Licensing and Patent Disclosure*

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Abstract

How does patent disclosure affect the *timing* of licensing? We address this question by analyzing the effects of the American Inventor's Protection Act (AIPA), which required US patent applications to be published 18 months after their filing, rather than at grant, from November 29, 2000. We develop a simple theoretical framework that yields predictions about the optimal timing of licenses before and after AIPA and test the predictions using a sample of 299 licenses of biomedical inventions negotiated between 1995 and 2010. Consistent with our predictions, we find that after AIPA, some inventors are *more* likely to license their inventions immediately after 18-month disclosure and some are *more* likely to license their inventions immediately after filing their applications. Overall, post-AIPA patent applications are licensed primarily before patent issue and substantially sooner than pre-AIPA patents. Pre-grant patent disclosure appears to accelerate the commercialization of inventions by reducing search costs in the market for ideas.

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Comments welcome.

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1. Introduction

Consider an inventor's choice of *when* to license an idea. Licensing early can benefit the inventor by maximizing the duration of market exclusivity enjoyed by the idea due to first-mover advantages (*e.g.*, Schmalensee 1978, Gilbert and Newbery 1982, Robinson 1990). But licensing early poses several challenges: the best licensee of the idea may not be immediately apparent and may require time and resources to search; the inventor has to credibly disclose the idea in negotiations with potential licensees; and, in the process of negotiations, the inventor has to safeguard against the ideas' expropriation by potential licensees (Arrow 1962, Anton and Yao 1994, 2003).

One option for an inventor facing the above challenges is to license the invention immediately after securing patent rights (Arrow 1962, Katz and Shapiro 1986, Teece 1986). A patent establishes a public record of the technical knowledge underlying the invention and certifies the inventor's property rights, thus mitigating the disclosure and expropriation issues associated with the disclosure of ideas. Indeed, Gans, Hsu and Stern (2008) find that the hazard rate of licensing goes up by 70 percent following patent grants to inventors, suggesting that patents accelerate licensing by facilitating disclosure.

How does the public disclosure of inventions required by patents affect licensing? Historically, US patent applications were published at patent grant, making it hard to disentangle the distinct effects of public disclosure and certification of property rights accomplished by patents. The enactment of the American Inventor's Protection Act of 1999 (AIPA) required all inventors filing for patents at the United States Patent and Trademark Office (USPTO) on or after November 29, 2000 to publish their applications 18 months after filing date. Since patent applications, on average, require about 40 months to be granted, we exploit AIPA's enactment as a quasi-natural experiment to isolate the effects of patent publication on the timing of licensing.

The potential effects of AIPA on the timing of licensing are not immediately obvious and we develop a simple theoretical framework to derive predictions about the optimal timing of licensing before and after AIPA. The framework examines inventors' licensing decision as a function of the net effects of monopoly rents, public disclosure, and the clarification of property rights on the inventors' profits, and provides the following predictions: (i) the likelihood of licensing after 18-month disclosure *increases* after AIPA; (ii) the likelihood of licensing after patent grant *decreases* post-AIPA; (iii) the likelihood of licensing immediately after filing a patent application can either increase or decrease post-AIPA, as some inventors postpone licensing from application date to 18-months, and others expedite licensing from patent issue to application date; and (iv) the average licensing delay might increase or decrease post-AIPA, depending on the balance of inventors who postpone licensing until 18-month disclosure versus those who expedite licensing to the disclosure date after AIPA.

We test the above predictions in a sample of 299 licenses of biomedical inventions, involving 581 US patents (patent applications and issued patents), negotiated between 1995 and 2010. We find that patents are licensed sooner after AIPA came into force. In particular, the likelihood of licensing immediately after patent application and in the window between 18-month disclosure and patent issue both increase significantly after AIPA. In addition, conditional on licensing after patent issue, licensing appears to occur much sooner after AIPA, perhaps because

the 18-month disclosure of patents requires a much curtailed search and negotiations process after the grant event. As a result of both the shift of licensing events towards patent application date and earlier licensing after issue, post-AIPA patents are licensed up to two years sooner than pre-AIPA patents (PLEASE NOTE: all estimates are preliminary).

We find that the estimated effects of AIPA are much less significant, both economically and statistically, for for-profit licensors than for non-profit licensors. Non-profit licensors are primarily universities and other institutions, which, arguably value the benefits of patent publication more than the costs of potential substitution facilitated by patent publication. The estimated effect of AIPA is also also much less significant for patents with foreign counterparts than for patents without. These findings are consistent with what we expect and add confidence to our conclusion that the change in public disclosure rules brought about by AIPA explains the differences in the timing of licensing across the two different disclosure regimes.

We are unable to estimate—or even, control for—the overall effects of pre-grant publication on the *ex-ante* incentives for patenting and licensing because of data limitations. We also fall short of pinning down the exact channels through which patent publication benefits early licensing. Despite the above limitations, our study contributes to a better understanding of the effects of pre-grant patent publication on the commercialization of inventions.[1] With the caveat that we do not yet have a good understanding of the overall welfare effects of AIPA (and thus of patent publication), our study suggests that conditional on the licensing event, pre-grant publication accelerates licensing.

The rest of the paper is organized as follows. Section 2 describes the institutional details and presents a simple theoretical framework to understand the potential effects of AIPA on inventors' licensing timing decisions. Section 3 introduces the sample and describes the data. Section 4 presents regression results. Section 5 concludes.

2. Institutional details and the timing of licensing

2.1 The American Inventor's Protection Act (AIPA)

Patent systems have two main objectives: to encourage innovation by awarding inventors monopoly rights to their inventions; and to promote knowledge diffusion by publishing the technical knowledge in the inventions so that those skilled in the subject area can learn from, and improve upon, the invention. Prior to AIPA, all US patents were published after their grant date—the technical knowledge represented in the patent application, the filing date of the patent application, and even the inventor's decision to seek a patent all remained secret until patent grant. In contrast, about 200 countries, including all European countries, Japan and

[1] A number of papers study the effect of Canada's 1989 Patent Act reform that switched from a confidential filing system with a first-to-invent priority rule to a pre-grant publication system with a first-to-file priority rule. Tepperman (2002) finds that after the reform, firms increased R&D investments and also increased their patenting intensity. Putnam (1997) estimates that pre-patent publication is associated with a $479 decrease in the mean value of patents. These studies however, do not separate out the effects of pre-grant publication from the effects of switching to first-to-file from first-to-invent which occurred simultaneously with the passage of Canada's Patent Act reform.

Australia have required pre-grant publication at eighteen months after the earliest filing date long before AIPA was enacted.[2]

AIPA required the publication of all US non-provisional utility patent applications filed on or after November 29, 2000 that are also filed in a foreign country that requires pre-grant publication. Consistent with the international rule, publication occurs eighteen months from the earliest filing date of the patent application for which benefit is sought, called the "priority date." **AIPA also granted provisional rights to the owner of the published application to pursue a reasonable royalty for the period between the date of publication and the issue date of the patent**.[3]

In order to balance concerns regarding the effects of mandatory disclosure, AIPA provided a loophole to escape 18-month publication: inventors can opt out of 18-month disclosure by filing with the application a certification that the application has not been, and will not be, filed in any foreign country that requires pre-grant publication.[4] Graham and Hegde (2012) assess post-AIPA data and report that only about 8% of all US patent applications, and 4% of applications covering biomedical inventions, choose to keep their inventions secret before patent grant. They find that US small inventors are particularly likely to prefer disclosure over secrecy for their most important inventions and argue that public disclosure allows small inventors to advertise their inventions to external investors and potential licensees. Indeed, in our sample of biomedical licenses, we find that none of the post-AIPA patents had opted out of 18-month disclosure and therefore, we do not investigate here the potential consequences of withholding 18-month disclosure after AIPA.

Prior to AIPA, US applications that were also filed in a foreign country were published eighteen months after the earliest filing date in these countries. Theoretically, the information of these applications was also available to the public in the US. However, as proponents for AIPA argued, there were frictions that increased the cost of obtaining this information (perhaps because, in many instances, the applications were published in the official language of the granting authority).[5] Hence, it is possible that the disclosure of US applications mandated by AIPA also affects those patents that were already filed and disclosed in foreign jurisdictions, but perhaps to a lesser extent.

How does the pre-grant disclosure of patent applications affect inventors' decisions regarding when to license their inventions? In the following section, we build on previous studies about

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[2] For example, if a US firm applies for a patent in the U.S. prior to filing for a patent in Japan, the publication in Japan will occur eighteen months from its U.S. filing date.

[3] To be entitled to this reasonable royalty, the patent owner is required to provide proper notice to the alleged infringer, and the published claims have to be "substantially identical" to the claims in the issued patent. See Subtitle E under "American Inventors Protection Act of 1999 is Law" available at: http://www.uspto.gov/patents/law/aipa/summary.jsp.

[4] See Ragusa (1992) and citations within for an account of the arguments for and against the enactment of pre-grant publication in the U.S.

[5] As is noted by Ragusa (1992), "It is theoretically possible for a U.S. inventor to locate patent applications when they are published in another country and to obtain English language translations of such publications. This is not, however, a practical alternative for small businesses with limited resources to invest in the patent application process. When a U.S. company conducts a search in the USPTO, it is more difficult for the company to discover and understand foreign language prior art than a U.S. patent."

the effects of disclosure and develop a simple theoretical framework that yields predictions about a licensor's decision regarding when to license her invention.

2.2 AIPA and the timing of licensing

When deciding the timing of licensing, the seller (licensor) faces the following tradeoffs. Licensing earlier yields more periods of revenues, which is important because of the fixed period of patent exclusivity from application date. However, the seller risks leaking confidential information while trying to sell the invention to various parties. For some inventions, the seller might benefit from waiting until the application is publicly disclosed; and for others, the seller may be better off waiting until the patent rights are granted. Gans, Hsu and Stern (2008) point to a number of frictions in the market for ideas that delay licensing.[6] But because of their focus on the patent-grant event pre-AIPA, they are unable to separate out the distinct effects of patent publication from the clarification of patent rights. The following paragraphs discuss the distinct reasons why publication and the clarification of patent rights affect the likelihood of licensing.

Why does patent publication matter?

First, patent publication helps reduce the information asymmetries between inventors and potential buyers. These asymmetries could be due to the inventors' superior technical knowledge about the invention, the scope of her property rights, or even the prior art related to the invention. The publication of patents resolves these asymmetries.

Second, publication reduces search costs for potential buyers. Before a patent application is published, no one is aware of its existence. Inventors' voluntary disclosures may either suffer from credibility issues or be hard to search. Publication of patent applications by the USPTO immediately notifies potential buyers, licensees and other patentees of the inventions thus significantly broadening the possible set of cooperative opportunities for both the inventors and licensees.

Third, inventors are entitled to collect royalties from licensees and others who infringed on their patents from the date of publication of the application (subject to the rider that the eventually issued patent associated with the application substantially resembles the claims in the published application).

Consistent with the above benefits of disclosure, Graham and Hegde (2012) show that after AIPA, a significant proportion of inventors, particularly small inventors, who could have kept their applications secret (because they do not seek foreign protection) chose not to do so.

Why does the clarification of patent rights matter?

According to Gans, Hsu and Stern (2008) inventors may have better knowledge regarding the likelihood of grant and the eventual scope of claims of their patents (since inventors have repeated interactions with patent examiners during the course of patent prosecution). Hence,

[6] As Gans, Hsu and Stern (2008) also point out, pure uncertainties should not result in licensing delays. Uncertainties can be priced in, while the productive efficiency implies that inventions should be licensed right away.

inventors with a higher likelihood of obtaining strong and broad patents might want to wait until the patent is issued. Second, if the inventor has to engage in costly search to locate the most suitable commercialization partner, the incentives to search may only be sufficient after a strong patent is granted, especially if the inventor fears substitution or imperfect imitation. Finally, if the inventor needs to engage in costly efforts to transfer tacit but hard-to-protect knowledge (which is necessary to make full, use of the invention), the inventor might have sufficient incentive to exert such efforts only with the backing of secure property rights.

We develop a simple framework which incorporates the distinct benefits and costs to inventors of patent application and grant and derive some predictions regarding their choice of the optimal time to license their ideas.

2.2.1 A simple analysis

Figure 1 illustrates sequence of events before and after AIPA. Let T_a, T_d, T_g, and T denote, respectively, the application date, the publication date, the date of patent issue, and the date of patent expiration. Before AIPA, $T_d = T_g$ and after AIPA, $T_d < T_g$.[7]

Figure 1 here

Let v be the per-period licensing revenue the inventor expects to get by licensing the invention right after the application date, d the difference the inventor expects to make to his per-period payoff once the patent application is published, and g the difference once the claims of the patent are clarified when the patent is issued. d and g could be positive or negative.

Let ρ be the probability that someone would obtain enough information to come up with a successful substitute during the sale process before the application is published; and this probability becomes one after the publication. For simplicity, assume that inventing around is immediate as soon as enough information about the technology is obtained; Δ is the corresponding loss in the per-period licensing revenue.

We abstract away from other transaction costs (e.g., the time taken to negotiate a contract). Therefore, once a relevant event occurs, there is no reason to delay further since the sooner the technology gets to the market, the better. We also do not explicitly model the choice among licensing and other outside options.

Before AIPA.

Given an invention, the inventor can either license the invention immediately after the application date or wait until the patent allowance date. The payoff from licensing right away is

$$U_a^{\text{before}} = (1-\rho)vT_g + \rho(v-\Delta)T_g + (v-\Delta)(T-T_g).$$

[7] It is possible that patents are issued before the eighteen-month disclosure date. We consider the more interesting case in the paper because AIPA would have no effect in such a scenario.

For periods before patent issue, with probability $1-\rho$, the inventor enjoys per-period revenue v; and with probability ρ the revenue is hurt by Δ because of inventing around. After the patent issue date, the invention becomes public and inventing around happens with probability one.

The inventor's payoff from licensing after the patent issue date is
$U_g^{\text{before}} = (v+d+g-\Delta)(T-T_g)$.

The inventor receives no revenues for periods before issue, while afterwards, the per-period licensing revenue changes by $d+g$, the net effect from publication and the clarification of patent rights. Hence, the inventor licenses the invention immediately if and only if the net benefit from earning licensing revenues for T_g more periods, while risking information leakage through the negotiation process, is greater than the combined net effect from public disclosure and the clarification of patent rights for the rest of the patent protection period. That is,

$$(v-\rho\Delta)T_g > (d+g)(T-T_g).$$

After AIPA.

The inventor chooses among three alternative dates for licensing in the post-AIPA period; and the payoffs of the three alternatives are, respectively,
$U_a^{\text{after}} = (1-\rho)vT_d + \rho(v-\Delta)T_d + (v-\Delta)(T-T_d)$,
$U_d^{\text{after}} = (v+d-\Delta)(T-T_d)$,
$U_g^{\text{after}} = (v+d+g-\Delta)(T-T_g) - \Delta(T_g-T_d)$.

Note that the term $-\Delta(T_g-T_d)$ in U_g^{after} reflects that once the patent application becomes public, inventing around would hurt the inventor regardless whether he licenses the invention out.

The inventor licenses immediately after application if neither the benefit from waiting for disclosure nor those from waiting for the clarification of patent rights outweighs the benefits from obtaining a longer period of royalties while risking information leakage from the negotiation process; that is,

$$(v-\rho\Delta)T_d > d(T-T_d) \text{ \& } vT_g - \rho\Delta T_d > (d+g)(T-T_g).$$

The inventor licenses after publication if the net benefit from disclosure is greater than the lost net profits of T_d period and if the marginal benefit from clarifying IP rights is less than losing revenues for $T_g - T_d$ periods; that is

$(v-\rho\Delta)T_d < d(T-T_d)$ & $(v+d)(T_g-T_d) > g(T-T_g)$.

The inventor waits until patent issue if neither of the above two conditions is met.

2.2.2 Empirical implications

Figure 2 illustrates the timing of licensing after significant patent-related events, before and after AIPA, as a function of the net effects of public disclosure, d, and the clarification of IP rights, g. Figure 2(a) shows that, before AIPA, inventors who would benefit substantially from the net sum of disclosure and clarification of property rights would delay licensing till patent issue date—i.e., when $(d+g) \geq \frac{vT_g - \rho\Delta T_g}{T-T_g}$.

Figure 2 here

Essentially, AIPA effected two changes, both of which are depicted by Figure 2(b). First, the earlier publication required by AIPA shifts some inventions from being licensed after the patent issue date to either immediately after the application date or after the eighteen-month publication date. In particular, Figure 2(b) shows that the line separating licensing before and after the patent issue date in the pre-AIPA era shifts rightward in the post-AIPA era. This is because AIPA expedites the public disclosure of information (and hence the risk of inventing around which now occurs after T_d, instead of after T_g). Thus, relative to waiting until the allowance date, starting to negotiate earlier is associated with fewer losses after AIPA than before. As a result, licensing is pushed earlier.

Second, the separation of the publication date from the issue date gives the inventors more options. For inventions that would have been licensed immediately after the application date (before AIPA), inventors who value public disclosure (i.e., when $d \geq \frac{vT_d - \rho\Delta T_d}{T-T_d}$) can now wait until the publication date. For inventions that would have waited until the issue date (before AIAP), inventors can now expedite licensing to publication date if their benefits from clarifying IP rights is relatively low compared to the licensing revenues foregone by waiting for patent issue (i.e., when $g \leq \frac{(d+v)(T_g-T_d)}{T-T_g}$).

Considering the net of the above effects yields the following predictions. Our first set of predictions concerns the effect of AIPA on the likelihood of licensing after various patenting-related events.

Prediction 1 [likelihood of licensing after patenting-related events]

Other things being equal, compared to before AIPA,
(a) the likelihood of licensing after eighteen months (i.e., the publication date) increases;
(b) the likelihood of licensing after the patent issue date decreases; and

(c) if concern for information leakage during pre-publication negation is small or when patent grant date is close to the publication date, the likelihood of licensing after the application date decreases.

It is clear from Figure 2(b) that incidences of licensing events after application date may increase or decrease after AIPA, depending on the relative number of inventions that move out from licensing at application date to publication date, and those that move in to licensing at application date from the issue date. However, the dashed line $(d+g)=\frac{vT_g-\rho\Delta T_g}{T-T_g}$ is close to the solid line $(d+g)=\frac{vT_g-\rho\Delta T_d}{T-T_g}$ when the likelihood of information leakage during the negotiation process (ρ) is small, when the damage from inventing around (Δ) is minimal, or when the patent grant delay is close to the publication date (i.e., when T_g is close to T_d). Then, the likelihood of licensing immediately after the application date would only decrease.

Note that the magnitudes of changes predicted by Prediction 1(a) and 1(b) depend on the density of d and g, and the values of the other parameters. For example, if the population distribution of d is mostly low (*i.e.*, the public disclosure does not bring sufficient benefits to a significant proportion of inventions), we will not observe a large increase in the likelihood of licensing after eighteen-month disclosure post AIPA. Our approach here does not make assumptions about the relative magnitudes of these parameters, but let the data speak for itself.

The second prediction concerns the effect of AIPA on the average licensing lag. In general, AIPA favors earlier licensing. However, there are some inventions that may be licensed later since they move from application date to the publication date. The overall effect, therefore, is theoretically indeterminate and we treat this as an empirical question.

"Prediction" 2 [licensing delay]
Other things being equal, the average licensing delay may increase or decrease after AIPA.

Our analysis does not explicitly model the outside option (e.g., not patenting). Pre-grant disclosure brought by AIPA implies greater technology spillovers (hence, a higher risk of inventing around). This makes opting out of patenting more attractive (see Aoki and Spiegel 2009). But AIPA also provides the inventor with an additional choice in terms of licensing timing which may make opting out of patenting less attractive. Eventually, whether or not AIPA strengthened the overall incentives for patenting depends on the relative values of the parameters. Recall that Aoki and Prusa (1998) also show that the R&D coordination effect pre-grant publication could increase the innovators' profits and hence their incentives to patent. In this paper, due to data limitations that do not permit us to observe inventors' decisions regarding patenting (or whether or not to license), we focus on testing the predictions of AIPA's effects on the timing of license conditional on the licensing event.

3. Sample and variables

3.1 Sample construction

US publicly traded companies are required by the Securities and Exchanges Commission (SEC) to disclose material transactions, including licensing agreements, to the public. In addition, a number of state governments require privately held companies with employee stock options to publish material transactions. Our data on licensing agreements are drawn from these disclosures. We obtain the agreements from Deloitte Recap's RecapIP, which assembles and maintains data on all publicly disclosed agreements, including licensing agreements, alliance contracts, R&D agreements, and manufacturing agreements in the biomedical industry. We supplemented Recap's data with our own search of SEC's EDGAR filings database.[8]

We finalized our sample after imposing several criteria to ensure that the agreements represent key elements of the licensing transactions considered by our framework. First, we exclude contracts that involve collaborative research, manufacturing, marketing, supply and distribution, alliance and other complex transactions, the timing of which may be influenced by considerations other than the state of the licensor's patent application.[9] Second, a license agreement between two parties might be followed by renegotiations and revisions. Because we are interested in the timing of the initiation of the license, we discard agreements that are amendments and revisions of the original licenses. Third, we retain only those agreements which involved the licensing of at least one non-provisional US patent application or granted patent.

We then assemble information on the following three key dates associated with each license agreement.

(i) License agreement date: The agreement date is typically specified in the contracts as "effective date," and represents the date from which the licensee can use the licensor's invention and infringe on the latter's patents. We gathered this date after perusing each agreement.

(ii) Patent application (priority) date: We collected information on every US patent (identified either by their application number or patent number) specified in the agreements. We then matched each patent associated with the licenses to the USPTO patent database and identified the relevant dates associated with the patents. Patent application date typically refers to the filing date of the last application associated with a granted patent and found on the cover of granted US patents. However, the first application date associated with a patent, called "priority date," may be different because applications can have "parents" in the form of related previous applications (*e.g.*, through continuations, divisionals, or continuations-in-part—these parent applications are typically abandoned when related applications, or "children," are filed). Hence,

[8] A number of papers have used Recap data, including Lerner and Malmendier (2010), Lerner and Merges (1998), Allain, Henry, and Kyle (2012), and Wakeman (2012). Lerner and Merges (1998) describe the database in detail.

[9] RecapIP has collected deals in the biomedical industry (primarily in the pharmaceuticals and biotechnology sectors) since 1973. There are 9,874 unique deals in the database. There are multiple types of deals; license (47%), acquisition (43%), research contracts (9%), development (8%), collaboration (5%) are the most common types. A deal can also be recorded as of different types. We include contracts that are identified by RecapIP as license only.

for a patent that issues from a series of related applications, priority date will necessarily be before application date (Hegde, Mowery and Graham (2009) show that nearly a third of all US patents issue are from previous related nonprovisional applications and the priority date for these patents precedes their application date by nearly a year, on average). Since the priority date legally establishes the date from which the inventor's legal rights begin, and AIPA's provisions specify 18-month publication from priority date, we collect and use data on the priority date of each patent in the agreements (henceforth, we use the term application date to refer to the priority date, unless otherwise noted). About half of the sample agreements license more than one patent and, in these cases, we use the *earliest* patent's application date in the license to characterize the agreement.

(iii) Patent issue date: The USPTO informs applicants of the allowance of their patent on the "patent allowance date." This date typically precedes the administrative patent grant date found on the cover page of patents, by about 4-5 months.[10] Since the date on which the inventor is officially informed of the grant is more relevant for license negotiations, we use this date in our analysis rather than the administrative grant date. For licenses with more than one patent, we use the date of the earliest allowance to characterize the agreement.

3.2 Sample selection and potential biases

We have more time to observe licensing events for the patent applications filed in the earlier years of our study than those filed during later years. This truncation bias, due to which patents that take longer to be licensed are underrepresented during later years, may lead us to incorrectly conclude that licensing occurs sooner in post-AIPA years. We mitigate this truncation bias by considering a uniform six-year window, starting with each license's earliest patent application date, in which to observe the licensing event. We thus drop from our sample, the 93 licenses for which more than six years had elapsed without a licensing event from their earliest patent application filing date. These 93 licenses concentrated in the early years of our study. The imposition of this window also restricts the last patent application year of our study to be 2006 (since we observe licensing events till the end of 2012). Hence, our sampling frame is all license agreements for which the earliest patent was licensed within six years from its application date, with the application dates ranging between June 8, 1995 and December 31, 2006.[11] The starting date of this range was chosen because US patent applications filed before

[10] This difference between the patent allowance date and the patent grant date is because after they receive the notice of allowance, inventors can choose to either have the patent granted by paying a stipulated fee or request modifications/revisions to the patent, or in some cases abandon the application by not paying the fee. The administrative grant date represents the date on which the inventors were officially issued the patent after paying the specified fees.

[11] We chose a six-year window since 75% of the sample licenses were negotiated within six years from the application date of their earliest patent. Choosing a shorter window (say four or five years) would not leave us with sufficient time to observe the grant event for a substantial number of patent applications since patent applications take on average 3-4 years to be granted, and according to Gans, Hsu, and Stern (2008) the hazard of licensing in the pre-AIPA years increases by 70% on patent issue. Choosing a longer-window (say seven or more years) will require us to limit the last patent application year for the licenses to be years prior to 2006 which will force us to drop the limited number of post-AIPA observations we have. Nevertheless, we experimented with both five-year and

the date enjoyed patent protection for 17 years from patent grant date rather than 20 years from application date. Including licenses based on patent applications filed before June 8, 1995 might confound the effects of AIPA with the effects of this earlier change in patent laws. We are thus left with our final sample of 299 license agreements negotiated between 1995 and 2010.

The licenses in our sample are not randomly drawn: they are among the contracts disclosed as material by one of the licensing parties likely to be a US public firm. The likely consequence of this sample selection is that we are oversampling valuable inventions. The advantage of this, of course, is that the contracting parties are more likely to behave like the value-maximizing agents depicted by our theoretical framework, perhaps making it more likely to observe the outcomes we predict. Still, we attempt to control for the quality of licensed patents in our regressions.

We only retain those agreements for which we have the full text of the contracts and omit redacted agreements. According to Verrecchia and Weber (2006), firms redact information when they have suffered financial losses to avoid adverse reactions from investors. At the same time, firms are also more likely to redact strategically important transactions to prevent scrutiny by competitors. Since these two commonly cited reasons for redactions appear unlikely to be systematically related to our tests about the effects of AIPA, the omission of redacted agreements is unlikely to systematically bias our analysis.

The 299 licenses in our sample collectively licensed out 581 US patents (applications and granted patents). 49 of the licenses specified a single US patent application and no granted patent. Of the 299 licenses, 73 had their earliest patent application after November 29, 2000, AIPA's effective date. Hence, 75.6% of our sample comprises of licenses with their earliest patent application before AIPA and the rest after AIPA. Although we have a comparable time-window in which to observe patent licenses before AIPA and after, we observe substantially more licenses before AIPA. This is because the total number of disclosed agreements was rising sharply in the later 1990's both due to the biotechnology bubble which resulted in a greater number of licensing deals, and the IPO bubble that resulted in a greater number of small public companies disclosing their material transactions. Licensing activity dropped precipitously in the post-2000 years after the two bubbles burst, leaving us with a smaller sub-sample of post-AIPA observations. It is unclear how this artifact of macroeconomic trends affects our estimations.

3.2 Variables

Our chief variables capture the timing of licensing with respect to the timing of three patenting-related events: patent application, patent disclosure at 18-months, and patent issue. As mentioned before, for licenses with multiple patents, we consider the dates and characteristics associated with the earliest patent application in the license.[12] Accordingly, we construct a categorical variable indicating whether the licensing event occurs in one of the three following windows: (i) before 18 months from patent application date; (ii) between 18 months from

seven-year windows and found our results robust to these alternative definitions of our sample frame.

[12] It is possible that a patent application filed after the patent with the earliest application date in a license is issued first. In such cases, which happen in about 10% of our sample cases, we use the earliest allowance date, not necessarily the date associated with the earliest application.

application and issue; (iii) after patent issue.[13] If patent allowance occurred prior to 18 months from application, then the categorical variable is classified under (i) if licensing occurred before allowance, and under (iii) if licensing occurred after allowance. We view the inventor as choosing among the three options for the timing of the license as a function of the patent disclosure regime (pre-AIPA or post-AIPA), characteristics of the invention and the parties. In our sample, 28.1% of the license agreements were negotiated before 18 months, 25.4% between 18 months and grant, and the rest after grant. In our data, the average lag between patent application and its license is 32.1 months, and the average lag between patent allowance and license is 1.6 months.

We construct the following control variables that may be correlated with the timing of patenting-related events and licensing. We control for the licensor type (among the licensors, 40.8% are non-profit organizations such as universities, hospitals and research institutes, 55.8% are corporations, and the rest are individuals). We also control for the licensing parties' experience levels and the extent of licensor experience, the extent of licensee experience, and the extent of the parties' experience in dealing with each other. We measure the licensor's experience as the number of deals (including licensing and other types of deals) the licensor has undertaken as a seller prior to the focal agreement, the licensee's experience as the number of deals the licensee has had as a buyer prior to the focal agreement, and relational experience as the number of prior deals in which the licensor and the licensee have transacted before the focal agreement.

We control for patent-related characteristics, including the number patents specified in the license and variables that capture importance, originality, novelty and breadth of the licensed patent. These characteristics are based on the earliest filed patent application in each license. We also construct a variable indicating whether the license also transfers technology knowhow.

Although all our sample agreements license out biomedical inventions, there may be systematic differences in the licensing and commercialization of inventions within this broad sector. Accordingly, we include controls for the technological class of the focal patent in each license. Of the 250 licenses with granted patents (the USPTO assigns technological classes to only granted patents), 55.2% of the patents belonged to the "Drugs" category, 23.2% to the "Surgery and Medical Instruments" category, 10.8% to the "Organic Compounds" category and the rest to miscellaneous classes.

Table 1 presents descriptive statistics for the above variables in our sample, as well as separately for pre-AIPA and post-AIPA subsamples.

Table 1 here

The Table suggests that pre-AIPA and post-AIPA patents vary significantly in terms of the timing of their licensing: post-AIPA licenses, on average, are more likely to occur sooner than pre-AIPA licenses. Post-AIPA licenses, on average, occur about nine months sooner from patent priority

[13] We verified from the USPTO that disclosure, for post-AIPA patents, does indeed happen after 18 months from application date (the mode application to disclosure lag was 18.2 months, and mean application to disclosure lag was 19.1 months due to administrative delays associated with publishing the applications.

date and a striking eighteen months sooner from patent issue date than pre-AIPA licenses. Part of the reason why post-AIPA licenses occur sooner may be because of the increasing pendency lags (time between patent application and issue) with time, such that later year patent applications require more time to be examined and issued by the patent office. We thus control for the average time taken by the patent office to examine patents in the application year of focal patents while estimating the effect of AIPA on the timing of licensing (the increases in the time for examining patents are exogenous and largely caused by vagaries in the resources available at the patent office for examination). Table 1 suggests that pendency lags in post-AIPA years are longer than during pre-AIPA years.[14]

The table also demonstrates that the characteristics of the patents and the licensing parties do not vary significantly in our before and after AIPA subsamples.

3.3 Descriptive evidence

In this section, we visually examine the patterns in the sample guided by our predictions. We then test whether the patterns are statistically robust in multivariate regressions.

Prediction (1a) suggests that if public disclosure brings significant benefits to inventors, we should observe an increase in the likelihood of licensing after disclosure date (18-months after the patent application date) after AIPA.

Figure 3 here

Figure 3 compares the density distribution of patent application to license lag (i.e., the number of months between the first patent application in a license and license date) for patent applications filed before and after AIPA. For patents filed before AIPA, the density of application-license lag displays a local peak shortly following application date, a "trough" around 12 months after application, and then again a local peak around 30 months from application. The latter period follows the pendency lags for pre-AIPA patents. For patent applications after AIPA, licensing appears to be concentrated around three events: (i) in the months immediately after application date; (ii) between 20-30 months from application date; and (iii) around 43-50 months from application date, just following the average pendency lag for post-AIPA patents. The "bump" in the concentration of licenses immediately after 20-months from application date is clearly unique to licenses with patents filed after AIPA.

Panel B of Table 2 shows that 37 percent of licenses occur between 18 months and patent allowance after AIPA whereas only 21.7 percent of the licenses before AIPA were negotiated in the comparable window. These patterns are consistent with our first prediction, suggesting that public disclosure is important for a significant number of inventors seeking to license their inventions.

Table 2 here

[14] The average pendency lag statistics calculate the lag in months between the application date on the cover page of patent applications and patent allowance date. Pendency lags, when computed from the priority date of patents appear significantly longer (by about 12-20 months).

Our next prediction (1b) is that the likelihood of licensing after patent allowance decreases after AIPA. Figure 4 plots the distribution of allowance to license lags (i.e., the number of months between patent allowance date and license date). In the figure, the mass of licenses to the left of zero are those signed prior to allowance, and the mass to the right of zero are licenses signed after allowance. The distribution of licenses for patents filed pre-AIPA is similar to the one presented in Figure 2 of Gans, Hsu and Stern (2008), showing a significant increase in the density of licenses after patent allowance.[15]

Figure 4 here

A couple of aspects stand out from the density distribution of post-AIPA patent licenses. First, a larger fraction of licenses are signed before patent allowance post-AIPA. Second, conditional on licensing after patent issue, the timing of licensing appears to shift closer to allowance date after AIPA. The above patterns suggest that the likelihood of post-grant licensing decreases after AIPA, which is consistent with our prediction that AIPA's 18-month disclosure requirement shifts the licensing date from the patent issue date to either the patent disclosure date or the application date. Furthermore, conditional on post-issue licensing, the average delay after allowance is reduced for post-AIPA patents. We conjecture that this is because 18-month disclosure (before patent issue) allows potential licensees to access, learn about, and perform due-diligence regarding the invention and its potential value earlier in the post-AIPA period, such that licensing occurs sooner after the legal rights of the inventor are certified by patent allowance than before AIPA.

Table 2 shows that 25.7 percent of inventions are licensed within 18 months from application date before AIPA, while 35.6 percent are licensed after AIPA (this difference is statistically significant at the 5 percent level). This result suggests that after AIPA, at least some inventors expedite licensing since they find the revenues foregone by waiting until patent issue is not sufficient to the benefits conferred by secrecy until 18 months .

Figure 5 plots the cumulative distributions of license-application lag for pre-AIPA and post-AIPA inventions. It shows a systematic shift towards earlier licensing; and the Kolmogorov-Smirnov test shows that these two distributions are statistically different from each other (at the 5 percent level).

Figure 5 here

The mean patent-application to licensing lag is 33.12 months before AIPA, and 28.9 months after AIPA—a difference of about 4 months. These patterns in the sample suggest that pre-grant patent disclosure accelerated licensing. Still, the above patterns in the raw data could be driven by other factors that may have changed over the period in ways that increased the benefits of earlier licensing. For example, as suggested by the last column of Table 4, there is a significant increase in the time required to grant patents post-AIPA compared to before. Patent grant delay could be an important confounding factor because longer grant delay (T_g) implies more periods

[15] There are however some differences between our sample and the one used in Gans, Hsu and Stern (2008). Their data on 198 licenses are spread across four different industries, while our 526 licenses are all in the biomedical industry. The (mean) patent allowance lag and patent application-licensing lag are, respectively, 38 and 48 months in Gans, Hsu and Stern (2008). They are, respectively, 33 and 46 months in our paper for the comparable, pre-AIPA period.

of lost revenues, hence, incentives to push for earlier licensing. In the following sections, we estimate the effects of AIPA on the timing of licensing after controlling for other factors that might influence the timing of licensing.

4. Regression results

4.1 Baseline results

4.1.1 Effects of AIPA on the likelihood of licensing after patenting-related events

We are interested in isolating the effects of patent disclosure on the timing of licensing, separate from the effects of patent grant. Hence, we control for several variables that may commonly influence the timing of licensing and patenting in multivariate regressions below. The conditional probability of licensing in each of the three licensing windows (before 18 months from application date, between 18 months and patent issue, and after patent issue) can be estimated by the following multinomial logit (MNL) model. We set the third option (license after issue) as the baseline outcome. The conditional likelihood that outcome $j \in \{1,2\}$ happens is given by

$$\Pr(Y_i = j \mid X_i) = \frac{\exp(\alpha_j \mathrm{PostAIPA}_i + X_i \beta_j)}{1 + \sum_{h=1}^{2} \exp(\alpha_h \mathrm{PostAIPA}_i + X_i \beta_h)},$$

where $\mathrm{PostAIPA}_i$ is a dummy variable which indicates whether patent in license i is applied after AIPA, X_i are control variables including characteristics of the invention, the licensing parties and the technology class, α_j and β_j, $j \in \{1,2\}$ are coefficients of the independent variables associated with the jth outcome.

The absolute value of the MNL estimates are hard to interpret. Therefore, we report the relative risk ratios corresponding to the estimates. A greater-than-one (less-than-one) ratio corresponds to a positive (negative) effect of one-unit increase in the independent variable on the probability of the outcome category relative to the baseline outcome (which, in this case, licensing after patent allowance).

Table 3 here

Table 3 reports the MNL estimates, after transforming them into risk ratios. Model (1) shows that the unconditional risk of licensing within 18-months of patent application after AIPA is 2.7 times the risk of licensing in the same period before AIPA, and the risk of licensing between 18 months and allowance is nearly 3.3 times the risk of licensing in the same period before AIPA, both relative to the corresponding baseline risk of licensing after allowance. Model (2) shows that after controlling for the number of patents specified in the license and the contracting parties' experience, the estimated effects of AIPA appear stronger, on inventors' choice of earlier licensing windows appear stronger. Model (3) adds more patent level variables, including measures of patent quality (number of claims, number of forward citations, patent originality and backward citations to scientific prior art), patent technology class, and the average time required by the USPTO to issue patent applications filed in the application year of

the focal patent. Using this full set of control variables reduces the number of observations in our estimating sample to 250. This is because 49 of our licenses licensed US patent applications that were not issued (these applications were either later abandoned or are still pending issue) and we do not have information on the characteristics of these patents (such as claims and citations). Still, the model reveals that post-AIPA patents face a 2.95 times higher risk of being licensed within the first 18 months of application and a striking 4.37 times higher risk of being licensed between 18 months and patent issue than pre-AIPA patents.

The MNL estimations show that post-AIPA patents are significantly more likely to be licensed before allowance, both immediately after application, and immediately after 18 month disclosure, holding constant important characteristics of patent and the licensing parties. A binary logit model (Model 1 of Table 4) shows that, conditional on licensing, post-AIPA patents are 24% more likely to be licensed before allowance, after controlling for the characteristics of the licensing parties and licensed patent. These results are consistent with Hypothesis (1a) and (1b), suggesting that public disclosure permits some inventors to license immediately following the disclosure event rather than wait till patent grant. In addition, the results suggest that some inventors, confronted with compulsory 18-month disclosure, find it more profitable to license out their inventions immediately after application, rather than wait till the allowance of their patent.

Table 4 here

4.1.2. Effects of AIPA on licensing delay

Our second "prediction" is that the effect of AIPA on overall licensing lag is theoretically indeterminate and depends on the balance of inventors who prefer to license immediately after 18-month disclosure rather than wait till grant, and inventors who postpone licensing immediately after patent application to 18-month disclosure after AIPA. Our findings from the previous section that the probabilities of both licensing immediately after application and licensing after 18-month disclosure increased after AIPA, suggest that overall licensing delays were reduced since more licensors now license their patents before patent issue. We next estimate the magnitude of this reduction in licensing delays after AIPA.

Model (2) of Table 4 reports OLS estimates for the lag between patent allowance and licensing. The estimates suggest that on average, licensing lag was shorter for post-AIPA patents by 22.98 months, after controlling for other invention and licensing party characteristics. As suggested before, this acceleration in licensing stems from two distinct effects of disclosure. First, as the previous section shows, licensing is substantially more likely to occur before patent issue after AIPA, reducing average licensing lags overall. Second, conditional on licensing after allowance, licensing also happens faster (See model (5) of Table 4 which suggests that post-AIPA patents that wait until patent issue for licensing, are licensed nearly an year sooner than pre-AIPA patents). This latter finding is consistent with the patterns in the sample shown in Figure 4. Post-AIPA patent face shorter licensing delays perhaps because 18-month disclosure facilitates the transmission of information about the invention to potential licensees such that the patents can be licensed sooner upon issue.

4.2 Heterogeneous effects

We have controlled for several observable factors while estimating the effect of AIPA on the timing of licensing. Still, there may be other factors that influence the timing of licensing and the selection of inventors to license their patents post-AIAA that we have not captured. The quasi-experimental setup of AIPA allows to estimate the before-and-after effects, but not for two separate control and treatment groups. We thus explore the heterogeneous treatment effects of AIPA for different types of patents and inventors and see whether the findings are consistent with our interpretation that the estimated effects of AIPA stem from its influence on disclosure.

4.2.1 The presence of foreign-patent counterparts

As explained in Section 2, prior to AIPA, US applications that were also filed in a foreign country were published eighteen months after the earliest filing date (priority date) in these countries. Hence, we should expect that US patents with foreign patent counterparts should be subject to the rule change brought by AIPA to a lesser extent than US patents that do not apply for foreign protection.

Table 5

Because of the small number of post-AIPA observations (73 in all and 52 with issued US patents), and the even smaller number of post-AIPA patent licenses for which we were able to definitively establish foreign protection (22 of the 52 post-AIPA patents with issued patents), we are unable to estimate this equation in a traditional differences-in-differences set up. However, we omit both pre-AIPA patents and post-AIPA patents with foreign protection and re-estimate the MNL model introduced in Section 4.1.1. Model (1) of Table 5 reports the corresponding estimates. Consistent with what we expect, we find that the effect of AIPA is substantially stronger (particularly in predicting licensing immediately after 18-month disclosure) in the sample of US patents without foreign counterparts.

4.2.2 Organization type of the licensor

Next, we run the analysis on two separate subsamples: inventions licensed out by non-profit organizations and inventions licensed out by for-profit corporations. Recall that 40.8% of the licensors in the sample are non-profit organizations (such as universities, hospitals and research institutes) and the rest are for-profit entities. We expect disclosure to matter more for non-profit organizations since they do not typically have the downstream complementary assets required to effectively advertise and search for potential licensees. Inventions from these non-profit organizations are also more likely to be disclosed before the patent is issued through means other than the publication of patent applications (e.g., academic publication or conference presentations). Hence, we anticipate that 18-month disclosure should be more likely to accelerate the licensing of patents owned by non-profit entities.

Models (2)-(3) report estimates of MNL regressions predicting licensing timing separately for non-profit and corporate licensors. The estimated effects of AIPA for non-profits are over twice the magnitude as the estimated effects for corporate licensors. This difference is consistent with what we might expect under the premise that these two types of organizations are different in the extent to which they might value the benefits of disclosure over secrecy (and the corresponding imitation costs associated with secrecy).

4.3 Robustness checks

To be completed.

5. Concluding thoughts

How does the public disclosure of inventions in patents affect the timing of their licensing? We study this question by analyzing the introduction of an important policy change, the American's Inventors Protection Act (AIPA), which required US patent applications filed on or after November 29, 2000 to publicly disclose their applications 18 months from filing date. We find that conditional on licensing, post-AIPA inventions are 28 percent more likely to be licensed before the patent issues than pre-AIPA patents. AIPA appears to have increased the probability of licensing immediately after the application date and in the window between the 18-month publication date and patent issue. Post-AIPA inventions, on average, are licensed about 23 months earlier than pre-AIPA inventions. These effects are much stronger for inventions belonging to inventors who depend primarily on licensing as a means of recouping their R&D investments and likely do not attach much importance to the threat of substitution brought about by early disclosure. They are also stronger for a subsample of patents (US patents that do not pursue foreign protection and are not subject to foreign disclosure rules before AIPA, or after). These findings are consistent with the predictions of our theoretical framework.

Our study has several limitations. We have not examined here the overall effects of pre-grant publication on inventors' ex-ante incentives for patenting and licensing. Our analysis also falls short of identifying the exact mechanisms through which pre-grant publication accelerates licensing. Both these aspects of disclosure are important, and when answered, could help us obtain a more complete picture of how patent disclosure affects the commercialization of inventions.

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Figures and Tables

Figure 1. Events before and after AIPA

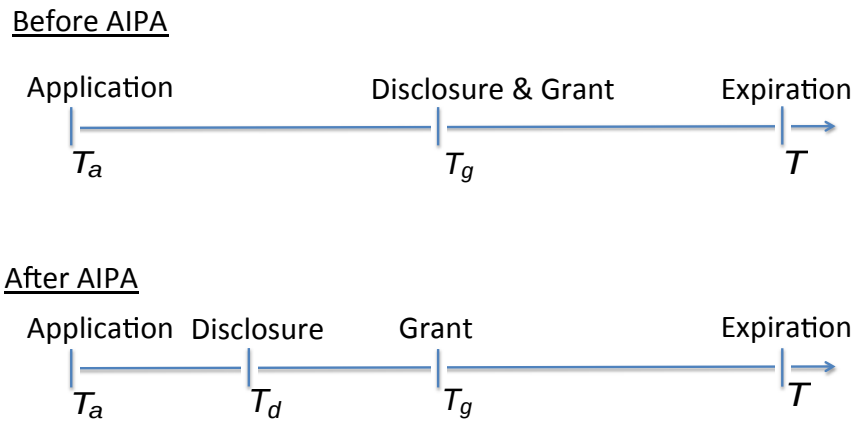
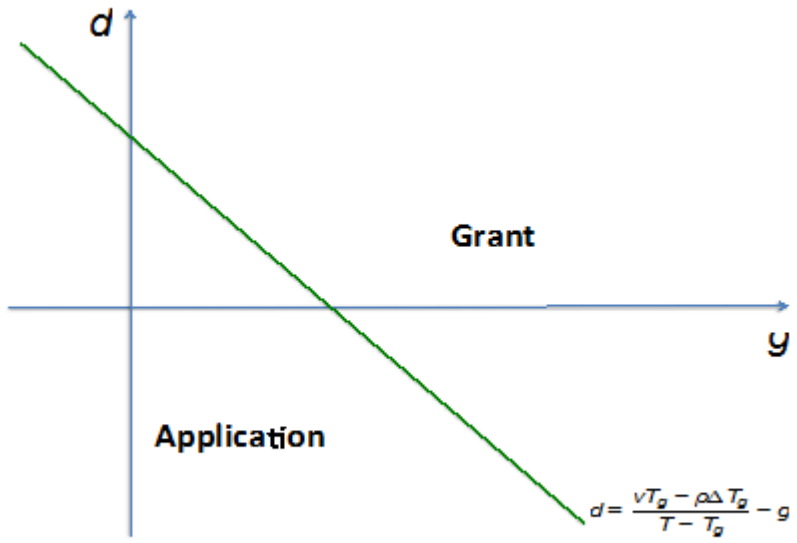


Figure 2. Timing of licensing before and after AIPA

(a) Before AIPA



(b) After AIPA

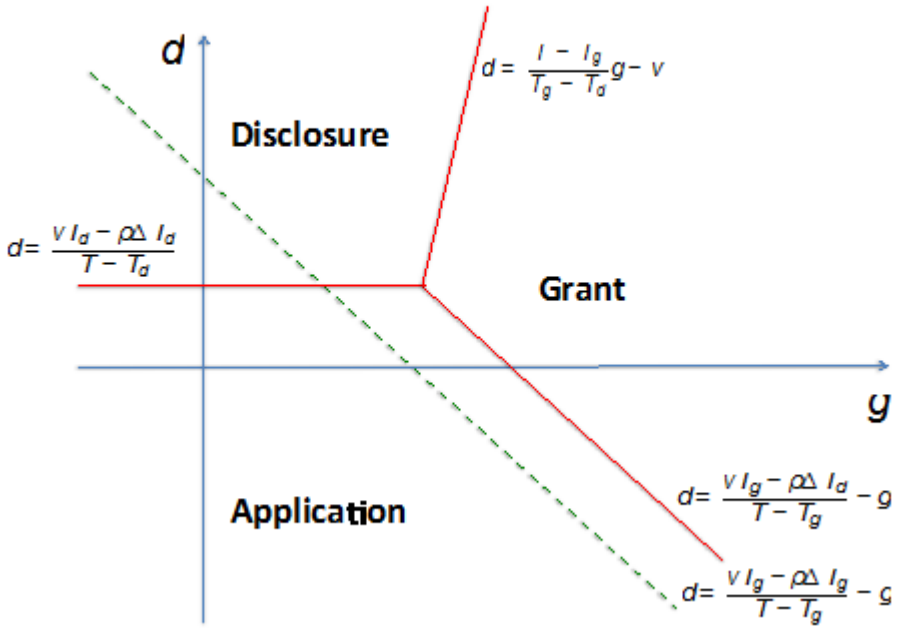


Figure 3. Distribution of difference between license date and patent application date

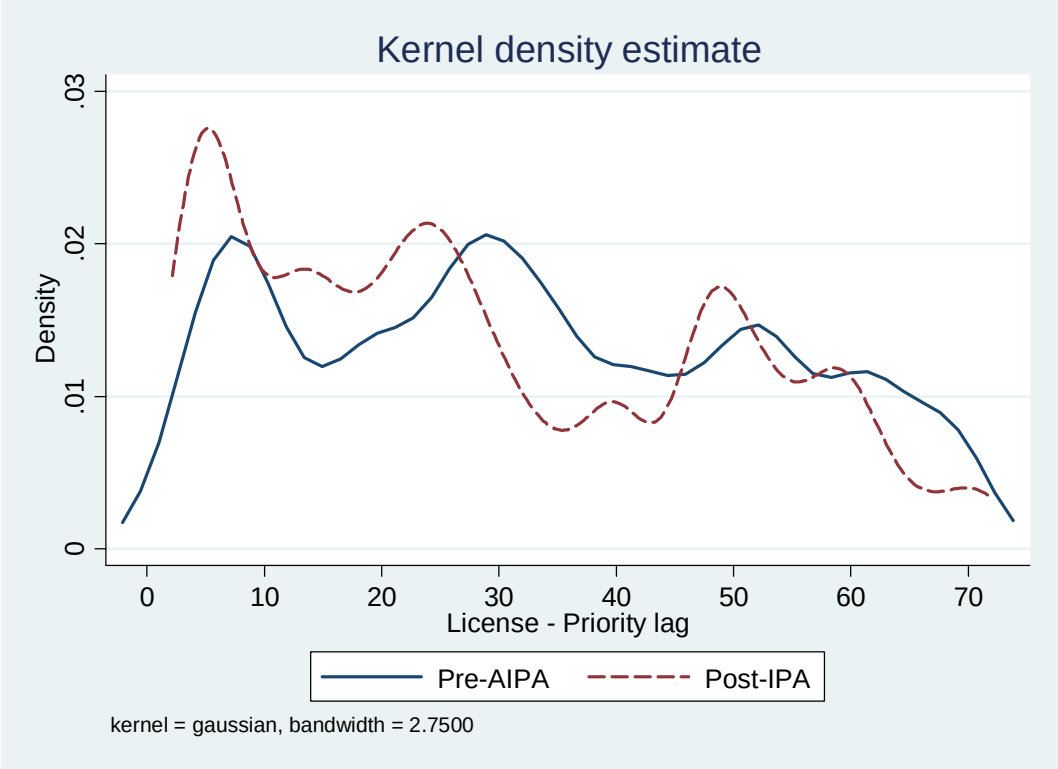
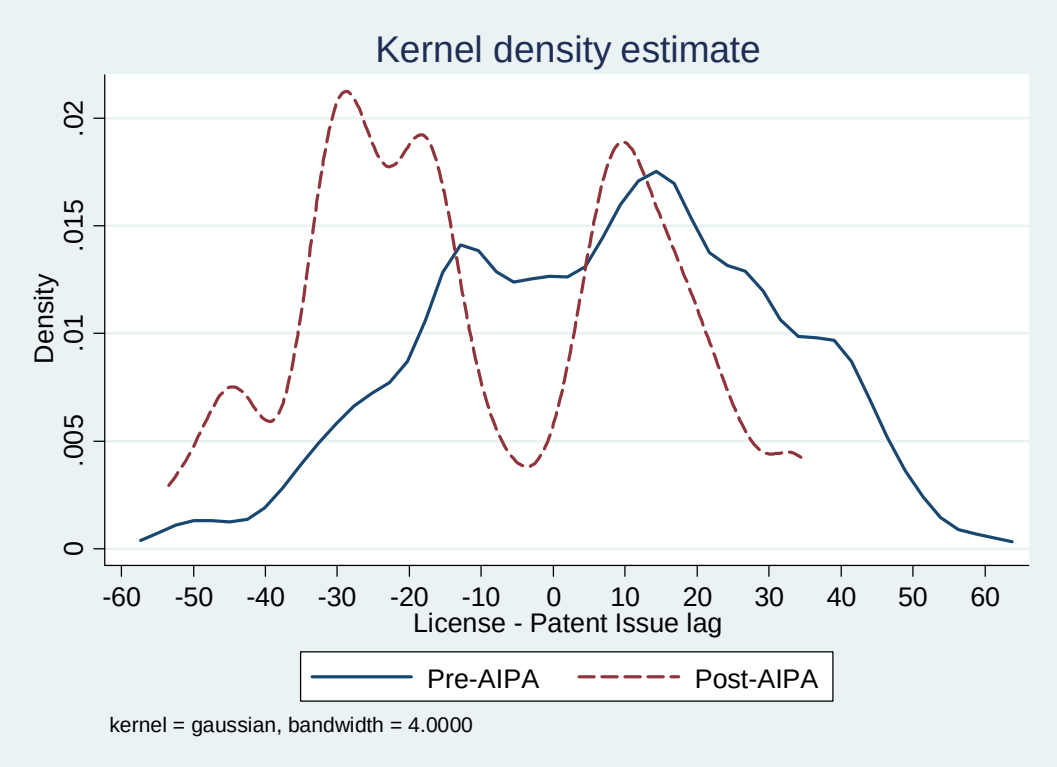


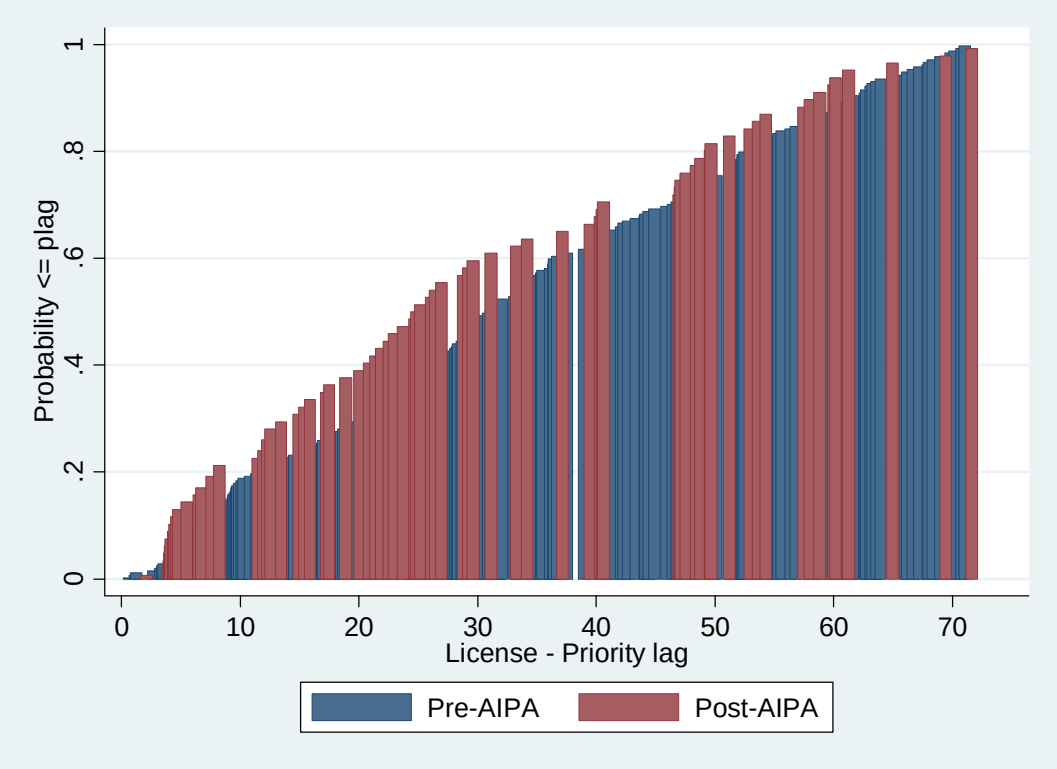
Figure shows kernel density estimates of the distribution of (license date — patent application date) for pre-AIPA and post-AIPA patents. The horizontal timeline is measured in months; zero means that licensing happens in the same month in which the patent is applied for. Licensing of post-AIPA patents appears to concentrate in three regions: (i) after application date; (ii) after 20 months from application date; and (iii) after about 45 months from application date.

Figure 4. Distribution of difference between license date and patent allowance date



The figure shows kernel density estimates of the distribution of (license date — patent allowance date) for pre-AIPA and post-AIPA patents. Data to the left of zero are licenses that happen prior to patent allowance, whereas data to the right of zero are licenses that happen after patent allowance. For post-AIPA patents, licensing is most likely to happen in two regions: (i) 10-30 months before the allowance date; and (ii) immediately after patent issue.

Figure 5. Cumulative distribution of difference between license date and application date



The figure shows the cumulative distribution of (license date — patent application date) for pre-AIPA and post-AIPA patents. It shows a systematic shift to earlier licensing — i.e., a shorter licensing delay.

Figure 6. Survival rates (to licensing) of pre-AIPA and post-AIPA patents

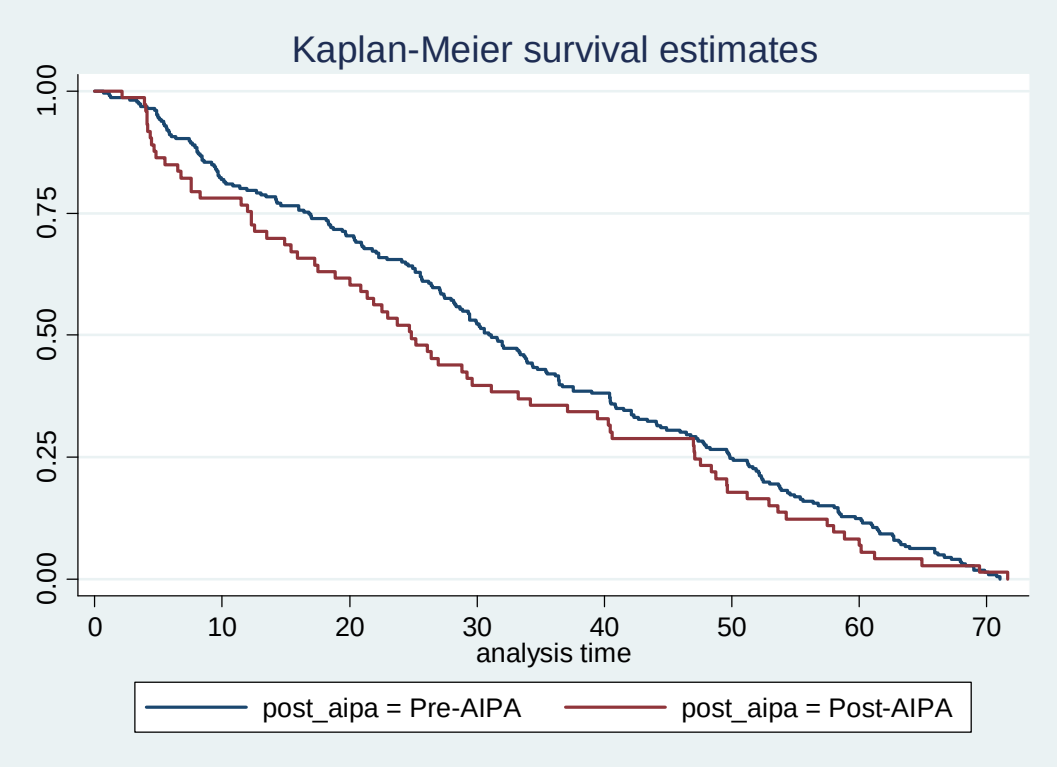


Figure shows survival estimates (survival without licensing) for pre-AIPA and post-AIPA patents from patent application date.

Table 1. Sample summary statistics

Variable	Mean	Before AIPA	After AIPA	Difference	T-test for Difference
Timing measures					
Patent application to license in months	32.08	33.12	28.87	-4.25+	0.11
Patent allowance to license in months	1.60	5.50	-13.27	-18.78**	0.00
Patent application to allowance	23.73	22.86	26.43	3.57**	0.00
Patent characteristics					
Number of patents	1.94	1.86	2.21	-0.35	0.11
Patent claims	24.07	22.85	28.71	-5.86	0.12
Patent citations	3.29	3.45	2.67	0.78	0.47
Patent originality	0.39	0.38	0.42	-0.04	0.42
Patent references to non-patent prior-art	5.58	5.43	6.15	-0.72	0.23
Party characteristics					
Number of prior licensor deals	15.18	11.30	27.19	-15.89**	0.01
Number of prior licensee deals	9.95	9.32	11.89	-2.57	0.20
Number of prior joint deals	0.22	0.21	0.23	-0.02	0.83

Table 2. The probability of licensing in different time windows before and after AIPA

PANEL A

Patent Priority Year	N of Licenses	License before 18m	License b/w 18m & patent issue	License after patent issue
1995	18	33.33	16.67	50
1996	53	26.42	22.64	50.94
1997	53	24.53	20.75	54.72
1998	38	28.95	21.05	50
1999	32	25	21.88	53.13
2000	32	18.75	25	56.25
2001	18	16.67	33.33	50
2002	17	29.41	41.18	29.41
2003	16	50	31.25	18.75
2004	8	37.5	50	12.5
2005	8	50	37.5	12.5
2006	6	50	33.33	16.67
Total	299	28.09	25.42	46.49

PANEL B

Patent Priority Regime	N of Licenses	License before 18m	License b/w 18m & patent issue	License after patent issue
Before AIPA	226	25.66	21.68	52.65
After AIPA	73	35.62	36.99	27.4

Table reports the percentage of licenses that occur after the three key patenting related events (application date, 18-month disclosure date, and patent allowance date) for pre-AIPA and post-AIPA patents, first by priority (PANEL A) year and then by regime (PANEL B).

Table 3. Multinomial Logit regression for the choice of licensing timing

Dependent variable = license timing window	Model (1)		Model (2)		Model (3)	
	Before 18 months	B/w 18 m. & allowance	Before 18 months	B/w 18 m. & allowance	Before 18 months	B/w 18 m. & allowance
Post AIPA patent	2.67**	3.28**	3.50**	4.09**	2.95*	4.37**
	[0.90]	[1.12]	[1.30]	[1.55]	[1.42]	[2.37]
Number of patents			0.61**	0.81+	0.75*	0.88
			[0.10]	[0.09]	[0.10]	[0.10]
No. of prior joint deals			1.08	1.29	1.03	1.3
			[0.26]	[0.22]	[0.25]	[0.21]
No. of prior licensee deals			1.01	1.01	1.01	1.01
			[0.00]	[0.00]	[0.00]	[0.00]
No. of prior licensor deals			1	1.01	1	1
			[0.01]	[0.01]	[0.02]	[0.02]
Patent claims					1	1
					[0.01]	[0.01]
Patent citations					1	1.02
					[0.02]	[0.02]
Patent originality					1.17	1
					[0.67]	[0.66]
Patent refs to non-patent art					0.96	1.03
					[0.05]	[0.05]
Log pendency lag					0.15	1.92
					[0.33]	[4.13]
Technology class dummies	Y		Y		Y	
Observations	299	299	299	299	250	250
Model chi-square	13.85		1421.51		2545.73	
Log-likelihood	-309.71		-284.82		-218.58	

Table presents MLNM estimates for the probability of licensing in each of the three distinct categories: (i) before 18 months from application, (ii) between 18 months and allowance, and (iii) after patent allowance. The base category, "after patent allowance," is omitted and coefficient estimates are in terms of relative risk ratios, with reference to the base category. Robust Standard Errors in brackets; ** p<0.01, * p<0.05, + p<0.1

Table 4. OLS estimates of timing of licensing before and after AIPA

Dependent variable	Model (1) Pr of License before issue	Model (2) Allowance to License lag in months	Model (3) Allowance to license lag; License before 18 m	Model (4) Allowance to license lag; License b/w 18 m & allowance	Model (5) Allowance to license lag; License after allowance
Post AIPA patent	0.28**	-22.98**	-16.42+	0.32	-12.13**
	[0.09]	[4.60]	[9.16]	[5.43]	[3.34]
Number of patents	-0.04*	2.66**	-1.84	-0.46	1.65*
	[0.02]	[0.95]	[1.86]	[0.84]	[0.70]
No. of prior joint deals	0.04	-3.51*	-8.86	-1.28	-1.04
	[0.03]	[1.69]	[7.75]	[1.09]	[2.49]
No. of prior licensee deals	0	-0.01	-0.02	0.13**	0.08+
	[0.00]	[0.05]	[0.05]	[0.05]	[0.04]
No. of prior licensor deals	0	-0.07	-0.31+	0.13	0.06
	[0.00]	[0.15]	[0.16]	[0.17]	[0.12]
Patent claims	0	-0.09	0.22	-0.16	-0.10*
	[0.00]	[0.06]	[0.13]	[0.09]	[0.04]
Patent citations	0	0.08	0.86**	0.09	-0.14
	[0.00]	[0.17]	[0.32]	[0.12]	[0.23]
Patent originality	0.01	-0.17	0.43	10.24	-2.32
	[0.11]	[5.32]	[8.46]	[6.95]	[3.58]
Patent refs to non-patent art	0	-0.27	-1.12	-0.73	0.03
	[0.01]	[0.49]	[0.79]	[0.77]	[0.35]
Log pendency lag	-0.16	18.5	21.96	-6.11	8.29
	[0.38]	[21.61]	[33.22]	[35.73]	[14.80]
Licensor Corporation	-0.29**	13.56**	-0.8	-6.86	6.80*
	[0.07]	[3.47]	[4.56]	[5.73]	[2.74]
Licensor Individual	-0.29	7.95	-0.16		2.11
	[0.18]	[7.90]	[10.68]		[5.97]
Observations	250	250	57	54	139
R-squared	0.146	0.228	0.438	0.547	0.222

Model (1) presents Linear Probability Model estimates of the relationship between the probability of licensing after patent issue and AIPA and other control variables. Model (2) presents OLS estimates of the relationship between patent issue-to-licensing lag and AIPA and other control variables. Models (3)-(5) separately estimate allowance-to-license lags for patents licensed before 18 months, between 18 months and allowance, and after allowance. Robust Standard errors are reported in the brackets. * p<0.10, ** p<0.05, *** p<0.01.

Table 5. Multinomial Logit regression for the choice of licensing timing, robustness checks

Dependent variable = timing of licensing	Model (1)		Model (2)		Model (3)	
	Before 18 months	B/w 18 m. & allowance	Before 18 months	B/w 18 m. & allowance	Before 18 months	B/w 18 m. & allowance
Post AIPA patent	2.82	7.29**	4.60+	7.22*	1.43	2.31
	[1.98]	[5.40]	[4.25]	[6.60]	[0.82]	[1.53]
Number of patents	0.95	0.99	0.79	0.92	0.69+	0.63*
	[0.10]	[0.12]	[0.15]	[0.15]	[0.14]	[0.13]
No. of prior joint deals	0.2	1.24	1.48	0.59	0.38	2.08*
	[0.20]	[0.52]	[0.71]	[0.33]	[0.31]	[0.61]
No. of prior licensee deals	1	1	1.04	1	1.01	1.01
	[0.01]	[0.01]	[0.03]	[0.03]	[0.01]	[0.01]
No. of prior licensor deals	1	1	0.98	0.99	1.02	1.02
	[0.02]	[0.02]	[0.02]	[0.02]	[0.03]	[0.03]
Patent claims	1	0.99	1.03+	1.01	0.99	1
	[0.01]	[0.02]	[0.02]	[0.02]	[0.01]	[0.01]
Patent citations	1.02	0.85+	1.11	1.1	0.92	0.91
	[0.03]	[0.08]	[0.07]	[0.08]	[0.07]	[0.07]
Patent originality	0.93	1.17	0.76	1.16	1.69	0.93
	[0.85]	[1.08]	[0.76]	[1.17]	[1.38]	[1.00]
Patent refs to non-patent art	1.05	1.19+	0.9	0.92	1.01	1.12
	[0.08]	[0.11]	[0.09]	[0.09]	[0.07]	[0.08]
Log pendency lag	4.58	0.07	0.00*	0.04	33.1	410.55
	[16.74]	[0.26]	[0.00]	[0.15]	[108.29]	[1,539.34]
Licensor Corporation	0.42	0.32+				
	[0.27]	[0.20]				
Licensor Individual	0.51	0.00**				
	[0.62]	[0.00]				
Technology Class Dummies	Y		Y		Y	
Observations	130		95		155	
Model chi-square	432.85		1515.05		1351.68	
Log-likelihood	-110.682		-85.008		-115.169	

Table presents MLNM models for probability of estimates for the probability of licensing in each of the three distinct time windows. Model (1) presents estimates after omitting observations for which patents had filed foreign patent applications. Model (2) restricts the estimation sample to licenses in which the licensor was a non-profit entity (universities and other research institutions). Model (3) restricts the sample to for-profit corporations. Robust Standard Errors in brackets; ** p<0.01, * p<0.05, + p<0.1