University of Connecticut

Department of Economics Working Paper Series

Patent Validity Challenges and The America Invents Act

by

Talia Bar
University of Connecticut

Brendan Costello
Yale Law School

Working Paper 2017-21
October 2017

365 Fairfield Way, Unit 1063
Storrs, CT 06269-1063
Phone: (860) 486-3022
Fax: (860) 486-4463
http://www.econ.uconn.edu/

Patent Validity Challenges and The America Invents Act*

October 2017

Talia Bar◊ and Brendan Costello◊◊

University of Connecticut and Yale Law School

Abstract: Patent reexamination or patent review systems can lower the cost of challenging patent validity and help improve patent quality. We empirically investigate post-grant patent validity challenges at the U.S. Patent and Trademark Office, and how the 2011 America Invents Act affected them. We compare the inter partes reexamination procedure with the inter partes review procedure that replaced it after the reform. To identify the effect of the policy changes, we exploit the fact that patents filed before the act passed, but granted after the new inter partes review system took effect, are not eligible for reexamination in the old system. We find that more patent challenges end with a patentee win after the policy change. Still,

* We would like to thank Edlira Kostallari, Geralda Laguerre Alex Rojas and Thomas Ropes for excellent research assistance. We are grateful to Jorge Aguero, Aija Leiponen, Mark Myers, Joseph Shapiro, Mike Shor, Robin Stitzing, Andrew Toole, Patrick Adams, and participants at the 2017 International Industrial Organization Conference and the USPTO Office of the Chief Economist's Visiting Speaker Series for insightful conversations and to Haim Bar for statistical consulting. We gratefully acknowledge Docket Navigator as the source of some of our data.
◊ Corresponding Author: Department of Economics, University of Connecticut. 365 Fairfield Way, Oak Hall Room 335, Storrs, CT 06269. E-mail: talia.bar@uconn.edu.
◊◊ Brendan Costello, email: brendan.costello@yale.edu.

at least one patent claim is canceled in more than 60% of the cases. Litigated patents issued to small entities more often had at least one claim canceled compared to other patents.

1. Introduction

For some time, scholars have expressed significant concerns over the quality of patents granted in the United States. They have referred to the patent system as "broken" (Jaffe and Lerner, 2004), and have wondered "what to do about bad patents?" (Lemley, Lichtman and Sampat, 2006). Others have even proposed abolishing the patent system altogether (Boldrin and Levine, 2013). The United States Patent and Trademark Office has itself recognized the importance of patent quality, noting that "High-quality patents enable certainty and clarity of rights, which fuels innovation and reduces needless litigation."[1]

As one measure aimed at improving patent quality, several patent systems in the world allow third parties (in particular, accused infringers) to challenge the validity of granted patents in administrative proceedings. The decision makers in these proceedings are housed within the patent system and deal predominately or exclusively with patent validity cases. Compared to traditional litigation, this degree of specialization could resolve challenges more quickly, more cheaply, and more accurately. Making use of such procedures could help eliminate bad patent claims and increase the quality of the pool of already-granted patents.

In 1999, the United States introduced inter partes reexamination (IPX), which for the first time allowed third parties to actively challenge patent validity at

[1] See http://www.uspto.gov/patent/initiatives/enhanced-patent-quality-initiative-0 last accessed 12/24/2016.

the patent office. In 2011, the America Invents Act substantially reformed these procedures. Effective September 2012, the AIA discontinued the inter partes reexamination system, and replaced it with a new system, inter partes review (IPR).[2] Because these administrative procedures are relatively new, not much is known about how they function or the effects of the recent reform. In this paper we present an empirical analysis of validity challenges at the patent office. We study the characteristics of patents that survive a challenge, and the effects of the recent policy reform on the outcomes of these challenges. We compile a new dataset that consists of patent validity challenges from 10/10/2010 to 08/24/2014.

Inter partes reexamination was slow to catch on, but gradually grew in importance. Administrative patent challenges became even more popular since the AIA; the number of patents challenged under IPR each year is several times greater than those challenged under IPX. While under both systems, challenges are predominantly used as a tool alongside litigation,[3] the new review procedure differs from the previous reexamination process in a number of ways. Notably, IPR costs more, is quicker and is more similar to a trial (see Section 3 for more details). Whereas before the policy change reexamination was handled by patent examiners, since the AIA, IPRs are conducted by the Patent Trial and Appeal Board (PTAB).

[2] The new system also includes a post grant review option that is limited to the first 9 months after patent grant. We do not include post grant reviews.

[3] 76% of IPX requests were for patents known to be in litigation according to USPTO statistics at http://uspto.gov/learning-and-resources/statistics. Likewise, an October 2015 study found that "over 80% of IPR filings were associated with co-pending federal court litigation" (Cutler 2015).

As the use of administrative validity challenges has grown, so too has the controversy surrounding these procedures. The PTAB has been referred to as a patent "death squad", accused of having anti-patent slant and harming innovators. (See for example Levy, 2015, Morinville, 2016 and comments to their articles in IPWatchdog). We use our data to examine the effect of the policy change, and whether it has disadvantaged patentees. We find no evidence that the policy change introduced a negative bias against the patentee in reexamination.

Since the AIA reform of the reexamination system, the share of patent challenges that end in a "patentee win"[4] has actually increased from about 22% to 36% of patent challenges. There are some differences in the characteristics of patents challenged before and after the policy change, including an increase in the average number of claims and in the composition of patent categories, in particular, an increase in challenges of patents in the Computers & Communications category, and a decrease in challenges of patents in the drugs and medical category. Controlling for observed patent characteristics, we still find that patentees are more likely to win a patent challenge case after the policy change.

[4] We explain the construction of our "patentee win" variable in detail in Section 4. In essence, we view a patentee win as a challenge where all claims are denied review or confirmed. Any cancelled claims would be a patentee loss under this definition.

One challenge in estimating the effect of the policy change is that the IPR "treatment" could be endogenous. This would be the case if reexamination petitioners can select between the two systems (at least close to the date of the policy change), and their selection is associated with patent quality, thus biasing the estimate of the effect of the policy change. In light of this concern, we estimate the model using an instrumental variables approach. Under this approach too, we find no evidence of negative bias towards the patentee resulting from the policy change.

Lastly, we are interested in comparing patent challenge outcomes for patents assigned to small entities. Scholars have stressed the importance of small inventors to our economy (see for example Lanjouw and Schankerman, 2004). The share of small entity patents is the same in both systems. Challenged small entity patents are less likely to end with a patentee win, as compared to those issued to other patentees. This could indicate that these patents are of lower quality compared to other reexamined patents. Or, it could be that these patentees are less able to defend their patent in reexamination. Our finding complements a similar result reported in Allison et al. (2011). The authors found that when the cases do not settle, patents originally issued to small entities are significantly less likely to win in trial or judgement.

The remainder of this paper proceeds as follows. In Section 2, we review existing literature on post-grant validity challenges and on small entities. In Section

3, we provide background information on IPX, IPR, and the change in policy introduced by the AIA. In Section 4, we describe how we constructed the dataset and in Section 5, we make preliminary descriptive observations. In Section 6, we present the results of our study; we compare the reexamination system before the AIA policy change (IPX) to the patent review system after the policy change (IPR). Section 7 offers concluding remarks.

2. Related Literature

Economics literature surrounding patent challenges has been relatively scarce, perhaps due to the somewhat infrequent use of patent reexamination in the United States, especially in the early years. Hall et al. (2004) provide a broad background on challenging a patent's validity post-issue. The authors compare the U.S. reexamination process to that of the European Patent Office, and conclude that there are welfare gains to be had by improving U.S. post-grant opposition and avoiding litigation costs. Chiou (2006) argues that a third party with invalidating prior art could collude with the patentee to share monopoly power.

Graham et al. (2003) compare patent opposition in the European Patent Office (EPO) with USPTO patent reexaminations in the ‘80s and ‘90s, in the technology categories of biotechnology and pharmaceuticals, and semiconductors and computer software. In both patent offices, valuable patents are more likely to be challenged and European oppositions are more frequent than U.S.

reexaminations. Graham and Harhoff (2014) propose revising the U.S. reexamination system to resemble the EPO post-grant review system. The authors predict a range of welfare gains in the billions of dollars, due to the revocation of bad patents and avoided litigation costs.

Reexamination trends and practices have received greater attention in the law literature. Gardella and Berger (2009) discuss the use of reexamination as a strategic tool by alleged infringers to stay pending litigation. They predict that success in the reexamination system will cause patent holders to file narrower patents that are less likely to be invalidated in these proceedings. In a recent contribution, Vishnubhakat et al. (2016) study how litigants use inter partes review and covered business method review. They find that the majority of inter partes review validity challenges are brought by district court defendants.

One of our main results involves patents issued to small entities, a class of patentees that has been investigated in prior literature. Lanjouw and Schankerman (2004) find that patentees with small patent portfolios run a higher risk of litigation. Schankerman and Gallaso (2015a) show that invalidation of patents owned by large firms triggers more follow-on innovation by small firms, and Schankerman and Gallaso (2015b) show that a loss of patent rights significantly increases the likelihood of exit for small firms. These contributions highlight the importance of outcomes of patent challenges for small entities.

3. Background on Patent Challenges at the USPTO

Historically, administrative procedures to challenge patent validity were not available in the United States. Starting in 1981, third parties could petition the patent office to reexamine a patent, however, these requests were ex parte - third parties were not able to actively participate in the challenge.[5] The only way for a third party to actively challenge a patent's validity was through district court litigation. Often, this happens defensively; a third party alleged to have infringed a patent will attempt to render infringement moot by proving that the patent was invalid to begin with.

In 1999, the American Inventors Protection Act (AIPA) created an administrative proceeding - inter partes reexamination (IPX) - that allows any third parties (including one sued for infringement) to request patent reexamination, to be part of the reexamination process and to submit evidence of patent invalidity.[6] Following the American Invents Act, The IPX system was then replaced by the inter partes review (IPR) proceeding.

Inter partes patent reexamination and review have significant benefits over challenges through litigation. First, petitioners must show invalidity by a "preponderance of the evidence", while, in court, patents are presumed valid and the challenger must prove invalidity with "clear and convincing evidence". This

[5] See http://fishpostgrant.com/ex-parte-reexamination/.
[6] See http://www.uspto.gov/web/offices/pac/mpep/s2601.html

means that there is a lower burden of proof to invalidate a patent in reexamination or review than in court. Second, reexamination and review costs are estimated to be substantially lower than litigation costs.[7] Finally, courts can, and often do, issue stays of litigation for pending patent suits, allowing the costly civil trial to be put on hold while the PTO adjudicates a reexamination or review.

The early reexamination process, IPX, was initially slow to be utilized. According to published USPTO statistics, only 26 inter partes reexaminations were filed in its first four years.[8] The next four years saw a still low 282 filings. However, filings appeared to be on an upward climb before IPX was discontinued in 2012 and was replaced with a new reexamination procedure. There were 1,081 IPX filings between 2008 and 2011, and 530 in 2012 alone.

USPTO patent challenges have grown in importance in light of the 2011 America Invents Act, which makes several changes to the procedure for third-party reexaminations. First, the AIA changed the standard for granting a request for reexamination, raising the bar from a "substantial new question of patentability" to "a reasonable likelihood that the requester will prevail with respect to at least one

[7] Southard and Prestia (2012) estimate costs of the various procedures, using data from the 2011 AIPLA Economic Survey. They find that the average costs to a final appealable decision are $128,000 for IPX, while median civil litigation costs are nearly $2.5 million dollars (for a patent controversy worth between $1-$25 million dollars) or $650,000 (for a controversy worth less than $1 million). A recent survey by RPX Corp places the average cost of IPR at $487,000 per petition, positioning it between IPX and civil litigation. See https://www.rpxcorp.com/2015/07/02/iprs-reality-amid-the-pyrotechnics/

[8] See http://uspto.gov/learning-and-resources/statistics

claim," which is expected to increase the rate of reexamination denials (Phillips and Laurence, 2011). This standard took effect for the final year of IPX and remains in effect for IPR. Furthermore, effective September 16, 2012, the Act replaced IPX with Inter Partes Review (IPR) and Post-Grant Review (available for only the first 9 months of a patent's life).[9]

The structure of reexamination has changed as well; it now appears closer to litigation and farther from original patent prosecution. Unlike IPX, IPR allows for the deposition of witnesses and other associated discovery, as well as an oral hearing with PTO officials. Stahl and Heckenberg (2011) explain that the "new review proceedings may also be more enticing to a patent challenger since they make available to the accused infringer more procedures analogous to those available in patent litigation." Most notably, the AIA has mandated that IPR proceed expediently, with an expected overall timing of 18 months, half the time expected of IPX.[10] Additionally, in IPX only patents filed after November 29, 1999

[9] Post-Grant Review, however, only applies to patents filed after 03/16/2013 (77 FR 48729). Patents filed earlier than this date are eligible for IPR immediately upon grant. The vast majority of outstanding patents, and all but 3 of the patents in the dataset described in the following section, are eligible for immediate IPR and not post grant review.

[10] IPR is given statutory time restrictions: 6 months to reach an institution decision (grant or deny), split into a 3-month period for patent owner response (37 C.F.R. § 42.107) followed by another 3-month period for USPTO decision (35 U.S. Code § 314). Then another 12 months to reach a final determination (cancel, confirm, etc.) (35 U.S. Code § 316). Limited 6-month extensions can be granted "for good cause shown". Thus, we would expect most IPRs to reach a final decision within 18 months, or 1.5 years. By contrast, the median time from filing to certificate issue is 32.7 months for IPX (http://www.uspto.gov/sites/default/files/documents/inter_parte_historical_stats_roll_up_EOY 2014.pdf).

could be reexamined while in IPR this restriction was lifted, expanding the set of patents that can be challenged.

However, not all changes are beneficial to the requestor. Challenges under the AIA have become substantially more expensive.[11] Furthermore, estoppel, which limits the accused infringer's ability to challenge in litigation the validity of the reexamined claims she earlier challenged in reexamination, has become more restrictive under IPR. Estoppel now binds earlier (before appeals), restricts both district court and future PTO actions, and applies not only to validity grounds that were actually raised in IPR, but to any that could have been raised.[12] Nevertheless, these changes combined still appear to render IPR more appealing or feasible as a reexamination tool for accused infringers and other third parties. IPR surpassed 3,000 requests in its first three years – over 1,000 more than IPX in its entire 13-year tenure.[13]

The policy change has already proven to be controversial. As we mentioned above, multiple concerns have been raised concerns that the PTAB is biased against patentees. Senator Chris Coons co-sponsored a bill that would make it harder to invalidate a patent at the PTO, arguing that the PTO tribunal has become far more

[11] This and other statistics on AIA changes from "IPX vs. IPR: A Cheat Sheet," via Sterne, Kessler, Goldstein.
[12] For a description of these estoppel changes, see article by Fish and Richardson LLP, available at http://fishpostgrant.com/post-grant-review/.
[13] AIA trial statistics through 9/2015 http://www.uspto.gov/patents-application-process/appealing-patent-decisions/statistics/aia-trial-statistics

powerful than Congress had originally envisioned.[14] Another concern is the potential for abuse of this new proceeding. According to Walker and Copeland's April 2015 Wall Street Journal article, Kyle Bass, a hedge fund manager, used inter partes review to challenge patents held by pharmaceutical firms solely to profit from short selling their stock or by buying their competitors'.

4. Data

Our data consists of patent reexamination and patent review filings from 10/10/2010 to 8/24/2014 and their corresponding patents.[15] The midpoint of our window is 9/16/2012, the date that the AIA policy change from IPX to IPR took effect. We next chose a window around this midpoint to ensure we were not truncating IPR outcomes. IPR petitions must be granted or denied (or partially so) within six months of the filing. A trial to decision should be reached within another year. We therefore chose the end date of our sample to be 1.5 years earlier than the last date on which we collected outcomes (2/24/2016), this ensures that each IPR filing in our data had at least 1.5 years from the time it was filed to reach a

[14] Senator Coons' comments are summarized in a January 6, 2016 Duke Law News article. See https://law.duke.edu/news/patent-pending/

[15] We concentrate only on utility patents for this analysis. We exclude design patents because they are plausibly systematically different in many respects from utility patents and because, as a practical matter, these patents are often missing in the datasets we use for our analysis. In total, we drop 11 design patents that would otherwise be within our window and have available outcomes.

decision.[16] Next, we took a window of equal duration right before the policy change, which determined our start date, 10/10/2010, allowing for 707 days on either side of the IPX/IPR policy change (9/16/2012).[17] We have a total of 1,013 IPX and 1,412 IPR observations, of which 610 and 931, respectively, have outcomes. Figure 1 illustrates a timeline of important dates and the window of time we use for comparing the two systems.

Each observation in our data represents a single (IPX or IPR) "challenge" which we define as a single patent challenged by one party who filed a petition on a certain date. In the IPX system, each challenge corresponds to one reexamination filing. In the IPR system, there could be multiple filings associated with one patent-party-date combination. For example, a party could split its challenge to two filings to overcome a new page limit. We collapse these to a single challenge.

To construct our dataset we combined data on IPX reexaminations, IPR reviews, and the corresponding challenged patents from a number of sources, including several public databases put out by the USPTO: the Patent Examination

[16] Note that this does not mean that all observations in the sample have outcomes. Many IPRs will be dropped or settled before ever reaching an outcome. However, this 1.5-year period at the end of the sample ensures that each challenge has had sufficient time for it to have reached an outcome under the provisions of the law.

[17] Because IPX took on average longer than IPR, it is possible that some of the later IPX observations in our sample were still pending when we extracted the reexamination certificates (in March 2016). However, since IPX terminated in 2012, each IPX in our dataset had at least 42 months to reach a decision. According to USPTO published statistics, a "Notice to Issue Reexamination Certificate" is available within 42 months for over 75% of IPX filings without appeals, and for nearly 50% of those with a PTAB appeal decision. See http://www.uspto.gov/about/advisory/ppac/20131121_PPAC_CRU.pdf.

Research Dataset (PatEx),[18] the Patent Full-Text and Image Database (PATFT),[19] the Patent Claims Research Dataset,[20] and the Patent Assignment Dataset.[21] We also use data from DocketNavigator,[22] and the Reed Tech database.[23]

IPX filings are identified via the PatEx database, which gives us the filing date of each IPX and its associated patent.[24] We gather data on the outcome of each reexamination using reexamination certificates (issued under 37 CFR 1.997) which are part of each IPX image file in the Reed Tech database. For file wrappers that were not yet available in the Reed Tech database, we downloaded the reexamination certificates that were available as of August 3, 2016 (the date we last looked for certificates) directly from the Public PAIR website. We then hand coded outcomes of the reexamination process using these certificates. Before a reexamination proceeding, the reexamination request must first be granted or denied by the USPTO. To record denials, we found instances where the image file wrapper contained a document entitled 'Determination – Reexam denied' and the

[18] PatEx is a comprehensive database with a range of bibliographic data on public patents. Public patents are those released in Public PAIR, a subset of the private PALM. This is a dataset of over nine million patents, through December 2014. See Graham, Marco, and Miller (2015).
[19] The PATFT database is an electronic database that allows searching for forward and backward citations of patents. See http://patft.uspto.gov.
[20] See Marco, Sarnoff, and deGrazia (October 2016).
[21] See Marco, Alan C., Graham, Stuart J.H., Myers, Amanda F., D'Agostino, Paul A and Apple, Kirsten, The USPTO Patent Assignment Dataset: Descriptions and Analysis (July 27, 2015).
[22] The Docketnavigator database provides data on IPR filings, institution decisions, and outcomes since the inception of IPR, as well as litigation filings through 2000. See http://home.docketnavigator.com/
[23] Reed Tech has a contract with the PTO to crawl their Public PAIR site and archive patent image file wrappers for public download, available at patents.reedtech.com.
[24] Coded as children in the "Continuity Data" dataset, with the prefix "95"

reexamination had ceased to go forward; we coded these as a complete denial of reexamination.

We obtained Data on IPRs from DocketNavigator in a similar method to that used by Vishnubhakat et al. (2016). We found patent review filings (by restricting to PTAB cases), and information on whether an IPR was granted, denied, or partially granted.[25] A Docket Navigator representative provided additional data with details on the determination of validity of each claim. To merge the different data sources, we used the combination patent-party-date.

[Insert Figure 1 (timeline)]

We have outcomes for 60% of our IPX observations and 66% of our IPR observations. Outcomes may be missing for several reasons. The process may have been terminated before final outcome for some reason, or it may still be ongoing as of the date of our data download. We've made an effort to minimize occurrences of ongoing cases by allowing for a 3-year gap between the end of IPX and the data download, and accounting for the statutory restriction on IPR to reach a decision within 1.5 years. IPX reexamination certificates are only issued after appeals are finished, so some of the IPX observations may still be caught up in the federal

[25] Denials occur at the claims level. Some claims are denied, while others are granted, reexamination. To account for this difference, we coded a complete denial when there were denials present for an IPR, with no grants or other institution outcomes (joinders, consolidations, etc.) present for that IPR. In this way, a complete denial represents the same thing for IPR as for IPX: a total denial of reexamination and a win for the patentee.

circuit. Additionally, IPR may terminate after the parties settle. We discuss later the effects these differences might have on the interpretation of our findings.

Each challenged claim may take on one of many outcomes. Claims in IPX may be cancelled (or, very rarely, voluntarily 'disclaimed' by the patent holder), confirmed, or amended, and new claims may be added. Compared to IPX, IPR limits the ability to amend or add claims, and is therefore more likely to result in claims that are either cancelled or confirmed. Figure 2 illustrates the frequency of cases that include each outcome in IPX and IPR.

[Insert Figure 2]

We create two new variables by aggregating claim outcomes to the challenge level. The first outcome variable, "Patentee win," takes the value 1 if the challenge results only in claim confirmations or the addition of new claims, or if reexamination/review was denied; 0 if the outcome was any cancelled, indefinite, disclaimed, or amended claims; and missing if we have no outcome data for the challenge. Because a total denial precludes any claim cancellation, we code Patentee win=1 in the case of a total denial of the reexamination or review request.[26] The AIA changed the standard for denials beginning in September 2011, a year earlier than the IPX to IPR transition. In our dataset, denials made up 8% of all outcomes pre-AIA, 13% of all outcomes in the intermediate period between the

[26] Except for a small share of patents that only have amended claims (2%), all the cases that are classified as patentee win equal 0 are such that at least one of their claims was canceled.

AIA and IPR, and 27% of outcomes in our sample of IPR. For certain parts of our analysis, we also examine a variant of this outcome variable, called "Patentee win excluding denials," which is constructed identically, except that cases with total denials are left as missing values.

Not all patent claims are of equal importance to the patentee. The first claim in a patent is likely to be one of particular importance, and breath.[27] We, thus, define an outcome variable "claim 1 cancelled" that takes the value 1 if the first claim was canceled and 0 if the challenge is denied or results in a different outcome. We consider this outcome to indicate a significant loss for the patentee.

Figure 3 illustrates the mean values of the outcome variables in IPX and IPR. In IPR, a larger share of challenges end in a patentee win, and claim 1 is invalidated in a smaller share of cases.

[Insert Figure 3]

To obtain data on each challenged patent, we use the variety of USPTO datasets introduced earlier. The PatEx database provides basic information such as filing date, patent grant date, and patent class. The Patent Claims Research Dataset provides the number of independent patent claims at grant, as well as the minimum number of words in these independent claims. We follow Marco, Sarnoff, and deGrazia (2016) and use these two variables as measures of patent scope. Patents

[27] See for example http://www.ipwatchdog.com/2014/07/12/understanding-patent-claims/id=50349/.

with more independent claims, or a fewer minimum number of words in these claims, are expected to be of greater scope. In addition, we sum the number of independent and dependent claims in order to generate claim-normalized variants of certain variables.

The USPTO Patent Full-Text and Image Database (PATFT) allows us to find the number of backward and forward citations. These variables are commonly used as proxies for patent value (see for example Lanjouw and Schankerman, 2001, and Harhoff et al., 2003). Forward citations are recorded using an automated search of the database using the 'ref' function. For a given patent number, this search tallies the number of other patents citing it in the PATFT database. Backward citations are listed in tables by type of citation in the PATFT page, and are gathered by tallying the number of patent, foreign, and other citations.

Using the existing PatEx data, we also calculate a variable "Age" as the time between patent issue date and the challenge filing date.[28] We similarly calculate "Prosecution" as the time between patent filing date and patent issue date. Following Lanjow and Shankerman (2001), we generate per-claim variants for forward and backward citations, as well as for prosecution. We collected forward citations that accrued as of a particular date (3/28/2016). This creates a truncation issue with forward citations since older patents have had more time to accrue

[28] The reexamination filing date was listed as earlier than the patent grant date in 5 observations, causing the age variable to be negative. We treat these as missing values.

citations. To alleviate this problem, we normalize the number of citations by the number of years between the patent's issue date and the date we collected forward citations.[29] The combination of these two transformations results in the new forward citations variable "Annual citations per claim".

We also classify patents according to their technology area in two distinct ways. First, we record each patent's USPC classification (included in the PatEx database); our data spans 308 unique USPC classes. Second, we classify each patent according to the six broader NBER patent categories as described in Hall et al. (2001).[30]

5. Preliminary Observations

5.1 The Frequency of Patent Challenges

Figure 4 provides an illustration of the frequency of USPTO challenges over time in our sample window. The figures show a gradual increase in reexamination challenges during the IPX years. Interestingly, there is a spike in IPX reexamination challenges in the last month of IPX in anticipation of its displacement by IPR. One

[29] There seems to be no perfect way to correct for truncation. See Hall et al. (2001) for the limitations of different methods, including the "fixed window" approach. Our data only includes total citations on a specific date, which is why we correct for truncation by finding the annual average. If citations increase at an increasing rate, we might be somewhat underestimating annual citations for younger patents. In section 6.1 we match patents using filing date and patent class alleviating this concern.

[30] Because the USPTO changes and adds patent classes over time, the original 2001 mapping from USPC class to NBER tech category yields several dozen observations with an unmatchable class in our dataset. To mitigate this problem, we use an updated version of the mapping provided by the NBER Patent Data Project, available online at https://sites.google.com/site/patentdataproject/Home/downloads/patn-data-description

explanation for this rush to apply before the change was implemented could be that the petitioners wanted to take advantage of the lower cost of IPX.[31] The rate of challenges was lower in the initial few months following the policy change during the last quarter of 2012, which can be explained by the spike that occurred in the last month of IPX. For the remaining IPR period, we observe significantly increased challenge rates.

[Insert Figure 4]

5.2 Mean Characteristics of Patents Reexamined in IPX and IPR

In Table 1, we compare the means of patent characteristics for patents reexamined in IPX with those of patents reviewed in IPR. We restrict to cases for which we observe outcomes. In total, we have 1,541 observations of which 610 are IPX observations and 931 (about 60%) are IPR observations. The mean number of claims is about 27 in IPX and about 31 in IPR, a significant difference. However, there is no significant difference in the number of independent claims; this result is driven by greater dependent claims in IPR than IPX. In addition, there is no significant difference in the minimum number of words in independent claims; we find no evidence of any difference in patent scope between IPX and IPR. There is also no significant difference in the number of annual forward citations per claim between patents in IPR and patents in IPX (0.23 in IPX and 0.26 in IPR), nor a

[31] See for example Sterne, Kessler, Goldstein & Fox P.L.L.C. "Consider requesting Inter Partes Reexamination (IPX) before it is displaced by Inter Partes Review (IPR) on September 16, 2012." Available at http://ptolitigationcenter.com/wp-content/uploads/2009/08/ipx-v-ipr.pdf

significant difference in backward citations per claim (5.81 in IPX and 6.57 in IPR). The difference in prosecution time per claim is not significant either (78 days in IPX and 71 days in IPR). The share of patents assigned to small entities is slightly more than 30% in both IPR and IPX.

[Insert Table 1 – compare means IPX and IPR]

Comparing the frequency of the 6 technology categories in the two systems, there are no differences between the systems for three of the groups; there are significantly more patents in the Computers & Communications category under IPR than under IPX, yet significantly less patents in the Drugs & Medical category and significantly less in the sixth category titled "Others".

There is a significant difference in the age of challenged patents in the two systems. In IPX the average age is close to 1,314 days (about 3.5 years) and in IPR it is close to 2,354 days (about 6.5 years). It is not surprising that older patents are reexamined in IPR because in IPX only patents filed after November 29, 1999 could be reexamined while in IPR there is no such restrictions.[32] Average age is still higher in IPR if we only remove patents filed before 1999, but if we remove patents filed before November 5, 2001 (707 days, after the November 29, 1999, to mimic

[32] The AIA policy reform has also introduced a post grant review for challenging patents filed after March 2013 in the first nine months after they were issued. However, as of April 2016, there are only 3 post grant reviews, and these being excluded from IPR would not explain the difference in average age. See http://www.kilpatricktownsend.com/en/Knowledge_Center/Alerts_and_Podcasts/Legal_Alerts/2013/01/Inter-Partes_Review_Dead_Zone_Eliminated_All_Issued_Patents_Are_Now_Eligible.aspx

the 1999 policy for the IPR period), the difference in age is small and not statistically significant

We also compare the outcome of patent challenges. As shown in Table 1, excluding denials, there is no difference between the share of cases that ended in a win for the patentee (all claimed confirmed). However, accounting for denials, which we believe should also be considered as a win for the patentee, the changes in procedures from IPX to IPR resulted in a significantly higher share of cases that ended with a win for the patentee: in IPR, 36% of the reviewed cases with outcomes were denied review or had all challenged claims confirmed, compared with only 22% of challenged claims in IPX. Our summary statistics also indicate a greater loss for the patentee in the earlier (IPX) system with 58% of IPX reexaminations ending in the first claim canceled compared to 47% in IPR.

5.3. Small Entities

In our analysis below, we distinguish between challenged patents that were issued to an applicant claiming small-entity status and other reexamined patents. In Table 2, we display the mean characteristics of the two groups, small entities and others. The number of claims in the challenged-patents group that were awarded to small entities is not statistically different than the number of claims for other challenged patents. The same is true for both independent claims and the minimum words in independent claims, our measures of patent scope. The patents also do not

differ significantly in the number of forward citations per year per claim. However, patents awarded to small entities have significantly fewer backward citations per claim. One possible explanation for this could be less diligence in the search for prior art at the time of patent application. A larger share of patents awarded to small entities come from the Chemical Technology category. The shares of patents from other categories are not significantly different.

[Insert Table 2 – small entities]

6. Results

We use different estimation methods to provide evidence on the effect of the AIA policy change on the outcomes of USPTO patent challenges, and on the relationship between these outcomes and the characteristics of the challenged patents. First we estimate the effect of introducing the new IPR procedure on the probability of a patentee win using nearest neighbor matching. We then present results of discrete choice models estimating the effects of various patent characteristics on the odds of patentee win. Finally, we account for the possibility that the IPR variable is endogenous because of selection between the systems.

6.1. Comparing IPX and IPR Outcomes using Nearest Neighbor Matching

We first examine the effect of the policy change from IPX to IPR using nearest-neighbor matching. We compare patents that are in the same technology

category and have similar observed characteristics: number of independent claims, minimum word count in independent claims, per-claim prosecution time, per-claim backward and forward citations (normalized by age), and small-entity status.[33] We restrict the matches to one match in the same technology category that is most similar, and replacement is allowed. The results of this comparison are described in Table 3.

[Insert Table 3 nearest neighbor]

This analysis suggests that the share of cases with a patentee win outcome is larger by 13 percentage points in IPR compared to IPX. As we argued earlier, denials of reexamination or review should be viewed as failure to successfully challenge the patent, and thus a win for the patentee. If one neglects to account for denials, the difference in patentee wins would seem small and insignificant.[34] We obtain qualitatively mirrored results when we consider the dependent variable to be whether the challenge resulted in a patent's first claim being cancelled.

[33] We use a bias adjustment to correct for the bias that exists when matching on more than one continuous covariate (age, claims, prosecution, forward and backward citations) as suggested by Abadie and Imbens (2006, 2011) and implemented by the STATA teffects command.

6.2. Challenge Outcomes and Patent Characteristics

In this section, we use a logit model to examine the relation between patent characteristics and the outcome of the challenge. The main specification of the model that we estimate is given by:

$$Prob(patentee\ win = 1|X, IPR) = \frac{exp(\alpha + \beta \cdot X + \gamma IPR)}{1 + exp(\alpha + \beta \cdot X + \gamma IPR)},$$

where X represents a vector of patent characteristics and IPR takes the value 1 for patents reviewed in the post-AIA IPR system and 0 if it was reexamined in the earlier IPX system, alternatively we replace the IPR dummy with a set of quarterly time dummies δt.

In Table 4, column (1) we include independent claims, minimum word count in independent claims, forward- and backward citations, prosecution, small-entity status, and the technology categories. We find that challenged patents that have a greater minimum number of words in their independent claims are more likely to have a patentee win outcome. In other words, patents of narrower scope are more likely to remain intact after a validity challenge.

[Insert Table 4 – outcome regression]

Patents in the Drugs & Medical technology category are associated with higher odds of patentee win. The drug industry is often considered an industry in which the patent system works particularly well. It is interesting to see that "bad"

patents seem to be less prevalent in this industry, at least among those patents which are challenged at the patent office.

Small entity status has a large negative and statistically significant effect on the odds of a patentee win. This could indicate that challenged patents with small-entity status are of lower quality (perhaps because they were less able to afford good patent attorneys or to conduct thorough prior art searches when preparing their patent applications) and are thus more likely to have invalidated claims. Alternatively, this result could be independent of the true quality of small entity patents, and instead driven by small entities having a weakened position in agency adjudication. Earlier studies (see, for example, Lanjouw and Lerner, 1997) argued that small entities are less likely to assert their patents and are perhaps forced to settle early due to high litigation costs. Small entity patentees could be less able to afford strong legal representation when their patent is challenged and, as a result of weaker legal counsel, they are more likely to have some claims canceled.

We attempt to test the latter hypothesis by looking at small entity patents that have been assigned to another firm. If the primary reason for the higher rate of small entity losses was due to resource constraints, we would expect small entity patents that have been purchased by a more resource-rich firm to fare better in challenges. Using the USPTO Patent Assignment Database, we identify those patents that have been assigned at least once before the date of their validity

challenge.[35] A variable interacting small entity status with assignment status does not come up statistically significant when included in our model. Therefore, we find no support for the resource constraint at challenge explanation. We note, however, that assignment is an imperfect proxy for the resources of the firm litigating a challenge. Further research that better identifies the assignees could help to explain our small entity result.

In column (2), we add the IPR dummy to the model. The coefficient is positive and significant, consistent with our finding in Section 6.1 that patentees are more likely to win in inter partes review than they were in inter partes reexamination. In column (3), we include, in addition to the IPR indicator, a dummy variable that takes the value 1 in the intermediate period between the passing of the AIA and the beginning of the IPR system, and takes 0 otherwise. Patents reexamined during this period were reexamined under the IPX system, but were subject to the initial policy change which is expected to make denials of reexamination requests more prevalent.

The coefficient of the IPR indicator remains positive and significant and the coefficient of the indicator for the intermediate period is also positive and significant. The coefficient of the IPR indicator is larger in magnitude than that of

[35] Our ability to discern the identity of the assignee is limited with this dataset. For our purposes, we narrow down as best we can to those assignments that appear to be a sale of a patent to another entity. We thus exclude name changes, government or security interests, corrections, mergers, and any assignment that the PTO has flagged as potentially from an individual inventor to her employer.

the intermediate period indicator, and a chi-squared test rejects the equality of these coefficients ($p < .01$). This suggests that the change in the standard for denials had an effect on patentee success, and further that the switch from IPX to IPR had a positive effect on patentee success beyond the effect of the changed denial policy.[36] The coefficients of other variables of interest remain similar to those reported in column (1). The coefficient of the drugs & medical product category remains significant.[37]

In column (4), we reproduced the model from column (2) along with time dummies for each quarter. We suppressed the coefficients of all time dummies in column (4). The omitted categories are the first quarter of IPX in our sample, which is the fourth quarter of 2010, and the last period of IPR, which is the third quarter of 2014.[38] Our results using time dummies remain qualitatively the same as those in column (2): the effects of minimum independent claim word count, small entity status, drugs & medical patents, and the IPR policy change maintain their sign and statistical significance.

[Insert Table 5]

[36] It is possible that IPR judges interpret the denial policy differently than IPX examiners, explaining the smaller increase in denials in the first year, when IPX was still in effect.

[37] Further breakdown of these product categories (into NBER sub-categories) shows a negative effect for a miscellaneous chemical subcategory (in broad category 1).

[38] If we only include time effects, the time effects before the policy change were not significantly different than for the first quarter in our data. Time effects are positive yet remain statistically insignificant for the first four quarters after the policy change. Starting in the last quarter of 2013, these effects become larger in magnitude and statistically significant.

In Table 5 we present results from the same models as in Table 4, except we replace the dependent variable with the first claim canceled outcome which represents a significant loss to the patentee. Again we find evidence consistent with patentees faring better in challenges in the IPR system. Both our denial policy indicator and our IPR policy indicator are associated with lower odds of having a patent's first claim cancelled. Small entities are more likely to suffer a significant loss in patent rights. In addition, patents with greater per-claim prosecution times are less likely to have their first claim cancelled. Patents with more independent claims are less likely to have the first claim invalidated, but using the minimum word count measure, broader scope patents do not appear to have a different probability of first claim cancelation.

6.3. Challenge Outcomes: Instrumental Variable Approach

The IPR coefficients estimated in tables 4 and 5 are consistent with the change in the challenge system favoring patentees. However, we might be concerned about the endogeneity of the IPR indicator. By timing their requests, some petitioners could have selected between the IPX and the IPR systems, and the IPR coefficient might be biased if this selection is associated with differences in patent quality. Indeed, figure 2b clearly shows a spike in IPX reexaminations right before the change to IPR. While we control in tables 4 and 5 for observed characteristics, there might be unobserved patent quality differences that drove

selection between the systems. In this section, we use an instrumental variable approach to account for the possible endogeneity of the IPR variable.

To construct our instruments, we exploit the fact that not all patents were eligible to be challenged in either system. Patents granted after September 16, 2012 when the IPR system took effect could only be challenged in this system. We define a new dummy variable "IPX-Ineligible" by assigning an observation the value 1 for patents granted after September 16, 2012. These patents were eligible for review under IPR but not IPX. IPX-Ineligible takes the value 0 for patents eligible to be challenged under either system.

Patents that were filed before November 29, 1999 are also eligible in IPR but not in IPX. However, the 1999 date also coincides with a more general reform of the general system (The American Inventor's Protection Act). Therefore, we exclude from our sample patents that were filed before November 29, 1999, so as to not conflate the effect of that Act with the change in IPR eligibility. Twelve percent of the IPR patents in this sample are IPX-ineligible.

Patents which are IPX-ineligible are reviewed, on average, closer to their grant date due to the truncation of the sample shortly after the IPR policy change. We handle this by controlling directly for a patent's age at the challenge in the IV regressions. Since neither patentee nor challenger control the grant date of patents, we think it is plausible that conditional on age, challenged patents granted after the IPR system took effect should not be of significantly different quality.

However, if the AIA incentivized patentees to file for patents of higher quality, one might worry that our proposed instrument IPX-ineligibility might not satisfy the exclusion restriction. To address this concern, we also estimate our models using a second instrument: "IPX-ineligible-2". Like the original instrument, this variable equals 0 if a patent was granted before September 16, 2012. However, this variable imposes the additional constraint that the patent must have been filed before September 16, 2011, the date that the AIA became law. This refined instrument should not be correlated with patent quality and it ensures that there is a degree of randomness in the assignment of a patent into either the mixed or IPR-only regime. In other words, because the patents were under review when the AIA was signed, patentees and challengers would be unable to perfectly predict whether the patent would issue in time to be eligible for IPX, or only for IPR.

Patents for which IPX-ineligible-2 is equal to 1 are younger by construction. However, controlling for age, none of the patent characteristics are significant in a test for balance with IPX-ineligible-2 as the dependent variable, nor is the joint F test significant.[39] This provides further reassurance that patents in this set are not of different quality due to selection between the challenge systems, nor due to patenting or challenging decisions. Seven percent of challenged patents satisfy the condition under IPX-ineligible-2. We see no reason for this instrument to directly

[39] For an explanation of this test see http://blogs.worldbank.org/impactevaluations/tools-trade-joint-test-orthogonality-when-testing-balance.

affect the quality of the patent or the strength of evidence against it, except through the policy change indicator, IPR. The results of the first stage, which show the strong effect of our instruments on the policy variable are presented in the appendix Table A1.

Table 6 presents the results of the second stage of a two-stage least squares model. In column (1) we estimate the model with patentee win as our dependent variable and IPX-Ineligible as an instrument, and in column (2) we use the modified version, IPX-Ineligible-2. Columns (3) and (4) similarly present results for the first claim canceled dependent variable. Qualitatively, the effects of observed patent characteristics are similar to those we found in the previous subsection. In particular, we find that patents of broader scope are less likely to win a validity challenge, but also less likely to suffer the significant loss of having their first claim cancelled. Patent issued to small entities are less likely to win a validity challenge, and more likely to have their first claim cancelled. When using the instruments to account for selection on unobservables, the effect of the IPR policy variable retains its sign and statistical significance in every specification.[40]

6.4. Can appeals or settlements explain the difference in patentee wins?

[40] In a reduced form discrete choice model in which we use the instruments directly in place of the IPR indicator, the coefficients for the IPR instruments are positive and significant, consistent with the two-stage estimation.

As we noted earlier, our dataset records the outcome of inter partes reexaminations at a later stage of the appeals process than inter partes reviews. More specifically, we record IPX outcomes from reexamination certificates, which are only issued after any appeals. By contrast, IPR outcomes are recorded immediately following the PTAB trials, before any appeals. We explain why this difference is highly unlikely to explain the higher rate of patentee win in IPR. Taylor and Kamkar (2017) examine the success rate of appeals of IPR. They find that (in 2016) the Federal Circuit affirmed 75% of appealed cases, reversed the PTAB decision only in 3% of the appeals and returned the remaining 22% to PTAB, where most were then partially affirmed. A quick back of envelope calculation shows that even if all patentee win cases were appealed and 25% of them were reversed, the rate of patentee win in IPR would decrease from 36% to 27%, which is still significantly different than the rate in IPX (22%).[41] Accounting for the facts that patentees can also appeal the outcomes of IPR, that there are more cases with at least one claim canceled than ones with patentee win, and that denials of IPR are only rarely reversed, we don't expect the share of patentee wins could drop as much with appeals.

Another difference between IPX and IPR is that settlements are possible during IPR which would result in termination of the review process. The same was

[41] Using a test of proportion equality under this hypothetical scenario, we reject the null hypothesis that the rates of patentee win would be equal (p=.03).

not true in the IPX system. This could explain a higher rate of patentee wins if patents of poor quality more likely settle. However, the parties in IPX challenges, likely faced similar incentives to settle, only before the request for reexamination. Moreover, denials of review are an important reason for the higher rate of patentee win in IPR, and these decisions are reached early in the process.

7. Conclusions

Filings of patent validity challenges at the patent office, while still low relative to litigation, have been increasing, especially since the change to the new IPR procedure. A system that offers an administrative venue to challenge patent validity is expected to improve patent quality and lower the private and social costs of resolving patent disputes. Indeed, our data shows that in more than two-thirds of cases the challenged patent had at least one claim canceled and in more than half of the cases the first patent claim was canceled. Thus, these patent challenges significantly reduce the breadth of challenged patents. This article sheds light on the characteristics of patents challenged at the USPTO, and how these characteristics are associated with the probability that a post-grant challenge results in a win for the patentee (claims confirmed or reexamination denied) or a significant loss (claim 1 canceled), and identifies the effects of the AIA policy change on patentee win outcomes.

The AIA resulted in an increase in the frequency of denied patent challenge requests. Accounting for denials, which we take to be a win for the patentee, we find that there are more patentee wins in the new IPR system than in the old IPX system. Some of this increase in wins may be due to changes in the characteristics of patents challenged under the new policy. We exploit the ineligibility of patents granted after the policy change to be challenged in the IPX system to instrument for the policy change indicator and correct for possible bias due to strategic selection between the two systems. We still find evidence that the policy change had a positive effect on patentee wins.

The drugs and medical category, for which the patent system is often considered to work best, stands out as one in which challenges are most likely to end in a patentee win. But other categories do not have a significant effect on outcomes. The share of patents in the drugs and medical category was in fact smaller since the policy change, which suggests that patent category composition changes is unlikely to have contributed to the increase in patentee wins in IPR.

Small-scale inventors make a significant contribution to innovation. Earlier studies have shown, however, that small patentees are disadvantaged when it comes to patenting and to asserting their patents. We find that small-entity-status patentees are significantly more likely to have at least one claim cancelled when challenged, and also more likely to suffer the significant loss of having their first claim cancelled. We proposed two possible explanations for this result; these patent

owners may be disadvantaged in validity disputes due to their limited resources, or they may have obtained weaker patents to start with. More research should be done into the cause of this effect, and the possible role that patent-assertion entities may play with regard to small entity patents.

The USPTO already offers reduced fees for small entities filing a patent application. Our findings suggest that there may be room for additional policy interventions. It is possible that providing small-entity inventors with an earlier subsidy to help them draft patent applications could improve patent quality and strengthen their positions in patent disputes. Similarly, if this effect is driven by weakened positions in patent challenges, the USPTO could consider whether there are ways to reduce the cost burden that inter partes review imposes on small entities.

The high rate of claims cancelation highlights the importance of having low cost procedure for third parties to challenge patent validity. Although patent reexamination filings have increased since the AIA policy change, some of this increase was likely driven by removal of a restriction on reexamination of patents filed before 1999, (which would have faded over time without the AIA), and possibly also by trends in filing litigation cases (see Bar and Costello, 2017). The AIA did not make patent reexaminations unambiguously more appealing compared to IPX (for example, reexamination costs have gone up), and we have also found a significant increase in denials and an overall lower success rate for challengers. A sharp increase in IPX filings immediately before the new IPR system took effect

also seems to suggest some third parties preferred the IPX system. If policy makers seek to significantly expand the uses of patent challenge procedures, further policy changes (for example cutting costs) may be needed.

References

1. Abadie, Alberto and Imbens, Guido W. 2006. “Large Sample Properties of Matching Estimators for Average Treatment Effects.” *Econometrica*.
2. Abadie, Alberto and Imbens, Guido W. 2011. “Bias-corrected matching estimators for average treatment effects.” *Journal of Business & Economics Statistics*.
3. John R. Allison and Joshua W. Walker. 2011. Patent Quality and Settlement Among Repeat Patent Litigants. *Georgetown Law Journal* 99, 677-712
4. Angrist, Joshua D., and Jörn-Steffen Pischke. 2008. *Mostly harmless econometrics: An empiricist's companion*. Princeton university press.
5. Athey, Susan, and Guido Imbens. 2016. “The State of Applied Econometrics-Causality and Policy Evaluation.” *arXiv preprint arXiv:1607.00699*.
6. Bar, T. and J. Kalinowski. 2016. “Patent Validity, Settlements and Litigation,” University of Connecticut.

7. Baughman, Steven. 2012. “Inter Partes Reexamination and Inter Partes Review: Weighing Strategic Choices Before the Clock Runs Out.” *BNA's Patent, Trademark & Copyright Journal*, 84 PTCJ 58.
8. Boldrin Michele and David K. Levine. 2013. “The Case Against Patents.” *The Journal of Economic Perspectives*, Volume 27 (1), pp 3-22.
9. Chiou, Jing-Yuan. 2006. “The Design of Post-Grant Patent Challenges.” Available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=941880
10. Cutler, Matt. 2015. “3 Years Of IPR: A Look At The Stats”. Available at http://www.law360.com/articles/699867/3-years-of-ipr-a-look-at-the-stats
11. Galasso, Alberto and Mark Schankerman. 2015a. “Patents and Cumulative Innovation: Causal Evidence from the Courts,” *Quarterly Journal of Economics*, 130 (1): 317-369.
12. Galasso, Alberto and Mark Schankerman. 2015b. “Patent Rights, Innovation and Firm Exit.” NBER Working Paper No. 21769.
13. Gardella, Greg H. and Emily A. Berger. 2009. “United States Reexamination Procedures: Recent Trends, Strategies and Impact on Patent Practice,” 8 J. Marshall *Review of Intellectual Property Law*. 381.
14. Graham, S., Marco, A., and Miller, A. (2015). “The USPTO Patent Examination Research Dataset: A Window on the Process of Patent Examination.” SSRN working paper, available at (TBD)

15. Graham, Stuart J.H., Bronwyn H. Hall, Dietmar Harhoff and David C. Mowery. 2003. “Patent Quality Control: A Comparison of U.S. Patent Re-examinations and European Patent Oppositions,” In: W. Cohen and S.A. Merill (eds.), Patents in the Knowledge-Based Economy. National Academy of Science, National Academies Press.

16. Graham, Stuart J.H. and Harhoff, Dietmar. 2014. “Separating Patent Wheat from Chaff: Would the U.S. Benefit from Adopting a Patent Post-Grant Review?” Research Policy 43, pp. 1649-1659.

17. Hall, Bronwyn H., Jaffe, Adam B., and Trajtenberg, Manuel. 2001. “The NBER Patent Citation Data File: Lessons, Insights, and Methodological Tools.” NBER Working Paper 8498.

18. Hall, Bronwyn H., Stuart Graham, Dietmar Harhoff, David C. Mowery. 2004. “Prospects for Improving U.S. Patent Quality via Postgrant Opposition.” National Bureau of Economic Research, volume 4: Innovation Policy and the Economy, Adam B. Jaffe, Josh Lerner and Scott Stern, editors. The MIT Press.

19. Harhoff Dietmar, Frederic M. Scherer and Katrin Vopel. 2003. “Citations, Family Size, Opposition and the Value of Patent Rights.” *Research Policy* vol. 32, issue 8, pages 1343-1363.

20. Jaffe, Adam B., and Josh Lerner. 2004. “Innovation and Its Discontents: How Our Broken Patent System is Endangering Innovation and Progress, and What To Do About It.” Princeton: Princeton University Press.

21. Lanjouw, Jean O. and Josh Lerner. 1997. “The Enforcement of Intellectual Property Rights: A Survey of the Empirical Literature.” National Bureau of Economic Research. Working Paper 6296. http://www.nber.org/papers/w6296.

22. Lanjouw, Jean O and Mark Schankerman. 2001. “Characteristics of Patent Litigation: A Window on Competition.” *The RAND Journal of Economics*, Vol. 32, No. 1, pp. 129-151.

23. Lanjouw, Jean O. and Mark Schankerman. 2004. “Protecting Intellectual Property Rights: Are Small Firms Handicapped?” *Journal of Law and Economics* 47 (1): 45-74.

24. Lemley, M., Lichtman, D. and Sampat, B. 2005. “What to do About Bad Patents?” *Regulation*, 28(4), pp. 10-13.

25. Marco, Alan C., Myers, Amanda F. and Graham, Stuart J.H. and D'Agostino, Paul A and Apple, Kirsten, The USPTO Patent Assignment Dataset: Descriptions and Analysis (July 27, 2015). USPTO Economic Working Paper No. 2015-2. Available at SSRN: http://ssrn.com/abstract=2636461 or http://dx.doi.org/10.2139/ssrn.2636461

26. Marco, Alan C. and Sarnoff, Joshua D. and deGrazia, Charles, Patent Claims and Patent Scope (October 2016). USPTO Economic Working Paper 2016-04. Available at: SSRN: https://ssrn.com/abstract=2844964.

27. Marco Alan C. and Richard D. Miller. 2016. “Patent litigation and USPTO trials: Implications for patent examination quality.” Available at

https://editorialexpress.com/cgi-bin/conference/download.cgi?db_name=IIOC2016&paper_id=154.

28. Morinville, Paul. 2016. “How the Patent Trial and Appeal Board Harms Inventors.” IPWatchdog. Available at: http://www.ipwatchdog.com/2016/09/13/how-the-patent-trial-and-appeal-board-harms-inventors/id=72554/
29. Phillips, Matthew and Laurence, Kevin. 2011. “Changes to Reexamination Under the America Invents Act.” Available at http://www.stoel.com/files/Changes_to_Reexamination_under_the_America_Invents_Act_November_2011_IP_Today.pdf
30. Quinn, Gene. 2013. “The Rise of Patent Litigation in America: 1980 -- 2012.” IPWatchdog. Available at: http://www.ipwatchdog.com/2013/04/09/the-rise-of-patent-litigation-in-america-1980-2012/id=38910/ Last accessed on October 15, 2016.
31. Southard, Thomas G. and Prestia, Paul F. 2012. “Economics and Logic of Patent Litigation Versus Post Grant/Inter Partes Patent Review.” Available at http://ratnerprestia.com/220?article=485
32. Stahl, Lawrence A. and Donald H. Heckenberg. 2011. “The Scope and Ramifications of the New Post-Grant and Inter Partes Review Proceedings at the USPTO.” Available at: http://www.fitzpatrickcella.com/publication/the-scope-

and-ramifications-of-the-new-post-grant-and-inter-partes-review-proceedings-at-the-uspto/. Last accessed, October 15, 2016.

33. Sterne, Kessler, Goldstein and Fox P.L.L.C. 2012. “IPX vs. IPR A Cheat Sheet.” Available at: http://ptolitigationcenter.com/wp-content/uploads/2009/08/ipx-v-ipr.pdf Last accessed on October 15, 2016.
34. Taylor Kerry S. and Daniel A. Kamkar (2017). “IPR Appeals: Pendency And Success Rates At Fed. Circ.” Law360, available at https://www.law360.com/articles/884916 (last accessed September, 2017).
35. Vishnubhakat, Saurabh, Rai, Arti K., and Kesan, Jay P. 2016. “Strategic Decision Making in Dual PTAB and District Court Proceedings.” *Berkeley Technology Law Journal*, Forthcoming Available through SSRN: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2731002
36. Walker Joseph and Rob Copeland. 2015. “New Hedge Fund Strategy: Dispute the Patent, Short the Stock,” The Wall Street Journal. Updated April 7, 2015.

Figure 1: Timeline of Samples

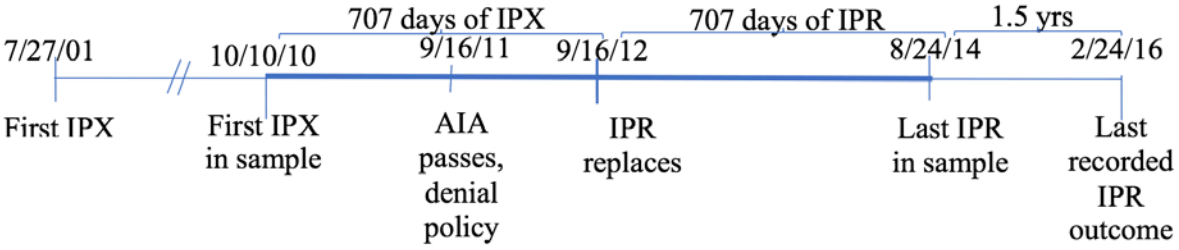


Figure 2: Percentage of Challenges Including Various Claim-level Outcomes

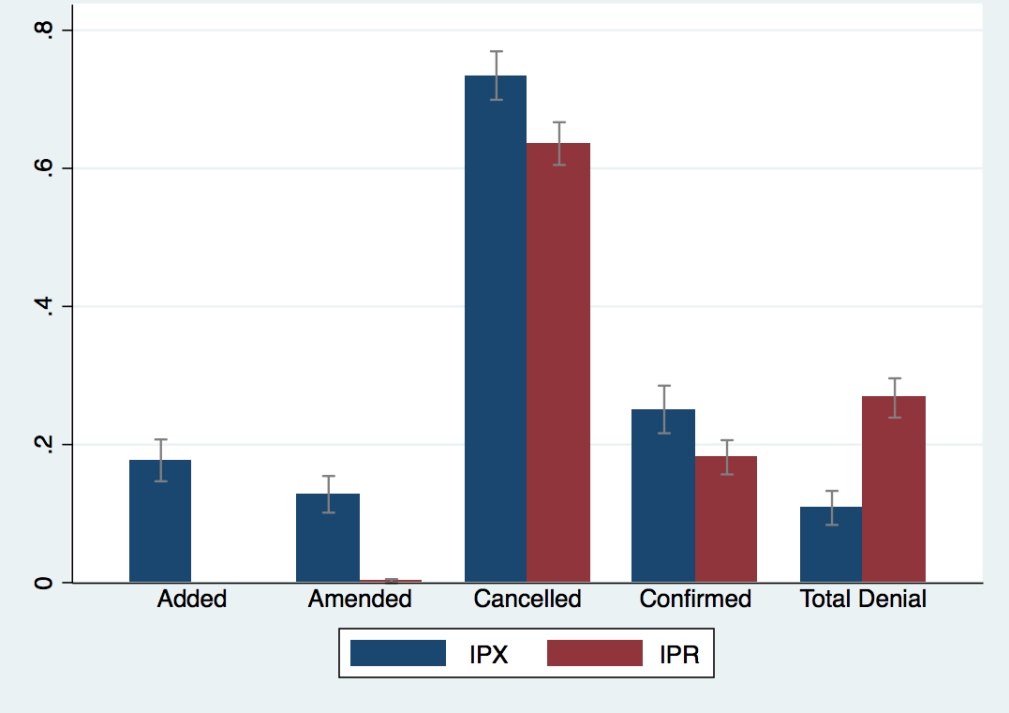


Figure 3: Comparing Challenge Outcomes in IPX and IPR

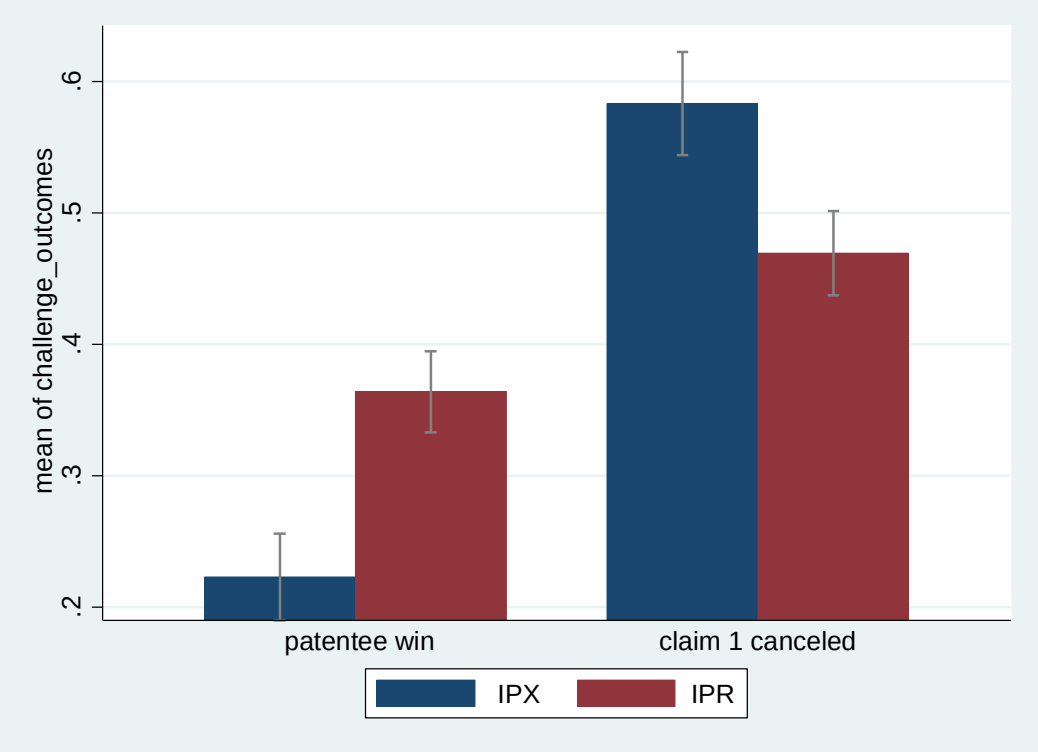
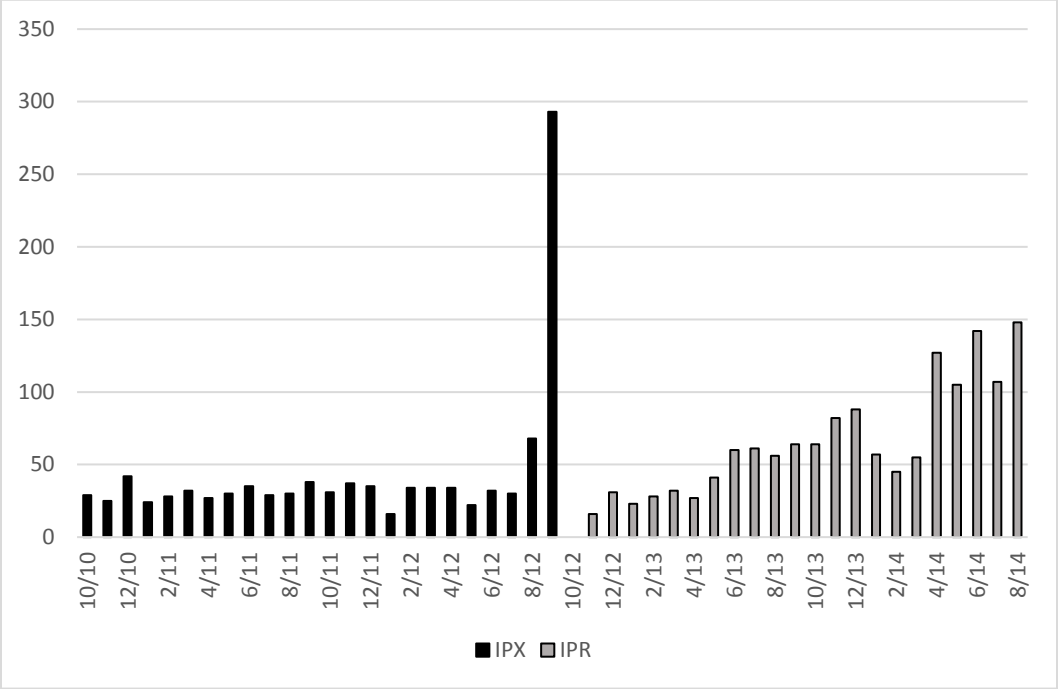


Figure 4: Challenges by Month



Reexamination challenges reported in this figure are at the patent-party-date level. The number is equal to filings in the IPX months, and is lower than the number of filings in the IPR months. The AIA passed in September, 2011, the denials change was implemented immediately, the change from IPX to IPR was implemented on September, 2012.

Table 1- Comparing IPX and IPR characteristics and outcomes

Variable	IPX	IPR	p-value
Independent claims	3.82	4.12	0.11
Min. word length in independent claims	137.44	137.36	0.98
Total claims	27.23	30.80	0.01
Annual forward citations per claim	0.23	0.26	0.49
Backward citations per claim	5.81	6.57	0.49
Prosecution per claim	78.42	71.46	0.32
Small entity	0.32	0.31	0.70
Age	1314.01	2354.50	0.00
N	610	931	
Tech Category 1 (Chemical)	0.06	0.05	0.56
Tech Category 2 (Computers & Communications)	0.40	0.51	0.00
Tech Category 3 (Drugs & Medical)	0.15	0.12	0.04
Tech Category 4 (Electrical & Electronic)	0.14	0.14	0.89
Tech Category 5 (Mechanical)	0.09	0.08	0.59
Tech Category 6 (Others)	0.17	0.09	0.00
N	610	930	
Patentee win excluding denials	0.13	0.13	0.87
First claim cancelled excluding denials	0.65	0.64	0.62
N	544	682	
Patentee win	0.22	0.36	0.00
First claim canceled	0.58	0.47	0.00
Denied Reexamination	0.11	0.27	0.00
N	610	931	

Sample includes reexamination cases between 10/10/2010 and 8/24/2014 with non-missing outcomes. Comparisons of small entity, denied reexamination, tech categories, and outcomes reflect two-sample tests of proportion equality. The remainder reflect two-sample t-tests of mean equality. “Patentee win” includes cases in which all reexamined claims were confirmed, or for which reexamination was denied. “Patentee win excluding denial” excludes from the sample cases in which reexamination was denied. The minimum word length variable is missing one observation.

Table 2- Comparing reexamined patents issued to small entities and non-small entities

Variable	Non-small	Small	p-value
Independent claims	4.05	3.90	0.44
Min. word length in independent claims	134.77	143.19	0.07
Total claims	29.75	28.59	0.43
Annual forward citations per claim	0.26	0.22	0.41
Backward citations per claim	7.71	3.08	0.00
Prosecution per claim	73.01	76.87	0.60
Age	1984.09	1850.69	0.14
N	1062	479	
Tech Category 1 (Chemical)	0.04	0.08	0.01
Tech Category 2 (Computers & Communications)	0.48	0.44	0.15
Tech Category 3 (Drugs & Medical)	0.13	0.12	0.57
Tech Category 4 (Electrical & Electronic)	0.13	0.16	0.18
Tech Category 5 (Mechanical)	0.09	0.06	0.06
Tech Category 6 (others)	0.11	0.13	0.25
N	1061	479	

Sample includes patents reexamined (with non-missing outcomes) between 10/10/2010 and 8/24/2014. This data is at the level of reexaminations, so some patents appear multiple times. Comparisons of tech categories reflect two-sample tests of proportion equality. The remainder reflect two-sample t-tests of mean equality. The minimum word length variable is missing one observation.

Table 3- IPR "treatment" effect

Effect\Sample	Include denials	Exclude denials
Average treatment effect of IPR on patentee win	0.13***	-0.00
AI Robust Std. Err.	(0.03)	(0.02)
Average treatment effect of IPR on First Claim Canceled	-0.08***	0.01
AI Robust Std. Err.	(0.03)	(0.03)
N	1,540	1,225

Standard error is robust to account for multiple continuous covariates, as suggested by Abadie and Imbens (2006, 2011).
*** significant at 1% level, ** significant at 5% level, * significant at 10% level.

Table 4: Patentee Win

Variable	(1)	(2)	(3)	(4)
Independent Claims	0.00563	0.00355	0.00356	0.00306
	(0.0164)	(0.0167)	(0.0167)	(0.0169)
Min. word count in independent claims	0.00185***	0.00187***	0.00185***	0.00178***
	(0.000667)	(0.000678)	(0.000678)	(0.000689)
Annual Forward citations per claim	-0.103	-0.122	-0.126	-0.142
	(0.1000)	(0.103)	(0.103)	(0.105)
Backward Citations per claim	0.000519	0.0000356	0.000135	-0.0000848
	(0.00258)	(0.00258)	(0.00258)	(0.00264)
Prosecution per claim	0.000646	0.000751	0.000752	0.000891*
	(0.000473)	(0.000482)	(0.000483)	(0.000488)
Small entity	-0.369***	-0.371***	-0.370***	-0.333**
	(0.126)	(0.127)	(0.127)	(0.130)
TC 1 (Chemical)	-0.180	-0.266	-0.285	-0.308
	(0.331)	(0.334)	(0.335)	(0.338)
TC 2 (Computers &	0.395**	0.258	0.249	0.254
Communications)	(0.190)	(0.193)	(0.193)	(0.196)
TC 3 (Drugs & Medical)	0.613***	0.565**	0.540**	0.582**
	(0.228)	(0.231)	(0.231)	(0.235)
TC 4 (Electrical & Electronic)	0.176	0.0701	0.0846	0.0434
	(0.231)	(0.234)	(0.235)	(0.238)
TC 5 (Mechanical)	0.287	0.203	0.184	0.218
	(0.257)	(0.260)	(0.260)	(0.264)
IPR		0.696***	0.978***	1.261***
		(0.121)	(0.187)	(0.377)
Denial Policy Change			0.437**	
			(0.211)	
Quarterly time effects	No	No	No	Yes
Constant	-1.323***	-1.661***	-1.931***	-1.749***
	(0.225)	(0.235)	(0.273)	(0.392)
pseudo R-sq	0.017	0.035	0.038	0.052

Notes: Sample includes 1539 reexamination cases between 10/10/2010 and 8/24/2014. Logit model estimated. Standard errors in parenthesis.
*** significant at 1% level, ** significant at 5% level, * significant at 10% level.

Table 5: First Claim Cancelled

Variable	(1)	(2)	(3)	(4)
Independent Claims	-0.0823***	-0.0809***	-0.0815***	-0.0807***
	(0.0175)	(0.0175)	(0.0176)	(0.0178)
Min. word count in independent claims	-0.000912	-0.000903	-0.000877	-0.000944
	(0.000640)	(0.000645)	(0.000645)	(0.000656)
Annual Forward citations per claim	-0.133	-0.126	-0.122	-0.120
	(0.0933)	(0.0936)	(0.0937)	(0.0946)
Backward Citations per claim	0.00243	0.00289	0.00279	0.00291
	(0.00258)	(0.00259)	(0.00259)	(0.00260)
Prosecution per claim	-0.00103*	-0.00116**	-0.00117**	-0.00121**
	(0.000536)	(0.000557)	(0.000559)	(0.000563)
Small entity	0.304***	0.308***	0.306***	0.263**
	(0.113)	(0.114)	(0.114)	(0.116)
TC 1 (Chemical)	-0.0941	-0.0390	-0.0228	-0.0257
	(0.273)	(0.274)	(0.275)	(0.279)
TC 2 (Computers & Communications)	-0.173	-0.0793	-0.0689	-0.0753
	(0.169)	(0.171)	(0.171)	(0.173)
TC 3 (Drugs & Medical)	-0.353*	-0.319	-0.294	-0.319
	(0.210)	(0.211)	(0.212)	(0.214)
TC 4 (Electrical & Electronic)	-0.00217	0.0682	0.0565	0.0910
	(0.205)	(0.207)	(0.207)	(0.210)
TC 5 (Mechanical)	-0.175	-0.117	-0.0997	-0.114
	(0.233)	(0.235)	(0.236)	(0.239)
IPR		-0.458***	-0.670***	-0.769**
		(0.108)	(0.154)	(0.322)
Denial Policy Change			-0.342**	
			(0.174)	
Quarterly time effects	No	No	No	Yes
Constant	0.654***	0.862***	1.065***	0.747**
	(0.206)	(0.213)	(0.238)	(0.326)
pseudo R-sq	0.021	0.029	0.031	0.043

Notes: Sample includes 1539 reexamination cases between 10/10/2010 and 8/24/2014. Logit model estimated. Standard errors in parenthesis.
*** significant at 1% level, ** significant at 5% level, * significant at 10% level.

Table 6: Instrumental Variable Approach (Second stage estimates)

Variable	Patentee win		Claim 1 canceled	
	(1)	(2)	(3)	(4)
Independent claims	0.000478	0.000978	-0.0164***	-0.0173***
	(0.00487)	(0.00498)	(0.00444)	(0.00457)
Min. word count in	0.000337**	0.000303*	-0.000224	-0.000167
independent claims	(0.000169)	(0.000175)	(0.000173)	(0.000180)
Annual Forward				
citations per claim	-0.0341	-0.0322	-0.0222	-0.0254
	(0.0231)	(0.0240)	(0.0200)	(0.0208)
Backward Citations per				
claim	-0.0000472	-0.000208	0.000556	0.000825
	(0.000640)	(0.000679)	(0.000675)	(0.000731)
Prosecution per claim				
(*100)	0.000217	0.000241	-0.000228**	-0.000267**
	(0.000151)	(0.000159)	(0.000108)	(0.000111)
Small entity	-0.0702***	-0.0707***	0.0755***	0.0764**
	(0.0262)	(0.0267)	(0.0292)	(0.0296)
TC 1 (Chemical)	-0.0647	-0.0766	-0.00606	0.0138
	(0.0588)	(0.0606)	(0.0711)	(0.0734)
TC 2 (Computers &	0.0287	0.0126	-0.0115	0.0156
Communications)	(0.0407)	(0.0430)	(0.0451)	(0.0472)
TC 3 (Drugs & Medical)	0.0876*	0.0801	-0.0676	-0.0550
	(0.0486)	(0.0494)	(0.0530)	(0.0534)
TC 4 (Electrical &				
Electronic)	-0.0243	-0.0362	0.0292	0.0490
	(0.0464)	(0.0482)	(0.0533)	(0.0552)
TC 5 (Mechanical)	0.0301	0.0196	-0.0134	0.00416
	(0.0544)	(0.0557)	(0.0606)	(0.0627)
IPR	0.242***	0.321***	-0.142**	-0.274***
	(0.0645)	(0.0877)	(0.0650)	(0.0865)
Age	0.00000245	-0.00000336	-0.0000162	-0.00000647
	(0.0000121)	(0.0000130)	(0.0000126)	(0.0000133)
Constant	0.106**	0.0858	0.728***	0.762***
	(0.0540)	(0.0570)	(0.0579)	(0.0615)

Notes: Sample includes 1338 reexamination cases between 10/10/2010 and 8/24/2014. Standard errors in parenthesis.
*** significant at 1% level, ** significant at 5% level, * significant at 10% level.

Table A1: Instrumental Variable Approach (First stage estimates)

Variable	Patentee Win		Claim 1 Canceled	
	(1)	(2)	(1)	(2)
Independent claims	-0.00429	-0.00551	-0.00429	-0.00551
	(0.00431)	(0.00439)	(0.00431)	(0.00439)
Min. word count in	0.000282*	0.000493***	0.000282*	0.000493***
independent claims	(0.000150)	(0.000163)	(0.000150)	(0.000163)
Annual Forward	-0.0231	-0.0206	-0.0231	-0.0206
citations per claim	(0.0175)	(0.0186)	(0.0175)	(0.0186)
Backward Citations	0.00164***	0.00193***	0.00164***	0.00193***
per claim	(0.000370)	(0.000447)	(0.000370)	(0.000447)
Prosecution per claim	-0.0000865	-0.000260*	-0.0000865	-0.000260*
(*100)	(0.000126)	(0.000149)	(0.000126)	(0.000149)
Small entity	-0.00416	0.00160	-0.00416	0.00160
	(0.0257)	(0.0272)	(0.0257)	(0.0272)
TC 1 (Chemical)	0.113*	0.156**	0.113*	0.156**
	(0.0609)	(0.0657)	(0.0609)	(0.0657)
TC 2 (Computers &	0.206***	0.209***	0.206***	0.209***
Communications)	(0.0377)	(0.0396)	(0.0377)	(0.0396)
TC 3 (Drugs & Medical)	0.0783*	0.0815*	0.0783*	0.0815*
	(0.0451)	(0.0478)	(0.0451)	(0.0478)
TC 4 (Electrical	0.153***	0.175***	0.153***	0.175***
& Electronic)	(0.0460)	(0.0486)	(0.0460)	(0.0486)
TC 5 (Mechanical)	0.0981*	0.128**	0.0981*	0.128**
	(0.0516)	(0.0557)	(0.0516)	(0.0557)
Age	0.000139***	0.000110***	0.000139***	0.000110***
	(0.0000108)	(0.0000112)	(0.0000108)	(0.0000112)
IPX-ineligible	0.689***		0.689***	
	(0.0212)		(0.0212)	
IPX-ineligible-2		0.624***		0.624***
		(0.0227)		(0.0227)
Constant	0.0951*	0.149***	0.0951*	0.149***
	(0.0513)	(0.0540)	(0.0513)	(0.0540)
R-sq	0.230	0.154	0.230	0.154

Notes: Sample includes 1338 reexamination cases between 10/10/2010 and 8/24/2014. IPX-ineligible and IPX-ineligible-2 are the instruments omitted in the second stage. Standard errors in parentheses. * p<.10 ** p<.05 *** p<.01