Pre-grant patent publication and the market for technology: licensing and patent transfers

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Abstract

We study the effect of pre-grant patent publication on the timing of transactions in the market for technology for two modes of exchange: licensing and patent transfers. In order to identify the effect of pre-grant publication we leverage the enactment of the American Inventor's Protection Act of 1999 (AIPA), which required all patent applications filed on or after November 29, 2000, to be published no later than 18 months after the earliest application date. To identify the causal effect of AIPA we implement a regression discontinuity design that compares deals involving patents with application date just before and just after the AIPA enactment date. Constraining identification around AIPA is important because later post-AIPA cohorts are subject to severe sample selection (must be licensed or transferred faster to make it into the sample). Our main finding is that AIPA did not have any effect on the timing of transactions in the market for technology. AIPA accelerated patent disclosure and knowledge diffusion (as captured by forward patent citations). However, such intermediate effects did not percolate to market for technology outcomes. Our findings reverse recent results in the literature.

Keywords: Market for technology; Patents; Disclosure; Licensing; Patent transfers.

JEL Codes: D23; L24; O34

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1 Introduction

The market for technology has the potential to generate social gains by enhancing allocative efficiency and promoting the specialization of innovative labor (Arora & Gambardella, 2010). Economists are concerned that these benefits will not be realized due to inefficiencies (Ali & Cockburn, 2016; Gans & Stern, 2010). An important source of inefficiency arises from information frictions between technology adopters and providers (Pisano, 1990). Some scholars argue that the disclosure function of the patent system could alleviate such frictions by reducing search costs and informational asymmetries, and mitigating adverse selection in bargaining between inventors and adopters (Hegde & Luo, 2017; Long, 2002; Spulber, 2015).

Recent research leverages the enactment of the American Inventor's Protection Act of 1999 (AIPA) to identify the effect of patent disclosure on knowledge diffusion and the market for technology (Baruffaldi & Simeth, 2018; Drivas *et al.* , 2018; Graham & Hegde, 2015; Hegde & Luo, 2017; Hegde *et al.* , 2018). Historically, U.S. patent applications were published at the time of grant. AIPA separated the patent publication and patent grant events, requiring all patent applications filed on or after November 29, 2000, to be published no later than 18 months after the earliest application date. Because the time elapsed from application to grant was substantially longer than the 18 month publication window for most patents, AIPA triggered substantial disclosure gains in the form of pre-grant publications.

Hegde & Luo (2017) provide an elegant framework for understanding the effect of AIPA on the timing of transactions in the market for technology. Before AIPA, the licensor's optimal choice was to license immediately after application or immediately after grant, the two significant dates upon which uncertainties were greatly alleviated during prosecution. AIPA might have affected the optimal timing of transactions in two ways. First, if pre-grant publication conveys benefits through a reduction in information frictions for a large enough number of technology providers, transactions should move away from the application and grant dates to bunch immediately after the publication date. Second, increased expropriation risk makes it less attractive to delay licensing to prolong secrecy, pushing transactions toward the application date. The interaction of these two effects generates two testable predictions: first, the likelihood of transacting pre-grant increases after AIPA (due to a *reduction in information frictions* or to an *increase in expropriation risk* or both); and second, the likelihood of transacting between 18 months and grant increases after AIPA (due to a *reduction in information frictions*). Hegde & Luo (2017) find empirical support for both predictions.

In this paper we re-examine the effect AIPA on the timing of transactions in the market for technology, not only for licensing deals but also for patent transfers. Patent applications are fairly uncertain property rights due to claim narrowing during prosecution (see Marco *et al.* , 2018). AIPA should only be expected to affect transaction patterns if uncertainties over property rights are kept at a minimum. Such uncertainties can be dealt with through different mechanisms depending on the mode of exchange. Licensing agreements allow parties to negotiate contingent terms, conditioning royalty rates to the final prosecution outcomes. Patent transfers are unsuited for contingent terms, but confer the buyer direct control over the prosecution process. Prosecution control might be desirable if the buyer is a more capable prosecutor or if crucial claims are published pre-grant but not actively prosecuted. Pre-grant publications are options on published claims that have value on their own right and could very well lead to a *market for prosecution control*.

We test the two predictions derived in Hegde & Luo (2017) for a sample of licensing deals drawn from SEC-mandated material disclosures and for the universe of patent transfers extracted from the USPTO Patent Assignment Dataset. To identify the causal effect of AIPA we implement a regression discontinuity design that compares deals involving patents with application date just before and just after the AIPA enactment date. Constraining identification around AIPA is important because later post-AIPA cohorts are subject to severe sample selection (must be licensed or transferred faster to make it into the sample).

The first application cohorts immediately after November 2000 were fully subject to pre-grant publication, but only marginally affected by sample selection (relative to the last application cohorts in the pre-AIPA period) so a regression discontinuity design should provide clean causal effects. Baruffaldi & Simeth (2018) also advocate for a regression discontinuity design to assess the effects of AIPA, in their application, on knowledge diffusion.

Our main result is that we do not find empirical support for the predictions derived in Hegde & Luo (2017) neither for licensing nor for patent transfers. In order to get to such result we proceed parsimoniously. First, we show that AIPA accelerated patent disclosure and knowledge diffusion (as captured by forward patent citations). Such intermediate effects have been well documented in Hegde *et al.* (2018) and Baruffaldi & Simeth (2018) and are a necessary condition for AIPA to have a positive impact on market for technology outcomes. In a second instance, we find that the positive effect of AIPA on patent disclosure and knowledge diffusion patterns did not percolate to market for technology outcomes. Not even for the subsample of patents with high grant lags which received more drastic disclosure gains after AIPA.

The discrepancy between Hegde & Luo (2017)'s results and ours could be motivated by differences in sampling or in the empirical strategy. Certainly, there are differences between the samples of licensing deals used in the two papers.[1] However, we believe that the main explanation for the diverging results is to be found in methodological aspects. Hegde & Luo (2017) rely on both a before-after analysis and a differences-in-differences approach, the latter comparing licenses of USPTO applications versus licenses of foreign applications (which were subject to the 18-month publication requirement well before AIPA and therefore were not affected by the policy). The before-after estimates are significant and so are most of the differences-in-differences ones. For our sample of licensing deals, the before-after estimates

[1] The samples of licensing deals used in both papers are drawn from SEC-mandated material disclosures, but are collected by two different companies each with its own methodology. Hegde & Luo (2017) work with Deloitte Recap's RecapIP, a proprietary product that collates information on agreements in the biopharmaceutical industry. Instead, we use ktMINE's Licensing Database which includes a fair share of biopharmaceutical deals, but is not specific to any particular sector.

are significant too, with coefficients comparable to those in Hegde & Luo (2017), but the regression discontinuity design estimates are not. The same pattern emerges for the sample of patent transfers. We defend that identification should restrict to periods in the neighborhood of AIPA because the first application cohorts immediately after the AIPA enactment date were already fully subject to pre-grant publication. Later post-AIPA cohorts were subject to the same disclosure requirements so additional differences manifesting gradually after AIPA, which are used for identification in a before-after or difference-in-differences setting, cannot be attributed to AIPA and should not be used for identification. Indeed, our before-after estimates seem severely contaminated by sample selection.

1.1 Related literature

Our paper is part of a growing empirical literature that studies whether the sequential resolution of uncertainties during patent prosecution augments trading opportunities in the market for technology. Gans *et al.* (2008) show that the probability of entering into an agreement rises sharply following allowance for a sample of publicly disclosed licensing deals. This result emphasizes that the willingness to contract over patent rights is strongly affected by the resolution of uncertainty about patent scope during the examination process. Ali *et al.* (2018) find that it is patent filing and patent issuance that trigger licensing rather than allowance for a different sample of patents offered for licensing in two major academic medical centers in the US. De Rassenfosse *et al.* (2016) and Drivas *et al.* (2018) study the importance of the publication and grant events on market for technology outcomes. De Rassenfosse *et al.* (2016) find that patent grant increases the success rate of negotiations, while patent publication does not, for a sample of technology transactions comprising a broad range of exchange modes (sale, license, cross, license, etc.) negotiated in Australia. Drivas *et al.* (2018) find the opposite result for a sample of academic inventions licensed at the University of California.

Our paper contributes to the literature that studies the effect of AIPA on knowledge diffusion. Hegde *et al.* (2018) study AIPA's causal effect using a differences-in-differences approach that compares treated applications filed at the USPTO with a counterfactual sample of control twins filed at the European Patent Office. They find that AIPA increased the rate and magnitude of knowledge diffusion associated with US patents which in turn had an effect on patent similarity, resulted on fewer abandonments, narrower claims, and clearer patents. Baruffaldi & Simeth (2018) use a regression discontinuity design to identify the causal effect of AIPA on knowledge diffusion. They document a positive effect of AIPA on knowledge diffusion. However, contrary to Hegde *et al.* (2018), they do not find significant effects on subsequent outcomes such as patent similarity, which suggests that the benefits from increased knowledge diffusion might have been low. Johnson & Popp (2003) find that pre-grant publication can bring small positive short-run effects through faster diffusion of higher quality applications which are in the patent office longer.

Finally, it is important to highlight that the papers relying on AIPA to study patent disclosure inevitably focus on pre-grant, as opposed to post-grant, disclosure. The absence of effects for patent applications does not imply that disclosure is not important. Perhaps disclosure is relevant but does not convey enough benefits to compensate for the costs of transacting over inherently uncertain property rights. Studying the role of disclosure for granted patents would seem important because the vast majority of applications stay in the office for a few years (generally no more than five), but have a much longer life span when they come out of it as issued patents. To the best of our knowledge, the only authors to have studied post-grant disclosure are Furman *et al.* (2018), who find a positive effect of the expansion of the USPTO Patent and Trademark Depository Library system between 1975 to 1997 on subsequent innovation. The same context could be used to study the impact of post-grant disclosure on trade in the market for technology. We leave that possibility to future research.

The remaining of the paper is organized as follows. Section 2 describes the expected effects of AIPA on the market for technology. Section 3 presents the data. Section 4 discusses the empirical strategy. Section 5 presents the results. Section 6 concludes.

2 AIPA and the market for technology

In this section we first discuss the institutional aspects of AIPA. Next, we summarize the testable predictions derived by Hegde & Luo (2017) on the effect of AIPA on the timing of transactions in the market for technology. Finally, we discuss particularities of the two modes of exchanged considered in this paper, namely licensing and patent transfers, which might have prompted different responses to AIPA.

2.1 AIPA as an information shock

Our summary of the institutional aspects of AIPA draws heavily on the excellent reviews by Graham & Hegde (2015), Hegde & Luo (2017) and Hegde *et al.* (2018). Before AIPA, U.S. patent applications were published at the time of grant. AIPA separated the patent publication and patent grant events, requiring all patent applications filed on or after November 29, 2000, to be published 18 months after the earliest application date (patents granted earlier kept being published upon grant). Because the time elapsed from application to grant was substantially longer than the 18 month publication window for most patents (the average in our sample being 34 months), AIPA triggered substantial disclosure gains in the form of pre-grant publications.

AIPA essentially harmonized the patent disclosure policy of the U.S. with those in the rest of the world where the 18-month pre-grant publication rule was already mandatory. Before AIPA, patent applications filed in the U.S. as well as in foreign jurisdictions (slightly less than half of all USPTO patents) were published by the patent offices in these foreign nations 18 months after the priority date. For such patents, AIPA triggered a less radical but still notable disclosure shock consisting in issuing pre-grant publications not only in foreign patent offices but also in the US.[2] Another important aspect of AIPA is that it allowed applicants seeking no foreign patents on the same invention to opt out of 18-month publication. This opt-out provision was included in response to concerns from policymakers and scholars that pre-grant disclosure might discourage invention by small inventors relying on secrecy as a means of protection. In practice, the opt-out provision has been rarely used with only 15% of applications not pursing parallel foreign applications opting out of pre-grant disclosure (Graham & Hegde, 2015). Therefore, AIPA did accelerate pre-grant publication for a vast majority of patent applications.

As Hegde & Luo (2017) note, voluntary pre-grant disclosure was already possible pre-AIPA through a variety of mechanisms such as posts on websites or reports in industry and trade bulletins. However, disclosure through the official USPTO repository is likely to have resulted in considerable additional information gains over such selective disclosure practices for several reasons. First, pre-grant patent publications disclose information in a systematic and standardized way. Second, disclosure in centralized USPTO databases reduces search costs. Third, prospective evaluation by USPTO examiners gives inventors the right incentives to disclose credible and accurate information. Finally, filing fees weed out low quality inventions and ensure that inventions published pre-grant comply with certain minimum quality standards (see De Rassenfosse & Jaffe, 2018). Overall, we view AIPA as an information shock with the potential to reduce information frictions in the market for technology.

[2] Publication in foreign countries is not as informative as publication in the US. Regular users of USPTO repositories were not able to easily access information in foreign patent applications prior to AIPA because USPTO patent applications were not linked to their foreign country equivalents. Therefore, AIPA is likely to have improved access to such applications with foreign priority too.

2.2 AIPA and the timing of transactions: testable predictions

In this subsection we review the framework proposed by Hegde & Luo (2017) which provides testable predictions of the effects of AIPA on the timing of transactions in the market for technology. In deciding when to transact, the technology provider faces a fundamental trade off. On the one hand, she has incentives to transact as early as possible after application because of limited patent life (up to 20 years since application). On the other hand, she has incentives to delay licensing until uncertainties over the scope of the claims in the patent and the technical aspects of the invention are resolved. There are at least three events that are likely to alleviate uncertainties throughout patent prosecution: publication, application and grant. Patent publication reduces information frictions while application and grant clarify property rights.

AIPA triggered a transition from an environment with two relevant events (application and publication/grant) to one with three relevant events (application, publication and grant). Such transition offers an opportunity for identifying the separate effects of patent publication. Before AIPA, it was optimal for providers to transact either immediatly after patent application or wait until publication/grant.[3] After AIPA, the incentives to transact might have changed through two channels: a *reduction in information frictions* and an *increase in expropriation risk*.[4] If pre-grant publication conveys benefits through a reduction in information frictions for a large enough number of technology providers, transactions should move away from the application and grant dates to bunch immediately after the publication date.[5]

[3]The technology provider licenses/transfers the invention after the application date if the net benefit from a longer-lived asset (the application) is greater than the net benefit from a shorter-lived asset (the granted patent) that has been publicly disclosed and has clearly delineated claims.

[4]Disclosure (not just public but also voluntary disclosure) may allow potential technology adopters or rivals in the market for technology to obtain enough information to come up with substitutes for the invention. Public disclosure (through pre-grant publication or grant) increases expropriation risk over voluntary bilateral disclosure because it makes the invention available to a broader set of firms. Importantly, Hegde & Luo (2017) define expropriation risk as the adopter's ability to legally invent around the invention. It is common in the literature to use broader definitions of expropriation risk which include outright infringement or copying. The main difference between the two types of expropriation risk is that the latter can be substantially lowered with patent protection while the former cannot.

[5]Some technology providers who would have waited until the grant date before AIPA will find it optimal

At the same time, increased expropriation risk makes it less attractive to delay licensing to prolong secrecy, pushing transactions toward the application date. The interaction of these two effects generates the following testable predictions:

- *Prediction 1.* The likelihood of transacting pre-grant increases after AIPA.

- *Prediction 2.* If pre-grant publication conveys benefits through reductions in information frictions: *(A)* the likelihood of transacting after 18 months and before grant increases after AIPA; and *(B)* the transaction lag (i.e. the time elapsed between the application date and the effective transaction date) converges to 18 months after AIPA.

The first prediction emerges from the combined effects of a reduction in information frictions and an increase in expropriation risk both of which reduce the likelihood of transacting post-grant. It is necessary to distinguish between the two because their welfare implications can be quite different. Reducing information frictions is likely to increase the total surplus of a transaction while increased expropriation risk may be associated with a loss. The second prediction helps clarify if pre-grant publication conveys informational benefits.

2.3 Singularities of licensing and transfers

Patent applications are fairly uncertain property rights. It is well known that patent office examiners often narrow the scope of patent claims in terms of both claim length and claim count (see Marco *et al.* , 2018). Uncertainty over the scope of property rights might deter parties from engaging in exchanges even when informational frictions are low. Therefore, AIPA should only be expected to significantly affect transaction patterns if parties are capable of contracting over uncertain property rights. The two modes of exchange studied in this paper, namely licensing and patent transfers, offer a different set of opportunities for dealing with such uncertainties.

to expedite transactions to the publication date. Other technology providers who would have transacted after the application date before AIPA will find it profitable to sacrifice months of patent life to contract over less uncertain assets and will delay transactions until the publication date.

A licensing agreement is a contract by which the licensor retains ownership of the invention but grants the licensee the right to use it for a given period. The extended duration of licensing agreements allows parties to negotiate contingent terms, conditioning royalty rates to the final prosecution outcomes. However, the additional complexity of negotiating contingent terms may be costly. Moreover, there are certain risks that not even contingent terms can account for. For instance, firms might be reluctant to invest in costly product development that will not be recovered without the possibility to exclude others.

In a patent transfer, the seller transfers ownership of the patent to the buyer in exchange for a price. The one shot transaction makes contingent terms virtually impossible and exposes the buyer to the risk of purchasing an overpriced asset if relevant claims are narrowed during prosecution. While it would seem that there are little incentives to purchase patent applications due to the difficulty in negotiating contingent terms, patent transfers offer other advantages. Patent transfers confer the buyer direct control over the prosecution process, which might be desirable if the buyer has better attorneys capable of securing relevant claims. Importantly, once a claim is published through a pre-grant publication it becomes impossible for other firms to obtain rights on the same claim through other patent applications because novelty, an important patentability requirement, can no longer be claimed. Therefore, pre-grant publications have value on their own right and could very well lead to a *market for prosecution control*.

3 Data

In this section we describe the construction of three datasets: a patent-level dataset used to study the effect of AIPA on patent disclosure and knowledge diffusion; a license deal dataset used to study the effect of AIPA on licensing outcomes; and a patent transfer dataset used to study the effect of AIPA on transfer outcomes. First, we define the main data sources used to build the three dataset. Next, we describe our datasets and definitions for the multiple variables used in the econometric analysis. Finally, we provide descriptive statistics and discuss sample selection issues that might bias our estimates.

3.1 Sources

Basic patent information: we extract information on 5,823,860 utility patents issued by December 2014 from the BASIC_14 and UCITES_14 files in the Custom Bibliographic Patent Data Extract DVD-ROM 2014 available for download on the USPTO website. The file BASIC_14 provides information on patent numbers, grant dates, application dates and USPTO technology classes all of which we use to define variables used in our analysis. The file UCITES_14 contains information on cites by issued patents to other issued patents or pre-grant publications (the latter only after the AIPA). Additionally, we extract pre-grant publication dates from the *application_ data* file in the USPTO Patent Examination Research Dataset also known as Public PAIR (see Graham *et al.* , 2015).

Licensing: we rely on ktMINE's Licensing Database to obtain information on licensing deals. The data are sourced from SEC-mandated material disclosures, wherein the licensing agreements are usually attached as exhibits.[6] The unit of observation in the dataset is a licensing agreement entered into by at least two parties (a licensor and a licensee). The filer must be a public firm, and is usually either the licensor or the licensee. The counterparty may be a private company or a non-commercial entity such as a university. Therefore, SEC disclosures by definition offer a broader coverage of economically significant deals in which at least one the parties in the agreement (and often all of them) are publicly traded firms. The database includes over 12,121 licensing deals with a distinct identifier, but some of these are duplicate records for the same agreement. For 2,277 of the deals we have

[6]Public companies are required to disclose "material" transactions in their filings. A "material" event is any significant event that affects the company's financial standing, such as a lawsuit, merger, employment of key personnel, joint venture, or license agreement. Public companies can be exempt from filing the standard SEC forms if they have fewer than 500 stockholders and less than $10 million in total assets.

detailed information on the licensed patent numbers which involve 7,752 patents overall. The licensing agreements in the sample are mostly exclusive and do not restrict to specific technological fields or industries even though most deals are in Drugs (SIC code 283) and Computer Programming (SIC code 737), which account for 33% and 11% of the deals in the sample respectively. We use the following variables from this dataset: license identifiers, effective execution dates and patent numbers of licensed patents.

Patent trades: we obtain information on patent transfers from the USPTO Patent Assignment Dataset (see Graham *et al.* , n.d.) which provides detailed information on changes in patent ownership. We work with the 2017 data files which cover 7,239,361 transactions recorded at the USPTO between January 1970 and February 2017.[7] Following Graham *et al.* (n.d.) and Serrano (2010) we define a transaction as an inter-firm patent transfer if it is the second or subsequent transaction record for the patent, the conveyance text identifies the transaction as an "assignment of the assignor's interest" and neither the assignor nor the assignee are individuals. We only retain trades of eventually issued utility patents (such patents may have been traded pre-grant, but must have been issued by February 2017) because trades of non-issued patents are not observed before AIPA. Overall, the selected dataset includes 305,630 assignments involving 920,297 patents (some of which are reassigned more than once). We use the following variables from this dataset: transaction identifiers, effective execution dates and patent numbers of transferred patents.

3.2 Datasets, samples and variables

We match patent information with transaction records by patent number to create three different datasets: a patent-level dataset, a license-level dataset and a transfer-level dataset. The patent-level dataset is used to study the effect of AIPA on disclosure and patent diffusion

[7] Updated versions of the USPTO Patent Assignment Dataset can be found at: http://www.uspto.gov/learning-and-resources/electronic-data-products/patent-assignment-dataset.

as measured by forward citations. The last two datasets are used to test the predictions derived in Section 2. We restrict to patents with application date (or licenses and transfers involving patents with earliest application date) between January 1 1998 and December 31 2003, which seems a reasonable time window within the AIPA enactment date in November 2000. For each one of these datasets we define a different set of outcome variables.

Patent-level dataset: The patent level dataset includes 1,165,809 patents with application date between 1998-2003. For these patents we create four variables using bibliografic information of the patent, forward citation counts and dates:

- *Disclosure lag:* difference in months between the disclosure date and the application date. Before the AIPA enactment date this is equivalent to the grant lag (i.e. difference in months between the grant date and the application date). After the AIPA enactment date disclosure lag is either eighteen months (if the patent is issued after the eighteen month window) or the grant lag (if the patent is issued before the eighteen month window between application and compulsory pre-grant publication or opts out of pre-grant publication).

- *Number of forward cites:* total number of forward cites received by the patent up to December 2014. During the pre-AIPA period only issued patents can be cited. In the post-AIPA period both issued patents and pre-grant publications can be cited. Consequently, in calculating forward cites for the post-AIPA period we add up both the citations received by the issued patent and the corresponding patent application before issuance. Duplicities (i.e. citing patents citing both the issued patent and the pre-grant publication of the issued patent) are removed.

- *Mean forward cite lag:* average difference in months between the application date of all the citing patents and the application date of the cited patent.

- *Minimum forward cite lag:* average difference in months between the application date of the first citing patent and the application date of the cited patent. We use minimum and mean lags because some patents are traded more than once. In such cases, the minimum lag is a better measure for estimating the impact of earlier disclosure. However, there is little variation between the two measures because most patents are traded just once.

License level dataset: The license-level dataset includes 374 licenses involving patents with earliest application date between 1998 and 2003. We create three outcome variables for each license using information on the effective license date and bibliographic information on the licensed patents. If the license includes a bundle of patents (about 43% of deals do) then we follow Hegde & Luo (2017) and use the earliest application and grant dates to characterize the agreement.

- *License pre-grant (0,1):* dummy variable with value one if the patent is licensed pre-grant.
- *License post-18 and pre-grant (0/1):* dummy variable with value one if the patent is licensed after 18 months since applicaton and prior to the grant date.
- *License lag - 18:* license lag in months (difference in months between the effective license date and the application date) minus 18, in absolute value. We use this variable to track whether the license lag converges to the 18 month publication window during the post-AIPA period. The main idea is that if patents are licensed around the 18 month disclosure date then difference (in absolute value) between the license lag and 18 should be close to zero.

Transfer level dataset: The patent trade-level dataset includes 67,494 transfers involving patents with earliest application date between 1998 and 2003. We create three variables for each transfer using information on the effective transfer date and bibliographic information on the transferred patents. Again, if the transaction includes a bundle of patents (about 23% of deals do) then we follow Hegde & Luo (2017) and use the earliest application and grant dates to characterize the agreement.

- *Transfer pre-grant (0,1):* dummy variable with value one if the patent is traded pre-grant.
- *Transfer post-18 and pre-grant (0/1):* dummy variable with value one if the patent is traded after 18 months since applicaton and prior to the grant date.
- *Transfer lag - 18:* transfer lag in months (difference in months between the effective transfer date and the application date) minus 18, in absolute value. We use this variable to track whether the transfer lag converges to the 18 month publication window during the post-AIPA period.

3.3 Descriptive statistics and sample selection issues

Table 1 reports descriptive statistics of the variables described above. There is a substantial decline in the disclosure lag from 31 months in the pre-AIPA period to 16 months in the post-AIPA period.[8] The average grant lag is 34 months which imples that the AIPA on average accelearted disclosure by 16 months. Regarding the outcome variables, the post-AIPA values tend to be lower than the pre-AIPA ones because selection is at play. Post-AIPA values in the citation related variables are mechanically lower because the clock starts ticking later for recent patents which results in fewer citations at a given cut-off date (2014 in our case). Post-AIPA values of citation, licensing and transfer lag variables are also lower because later patent applications must be cited, licensed or transferred faster to make it into the sample.[9]

[8]Notice that declines in the disclosure lag below the 18 month time window are possible because in the post-AIPA period assignees can voluntarily decide to disclose the patent before the mandatory pre-grant disclosure date (voluntary pre-grant disclosure generally takes place 6 months after the filing date).

[9]For instance, the patent assignment dataset includes transactions recorded with the USPTO up to 2017. This implies that patents with application date in early 1998 (the first application cohorts in the

Truncation could lead us to underestimate the effect of pre-grant disclosure on citation counts and to overestimate its effect on citation and transaction lags.

Figure 1 illustrates how truncation could be wrongly interpreted as a disclosure effect on transaction lags. Panels A and B at the top of the figure plot the distribution of licensing and transfer lags (time elapsed between application and license or transfer) respectively. In both cases, such distribution is shifted to the left (i.e. closer to the application date) for post-AIPA cohorts (dashed blue line) and to the right for pre-AIPA cohorts (solid black line). Panel A is indeed similar to Figure 3 in Hegde & Luo (2017), with licensing concentrated shortly after 18 months (indicated by the vertical line) for application cohorts after AIPA. Bunching around 18 months for post-AIPA cohorts suggests that pre-grant publication is a relevant event that conditions the timing of transactions. However, densities for finer-grained application cohorts in panels C and D suggest that differences in transaction lags are due to sample selection rather than disclosure. The transaction lags of the first post-AIPA cohort (short-dashed red line) and the pre-AIPA cohorts are similarly distributed. The distribution of transaction lags is shifted to the 18 months date only for the later post-AIPA application cohorts (dashed blue line) for which selection is stronger. Our research design explicitly takes care of selection by exploiting discontinuities between cohorts filed just before and just after the AIPA enactment date.

4 Research design

AIPA triggered a discontinuous decrease in publication lags (i.e. an increase in pre-grant disclosure) for most patents with application date after November 29, 2000. We exploit such

pre-AIPA period) can be traded any time during their life while patents with application date in late 2003 (the last application cohorts after AIPA) must have been traded in no more than 13 years to make it in our sample. Selection is likely to be even stronger for licensing deals because those were sampled prior to 2014. Moreover, licensing deals reported to the SEC are often originally redacted by virtue of a Confidential Treatment Request (CTR) and can only be accessed through Freedom of Information Act (FOIA) requests ten years after the original filing upon the expiration of the CTR. Both sampling conditions push licensing lags towards the application date for recent application cohorts.

discontinuity to isolate the effect of pre-grant publication on patent-related outcomes by comparing application cohorts filed right before and right after AIPA. Our baseline equation is the standard parametric specification of the discontinuity design (see Lee & Lemieux, 2010):

$$y_{it} = \alpha_0 + \alpha_1 PostAIPA_t + f(trend) + \beta X_{it} + \varepsilon_{it} \tag{1}$$

where i indexes patents, licenses or patent reassignments; t indexes application cohorts in months; y_{it} is the outcome of interest; $PostAIPA_t = 1\{t > Nov00\}$ is a dummy variable with value one for patent cohorts with application date in the post-AIPA period; $trend = t - Nov00$ is an application cohort trend centered at the AIPA date; $f(trend)$ is a function which captures smooth changes in the outcome variable over time; X is a matrix of patent or deal specific controls; and ε_{it} is an error term. The exact functional forms for $f(trend)$ is a third order polynomial which is allowed to differ on either side of the AIPA date to account for the fact that the treatment may impact not only on the intercept, but also on the slope of the regression line.[10] The parameter of interest is α_1 which captures an immediate intercept change in the outcome variable for all the cohorts with application date after November 2000. Under the assumptions that $f(trend)$ is correctly specified and that firms do not react strategically to the policy change, α_1 is the causal effect of AIPA on the outcome variable. Notice that constraining identification around the AIPA date is important because the first application cohorts immediately after November 2000 were fully subject to pre-grant publication. Later post-AIPA cohorts were subject to the same disclosure requirements so additional differences manifesting gradually after AIPA, which would be used for identification in a before-after or difference-in-differences setting, cannot be attributed to AIPA and should not be used for identification.

[10] In particular, $f(trend) = \alpha_2 trend + \alpha_3 trend^2 + \alpha_4 trend^3 + \alpha_5 trend \times PostAIPA + \alpha_6 trend^2 \times PostAIPA + \alpha_7 trend^3 \times PostAIPA$.

5 Results

Table 2 displays OLS estimates of specification (1) for several outcomes of interest. Figure 2 provides complementary graphs displaying the evolution of each outcome variable around the AIPA date. Table results simply translate into numbers the patterns observed in the graphs. If no clear discontinuity can be detected around the AIPA date through simple visual inspection then statistically significant estimates should not be expected. We present three sets of results. First, we estimate the effect of AIPA on disclosure lags and citation outcomes to confirm that AIPA had a significant effect on patent disclosure and knowledge diffusion. Second, we study the effect of AIPA on licensing outcomes. Finally, we show results on the effect of AIPA on patent transfers.

Disclosure and diffusion. The coefficient estimates reported in column 1 confirm that AIPA clearly triggered a sharp decrease in disclosure lags. The coefficient on the PostAIPA dummy variable is -16.75 which implies that after AIPA, disclosure lags of eventually granted patent applications declined by slightly more than sixteen months on average (from an average of 33 pre-AIPA to an average of 16 post-AIPA). This discontinuity in disclosure lags can be clearly appreciated in panel 1 of Figure 2. If pre-grant publication had an impact on other outcomes we would expect to observe a discontinuity in the evolution of such outcomes around the AIPA date too. Columns 2 to 4 document statistically significant effects of AIPA on patent citation patterns. Column 2 results indicate that post-AIPA application cohorts receive about three additional forward citations on average, experience a reduction in the average citation lag of more than one month, and a decline in the time to receive the first citation of three months and a half. Such statistically significant intercept changes in citation patterns can be visually appreciated in panels 2 to 4 of Figure 2 in the form of discontinuities for patents belonging to application cohorts immediately after the AIPA date. Our results on patent citations are consistent with the results in Hegde *et al.* (2018) and Baruffaldi & Simeth (2018).

Licensing. The results in columns 1 to 4 imply that AIPA triggered an information shock that accelerated knowledge diffusion. Were the gains conveyed by such information shock high enough to accelerate licensing? The results in columns 5 to 7 suggest that they were not, with the coefficient on the PostAIPA dummy variable being statistically insignificant for all the licensing outcomes. *Prediction 1* states that the percentage of licenses taking place pre-grant should increase after AIPA either because of a decrease in information frictions or an increase in expropriation risks (or both). The results in column 5 show that this was not the case, with the percentage of licenses taking place pre-grant remaining unchanged after AIPA. *Prediction 2A* states that if pre-grant publication conveys benefits through reductions in information frictions, the likelihood of transacting between pre-grant publication and grant should increase after AIPA. Column 6 shows that the percentage of licenses taking place between pre-grant publication (18 months since application) and grant remained unchanged. *Prediction 2B* states that if pre-grant publication conveys benefits through reductions in information frictions, the transaction lag (i.e. the time elapsed between the application date and the effective transaction date) converges to 18 months after AIPA. Column 7 shows that the license lag (time elapsed between application and license effective date) failed to converge to the 18 month pre-grant publication date. In line with the regression results, the graphs in panels 5 to 7 of Figure 2 show no clear discontinuities in licensing outcomes around the AIPA date.

Patent transfers. The results in columns 8 to 10 suggest that AIPA had no effects on the timing of patent transfers either. The PostAIPA dummy variable is insignificant for all the patent transfer outcomes: the percentage of patent transfers taking place pre-grant did not increase after AIPA (column 8), the percentage of patent transfers taking place between pre-grant publication and grant remained stable post AIPA (column 9), and the transfer lag did not converge to the 18 month pre-grant publication date. The graphs in panels 8 to 10 of Figure 2 show no clear discontinuities in patent transfer outcomes around the AIPA date either. That is, none of the predictions finds empirical support in the data. One of the implications of this set of results is that AIPA did not trigger a systematic market for *patent prosecution control*. Such a market could have arisen if a group of applicants had found it profitable to strategically file patents with the only purpose of leaving valuable claims unprosecuted in the public domain for others to buy. Our results imply that such strategic bahaviour did not emerge or at least not with enough impetus to shift average transaction patterns.

5.1 Heterogeneity: high grant lag patents

Patents with short grant lags were already disclosed shortly after application through grant before AIPA. Disclosure gains were most pronounced for patents with high grant lags which experienced substantial declines in disclosure lags through compulsory pre-grant publication. Perhaps AIPA only had significant effects on the timing of transactions for the latter group of patents with high grant-lags. We study whether this is the case by re-estimating specification (1) separately for the subsample of patents with high grant lags (34 or more months from application to grant). Such estimates are reported in Table 3. Column 1 indicates that the decrease in the disclosure lag triggered by AIPA is –31.25 for the sample of patents with high grant lags, an effect nearly twice as large (in absolute value) than that reported for the whole sample (in column 1 of table 2). Similarly, the effects of AIPA on patent citation patterns reported in columns 2 to 4 are considerably larger for the sample of high grant lag patents: post-AIPA application cohorts with high grant lags receive about five additional forward citations on average (versus only three for the whole sample, column 2 of table 2), experience a reduction in the average citation lag of more than three months (versus only more than one for the whole sample, column 2 of table 2), and a decline in the time to receive the first citation of nine months (versus only three months and a half for the whole sample, column 2 of table 2). Despite the strong effects of AIPA on patent disclosure and knowledge diffusion we find no statistically significant effects of AIPA on any of the market for technology outcomes (columns 5 to 10 in table 3). Such statistically insignificant effects for the sample of patents with high grant lags confirms our main results.

5.2 Before-after specification

Table 4 reports results for a naive before-after comparison that excludes the polynomial $f(trend)$. In practice this means that the PostAIPA dummy variable now does not just capture differences in the outcome variable around the AIPA date but in time periods that are further away from AIPA. Opening identification to the entire period turns on a sample selection bias that goes in the directions discussed in Section 3.3. The coefficient on the PostAIPA dummy variable in column 2 is now negative instead of positive because the clock starts ticking later for recent patents which results in fewer citations. The bias on the outcomes involving time lags goes in the opposite direction. For instance, the coefficient on the PostAIPA dummy variable in columns 3 and 4 is substantially more negative because patents need to be cited earlier for the citation to make it into the sample. Similarly, the coefficients in columns 7 and 10 are now negative and statistically significant because patents must be licensed or sold faster in order to make it into the sample. For the same reason, the coefficients in columns 5 and 8 are positive because post-AIPA applications are more likely to be transacted pre-grant. The coefficient in columns 6 and 9 remains insignificant in the before-after comparison which means that the probability of a transaction between 18 months and grant remained fairly stable. These results emphasize the importance of constraining identification around the AIPA enactment date.

6 Conclusion

The American Inventor's Protection Act of 1999 (AIPA) separated patent publication and patent grant requiring all patent applications filed on or after November 29, 2000, to be published no later than 18 months after the earliest application date. Hegde & Luo (2017) develop an elegant framework that yields two testable predictions on the effect of AIPA on the timing of transactions in the market for technology: first, the likelihood of transacting pre-grant increases after AIPA (due to a *reduction in information frictions* or to an *increase in expropriation risk* or both); and second, the likelihood of transacting after 18 months and before grant increases after AIPA (due to a *reduction in information frictions*). Hegde & Luo (2017) find empirical support for both predictions for a sample of licenses of biomedical inventions using before-after and differences-in-differences comparisons.

In this paper we re-examine these two predictions for a different sample of licensing deals drawn from SEC-mandated material disclosureand also extend the analysis to patent transfers extracted from the USPTO Patent Assignment Dataset. The uncertainties of contracting over inherently uncertain property rights such as patent applications can be resolved differently with each mode of exchange. Licensing agreements allow parties to negotiate contingent terms while patent transfers confer the buyer direct control over the prosecution process. Because pre-grant publications are options on published claims, could very well lead to a *market for prosecution control.*

To identify the causal effect of AIPA we implement a regression discontinuity design that compares deals involving patents with application date just before and just after the AIPA enactment date. Constraining identification around AIPA is important because later post-AIPA cohorts are subject to severe sample selection (must be licensed or transferred faster to make it into the sample). Regression discontinuity design estimates reveal that AIPA accelerated patent disclosure and knowledge diffusion (as captured by forward patent citations). However, we do not find empirical support for any of the predictions in Hegde & Luo (2017).

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Tables and figures

Table 1. Descriptive statistics

Notes: This table reports summary statistics of the variables used in the regressions corresponding to issued patents with application date between 1998 and 2003. Lags are defined in months. For the patent dataset samples differ across variables because some definitions are conditional on the patent being cited.

	Whole sample			Pre-AIPA			Post-AIPA		
	# obs	Mean	S.D.	# obs	Mean	S.D.	# obs	Mean	S.D.
Patent level									
Disclosure lag	1,165,809	23	16	524,980	31	17	640,829	16	13
Number forward cites	1,165,809	15	29	524,980	17	32	640,829	14	26
Mean forward cite lag	959,876	69	25	459,436	77	26	500,440	62	22
Minimum forward cite lag	959,876	30	27	459,436	32	28	500,440	27	25
License deal level									
Licensed pre-grant (0,1)	374	0.46	0.50	207	0.34	0.48	167	0.60	0.49
Licensed between 18 month and grant (0,1)	374	0.06	0.23	207	0.07	0.25	167	0.04	0.20
License lag - 18 month	374	37	31	207	44	33	167	30	27
Transfer deal level									
Traded pre-grant (0,1)	67,494	0.43	0.50	34,640	0.41	0.49	32,854	0.45	0.50
Transferred between 18 month and grant (0,1)	67,494	0.08	0.27	34,640	0.08	0.27	32,854	0.08	0.27
Transaction lag - 18 months	67,494	51	49	34,640	54	53	32,854	48	44

Table 2. Regression results: main results

Notes: This table reports estimates of specification 1 for several outcomes. ***, ** and * indicate significance at a 1%, 5% and 10% level respectively. Standard errors, in parentheses, are robust to heteroskedasticity and clustered at the USPTO technology class level.

	Disclosure and difussion				Licensing			Trades		
	Disclosure lag	Number cites	Mean cite lag	Min cite lag	Licensed pre grant	Licensed btw 18 and grant	License lag - 18	Traded pre grant	Traded btw 18 and grant	Transfer lag - 18
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PostAIPA	-16.754***	3.221***	-1.537***	-4.303***	-0.139	-0.223	24.464	0.018	0.008	-0.722
	(2.077)	(0.657)	(0.447)	(0.509)	(0.377)	(0.133)	(22.984)	(0.017)	(0.010)	(1.519)
Intercept	32.678***	5.097***	73.404***	43.165***	0.736***	0.009	27.617**	0.425***	0.150***	45.525***
	(1.450)	(0.633)	(0.411)	(0.486)	(0.190)	(0.027)	(11.283)	(0.016)	(0.012)	(1.237)
f(trend)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,165,809	1,165,809	959,876	959,876	374	374	374	67,494	67,494	67,494

Table 3. Regression results: high grant lag patents

Notes: This table reports estimates of specification 1 for several outcomes. ***, ** and * indicate significance at a 1%, 5% and 10% level respectively. Standard errors, in parentheses, are robust to heteroskedasticity and clustered at the USPTO technology class level.

	Disclosure and difussion				Licensing			Trades		
	Disclosure lag	Number cites	Mean cite lag	Min cite lag	Licensed pre grant	Licensed btw 18 and grant	License lag - 18	Traded pre grant	Traded btw 18 and grant	Transfer lag - 18
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PostAIPA	-31.259***	5.403***	-4.492***	-9.040***	0.157	-0.056	9.437	0.001	-0.013	1.214
	(1.582)	(0.684)	(0.473)	(0.349)	(0.404)	(0.118)	(33.308)	(0.023)	(0.013)	(1.965)
Intercept	52.325***	5.230***	78.193***	40.745***	0.325*	0.023	72.130***	0.469***	0.076***	49.560***
	(1.301)	(0.478)	(0.392)	(0.644)	(0.177)	(0.049)	(9.138)	(0.020)	(0.009)	(1.593)
f(trend)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	458,052	458,052	367,956	367,956	224	224	224	32,616	32,616	32,616

Table 4. Regression results: before-after analysis

Notes: This table reports estimates for several outcomes using a specification similar to equation (1) but for a naive before-after estimator that excludes the polynomial f(trend). ***, ** and * indicate significance at a 1%, 5% and 10% level respectively. Standard errors, in parentheses, are robust to heteroskedasticity and clustered at the USPTO technology class level.

	Disclosure and difussion				Licensing			Trades		
	Disclosure lag	Number cites	Mean cite lag	Min cite lag	Licensed pre grant	Licensed btw 18 and grant	License lag - 18	Traded pre grant	Traded btw 18 and grant	Transfer lag - 18
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PostAIPA	-14.714***	-3.355***	-15.032***	-4.293***	0.324***	-0.021	-13.857***	0.035**	-0.005	-5.329***
	(1.503)	(0.869)	(0.368)	(0.352)	(0.051)	(0.022)	(4.197)	(0.013)	(0.003)	(0.908)
Intercept	29.594***	8.795***	79.104***	41.917***	0.004**	0.000	98.509***	0.378***	0.132***	51.011***
	(0.718)	(0.416)	(0.165)	(0.158)	(0.002)	(0.000)	(0.161)	(0.007)	(0.002)	(0.554)
f(trend)	No	No	No	No	No	No	No	No	No	No
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,165,809	1,165,809	959,876	959,876	374	374	374	67,494	67,494	67,494

Figure 1. Distribution of transaction lags for pre-AIPA and post-AIPA cohorts

This figure graphs the distribution of transaction lags (months elapsed between application and transaction date) for deals (patents) with application date pre-AIPA and post-AIPA. The vertical line marks the 18 month pre-grant publication event. Panels A and C report figures for licensing deals while Panels B and C report figures for patent transfers.

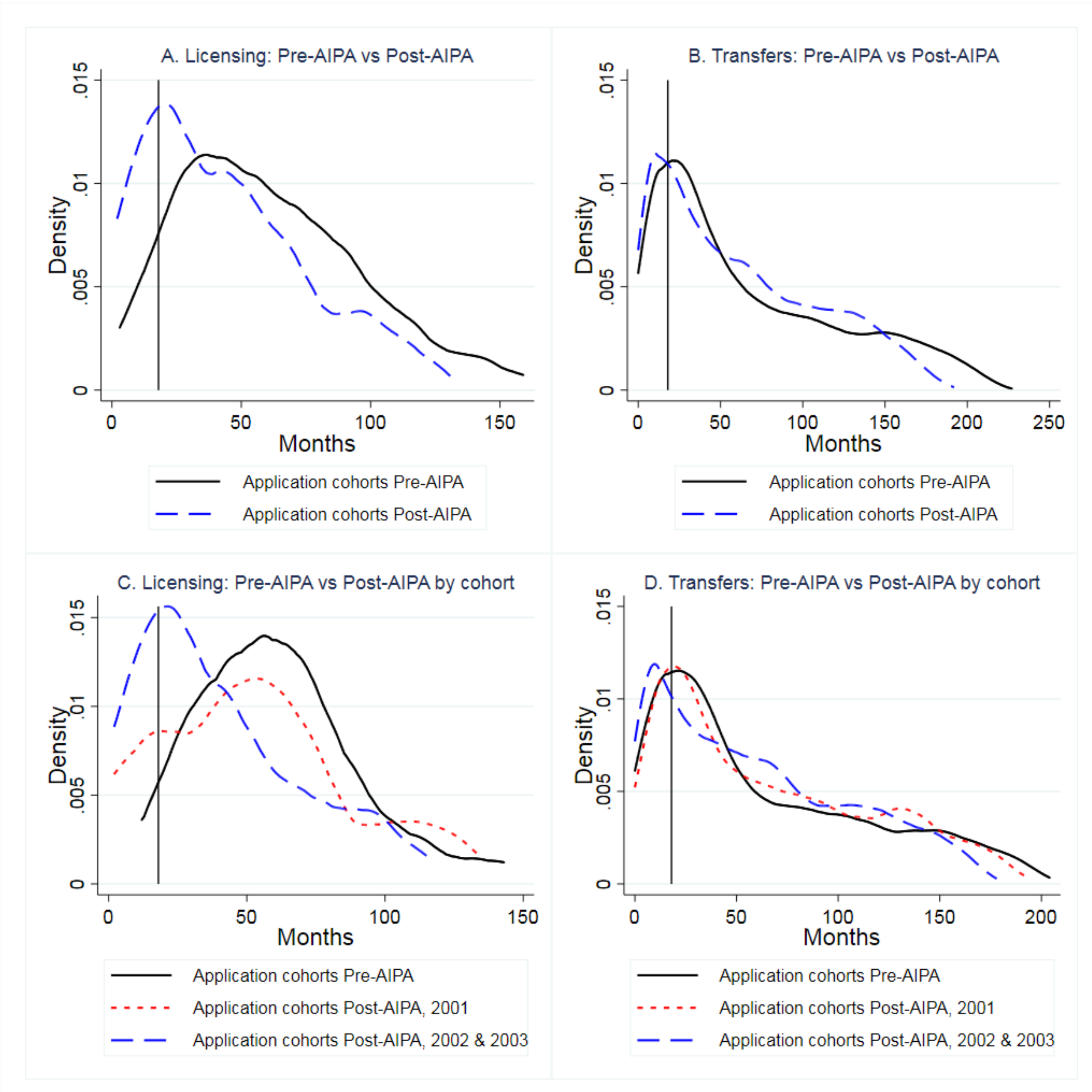

Figure 2. Evolution outcomes around AIPA date

This figure graphs binned outcome means (bins are defined at the month level) and a third order global polynomial fit estimated separately for pre-AIPA and post-AIPA observations. The AIPA date (November 2000) is indicated with a vertical line.