Winter 2015

Are Prior Art Citations Determinative of Patent Approval?: An Empirical Analysis of the Strategy Behind Citing Prior Art

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by JAMES H. RICHARDSON*

I. Introduction

When an inventor applies to the U.S. Patent and Trademark Office ("USPTO") for a patent, there are legal and procedural requirements to the prosecution[1] of that patent. One such requirement is the citation of similar inventions and patents that might enable, narrow, preclude, or otherwise relate to the patent currently being filed. Patent examiners subsequently review the patent application, any accompanying diagrams and descriptions, and any inventor cited prior art. Additionally, examiners may (and often do) attach further relevant citations to these applications. Empirical evidence, as well as common sense, suggest that patent examiners, assigned to parse through and assess the validity of patents, are overextended, and can devote only a relatively small amount of time and effort to the review of each individual patent. Thus, applicants, if they are so-inclined can choose to either overwhelm or underwhelm the examiner with lengthy and burdensome prior art citations, knowing full well that adequate attention will not be given to this bibliography.

This paper empirically evaluates the extent to which inventors either over, or underwhelm the patent office with information. This data is then channeled into an analysis of the effect of behavior upon the time from the filing of the patent to the eventual successful granting of that patent. Given the lack of available data on unsuccessful patent applications, as well as the fact that the overwhelming majority of patent applications are eventually successful, this paper focuses on time to patent, as opposed to deterministic outcome.[2] Here, time is taken as a proxy for depth of analysis and scrutiny by a patent examiner. The paper performs two discrete analyses. First, this paper presents a careful analysis of the relationship between patent examiner citations and the amount of prior art cited by the applicant at the time that a patent is applied for. This analysis yields that the two statistics are inversely related. Specifically, the less prior art that is cited by the applicant, the more prior art the examiner eventually includes during prosecution. This association indicates that underwhelming the patent officer indeed leads to increased labor on behalf of patent examiners.

In light of this first analysis, a careful tabulation and discussion of the time to approval relative to the quantity of prior art cited is performed to create a foundational understanding of the extent to which this

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1. Prosecution here refers to the process of applying for and receiving a patent.

2. *See* FTC, TO PROMOTE INNOVATION: THE PROPER BALANCE OF COMPETITION AND PATENT LAW AND POLICY 217 (2003), *available at* http://www.ftc.gov/os/2003/10/innovationrpt.pdf (stating that the proportion of patent applications that are eventually approved is potentially as high as 98%).

overwhelming and underwhelming is impacting the time to receive a patent– a proxy for thoroughness. Empirical results indicate that while the time spent on examination increases with increased applicant citations, it does so marginally.   This result taken in conjunction with the inverse relationship between applicant citations and examiner citations leads to the conclusion that applicants are better off citing little or no prior art, as this ensures that the examiner will spend more time searching for prior art, and less time evaluating the merits of the claims presented.

II. Literature Review

Empirical examination of the process of patent application has increased substantially in accord with the increasing amounts of data made available by the USPTO.[3] The process of patent application obliges inventors to report any relevant inventions or discoveries that predate the inventors' own, through citations to *prior art*.[4] Prior art citations are then evaluated by a patent examiner at the U.S. Patent and Trademark Office in order to determine whether the invention is novel enough to merit patent protection.[5] The preclusive effect of prior art citations, therefore, incentivizes inventors to conceal this information, either through over-citing, and attempting to bury the information, or by under-citing, and hoping that the patent officer will not find the relevant information in independent queries.   Prior art citations are disaggregated into two categories: (i) applicant citations—prior art cited by the inventor or applicant, and (ii) examiner citations which are provided by the patent examiner during the process of patent approval. Prior art citation has been discussed extensively throughout the literature, and has long been one of the primary areas of research in patent law.[6] Much of the literature focuses

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3.   *See* Bhaven Sampat, *When Do Patent Applicants Search for Prior Art?*,53 J. L. & ECON. 399 (2010); *see also* Mark A. Lemley & Bhaven Sampat, *Examiner Characteristics and Patent Office Outcomes*, 94(3) REV. ECON. & STATS. 817 (2010); *see also* Bronwyn H. Hall & Rosemarie H. Ziedonis, *The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995*, 32(1) RAND J. OF ECON. 101 (2001); *see also* Jean O. Lanjouw, Ariel Pakes & Jonathan Putnam, *How to Count Patents and Value Intellectual Property: The Uses of Patent Renewal and Application Data*, 46(4) J. INDUSTRIAL ECON. 405 (1998).

4.   U.S. PATENT AND TRADEMARK OFFICE, MANUAL OF PATENT EXAMINING PROCEDURE, Vol. 9 § 2121 (9th ed. March 2014).

5.   *See id.*

6.   *See* Note, *Prior Art and in the Patent Law*, 73 HARV. L. REV. 369, 372 (1959) (discussing prior art, the standard of evaluation, and instances in which patents are not granted as a result of prior art conflicts).

on the importance of applicant cited prior art on examiner behavior.[7] Research has also suggested that citations to prior art[8] may be an indicator of patent value.[9]

Building upon the model of backward citations as indicators of patent value, Hall et al. use the stock market valuation of the intangible assets of patent-holder corporations to intuit the value of these companies' intellectual property.[10] Under this metric, self-citations made by the applicant are a better predictor of patent value than are examiner citations; specifically, a one unit increase in the number of self-citations for all patents owned by a firm yields a 3% increase in that firm's market value.[11] Hegpe and Sampat find that the opposite conclusion holds relative to the *private value* of patents.[12] Namely, examiner citations are a stronger predictor of the value ascribed to inventions by the inventors. Irrespective, this association of value and citations makes clear the importance of prior art citation in the literature, as well as practically.[13]

The value of patents—private, as well as public—underscores the importance of the process of approval. Patent prosecution is an extremely high-stakes field, and backward citations have a substantial impact on the value.[14] Accordingly, inventors, research companies and law firms all have an interest in the implications of prior art citation. The importance of citations is tied intrinsically to the relationship between the examining officer, and increased patent applications. There is a growing sentiment that the USPTO is increasingly overwhelmed by the growing influx of patent applications; in comparison to the stagnation of resources

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7. *See* Mark A. Lemley & Bhaven Sampat, *Examining Patent Examination*, 2010 STAN. TECH. L. REV. 2 (2010).

8. Also commonly referred to as "backward citations," as opposed to forward citations, which account for an issued patent being cited by newer patents.

9. *See* Manuel Trajtenberg, *A Penny for Your Quotes: Patent Citations and the Value of Innovations.* 21 RAND J. OF ECON. 172, 185 (1990).

10. *See* Bronwyn H. Hall, Adam Jaffe & Manuel Trajtenberg, *Market Value and Patent Citations*, 36 RAND J. OF ECON. 16–38, (2005).

11. *See id.* at 34.

12. *See* Deepak Hegde & Bhaven Sampat, *Examiner Citations, Applicant Citations and the Private Value of Patents,* 108 ECON. LETTERS 287, 289 (2009) (discussing where private value is taken to mean the likelihood of patent renewal by an inventor; and thus the value to the inventor, as opposed to the market).

13. *See id.*

14. *See* Dietmar Harhoff, Fredricm. Scherer & Katrin Vopel, *Citations, Family Size, Opposition and the Value of Patent Rights*, 32(8) RES. POL'Y. 1343 (2002) (showing that references to prior literature are positively correlated with patent value).

apportioned to the office.[15] Sag and Rohde discuss the current shortcomings of the patent approval process.[16] In particular, they point out that the USPTO suffers from a severe dearth of resources and also from distorted incentive schemes.[17] They propose a theoretical economic model devised to explain why poor examination leads to negative public utility outcomes.[18] Thus, they posit, insufficient or inadequate patent examination stymies innovation, as it creates inventor reticence to challenge deficient patents.[19] It would seem, then, that inventors' over- or underwhelming examiners with either cumbersome quantities of prior art citations, or a complete dearth of prior art, lends itself to this same implication. Hence, the temporally determinative effects of patent applicant citations have a bearing on the socially unproductive approval of meritless patents.

Commensurate with the concerns of patent officers being overwhelmed by applications generally, is the concern that patent examiners lack the time, resources and capabilities to seek out prior art in the absence of some direction by the inventor.[20] The literature has thus far focused on the proportionality of prior art citations by examiners relative to inventors.[21] Empirical evaluation has shown that applicants often contribute an overwhelmingly low proportion of the prior art present in the final application.[22] In fact, approximately 40% of patent applications contain *only* examiner citations, and no applicant citations.[23] Yet, research also

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15.   *See* Douglas G. Lichtman & Mark A Lemley, *Rethinking Patent Law's Presumption of Validity*, 60 STAN. L. REV. 45, 51 (2007) (pointing out that patent examiners are overwhelmed by the influx of patent applications); *see also* Brian Fung, *Inside the Stressed-Out, Time-Crunched Patent Examiner Workforce*, WASH. POST (July 31, 2014) *available at* http://www.wash

ingtonpost.com/blogs/the-switch/wp/2014/07/31/inside-the-stressed-out-time-crunched-patent-examiner-workforce/; *see also* U.S. Patent Statistics Chart Calendar Years, 1963-2013, USPTO, *available at* http://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm (showing the increasing uptick in patent applications filed year-over-year).

16.   *See* Matthew Sag & Kurt Rohde, *Patent Reform and Differential Impact*, 8 MINN. J.L. SCI. & TECH. 1, 16 (2007).

17.   *See id.*

18.   *See id.* at 22-28. This model takes into account the cost and outcome of subsequent litigation relative to the cost of licensing.

19.   *See id.*

20.   *See* Lichtman & Lemley, *supra* note 15.

21.   *See* Bhaven N. Sampat, *When Do Patent Applicants Search for Prior Art?,* 53 J.L. & ECON. 399 (2010); *see also* Juan Alácer, Michelle Gittleman & Bhaven Sampat, *Applicant and Examiner Citations in U.S. Patents: An Overview and Analysis*, 38 RES. POL'Y. 415, 416 (2009).

22.   *See* Sampat *id.* at 402.

23.   *See* Alácer, Gittleman & Sampat, *supra* note 21, at 416.

suggests that this dearth of applicant citations is largely irrelevant, as examiners generally do not rely on these citations.[24]

Yet, the bulk of the research on prior art citations focuses on examiner versus applicant cites, and the impact on the value of patents.[25] While studies point to the importance of prior art citations in the discussion of overwhelming patent examiners, no research to date has examined the effect of backward citations on the time spent examining patents. An evaluation of the effect of prior art citations on the time for approval would corroborate intuitions regarding the overwhelming of patent examiners.

III. Theory and Model

While research has pointed out the importance of backward citations, and has speculated that this contributes to the overwhelming of patent examiners at the USPTO,[26] no research to date has analyzed the temporal effects of either overwhelming or underwhelming patent examiners with prior art citations. By either grossly over- or under-citing to prior art in a patent application, an inventor might effectively shift the onus of searching for or researching preclusive art onto the patent examiner. Inventors (or more likely, law firms prosecuting patents) are likely fully abreast of the fact that the patent office and its examiners are overworked and under-resourced. Thus, strategically, applicants have an incentive to conceal any prior art or research that might undermine the probability of receiving a patent. This can be done either by willful omission of potentially preclusive prior art—or more frequently, a failure to cite *any* prior art. It can also be achieved by over-citing prior art, and forcing the examiner to mine through the sources listed—many of which are tangentially, if at all related to the invention submitted to the USPTO.

This strategic method of backward citation should lead to less preclusive prior art being discovered by examiners. And, therefore, patent applications which either under- or over-cite to existing inventions are less likely to be blown up during the approval stage. This then implies that patents with little innovative value-added will be more likely to be granted. Further, as patents are afforded the presumption of validity[27] once

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24.   *See* Christopher A. Cotropia, Mark A. Lemley & Bhaven Sampat, *Do Applicant Patent Citations Matter*, 42 RES. POL'Y. 844, 854 (2013) (pointing out that this failure to heed applicant citations is magnified by the fact that examiners are not well adapted to seek out non-patent prior art).

25.   *See* Alácer, Gittleman & Sampat, *supra* note 21, at 416; Hegde & Sampat.

26.   *See supra* note 15.

27.   *See* Black's Law Dictionary, 1306 (9th ed. 2009) (the presumption of validity is "[t]he doctrine that the holder of a patent is entitled to a statutory presumption that the patent is valid

approved, potentially thin patents can preclude *actual* innovation.[28] Once a patent has been issued, potential competitors will have to factor in the added hurdle of litigation when determining whether or not to enter a particular market.[29] Thus, patents which should never have been afforded protection might preclude more robust innovation, as future litigation must defer to decisions made by over-burdened patent examiners.

A. Examiner Citations as a Function of Applicant Citations

This paper performs a two-part analysis in order to determine the effect of over- and under-citation. First, the paper examines the extent to which the quantity of examiner citations is a function of the number of applicant citations. This question looks to the effect of inventors' or applicants' behavior on patent examiners. Prior to an analysis of the temporal implications of applicant citation, the effect on the examiner is warranted.

1.   *Hypothesis: Examiner Citations Vary Inversely with Applicant Citations*

Intuition suggests that patent examiners must provide more citations for [applicant] citation deficient applications. Thus, examiner citations will increase in inverse proportion to applicant citations. If this is the case, this suggests that much of patent examiners' time is being used performing research and citing to prior art. This has implications for subsequent analysis, irrespective of the effects of applicant citations on time required to patent. The model for this inverse relationship can be observed in the equation below:

$$\widehat{Examiner} = \beta_0 + \beta_1 \cdot \frac{1}{Applicant} + \beta_2 \cdot X + \varepsilon$$

Here, **Examiner** represents the number of citations provided by the examiner, **Applicant** represents the number of applicant citations provided with the initial patent application, and **X** corresponds to a control vector. This control vector contains data regarding the number of claims present in the patent application (a measure of complexity), forward citations—the

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and that the burden is on the challenger to prove invalidity." Thus decisions made by oft-overworked patent examiners are afforded a statutory presumption in subsequent litigation).

28.   *See* Lichtman & Lemley, *supra* note 15, at 72 (2007) (suggesting that the granting of a higher burden of proof once patents are granted stymies innovation, given that patent examiners are over-utilized and do not posses the requisite resources to properly evaluate patents, or to discern which patents are potentially valuable versus those that are not).

29.   *See* John R. Allison & Mark A. Lemley, *Empirical Evidence on the Validity of Litigated Patents*, 26(3) AMER. INTEL. PROP. L. ASSOC. Q. J. 185 (1998); *see* Mark A. Lemley & Carl Shapiro, *Probabilistic Patents*, 19(2) J. ECON. PERSPECTIVES 75 (2005).

number of times that the patent is cited as prior art in subsequent patent filings (a measure of eventual importance of the patent), and the year in which the patent is issued (a *de facto* control for time).

In the event that the above hypothesis is not corroborated by the data, this provides evidence that overwhelming is taking place. If patent examiners are providing the similar amounts of prior art (or perhaps more) when more prior art is cited by the applicant, this suggests that either (i) applicants are citing erroneous prior art, (ii) examiners are essentially starting from scratch with each application and ignoring prior art citations by the applicant, or (iii) some combination of the two. Thus, this analysis, too, would provide important insight regarding the strategic benefit of overwhelming. Irrespective of the result of this preliminary analysis, subsequent analysis of the effects of citation on the time to prosecute the patent is necessary to contextualize the results.

B. Time to Patent Approval as a Function of Applicant Citations

After examining the extent to which examiners adjust their behavior relative to applicant citations, analysis proceeds to the time to patent approval from date of filing as a function of the number of applicant provided citations. The first analysis purports to explain the extent to which patent examiners are adjusting behavior in response to applicant gamesmanship. The model for this second analysis is seen in the equation below:

$$\widehat{Patent\ Time} = \beta_0 + \beta_1 \cdot Applicant + \beta_2 \cdot X + \varepsilon$$

In this equation, **Patent Time** represents the time (in days) from the initial application up to the time that the patent is granted. **Applicant**, as in the equation above, represents the overall number of applicant citations provided in the patent application. And again, as above, **X** represents the control vector, containing data regarding the number of claims present in the patent application, forward citations – the number of times that the patent is cited as prior art in subsequent patent filings, and the year in which the patent is issued.

The implications of this research question have a bearing on both practitioner strategy and on policy. If little temporal variation is observed across examiner citations, there is a clear incentive toward strategically over- or underwhelming the examiner.[30] If significant variation is observed, this too has practical implications. Such a finding shifts the calculus to a

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30. Note, also, given the compensation scheme for most law firms, practitioners will have an incentive to bill more hours, and thus to spend time overwhelming, as opposed to underwhelming.

balancing of interests: patent applicants will have to calculate the risk of not receiving a patent, relative to a delay in the time to approval. Under this rubric, a cash-strapped, infant company with a valuable patent will likely cite in a manner apt to promote the most expedited process of review, with less concern for the viability of the patent. Whereas, a corporation with deeper pockets can afford to wait longer to roll out a product.[31] From a policy standpoint, this analysis provides concrete evidence as to the extent that patent examiners are overworked. If time to approval is taken as an appropriate proxy for the amount of time spent examining a patent, the variation in filing periods across applicant citations will provide insight as to whether there is increasing, decreasing or fixed marginal thoroughness of examination. Further, to the extent that applicants are engaging in strategic backward citation, this result should grab lawmakers' attention. Such strategic opportunities stand opposite the overarching goal of Patent Law—"[t]o promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."[32]

1.   *Primary Hypothesis: Time to Patent Approval Does Not Differ Greatly Across Applicant Citations*

Intuitively, if patent examiners are overworked, then they have a limited amount of time to apportion to all patent application reviews.[33] Thus, they should spend approximately the same amount of time examining patent applications, irrespective of complexity or the quantity of prior art citations. Provided that this hypothesis holds true, applicants have a clear incentive to obscure the search for prior art, and to make the process of review less straightforward to the examiner; no matter the relevance of applicant citations, examiners will spend the same amount of time reviewing the application. Moreover, given the statutory presumption of validity afforded to approved patents, patents are significantly harder to invalidate once granted.[34] Thus, *all* patent applicants have a strategic incentive to over- or under-cite. In so doing, the applicant turns the application process into a *de facto* rubber stamp, which is then afforded increased protection in subsequent litigation. Moreover, this strategic incentive is magnified for inventors of patents less likely to pass muster.

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31.   Though, as mentioned above, the presumption of validity likely mitigates this balancing test.

32.   U.S. Const. art. I, § 8, cl. 8.

33.   *See supra*, note 15; *see also* Jon W. Dudas, *The Patent System: Today and Tomorrow*, Speech Before the Subcommittee on Intellectual Property (Apr. 21, 2005) (pointing to increasing patent applications and the resulting constraint on examiner resources as a result).

34.   *See* Lichtman & Lemley *supra*, note 15.

If this hypothesis holds true, it provides empirical validation to the criticism that patent officers are overworked. It also shows that there is a clear incentive for inventors, research companies and the legal firms prosecuting a patent to engage in strategic gamesmanship; a problem which merits statutory consideration—or, at a minimum, larger resource apportionment to the USPTO.

2. *Alternative Hypothesis: Time to Patent Approval Differs Across the Quantity of Applicant Citations*

In the event that the above result does not follow from the analysis, and the time from initial filing until approval does in fact vary with the quantity of applicant citations, this result, too, has implications for practitioners as well as policy-makers. On the one hand, if time to approval increases with applicant citations, there is a question of whether this increases proportionally, or at a decreasing marginal rate. In either case, this increased time of review will lead to strategic decision-making by inventors looking to file for patent protection. However, in the event that the time to review decreases with increasing citations (or with no citations), this would suggest either (i) that examiners become more resigned when they receive no initial citations, or (ii) that more applicant citations is a self-selecting measure, and implies a more robust application which thus requires less time to review. No matter the implication, the outflow will again be strategic over-citation to dissuade examiners from laboring over the approval process.

Regardless of the results of this analysis, the association of the quantity of applicant cited prior art and time to patent approval has implications for practitioners as well as policymakers. That patent officers are overworked and that the majority of patents are eventually approved is well documented.[35] However, little empirical evidence or exploration exists to corroborate these notions. Thus, this paper seeks to fill an important gap in the empirical literature surrounding prior art and its role in the process of patent application.

IV. Data

This paper utilizes two discrete datasets compiled from information released by the USPTO. The first dataset is comprised of metadata from

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35. *See* Lichtman & Lemley, *supra* note 19, (suggesting that patent examiners are overworked, leading to the need for reform to the presumption of validity); *see also* Bronwyn H. Hall & Dietmar Harhoff, *Post-Grant Reviews in the U.S. Patent System–Design Choices and Expected Impact*, 19 BERKELEY TECH. L.J. 989 (for a useful discussion of definitional issues related to the term "patent quality").

US utility patents issued from 1975 until the end of 2010.[36] This data is a compilation of patent characteristics, including filing date, date of issue, number of claims, and number of backward as well as forward citations for patents published from Jan. 1, 1975, to Dec. 31, 2010. This data was assembled from the "front page" data for issued patents and consists of information on 3,995,847 patents spanning 109 years.[37] It was extracted by Bhaven Sampat from the USPTO's *Casis* BIB Patents DVD.[38]

The second dataset utilized in analysis makes a distinction between different types of citations. In 2001, the USPTO began demarcating citations as either examiner citations or as applicant citations, in order to "better consider whether changes are required to the rules governing prior art statements."[39] This second dataset, too, was compiled by Sampat from publicly available information provided by the USPTO.[40] This data set contains the variable of interest for this paper. The final dataset used for analysis was created by augmenting the 1975 to 2010 bibliographic dataset with the newer data containing information regarding examiner citations. Because this data is limited to patents approved from 2001 to 2010, the data analyzed in this paper was limited to these patents only. Taken together, this final dataset includes the time of publication, the patent number, the number of claims, the quantity of forward citations,[41] the quantity of examiner citations and the quantity of applicant citations for each patent. In total, this dataset documents 1,643,596 patents granted across 9 years, with application dates extending as far back as December 15, 1944.

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36. *See* Bhaven Sampat, USPTO Patent and Citation Data, HARVAD DATABASE NETWORK (Sept. 3, 2012), http://hdl.handle.net/1902.1/16412UNF:5:ERqPZ7
enbwBRimghqDD4gQ== BhavenSampat[Distributor]V4[Version].

37. The earliest filing date is 1911.

38. *See* Sampat, *supra* note 24 (note, see codebook explaining the dataset).

39. UNITED STATES PATENT AND TRADEMARK OFFICE, MANUAL OF PATENT EXAMINING PROCEDURE (2001), *available at* http://www.uspto.gov/web/offices/pac/mpep/s1302.html.

40. Bhaven Sampat, Examiner Citation Data, HARVARD DATABASE NETWORK (Aug. 6, 2011), http://hdl.handle.net/1902.1/18735UNF:5:mKUxLoeuskOler9Lq8l7cw==
BhavenSampat[Distributor]V2[Version];

41. Note, the number of forward citations is (expectedly) right-skewed toward older patents, given that more recently issued patents have been published for less time, and therefore will not likely be drawn upon as heavily.

V. Analysis

A. Examiner Citations as a Function of Applicant Citations

Prior to regression analysis, qualitative examination was performed on the data to visually evaluate for trends. The first relationship analyzed is that between examiner citations and applicant citations. A scatterplot of the two variables provides a fairly clear portrayal of the relationship between the two variables. Note that, given the enormous size of the dataset—1,643,596 patents—scatterplots of the dataset in its entirety are unfeasible; as such, all scatterplots are comprised of a 1% sample (or 164,360) of the patents in the overall dataset. **Figure 1** displays the scatterplot of the relationship between examiner and applicant citations. As hypothesized, there is a [visually discernible] inverse relationship between the two in the shape of a hyperbolic function. Repeated iterations of this plot with differing random samples confirmed this general trend. This figure indicates that the quantity of examiner citations appears to increase when the quantity of applicant citations is low, and decrease as applicants cite more data. This association implies that patent examiners are forced to spend more time on prior art searches and citations when the applicant opts to underwhelm the USPTO with prior art.

Building on this graphical representation, the inverse of applicant citations was generated. Subsequently, utilizing the statistical modeling package curvefit yielded that an inverse relationship did in fact exist.[42] Ordinary least squares regression of this function was then carried out. **Table 1** tabulates these coefficients. Regression (1) confirms that there is a significant inverse relationship between the two.[43] This effect indicates that the marginal impact of an additional applicant citation is a reduction of the quantity of prior art cited by the examiner. Regressions (2) and (3) confirm this effect. Indeed, as more control variables are introduced, the effect actually increases slightly—meaning that the deleterious effect on examiner citations of each marginal applicant citation is magnified. Thus, there is strong empirical validation that applicant citations are inversely associated with the quantity of examiner citations; and, accordingly, with the amount of time spent in examination.

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42.   Liu Wei, "CURVEFIT: Stata module to produces curve estimation regression statistics and related plots between two variables for alternative curve estimation regression models," Statistical Software Components S457136, Boston College Department of Economics (2010), revised 13 Apr 2013; Note, in this instance the inverse of the number of applicant citations was generated and then tested against the number of examiner citations using the linear OLS model.

43.   It is important to bear in mind that all figures are apt to be statistically significant in the analysis of such enormous data. Overpower aside, analysis indicates that this relationship is significant at the 99.99999% level.

In order to provide context for this analysis, it is necessary to understand the extent to which inventors and applicants provide citations. **Figure 2** illustrates that the large majority of patent applicants cite little or no prior art in patent applications. Nearly 40% of applicants provide no references;[44] and, the mean number of citations is 10.5. Coupled with the inverse relationship presented above, this implies that many if not most patent examiners spend the bulk of their time searching for relevant prior art. This is a task which—given the broad range of inventions that flow through the Patent Office each day—examiners are significantly less equipped to discover than are inventors specializing in a narrow field.

Given that examiners are spending more time on citations (or are at least adding in more citations of their own) when applicants cite less prior art, the question shifts to whether or not applicants are spending grossly different amounts of time on applications based on the amount of prior art cited. If the USPTO is spending significantly more time on patents with fewer citations, this undermines the importance of the above result. If the USPTO were to take more time to approve patents with fewer applicant citations, this would merely reflect the increased time spent on providing more examiner citations. If, however, the time to patent approval did not vary greatly across the quantity of applicant cited prior art, then this would suggest that applicants who cite less prior art (and thus shift this burden onto the examiner) are deflecting attention from the merits of their patent application and are forcing the examiner to search for a "needle in a haystack," so to speak; instead of spending time evaluating the substance of the patent application.

B. Time to Patent as a Function of the Quantity of Applicant Citations

The analysis of the temporal effects of strategic applicant prior art citations then carries significant weight. In order to ascertain specifically how to model the data, again, graphical representation was utilized. **Figure 3** presents a scatterplot of the time from initial filing until patent approval against the quantity of prior art cited by the applicant. This chart illustrates a seemingly flat trend with select extreme values. Given these extreme values for the time to patent, a log transformation appeared appropriate. Applying this transformation to the dependent variable and re-plotting yielded **Figure 4**. Figure 4 provides a slightly more discernible trend. Once again, applying the curvefit package to this data, a log-linear relationship was confirmed. This model is seen in Figure 4 as an overlay.

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44. *See* supra, note 16 (this result comports with the findings of Alcier et al., indicating external validation for these results).

Imposing a regression upon this log-linear relationship gave **Table 2**. Regression (1) delineates a positive, significant relationship between the number of applicant citations and the time between filing and approval. However, this effect is extremely small: 0.08%. Placing this result in context, this implies that for each additional prior art citation provided by an applicant for a patent, the time to approval increases by less than one one-thousandth of the overall time taken in the patent process. Applying this margin to the average time to receive a patent—1098 days, or almost exactly 3 years—each additional citation provided increases the time to receive a patent by 0.94 days. Even by adding 100 applicant citations, the increase in time spent examining would be only 9.4 days. Which, given the overall length of time spent in examination, is relatively trivial.[45] By adding in additional controls, this already small effect is nearly wiped out entirely, regressions (2) and (3) show that the effect becomes negligible as more controls are applied.

That the time to patent increases with the quantity of prior art citations, albeit negligibly, in fact bolsters the claim that underwhelming the Patent Office is associated with an examiner spending a larger proportion of the time allotted to patent evaluation on finding and citing to prior art. And, to the extent that this task is mutually exclusive of substantive evaluation of the claims of the application, this has the effect of less deserving patents being afforded protection. It should, however, be noted that this result is not inconsistent with intuition: that higher quantities of applicant citations imply a higher degree of complexity, and therefore a prolonged period of review. Yet, this impact is theoretically controlled for by the inclusion of the number of individual claims in the application (a proxy for complexity). Indeed, the inclusion of this variable, and other controls has a deleterious effect upon the size of the coefficient. Regression (3) presents a minimally impactful effect of applicant citations on the time required for patent approval.

VI. Conclusion

The results of this analysis indicate (1) that patent examiners cite significantly more prior art when applicants provide less (which is often), and (2) applicants spend nominally more time on patents with more applicant cited prior art. Taken together, this implies that though examination time varies little with increased applicant citations to prior art, the quantity of examiner citations varies greatly. So too, then, does the time required of the examiner to provide these citations. And, since the

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45. Adding an additional 200 citations, corresponds to only an 18.8 day increase. Though, adding 1000 additional examiner cites yields a less negligible 94 day (3 month) delay.
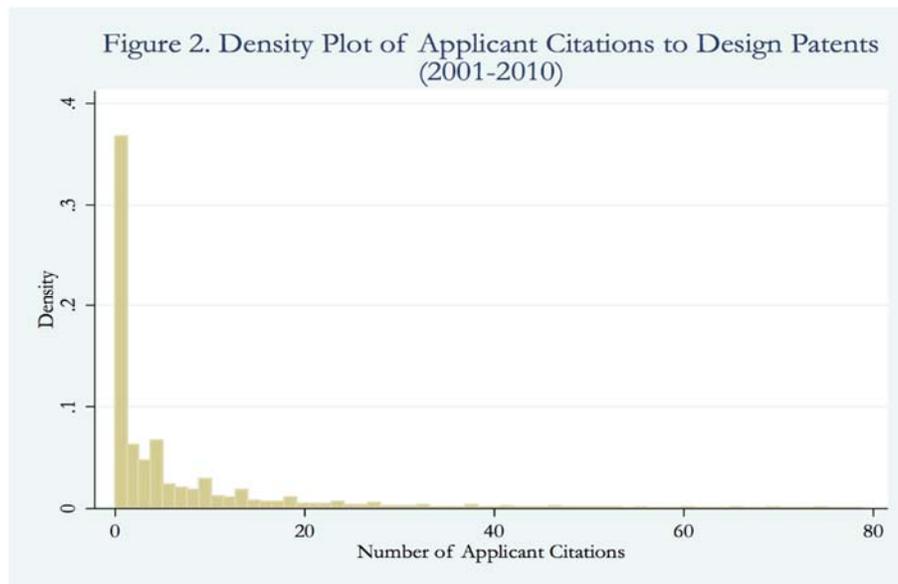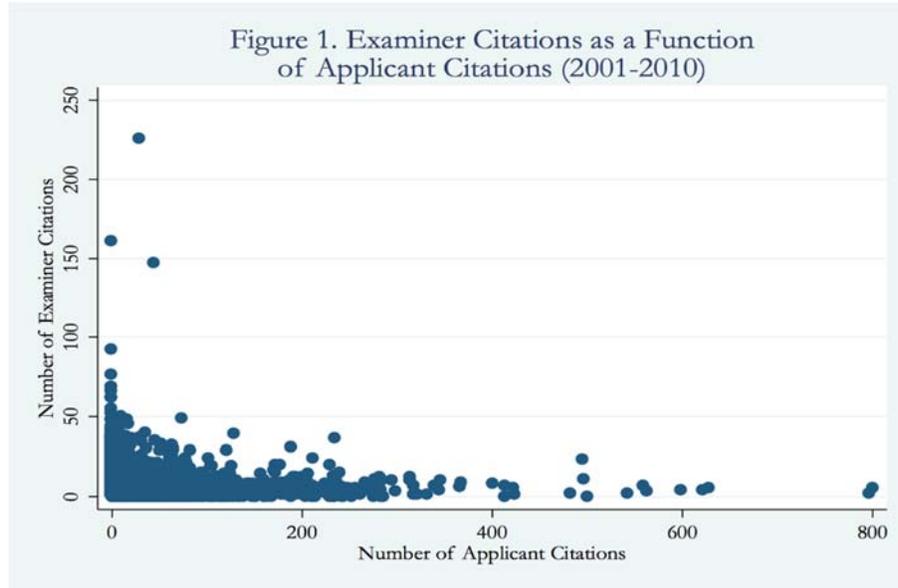
time spent in the approval process appears relatively fixed across applicant citations, applicants who purposefully omit prior art stand to gain by the examiner spending a larger share of this examination time seeking out relevant prior art.
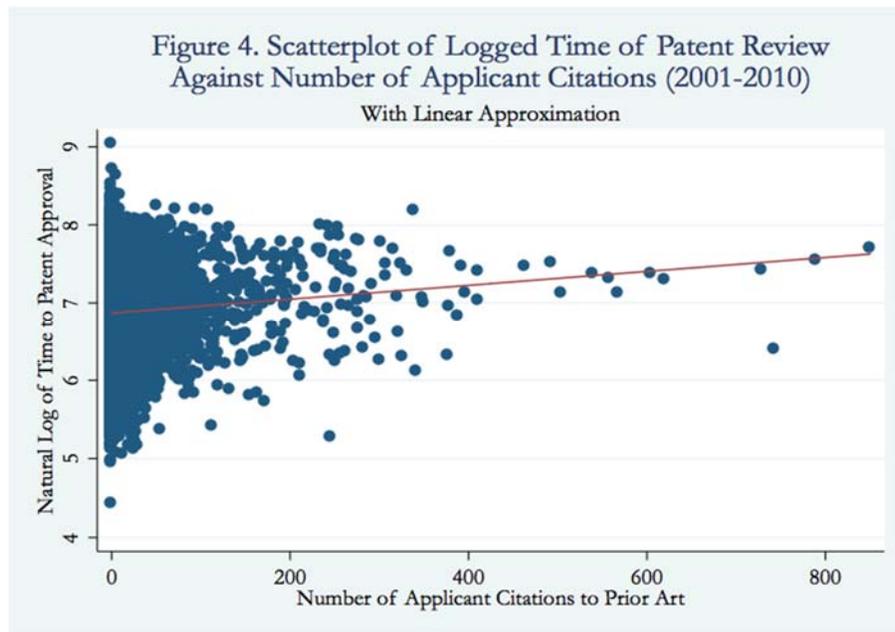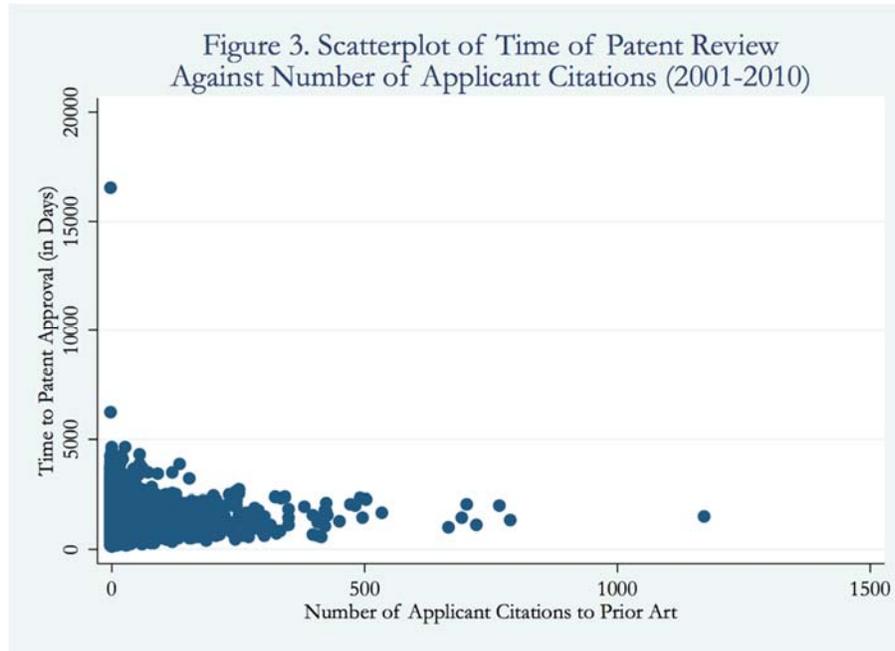
Thus, applicants who under-cite or fail to cite any prior art stand to gain from decreased attention to the merits of their patent application. This effect is magnified for applicants of particularly weak patents. Moreover, given the strength of the presumption of validity, these patents are likely to be upheld in subsequent litigation, and also to preempt innovation more deserving of protection. Further, this analysis suggests that though the time to approval increases with applicant citations, it does so only marginally. This result lends weight to the conclusion that the USPTO is severely over-worked and under-resourced, and is applying a "one-size-fits-all" approach to the process of patent approval, apportioning approximately the same amount of time to all patents, regardless of their innate complexity.

In order for these conclusions to be strengthened, further research is necessary. In particular, it would be useful to understand the amount of time required of an examiner to cite prior art. It is possible that given the state of patent application, examiners have become particularly adroit at quickly finding and listing relevant prior art. Additionally, it is of interest the extent to which this process of searching for prior art overlaps with substantive evaluation of patents. It is indeed possible that in searching for prior art, examiners perform much of the diligence that they would otherwise perform in evaluating the patent. Though, it stands to reason that at least some time is wasted (*i.e.*, the time wasted in finding unrelated patents). Notwithstanding, these conclusions have reaching implications for applicants, practitioners and policymakers. The current structure of the USPTO incentivizes applicants to shirk the task of citing to relevant prior art. This burden-shifting distracts examiners from their actual task of evaluating patents on their merits. Given the patent office's justification for providing increased availability to examiner citation data, the PTO should take note of this phenomenon of under-citing and take the necessary actions to mitigate its impact.

VII. Appendix

A. Figures

Figure 1. Examiner Citations as a Function of Applicant Citations (2001-2010)

Figure 2. Density Plot of Applicant Citations to Design Patents (2001-2010)

Figure 3. Scatterplot of Time of Patent Review Against Number of Applicant Citations (2001-2010)

Figure 4. Scatterplot of Logged Time of Patent Review Against Number of Applicant Citations (2001-2010)
With Linear Approximation

B. Tables

Table 1. OLS Regression of No. of Examiner Citations on the Inverse of No. of Applicant Citations

VARIABLES	(1) Examiner Citations	(2) Examiner Citations	(3) Examiner Citations
1/(Applicant Citations)	0.0113	0.0117	0.0118
	(8.82e-05)	(8.90e-05)	(8.80e-05)
Number of Claims		0.0109	0.0109
		(0.000296)	(0.000297)
Number of Forward Cites as of 12/31/2010			0.0319
			(0.000451)
Primary U.S. Patent class as of 12/31/10			-0.00542
			(3.70e-05)
Issue Date			0.000124
			(4.10e-06)
Constant	4.896	4.685	3.867
	(0.00522)	(0.00773)	(0.0699)
Observations	1,643,596	1,643,596	1,638,694
R-squared	0.010	0.011	0.025

Standard errors in parentheses

Note: All statistics are significant at a level in excess of $p<0.000001$.

Table 2. Log-Linear Regression of Time to Patent on the No. of Applicant Citations

VARIABLES	(1) ln(Time to Patent)	(2) ln(Time to Patent)	(3) ln(Time to Patent)
No. of Applicant Citations	0.00086	0.00064	0.0000668
	(1.21e-05)	(1.20e-05)	(1.10e-05)
No. of Examiner Citations		0.0116	0.0139
		(7.11e-05)	(6.52e-05)
Number of Claims		0.0038	0.00331
		(2.72e-05)	(2.50e-05)
Number of Forward Cites as of			0.00166
			(3.81e-05)
Primary U.S. Patent class as of 12/31/10			0.000877
			(3.12e-06)
Issue Date			0.00017
			(3.46e-07)
Constant	6.871	6.744	3.643
	(0.000409)	(0.000720)	(0.00586)
Observations	1,643,596	1,643,596	1,638,694
R-squared	0.003	0.031	0.208

Standard errors in parentheses

Note: All statistics are significant at a level in excess of $p<0.000001$.