+ Years				-0.005***	0.042***	0.028***	-0.004***	0.043***	0.027***	0.012***	0.076***	0.042***
				[0.002]	[0.004]	[0.004]	[0.002]	[0.004]	[0.004]	[0.002]	[0.005]	[0.004]
Foreign Assignee							-0.026***	-0.017***	0.020***	-0.026***	-0.016***	0.021***
							[0.001]	[0.002]	[0.002]	[0.001]	[0.002]	[0.002]
Two Examiners										-0.035***	-0.071***	-0.033***
										[0.001]	[0.002]	[0.002]
Constant	0.089***	0.696***	0.694***	0.091***	0.666***	0.676***	0.102***	0.673***	0.665***	0.107***	0.681***	0.668***
	[0.001]	[0.002]	[0.001]	[0.002]	[0.004]	[0.003]	[0.002]	[0.004]	[0.004]	[0.002]	[0.004]	[0.004]
Class Effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Observations	433800	170898	248827	433800	170898	248827	433800	170898	248827	433800	170898	248827
R-squared	0.14	0.15	0.08	0.14	0.15	0.08	0.14	0.15	0.08	0.14	0.16	0.08

Notes:

Robust standard errors in brackets

All models include patent class fixed effects

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4.5: "Self" Citations, By Type of Citation
U.S. Patent-U.S. Patent Citations Only

	1 Citing Examiner=Cited Examiner	2 Citing Assignee=Cited Assignee	3 All Citations
Examiner Inserted	138,552	201,460	1,791,317
Column Percentage	*55%*	*41%*	*41%*
Row Percentage	*8%*	*11%*	*100%*
Applicant Inserted	112,293	285,679	2,589,963
Column Percentage	*45%*	*59%*	*59%*
Row Percentage	*4%*	*11%*	*100%*
Total	250,845	487,139	4,378,280
Column Percentage	*100%*	*100%*	
Row Percentage	*6%*	*11%*	

Table 5.1 Distribution of Citations in Nanotechnology and Comparison Sample Patents

	Share of Citations	
	Comparison Sample	**Nanotechnology Sample**
U.S. Patent	63.68%	58.32%
Foreign Patent	15.97%	12.56%
Non-Patent Literature	20.35%	29.12%

Table 5.2	Table 5.2 Nanotechnology vs. Control Sample Regressions									
	1	2	3	4	5	6	7	8	9	10
	Examiner Citation: (Yes=1)				Share of Examiner Citations to US Pats	Share of Examiner Citations to NP Lit	Share of Examiner Citations to For Pats	Share of Examiner Citations to US Pats	Share of Examiner Citations to NP Lit	Share of Examiner Citations to For Pats
Nanotechnology Sample(1=Yes)	-0.048***	-0.066***	-0.043***	-0.060***	-0.061***	-0.023***	0.018**	-0.057***	-0.022***	0.023***
	[0.001]	[0.002]	[0.001]	[0.002]	[0.006]	[0.007]	[0.008]	[0.006]	[0.007]	[0.008]
Foreign Reference (1=Yes)	-0.250***	-0.252***	-0.247***	-0.248***						
	[0.000]	[0.000]	[0.000]	[0.000]						
Non-Patent Reference (1=Yes)	-0.235***	-0.235***	-0.232***	-0.232***						
	[0.000]	[0.000]	[0.000]	[0.000]						
Nanotechnology * Foreign		0.082***		0.089***						
		[0.003]		[0.003]						
Nanotechnology * Science		0.026***		0.021***						
		[0.002]		[0.002]						
Constant	0.364***	0.365***	0.363***	0.363***	0.598***	0.172***	0.187***	0.598***	0.172***	0.187***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Class Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Examiner Effects			Yes	Yes				Yes	Yes	Yes
			Sig.	Sig.				Sig.	Sig.	Sig.
Observations	5515310	5515310	5515310	5515310	284383	117464	161592	284383	117464	161592
R-squared	0.14	0.14	0.17	0.17	0.1	0.06	0.06	0.15	0.16	0.15

Notes:

Robust standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6.1: Descriptive Statistics for Jan/Feb 2001 Sample

Variable	Obs	Mean	Std. Dev.	Min	Max
Importance (Number of ""Forward" Citations to February 2004)	24522	1.865712	2.826572	0	42
Patent Family Size	24522	4.173925	3.777234	1	40
U.S. Priority Country (1=Yes)	24522	0.5720985	0.4947846	0	1
Foreign Assignee (1=Yes)	24522	0.475002	0.4993849	0	1
Assignee Patent Volume, Previous 5 Years	24522	1428.942	2653.21	0	11892
Examiner Experience, Number of Years	24522	9.214053	7.137677	0	25
Two Patent Examiners (1=Yes)	24522	0.4615855	0.4985323	0	1
Share of Examiner Inserted Citations, for Citations to U.S. Patents	24132	0.6260488	0.3787786	0	1
Share of Examiner Inserted Citations, for Citations to Non-Patent Literature	9160	0.1960862	0.3581493	0	1
Examiner Share of Citations to U.S. Patents=100% (1=Yes)	24132	0.3943726	0.4887256	0	1
Examiner Share of Citations to Non-Patent Literature=100% (1=Yes)	9160	0.1385371	0.3454817	0	1
Examiner Share of Citations to U.S. Patents=0% (1=Yes)	24132	0.0960965	0.2947296	0	1
Examiner Share of Citations to Non-Patent Literature=0% (1=Yes)	9160	0.6815502	0.4659004	0	1

Table 6.2	Dependent Variable: Share of Examiner Inserted Citations in Patent, By Type of Prior Art Cited													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.
Importance (Number of Forward Citations)	-0.011***	-0.004***	-0.011***	-0.003***	-0.006***	-0.003**	-0.006***	-0.003**	-0.006***	-0.003**	-0.006***	-0.003**	-0.006***	-0.003**
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Patent Family Size			-0.007***	-0.005***	-0.014***	-0.006***	-0.014***	-0.006***	-0.014***	-0.006***	-0.014***	-0.006***	-0.013***	-0.005***
			[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
US Priority Application					-0.219***	-0.039***	-0.116***	-0.008	-0.109***	-0.005	-0.109***	-0.005	-0.109***	-0.004
					[0.005]	[0.008]	[0.008]	[0.015]	[0.008]	[0.015]	[0.008]	[0.015]	[0.008]	[0.015]
Foreign Assignee							0.126***	0.037**	0.131***	0.038***	0.131***	0.039***	0.131***	0.039***
							[0.008]	[0.014]	[0.008]	[0.014]	[0.008]	[0.014]	[0.008]	[0.014]
Assignee Patent Volume, Second Quartile									-0.016**	-0.003	-0.016**	-0.003	-0.015**	-0.002
									[0.008]	[0.012]	[0.008]	[0.012]	[0.008]	[0.012]
Assignee Patent Volume, Third Quartile									0.005	0.002	0.005	0.002	0.006	0.002
									[0.006]	[0.009]	[0.006]	[0.009]	[0.006]	[0.009]
Assignee Patent Volume, Top Quartile									0.029***	0.014	0.029***	0.014	0.029***	0.015
									[0.007]	[0.011]	[0.007]	[0.011]	[0.007]	[0.011]
Examiner Experience, 2-3 Years											0.029**	0.008	0.023*	0.001
											[0.012]	[0.017]	[0.012]	[0.017]
Examiner Experience, 4-5 Years											0.016	-0.015	0.003	-0.028*
											[0.011]	[0.016]	[0.012]	[0.017]
Examiner Experience, 6-7 Years											0.024**	-0.018	0.011	-0.033*
											[0.012]	[0.016]	[0.012]	[0.017]
Examiner Experience, 8-9 Years											0.017	-0.01	0.002	-0.025
											[0.013]	[0.019]	[0.013]	[0.019]
Examiner Experience, 10-11 Years											0.039***	-0.007	0.02	-0.025
											[0.014]	[0.021]	[0.014]	[0.021]
Examiner Experience, 12-13 Years											0.016	-0.008	-0.002	-0.028
											[0.014]	[0.022]	[0.014]	[0.023]
Examiner Experience, 14+ Years											0.024**	-0.002	0.005	-0.021
											[0.011]	[0.017]	[0.012]	[0.017]
Two Examiners													0.041***	0.041***
													[0.005]	[0.008]
Constant	0.647***	0.204***	0.676***	0.227***	0.823***	0.255***	0.702***	0.221***	0.688***	0.215***	0.666***	0.221***	0.660***	0.214***
	[0.003]	[0.004]	[0.004]	[0.006]	[0.005]	[0.009]	[0.009]	[0.016]	[0.010]	[0.017]	[0.014]	[0.022]	[0.014]	[0.022]
Class Effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Observations	24132	9160	24132	9160	24132	9160	24132	9160	24132	9160	24132	9160	24132	9160
R-squared	0.11	0.13	0.12	0.14	0.19	0.14	0.2	0.14	0.2	0.14	0.2	0.14	0.2	0.14

Notes:

Robust standard errors in brackets

All models include patent class fixed effects

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6.3	Dependent Variable: Did Examiner Insert *All* Citations in Patent? (Yes=1) By Type of Prior Art													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.
Importance (Number of Forward Citations)	-0.013***	-0.003***	-0.012***	-0.003**	-0.008***	-0.002**	-0.008***	-0.002**	-0.008***	-0.002**	-0.008***	-0.003**	-0.008***	-0.003**
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Patent Family Size			-0.012***	-0.004***	-0.019***	-0.005***	-0.018***	-0.005***	-0.018***	-0.005***	-0.018***	-0.005***	-0.018***	-0.005***
			[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
US Priority Application					-0.205***	-0.032***	-0.088***	-0.006	-0.079***	-0.004	-0.078***	-0.004	-0.078***	-0.003
					[0.007]	[0.008]	[0.011]	[0.015]	[0.011]	[0.015]	[0.011]	[0.015]	[0.011]	[0.015]
Foreign Assignee							0.142***	0.031**	0.149***	0.032**	0.149***	0.033**	0.149***	0.033**
							[0.011]	[0.014]	[0.011]	[0.014]	[0.011]	[0.014]	[0.011]	[0.014]
Assignee Patent Volume, Second Quartile									-0.008	-0.007	-0.008	-0.008	-0.008	-0.007
									[0.010]	[0.012]	[0.010]	[0.012]	[0.010]	[0.012]
Assignee Patent Volume, Third Quartile									0.007	-0.005	0.007	-0.005	0.007	-0.005
									[0.008]	[0.009]	[0.008]	[0.009]	[0.008]	[0.009]
Assignee Patent Volume, Top Quartile									0.040***	0.008	0.040***	0.008	0.040***	0.008
									[0.009]	[0.011]	[0.009]	[0.011]	[0.009]	[0.011]
Examiner Experience, 2-3 Years											0.032**	0.017	0.030*	0.012
											[0.016]	[0.017]	[0.016]	[0.017]
Examiner Experience, 4-5 Years											0.01	-0.004	0.006	-0.014
											[0.015]	[0.016]	[0.015]	[0.016]
Examiner Experience, 6-7 Years											0.025*	-0.007	0.021	-0.018
											[0.015]	[0.016]	[0.015]	[0.016]
Examiner Experience, 8-9 Years											0.015	0.008	0.01	-0.004
											[0.017]	[0.019]	[0.017]	[0.019]
Examiner Experience, 10-11 Years											0.034*	0.018	0.028	0.004
											[0.018]	[0.021]	[0.018]	[0.021]
Examiner Experience, 12-13 Years											0.008	0.022	0.002	0.006
											[0.019]	[0.022]	[0.019]	[0.023]
Examiner Experience, 14+ Years											0.019	0.012	0.013	-0.003
											[0.015]	[0.017]	[0.015]	[0.017]
Two Examiners													0.012*	0.033***
													[0.007]	[0.008]
Constant	0.419***	0.146***	0.468***	0.166***	0.605***	0.190***	0.469***	0.161***	0.448***	0.159***	0.429***	0.152***	0.427***	0.146***
	[0.004]	[0.004]	[0.005]	[0.006]	[0.007]	[0.009]	[0.012]	[0.016]	[0.014]	[0.017]	[0.018]	[0.022]	[0.019]	[0.022]
Class Effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Observations	24132	9160	24132	9160	24132	9160	24132	9160	24132	9160	24132	9160	24132	9160
R-squared	0.06	0.09	0.07	0.09	0.1	0.09	0.11	0.09	0.11	0.09	0.11	0.09	0.11	0.1

Notes:

Robust standard errors in brackets

All models include patent class fixed effects

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6.4	Dependent Variable: Did Examiner Insert *No* Citations in Patent? (Yes=1) By Type of Prior Art													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.	US Patents	Non Patent Lit.
Importance (Number of Forward Citations)	-0.001	0.002	-0.001	0.002	-0.001**	0.002	-0.001**	0.002	-0.001**	0.002	-0.001**	0.002	-0.001**	0.002
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Patent Family Size			0.003***	0.006***	0.004***	0.006***	0.004***	0.006***	0.004***	0.005***	0.004***	0.005***	0.004***	0.005***
			[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
US Priority Application					0.034***	0	0.012*	-0.003	0.011*	-0.006	0.011*	-0.006	0.011*	-0.008
					[0.004]	[0.010]	[0.006]	[0.017]	[0.006]	[0.018]	[0.006]	[0.018]	[0.006]	[0.018]
Foreign Assignee							-0.027***	-0.004	-0.027***	-0.005	-0.027***	-0.006	-0.027***	-0.007
							[0.006]	[0.017]	[0.006]	[0.017]	[0.006]	[0.017]	[0.006]	[0.017]
Assignee Patent Volume, Second Quartile									-0.006	-0.004	-0.006	-0.002	-0.006	-0.003
									[0.006]	[0.015]	[0.006]	[0.015]	[0.006]	[0.015]
Assignee Patent Volume, Third Quartile									-0.001	-0.016	-0.001	-0.016	-0.001	-0.016
									[0.005]	[0.012]	[0.005]	[0.012]	[0.005]	[0.012]
Assignee Patent Volume, Top Quartile									-0.004	-0.019	-0.004	-0.019	-0.004	-0.02
									[0.005]	[0.014]	[0.005]	[0.014]	[0.005]	[0.014]
Examiner Experience, 2-3 Years											-0.020*	0.014	-0.017	0.025
											[0.010]	[0.022]	[0.010]	[0.022]
Examiner Experience, 4-5 Years											-0.012	0.043**	-0.003	0.064***
											[0.010]	[0.021]	[0.010]	[0.021]
Examiner Experience, 6-7 Years											-0.026**	0.059***	-0.017	0.082***
											[0.010]	[0.022]	[0.010]	[0.022]
Examiner Experience, 8-9 Years											-0.022*	0.038	-0.012	0.061**
											[0.012]	[0.024]	[0.012]	[0.025]
Examiner Experience, 10-11 Years											-0.025**	0.046*	-0.013	0.075***
											[0.012]	[0.027]	[0.012]	[0.027]
Examiner Experience, 12-13 Years											-0.019*	0.048*	-0.008	0.080***
											[0.012]	[0.028]	[0.012]	[0.029]
Examiner Experience, 14+ Years											-0.016	0.060***	-0.004	0.090***
											[0.010]	[0.022]	[0.010]	[0.023]
Two Examiners													-0.026***	-0.066***
													[0.004]	[0.010]
Constant	0.097***	0.677***	0.087***	0.650***	0.064***	0.650***	0.090***	0.654***	0.092***	0.667***	0.110***	0.626***	0.114***	0.638***
	[0.002]	[0.005]	[0.003]	[0.008]	[0.004]	[0.011]	[0.007]	[0.019]	[0.008]	[0.021]	[0.012]	[0.027]	[0.012]	[0.027]
Class Effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Observations	24132	9160	24132	9160	24132	9160	24132	9160	24132	9160	24132	9160	24132	9160
R-squared	0.14	0.19	0.14	0.19	0.14	0.19	0.14	0.19	0.14	0.19	0.14	0.19	0.14	0.2

Notes:

Robust standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6.5: Regressions of Number of Examiner and Applicant Citations on Importance						
	Citations to U.S. Patents			Citations to Non-Patent Lit		
	Number of Applicant Citations	Number of Examiner Citations	Number of Examiner Citations	Number of Applicant Citations	Number of Examiner Citations	Number of Examiner Citations
IMPORTANCE	**0.746*** **	**0.081*** **	**0.092*** **	**0.296*** **	**0.052*** **	**0.032*** **
	[0.040]	[0.011]	[0.011]	[0.023]	[0.008]	[0.008]
NUMBER OF APPLICANT CITATIONS			**-0.015*** **			**0.027*** **
			[0.002]			[0.001]
Constant	**5.280*** **	**4.787*** **	**4.866*** **	**2.056*** **	**0.331*** **	**0.187*** **
	[0.130]	[0.034]	[0.035]	[0.075]	[0.025]	[0.026]
Class Effects	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Observations	**24522**	**24522**	**24522**	**24522**	**24522**	**24522**
R-squared	**0.07**	**0.15**	**0.16**	**0.16**	**0.06**	**0.08**
Standard errors in brackets						
* significant at 10%; ** significant at 5%; *** significant at 1%						

Figure 3.1: Distribution of Examiner Share of Citations in 2001-2003 Patents
By Type of Prior Art

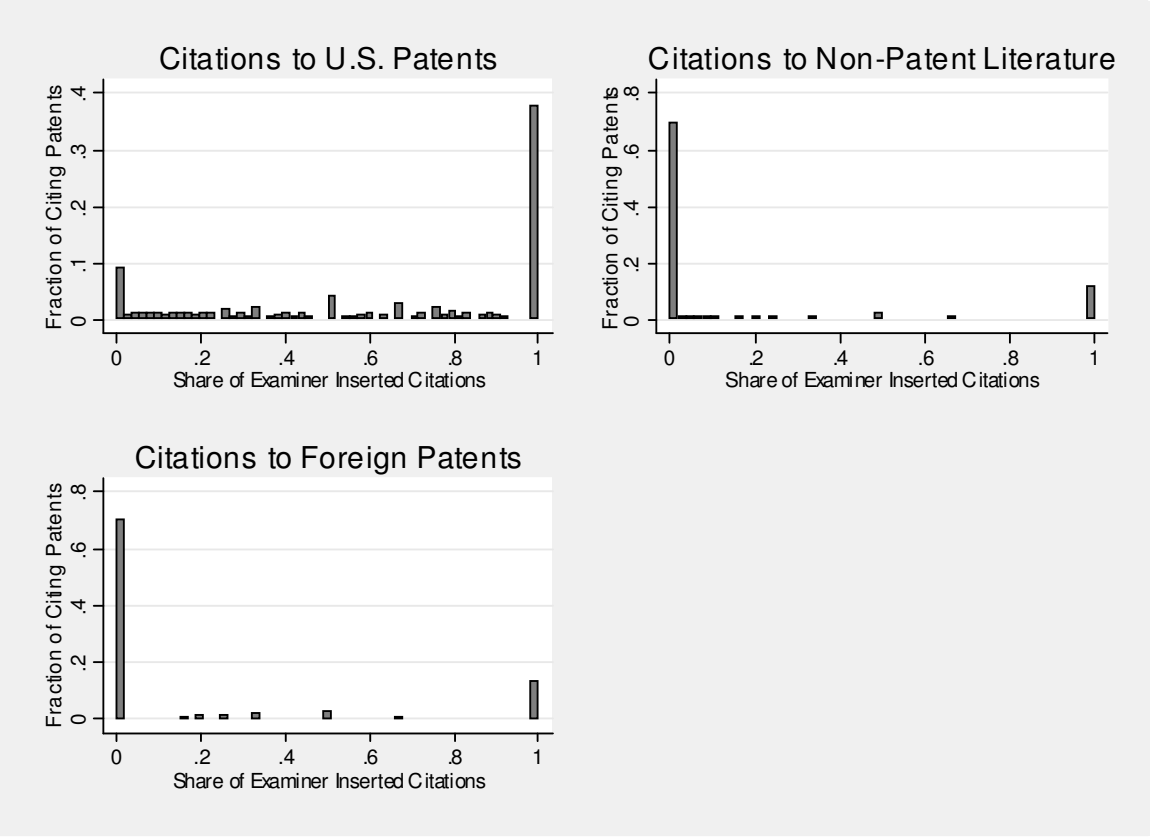

Figure 3.2: Share of Patents Where Examiners Insert 0% or 100% of Citations to *U.S. Patents*, By Field
(Computed only for Patents Citing U.S. Patents)

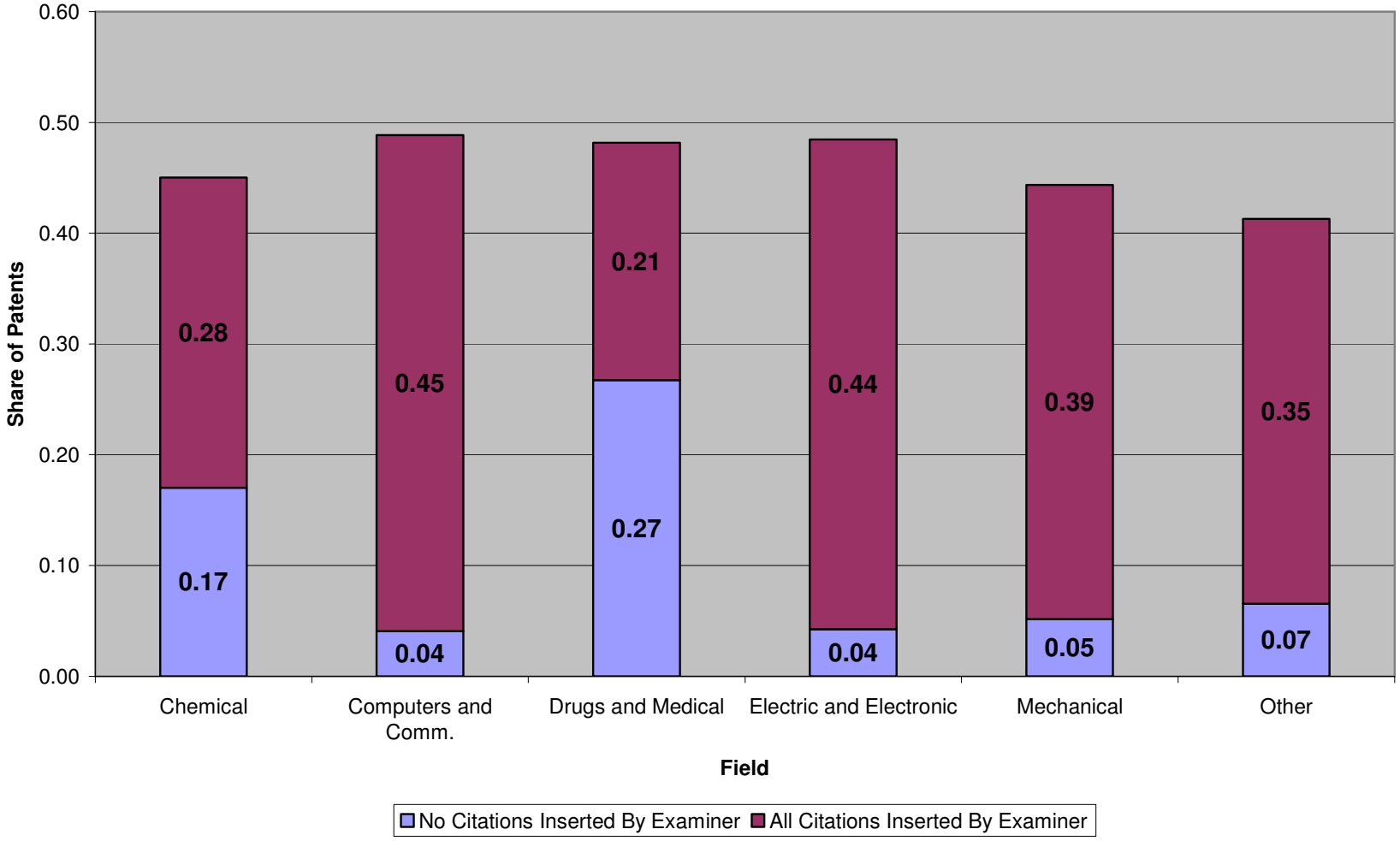

Figure 3.3: Share of Patents Where Examiners Insert 0% or 100% of Citations to *Non-Patent Literature*, By Field
(Computed only for Patents Citing Non-Patent Literature)

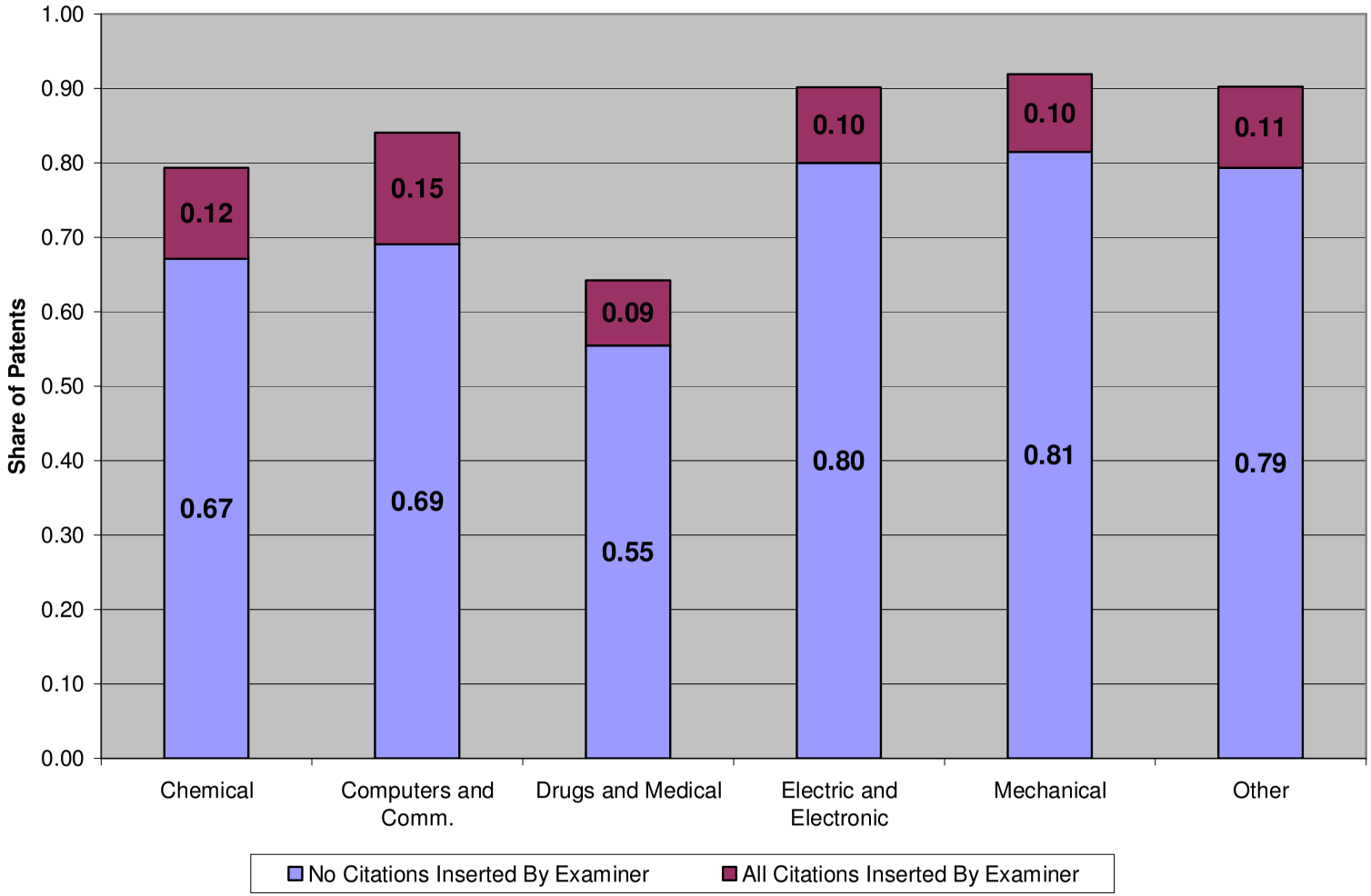

Figure 3.4: Share of Patents Where Examiners Insert 0% or 100% of Citations to Foreign Patents, By Field (Computed only for Patents Citing Foreign Patents)

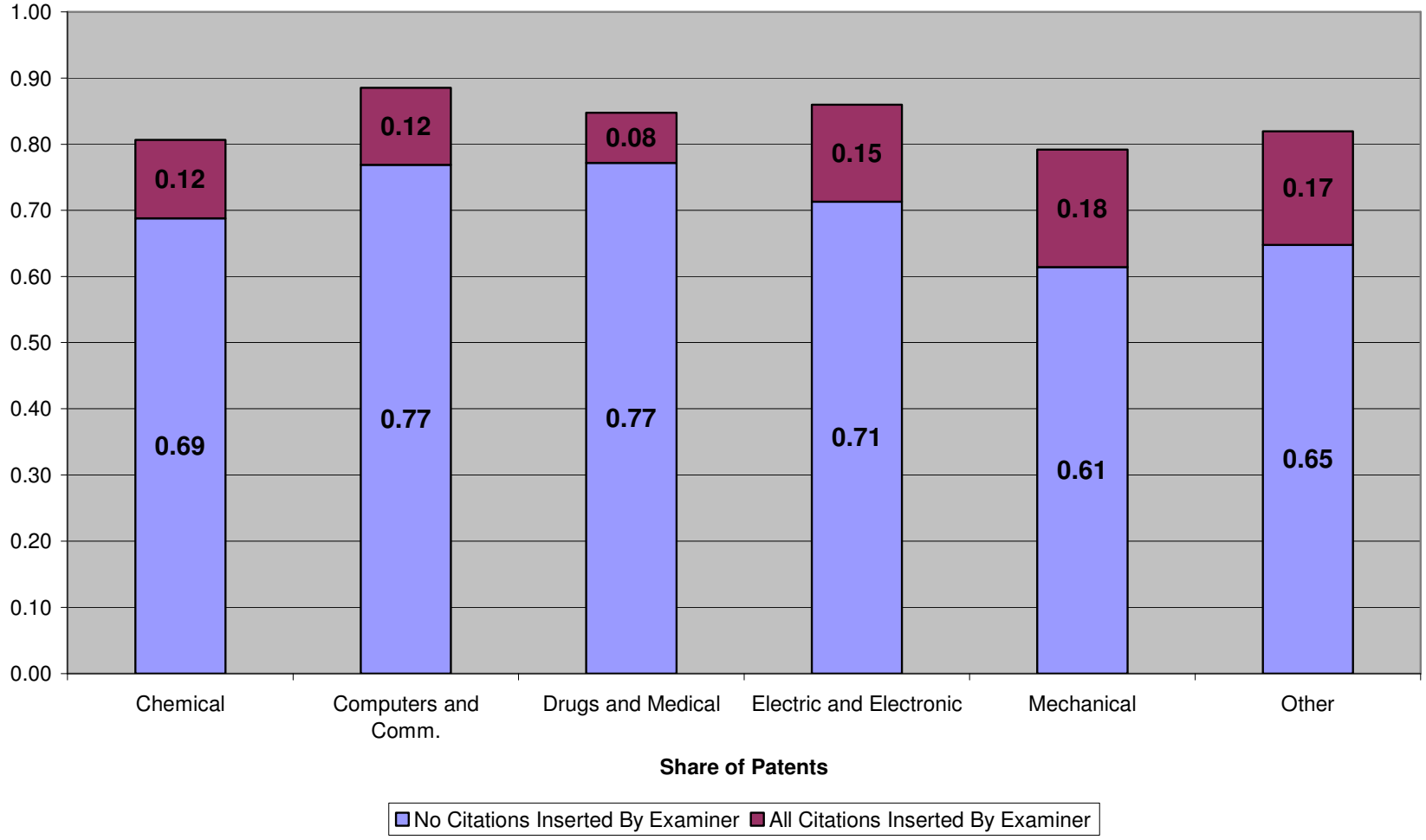

Figure 4.1: Share of "Self" Citations Inserted By Examiner, By Field