

Patent Publication and the Market for Ideas*

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Abstract

In this paper, we study the effect of invention disclosure through patent publication on the market for ideas. We do so by analyzing the effects of the American Inventor's Protection Act of 1999 (AIPA)—which required US patent applications to be published 18 months after their filing date rather than at patent grant—on the timing of licensing deals in the biomedical industry. We find that post-AIPA US patent applications are significantly more likely to be licensed before patent grant and shortly after 18-month publication. Licensing delays are reduced by about ten months, on average, after AIPA's enactment. These findings suggest a hitherto unexplored benefit of the patent system: by requiring inventions to be published through a credible, standardized, and centralized repository, it mitigates information costs for buyers and sellers and, thus, facilitates transactions in the market for ideas.

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1 Introduction

An efficient market for ideas can facilitate specialization among innovators, reduce R&D duplication, and accelerate the commercialization of inventions (Teece (1986); Arora et al. (2001); Gans and Stern (2003)). However, information frictions pose challenges for the smooth functioning of the market. For example, inventors can be reluctant to disclose private information about their inventions for fear of expropriation (Arrow (1962)). Scholars have argued that patents, by securing inventors' property rights, encourage the voluntary disclosure of proprietary knowledge and facilitate the trade of ideas (e.g., Arora (1995); Merges (2005); Hellmann (2007); Elfenbein (2007)).¹

In this paper, we study the effects of another key function of patents—the mandatory disclosure of patented inventions to the public—on the market for ideas. We argue that, apart from challenges associated with disclosing proprietary information, the market for ideas suffers from a broad set of frictions due to a general lack of information about buyers, sellers, and inventions (Arora and Gambardella (2010)). Even for inventions voluntarily disclosed by sellers, potential buyers may find it costly to acquire adequate information about the inventions and evaluate them against substitutes. We hypothesize that patent publication through a credible, standardized, and centralized intermediary, such as the patent office, infuses more information into the market and augments trading opportunities.² We empirically test this hypothesis, since, given that inventors can always voluntarily disclose their inventions, it is not immediately apparent that public disclosures through patent publication have a meaningful impact on real world transactions.

Empirically distinguishing the effect of patent publication from that of the property rights conferred by patents is hard because the two factors are often tied together. Here, we leverage the enactment of the American Inventor's Protection Act of 1999 (AIPA) which separated the patent publication and patent grant events. Historically, US patent applications were published at the time of grant. AIPA generally required inventors filing for patents at the US Patent and Trademark Office (USPTO) on or after November 29, 2000 to publish their applications 18 months after they are filed. Because the median patent filed in 2000 took 32.5 months to be granted, AIPA resulted in pre-grant publication for a majority of applications. We evaluate the impact of AIPA on the timing of licensing—an important variable that determines the rate at which ideas are commercialized and, thus, the surplus achieved through these transactions.³

¹Arora and Gambardella (2010) provide an overview of the literature on the relationship between intellectual property rights and the market for technologies. A number of studies also examine the inventors' contracting and disclosure strategies (e.g., Bhattacharya and Ritter (1983); Gallini and Wright (1990); Anton and Yao (1994, 2002)).

²Lamoreaux and Sokoloff (1996, 2002) document the role of informational intermediaries (e.g., patent agents and patent lawyers) in the rise of a market for patents in the U.S. in the nineteenth century. Arora and Gambardella (2010) note that patent offices themselves, along with patent agents and lawyers, can be a focal institution for organizing technology trade.

³A number of studies examine the timing of the sale of ideas. See Jensen and Thursby (2001) on faculty's choice to disclose

We first develop a theoretical framework to clarify AIPA's effects on the inventor's decision of when to license her patent. Before AIPA, an inventor's choice is either to license immediately after patent application or to wait until the patent is granted. The inventor chooses the former if earning licensing revenues sooner—while risking information leakage during the search and negotiation process—outweighs the combined effect on licensing revenues of patent publication and clarifying patent rights, both of which occurred at patent grant. We show that, by separating patent publication and patent grant, AIPA has two different effects. First, for inventors who could benefit sufficiently from public disclosure (due to reduced information frictions, for example), AIPA provides an additional, viable option of licensing between patent application and grant. Second, because publication happens sooner, the law makes it less attractive to delay licensing in order to prolong secrecy.

The above two effects of AIPA both imply that the inventor is less likely to wait until grant after AIPA, but may have contrasting implications for firms in terms of the total surplus of a transaction: The reduction in information frictions is likely to enhance the surplus, while increased expropriation risk may reduce the surplus of the transaction and, eventually, decrease the ex-ante value of patenting and licensing. A distinction between these two effects is that the former increases the likelihood of licensing immediately after the publication date, while the latter increases the likelihood of licensing immediately after the application date. We use this distinction in the resulting change in the licensing timing to empirically disentangle these two effects.

Our sample has 440 licenses of biomedical inventions involving 1,370 patent applications filed between mid-1995 and 2011. We use two approaches to investigate AIPA's effects on the timing of licensing. First, we compare the timing of transactions involving US applications that do not file for equivalent foreign patents before and after AIPA's enactment, controlling for observable characteristics of the inventions, the licensing parties, and the markets. Second, most foreign nations required applications to be published 18 months after filing even before AIPA, and inventions with US applications which also sought foreign protection were published by the foreign patent offices 18 months after the filing date of the first related application regardless of where the first application was filed. This institutional feature allows us to construct a comparison group using transactions involving foreign applications (applications filed exclusively in foreign jurisdictions and US applications with foreign equivalents) and investigate AIPA's effect in a difference-in-differences (DID) framework to further isolate other factors that might also change during the sample period.

We find that the probability of licensing after patent grant decreases by about twenty percentage points

their inventions at the proof-of-concept versus prototype stage, and its effects on licensing terms; Gans et al. (2008) for the impact of resolving uncertainty over the scope of IP rights; Allain, Henry, and Kyle (Allain et al.) for impacts of downstream market structure on the stage of licensing in the biotech industry; and Luo (2014) on the relationship between the sale stage and the seller's observable experience in the market for original movie ideas. Our paper is distinct in its focus on the role of patent publication on the timing of ideas' sales.

for post-AIPA US patent applications without corresponding foreign applications. This reduction appears to be primarily driven by an increase in the likelihood of licensing shortly after the 18-month publication date. This result is robust to a number of different empirical specifications. The significant 18-month effect is consistent with our hypothesis that patent publication helps reduce information frictions and benefits at least some inventors. This interpretation of our results is also corroborated by our findings regarding AIPA's heterogeneous effects. Specifically, the effect of 18-month publication is significantly stronger for for-profit than for non-profit licensors (such as universities, medical schools, and other research institutions), perhaps because the inventions underlying the latter's patents are already disclosed in other venues, such as academic publications and conference presentations. The 18-month effect is also significantly stronger for licensors with less prior licensing experience—a finding consistent with the hypothesis that the marginal benefit of patent publication is higher for inventors who lack the reputation or resources to overcome some of the information frictions (Rosenberg (2002); Long (2002)).

AIPA's effect on licensing after the application date are mixed: some specifications suggest a significant increase, while others show no change. Our theory predicts that if the expropriation risk were negligible to start with, AIPA would reduce the likelihood of licensing after application. Thus, even with the mixed results, it is reasonable to conclude that expropriation concerns are not negligible and may have a bearing on the timing of licensing. It is, however, empirically challenging to quantitatively compare the benefits of disclosure and the costs due to increased expropriation risk, especially because we lack good data on the pricing of licenses and on the inventors' decision of whether or not to license given a patent. In theory, the effect of pre-grant publication on the ex-ante value of licensing and patenting is ambiguous (Aoki and Prusa (1996); Aoki and Spiegel (2009)). Existing empirical evidence seems to find no significant dampening effect on patenting post-AIPA (Graham and Hegde (2015)).

Our study contributes a step towards remedying the dearth of research on the effects of invention disclosure, which is considered one of the two main objectives of patent systems (the other being the promotion of innovation through the award of exclusive rights). In a closely related study, Gans et al. (2008) use the variation in the time patents take to be granted and show that patent grant increases the hazard rate of licensing by over 70 percent. This striking increase reveals the salience of market frictions, but because their sample comprises of only pre-AIPA patents, the increase could be due to patent publication, exclusive rights, or both. AIPA provides an important context to disentangle the two main functions of patents, and the significant 18-month effect we identify shows that patent publication plays a distinct role in facilitating the trade of ideas.

AIPA is considered one of the most important patent laws enacted in recent decades. Despite the wide debate over its potential impacts (e.g., Ragusa (1992); Aoki and Prusa (1996), Modigliani et al. (1999);

Gallini (2002); Aoki and Spiegel (2009)), empirical assessments of its effects have been scarce (Johnson and Popp (2003); Graham and Hegde (2015) are exceptions). We evaluate the potential effects of this important policy change and show that the law significantly reduced licensing delay. While faster licensing does not necessarily translate to higher welfare, existing evidence seems to suggest that shorter delays could benefit both licensors and licensees, at least in the biomedical industry. For example, Hegde (2014) suggests that a one-year delay in licensing can cost the inventor and the developer millions of dollars in forgone revenues. Budish et al. (2015) show that short effective patent exclusivity reduces private incentives to engage in R&D. While a complete welfare analysis is beyond the scope of our study, we find that one potential positive impact of AIPA is to reduce information frictions in the market for ideas, a benefit that appears more important for smaller inventors. Thus, our findings contribute some evidence to the evaluation of current policy proposals to restrict pre-grant patent disclosure (e.g., H.R. 5980 at the Congress) that are based on the assumption that it is privately harmful for small inventors.

Our sample is among a few that hand-collect information on each licensed patent in contracts. Data-availability challenges result in a small sample size and limit our analysis in certain ways. Compared to the population of licensing deals in the biomedical industry, our sample licenses tend to involve less-experienced licensors and licensees, and the licensors are more likely to be non-profit entities. Even though we address these sampling issues to some extent (e.g., by investigating whether the effects of AIPA are different across different types of licensors), the limited sample size and potential selection issues should be taken into consideration when interpreting our findings.

The rest of the paper is organized as follows: Section 2 describes the institutional details and presents a theoretical framework that derives the potential effects of AIPA on inventors' licensing timing decisions. Section 3 introduces the sample and describes the empirical methods and the data. Section 4 presents our empirical analyses and results. Section 5 concludes.

2 Institutional context and predictions

2.1 The American Inventor's Protection Act (AIPA)

Before AIPA was enacted, patent applications filed in all European countries, Canada, Japan, and Australia were published 18 months after their earliest application date (called "priority date") by patent offices in these countries.⁴ In contrast, US patent applications were published by the USPTO only upon grant; the

⁴The priority date of a patent application refers to the filing date of the earliest related application, regardless of where the application was filed. For example, if a firm files an application in Germany (unrelated to any other application it has filed before) prior to filing in Canada, publication in Canada occurs 18 months from the filing date in Germany.

technical knowledge represented in the patent application, the filing date of the patent application, and even the inventor's decision to seek a patent generally remained secret until grant. However, patent applications filed in the US as well as in foreign nations (that is, US patent applications with foreign equivalents) were published by the patent offices in these foreign nations 18 months after the priority date.

AIPA sought to harmonize the patent disclosure policy in the US with those in the rest of the world and generally required inventors filing for patent protection in the US on or after November 29, 2000 to publish their applications 18 months after their priority date. In order to address concerns that pre-grant disclosure may expose small firms to expropriation risk, AIPA provided a way to avoid 18-month publication: Inventors could opt out of 18-month publication by agreeing not to file the application, or its equivalent, in any foreign country that required 18-month publication. In practice, however, this opt-out provision is rarely used. Graham and Hegde (2015) show that 4.3 percent of all US applications in the biomedical industry filed after AIPA's enactment and granted by 2012 (6.9 percent of the patents that did not have foreign equivalents, and nearly none of the more-important patents) opted out of 18-month publication.⁵ Therefore, the rest of our analysis ignores the opt-out provision.

2.2 Patent publication versus voluntary disclosure

Both before and after AIPA, inventors could voluntarily disclose their inventions and patent applications through a variety of mechanisms, including postings on their websites, publications, reports in industry and trade bulletins. If voluntary disclosure under (potential) patent protection can sufficiently alleviate informational frictions, the effect of pre-grant patent publication by patent offices may be negligible or even negative due to greater expropriation concerns (Bessen (2005)). Drawing on the work of legal scholars (Rosenberg (2002); Long (2002); Merges (2005)), we argue that public disclosure through an official, standardized, and centralized repository may affect market transactions in ways that cannot be achieved through voluntary disclosure.

First, the information disclosed in patent applications is arguably more credible than that in voluntary disclosures because inventors may risk delay or denial of their patent applications by claiming either too much or too little. In addition, the value of an invention is relative, and the inventor may possess superior knowledge about prior art or competing substitutes for her invention relative to potential buyers. Under a voluntary-disclosure regime, even if an inventor discloses her own invention, it may be hard to ensure the credible disclosure of other related inventions. Publication mandated and regulated by law makes the market

⁵In our sample, patentees opted out of 18-month publication for less than two percent of the patents. In all such instances, the patents were not the earliest filed patent that the contract licensed out.

more transparent overall and, thus, may reduce information asymmetries regarding the relative merits of an invention.

Second, patent publication may enlarge the set of licensing opportunities beyond what can be achieved through voluntary disclosures, which tend to be dispersed and limited in scope. Patent publications notify the public of new inventions, are systematically catalogued, and are easily searchable through centralized repositories. Thus, patent publication may reduce the search costs for sellers (by providing better information about related inventors and, hence, potential buyers); facilitate buyers' search for potential inventions; and broaden the set of licensing opportunities between buyers and sellers in ways that are difficult to achieve through dispersed voluntary disclosures.⁶

Third, the easy verifiability of disclosure through patent publication permits the owner of the published application to sue others for infringement and demand royalties for the period between the publication date and the patent grant date. This recourse, which mitigates expropriation risk (also discussed below), is generally not available for inventions disclosed through other channels.

Of course, earlier publication reduces the duration of secrecy and, hence, potentially increases the expropriation risk and decreases rivals' costs of inventing around the patent. These drawbacks may reduce the incentive to participate in the market for ideas in general, while providing the incentive to engage in transactions sooner, conditioned on participation. However, as noted before, only a very small percentage of patent applications opt out of 18-month publication even if the patentees could choose to delay publication until grant (about 50 percent of all US applications do not file for foreign protection). This suggests that the private benefits of disclosure outweigh its costs for a majority of patentees who have such a choice,

In the following, we develop a simple framework that considers these benefits and costs of public disclosure to understand AIPA's effects on inventors' decisions about when to license their inventions.

2.3 AIPA and the timing of licensing

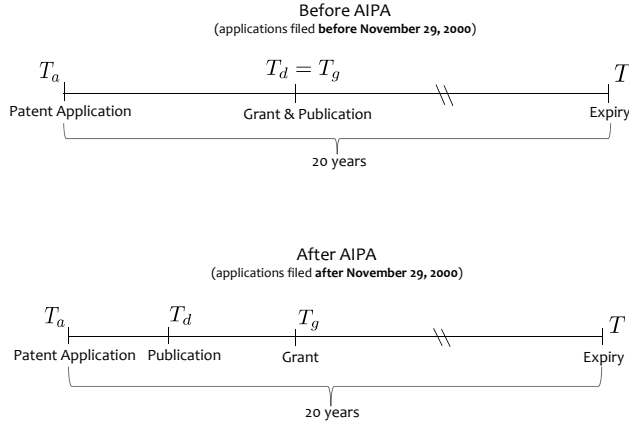
Figure 1 illustrates the sequence of events. Let T_a , T_d , T_g , and T denote, respectively, the dates for application, publication, grant, and patent expiration. Before AIPA, $T_d = T_g$ and after AIPA, $T_d < T_g$.⁷ In terms of the timing of licensing, before AIPA, the inventor has two options: either license after the application date or wait until the grant date; after AIPA, however, the inventor has the same two options and an additional one, which is to license after the publication date. For simplicity, we do not consider transaction costs, such as the time

⁶Rosenberg (2002) suggests that inventors primarily use "patents as an advertisement for the sale of accompanying know-how." Long (2002 p 625) argues that inventors acquire patents "to signal information about themselves that would be more expensive to do through other means."

⁷It 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.

taken to negotiate with licensing partners. Thus, licensing happens immediately after a certain event.

Figure 1: Patenting events before and after AIPA



In deciding when to license, the seller faces tradeoffs. Licensing early yields revenues for a longer period, which is important because of limited patent life. However, market frictions may lead some inventors to delay licensing. For example, though the expectation of receiving legal protection may encourage voluntary disclosure before patent grant, to avoid being paid at the average valuation, inventors who expect stronger and broader patents may still want to wait until the uncertainty over the scope of their IP rights is resolved. As discussed in the previous section, public disclosure through publication may help to credibly convey private information and to broaden the scope of collaborative opportunities.

We use the following reduced-form parameters to represent the above tradeoffs. Let the per-period baseline licensing revenue be v , which is the average revenue that the licensor obtains given the observable characteristics, including the fact that the invention is licensed before both events.⁸ Let d be the effect of public disclosure on the per-period revenue if the licensor waits until the publication event, and g be the effect of clarifying IP rights if the licensor waits until the grant event. Note that these effects are deviations from the average revenue v and, thus, can be positive or negative.

Disclosure is often accompanied by expropriation risk. For example, a potential licensee may obtain enough information to come up with a successful substitute for the invention. Let the probability of inventing around be $\rho < 1$ if the inventor chooses to voluntarily disclose before publication during the process of searching and negotiating with potential licensees. Let the probability be 1 after publication, which is a simple way of reflecting a higher expropriation risk of public disclosure. Let Δ be the expected loss to the

⁸In a similar setup, Luo (2014) shows that a unique separating equilibrium exists such that better ideas are sold at a later stage. The buyer, knowing the seller's decision threshold, evaluates an idea that is offered for sale at an early stage at the conditional expected value of all possible values below this threshold.

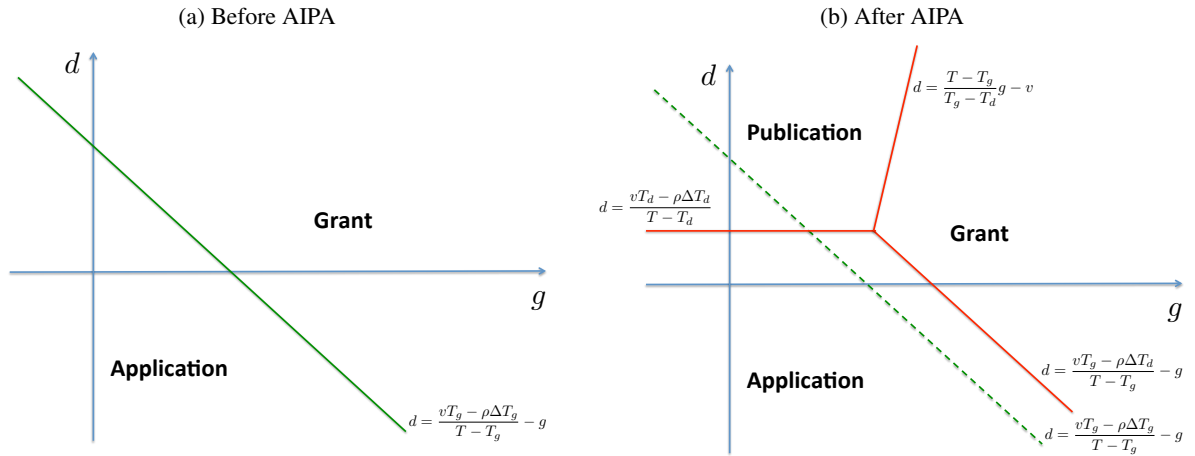
inventor in each period, given expropriation.

Refer to Appendix A in the Online Supplementary Appendix for the inventor’s payoffs from licensing at different times under different disclosure regimes, as well as for the resulting decision rules. Note that we do not consider the choice between licensing and other outside options. We discuss the potential effects of AIPA on the overall incentive to license (or to patent in the first place) after reporting the results.

2.4 Empirical implications

Figure 2 illustrates the decision rules as a function of the effect of public disclosure, d , and the effect of clarifying IP rights, g . Figure 2a shows that, before AIPA, the inventor licenses the invention immediately after the application date if the net benefit from earning licensing revenues before grant—while risking information leakage through the search and negotiation process—is greater than the combined net effect from public disclosure and the clarification of patent rights for the rest of the protection period—i.e., when $vT_g - \rho\Delta T_g > (d + g)(T - T_g)$. Otherwise, she waits until patent grant.

Figure 2: Decision rules on licensing timing before and after AIPA



The solid lines in Figure 2b denote the decision rule after AIPA, and the dashed line replicates the decision rule before AIPA. Comparing the solid and dashed lines shows that AIPA has two effects. First, when publication conveys benefits beyond what can be achieved through voluntary disclosure (that is, there is a sufficient density of transactions characterized with high values of d), some inventors who would have waited until the grant date before AIPA would want to expedite licensing to the publication date as long as the effect of clarifying IP rights is relatively low; and some other inventors who would have licensed out their inventions after the application date before AIPA would want to delay licensing till publication to enjoy its benefits. Second,

licensing soon after application is associated with a smaller loss after AIPA than before because the invention is disclosed to the public at an earlier date with pre-grant publication. The increased expropriation risk makes some inventors who would have waited until the grant date before AIPA to expedite licensing towards the application date.

Figure 2b shows that the two effects described above reduce inventors' incentive to wait until the patent is granted; that is:

Prediction 1 (likelihood of licensing after grant). *Other things being equal, the likelihood of licensing after the patent grant date decreases after AIPA.*

The implications of these two effects for firms can be quite different. Reducing information frictions is likely to be associated with an increase in the total surplus of a transaction, while the increased expropriation risk may result in a loss and, eventually, reduce the ex-ante value of licensing and patenting. It is beyond the scope of this paper to quantitatively compare these two effects. Our goal is more modest: We want to investigate whether public disclosure brings significant benefits to the licensing parties beyond those of the voluntary disclosure that had always been available before AIPA. Even though both effects reduce licensing after grant, the effect from increased expropriation risk pushes licensing towards the application date, while the effect from reducing informational frictions pushes licensing towards the publication date. Therefore, if we find that, after AIPA, the likelihood of licensing shortly after 18 months significantly increases, we can reject the null hypothesis that publication does not bring significant benefits to licensing parties beyond the voluntary-disclosure regime.⁹

Prediction 2 (likelihood of licensing after 18 months). *If public disclosure benefits inventors, the likelihood of licensing after 18 months increases after AIPA.*

Figure 2b shows that the combination of the two effects discussed above makes AIPA's effect on the probability of licensing immediately after the application date ambiguous: It depends on the number of inventions that are now licensed at publication date rather than application date versus those that are licensed at application date rather than at grant. However, if expropriation concerns were small in the market (that is, when $\rho\Delta$ is negligible), AIPA would result in little change in the relative downside of licensing before information is disclosed to the public. Then, the likelihood of licensing immediately after the application date would only drop after AIPA.

⁹We may also not find a significant 18-month effect when the publication and the grant dates are sufficiently close. In the data, the average gap between these two dates is a non-trivial 24 months, which amounts to ten percent of the patent term.

Finally, we examine the effect of AIPA on the average licensing lag (that is, the difference between the application date and the license date). Because some inventions are licensed earlier and others later, the overall effect of AIPA on the licensing lag is also ex-ante indeterminate.

3 Sample, methods, and variables

3.1 Sample construction

Publicly traded companies in the US are required by the Securities and Exchange Commission (SEC) to make their material transactions public. These transactions are filed by the companies along with their quarterly and annual reports at the SEC, which in turn publishes the filings on its Electronic Data Gathering, Analysis, and Retrieval (EDGAR) website. In addition, several state governments require privately-held companies with employee stock options to publish their material transactions. The license agreements in our sample are drawn from these disclosures. We obtained the complete texts of the agreements from Deloitte Recap's RecapIP, a proprietary product that collates information on agreements in the biopharmaceutical industry.¹⁰ We supplemented RecapIP's data with data from our own search of the SEC's EDGAR database, which yielded information on a small number of additional licenses in the medical instruments industry.

We finalized our sample after imposing the following criteria. First, because we focus on licensing agreements, we excluded agreements that governed mainly manufacturing, marketing, supply, distribution, joint ventures, post-litigation settlements and other activities.¹¹ Second, a license agreement between two parties may be followed by renegotiations and revisions to the original agreement. Because we are interested in the initiation of licensing agreements, we discarded agreements that were amendments of original licenses. Third, we retained those agreements that involved the licensing of at least one identifiable non-provisional patent application or granted patent (filed either in the US or in a foreign country), thus excluding contracts in which the identity of the patents was redacted. Because our primary data sources under-sample agreements that involve privately-held companies, foreign companies, and other entities not bound by the SEC's reporting requirements, our sample licenses are based mostly on patents filed in the US either with or without foreign equivalent applications (together, constituting 87.9 percent of the licenses), followed by patents filed at the World Intellectual Property Organization (Patent Cooperation Treaty applications; 6.1 percent), European Patent Office (2.5 percent), Japan (1.8 percent), Australia (one percent), and Great Britain (less than one

¹⁰A number of studies have used Recap data, including Lerner and Merges (1998); Lerner and Malmendier (2010); Wakeman (2012); Allain, Henry, and Kyle (Allain et al.). Lerner and Merges (1998) describe the database in detail.

¹¹We later use these non-licensing agreements (1) to check whether their frequency over time differs from that of licensing agreements, and (2) as an alternative comparison group in a difference-in-differences type of analysis.

percent).

We perused each agreement in our sample and assembled information on the following three dates.

(i) License agreement date: This is the date on which the licensor and licensee officially commence their partnership. The licensee earns the right to use the licensor's patents, typically in return for an upfront fee, on or around the agreement date.

(ii) Patent application date: We gathered the identities of every patent and patent application specified in each contract in our sample. We then matched the patents to the USPTO's database (for US applications and patents) and the European Patent Office's EPSTAT database (which provides information on patent applications filed at the EPO and at other patent offices across the world) and identified the important dates associated with each patent. The first application date associated with a patent, the "priority date," may be different from the application date found on the cover page of patents because applications can have "parents" (these parent applications are typically abandoned when related applications, or "children," emerge through procedures such as continuations, divisionals, and continuations-in-part). Since AIPA's provisions specify publication 18 months after the priority date, we use the priority date as the actual application date (and, henceforth, use the term "application date" to refer to the priority date). When the agreements license more than one unique patent (patents are considered unique if they do not claim the same subject matter in filings across different countries), we use the application date of the earliest patent application in the license.

(iii) Patent grant date: "Patent grant date" here refers to the day on which a patent office notifies the applicant of the allowance of her patent and typically precedes the administrative grant date reported on the cover page of patents by three to four months. Since notification resolves uncertainty about the fate and scope of pending patent applications, we use this date rather than the administrative grant date in our analysis (and, henceforth, refer to the allowance notification date as the grant date). For licenses with more than one unique patent, we use the earliest grant date to characterize the agreement.

A law change stipulated that US patents' duration is to be 20 years from the application date rather than 17 years from the grant date for applications filed after June 8, 1995. This change may have affected patentees' licensing timing decision, and we exclude licenses with their earliest US patent applications filed before June 8, 1995 to avoid conflating the effects of AIPA with the effects of this prior patent law change. Thus, our final sample has 440 licenses, which licensed patent applications filed between mid-1995 and 2011. Eighty licenses (18.2 percent) specified patent applications without any granted patent (some of these applications were abandoned and the rest were pending as of end-2013).

3.2 Sample selection

Because we have a longer time window to observe licensing events for patent applications in the earlier years, patents that take longer to be licensed may be underrepresented in the later years of our sample. For the before-and-after specifications, this truncation could lead us to incorrectly infer that licensing lags are shorter after AIPA, though it is less of a concern for DID specifications. We address this potential bias by including specifications that use only licenses based on patents with application dates before Dec 31, 2007 and that were licensed within six years from the application date (the 72-month sample).¹²

Patents in our sample are substantially more valuable than an average US patent in the biomedical industry. In particular, compared to all biomedical patents filed in the US between 1995 and 2010, the US patents in our sample have, on average, a significantly higher number of forward citations (2.9 vs. 1.2), a higher number of claims (24.8 vs. 18.8), and a higher number of backward references to non-patent (scientific) literature (6.1 vs. 4.4), and they are issued more quickly (40.2 vs. 45 months). This is not surprising given that valuable patents are likely to be licensed.

Without good data on whether or not a given patent is licensed or not, we cannot evaluate the effects of pre-grant publication on the decision of licensing (we discuss this again later in Section 4.4); nor can we assess how our sample patents compare to the population of patents that are licensed. We can, however, have a sense of how the licensing parties in our sample compare to all the licensing agreements captured by the RecapIP database during the same time period. RecapIP is known for its comprehensive coverage of deals in this industry, a vast majority of which are captured from press releases rather than from SEC disclosed contracts. These comparisons are summarized in Table 1.

First, the licenses in our sample were disclosed as material by one of the licensing parties (a publicly listed firm in the US). Panel 1 in Table 1 shows that, compared to licensing agreements without disclosed contracts, the licensors of licenses for which the contracts are available in the RecapIP database are not statistically different in their prior licensing experience (as sellers) but are significantly more likely to be non-profit organizations (such as universities, hospitals and other research institutes). This may be, in part, because these organizations are more likely to license first to smaller biotech firms, which, in turn, further develop and license the technologies to larger pharmaceutical companies; and smaller licensees are more likely to disclose contracts because the deals are more likely to be material relative to their firm size. Consistent with this, the licensees of licenses with disclosed contracts are significantly less experienced (as buyers).

Second, our sample includes only licenses for which the contracts are not redacted. Panel 2 in Table 1

¹²We chose 2007 as the cut-off year since most applications filed in this year were either granted or abandoned by end-2013, the last year of our patent data.

shows that, among licenses with disclosed contracts, compared to redacted ones, the licensors of non-redacted licenses have less prior licensing experience but are equally likely to be non-profit organizations, and the licensees are also less experienced. Combining the two steps, it seems that our sample licenses tend to capture less-experienced licensors and licensees and more likely to include technologies licensed out by non-profit organizations (see Panel 3 of Table 1). We address these sample-selection issues to some extent by investigating the heterogeneity in the effect of AIPA for different types of licensors. As we show later, the effect of AIPA on the licensing likelihood shortly after 18 months is stronger for smaller licensors but less salient for non-profit licensors. Thus, it is not obvious to assign the direction in which our sample bias may affect the average results.

3.3 Empirical methods

Our empirical strategy exploits the feature that AIPA separates the patent publication date from the grant date for US applications that are not filed abroad (about 50 percent of the applications filed at the USPTO between 1995 and 2005 and issued by 2013). Because US applications without foreign equivalents filed in 2000 took, on average, 43.1 months to be granted (and 42 months to be granted for applications filed in 2005), there is a significant lag between publication and grant for the average post-AIPA application; only about ten percent and six percent of the applications filed in 2000 and 2005, respectively, were granted within 18 months.¹³ We first analyze licensing timing as a function of this before-and-after variation in the timing of patent publication for US applications (without corresponding foreign applications), controlling for characteristics of the inventions and the licensing parties, as well as for the technology classes and markets.

In addition to the before-and-after analysis, we leverage the institutional differences between the US and the rest of the world to construct a control group that helps to further isolate AIPA's effects. The control group includes two types of licenses: (1) licenses of patent applications that are filed only in foreign countries; and (2) licenses of US applications that are also filed in foreign countries. We believe that the licenses of patents filed only abroad are better controls because AIPA did not alter their information environment. Prior to AIPA, US applications with foreign equivalents were published 18 months after the priority date by the foreign country in which they were filed. Publication in foreign countries is not the same as publication in the US because of the lack of public records, prior to AIPA, that linked US patent applications to their foreign country equivalents. The equivalent foreign patent applications may also have been published in foreign languages, and many US based licensees may only search the USPTO's patent databases due to resource

¹³US patent applications (without foreign equivalents) in the biomedical industry took longer to be approved. Average pendency was 47.1 months and 47.6 months, respectively, in 2000 and 2005 (median pendency was 39.4 months and 48.5 months, respectively). Six percent of the applications in 2000 and four percent of the applications in 2005 were granted before 18 months from application.

and time constraints (see, e.g., a comprehensive discussion of these frictions in Ragusa (1992)). Thus, AIPA may have had a subdued effect on the informational environment of such “international” patents. Combining licenses based on foreign patents and international patents (US patents with foreign equivalents) provides us with a sufficient number of observations in our control group for DID estimations. In the regressions, we include a binary indicator to account for the differences between the two types of control licenses, and in robustness checks, we also investigate whether the DID estimates of AIPA are sensitive to excluding US patents with foreign equivalents from the control group.

We emphasize that, in addition to the limited sample size, the control group is also far from ideal. Even though AIPA did not directly change the publication requirement for patents filed abroad, the US is an important patenting destination for many foreign firms. Thus, changes in disclosure policies in the US are likely to have indirectly affected the timing of licensing of foreign patents through their effects on the overall informational environment and competition in the market for ideas. Due to the data and identification challenges that studies of licensing face in general, we view different empirical approaches and robustness checks as complementing each other, and the consistency in the results obtained across different specifications would add confidence to our overall conclusions.

3.4 Variables

A. Dependent variables

Our analysis explains the timing of patent licensing with respect to the timing of three patenting-related milestones: patent application, 18-month patent publication, and patent grant. To test Prediction 1, we construct a binary variable that equals one if the licensing event occurs after patent grant. To test Prediction 2, we construct a categorical variable indicating whether the licensing event occurs in one of the following three windows: (i) sooner than 18 months from the patent application date and before patent grant; (ii) after 18 months since patent application and before patent grant; and (iii) after patent grant. We also construct a variable measuring the licensing lag, which is the number of months between the patent application date and the license date.

Panel 1 in Table 2 shows that 17.7 percent of the sample licenses are negotiated before 18 months from the earliest patent application, 23.6 percent between 18 months and earliest patent grant, and 58.6 percent after grant. Table 3 shows that the average patent is licensed 48.2 months after application.

B. Independent variables

The variable of interest for the before-and-after specifications is the binary indicator, Post AIPA, which

equals one for licenses based on patent applications filed on or after November 29, 2000 (AIPA's effective date) and zero for applications filed before this date. For the DID specifications, we create a binary variable, US patent, which equals one for licenses based on US patent applications without foreign equivalents (i.e., the treatment group) and zero for foreign applications and US applications with equivalent foreign applications. Thus, the interaction term between Post AIPA and US patent is our estimator of interest for the DID specifications. We also include a binary indicator for US patents with foreign equivalent patents to account for differences between these two types of control licenses. 22.5 percent of the 440 licenses belong to the post-AIPA regime, and 52.7 percent of the licenses belong to the treatment group.

We construct control variables related to the characteristics of the license, licensed patents, transaction parties, and the technological classes and markets (see Table 4 for the summary statistics).

The observed characteristics of the licensing parties include indicators for the licensor's organizational type (among the licensors, 68.6 percent are for-profit entities; the rest are non-profit entities); the licensing parties' experience levels; and the extent to which they deal with each other. We measure the licensor's experience as the number of deals captured by the RecapIP database (all types of deals, including those that do not contain contracts or identifiable IP information) that the licensor has undertaken as a seller prior to the focal agreement; the licensee's experience as the number of deals that the licensee has made as a buyer prior to the focal agreement; and the relational experience as the number of prior deals that the licensor and the licensee have transacted before the focal agreement.

The observed characteristics of the license include information on whether or not the invention is licensed exclusively to the inventor (60 percent of the licenses) and whether the license specifies the transfer of know-how and, thus, requires ex-post involvement of the licensor in downstream development activities (88 percent of the licenses).

Pendency is the time taken by the patent office to examine and allow patent applications, which is an important control because longer pendency may incentivize sooner licensing. For patent applications that are not yet granted, we use expected pendency, which is the average pendency for granted patents filed in the same year and technology class. We control for the qualities of licensed patents by including three variables: (i) three-year forward citations (since some of our post-AIPA patents are granted as late as 2013, we cannot observe forward citations in a longer time window for a fraction of post-AIPA patents); (ii) the number of claims; and (iii) the number of references to non-patent prior art. Data on these patent value measures are not available for the foreign applications and patents in the control group¹⁴ or for ungranted applications in the

¹⁴EPSTAT, our datasource for information on foreign patents, does not provide readily usable data on these variables; foreign patents in our sample are also from different countries, and institutional differences among the offices of these countries make it difficult to compare cross-national data on these variables.

treatment group.

Finally, based on the technology class of the focal patent and information provided by RecapIP, we control for the technological field and the therapeutic market of the licensed invention in each license to capture systematic differences in licensing strategies. Forty-seven percent of the licenses involve patents belonging to the “Drugs” category, 13 percent to the “Surgery and Medical Instruments” category, and the rest to miscellaneous and unknown classes. We include a set of dummy variables indicating each of the top ten therapeutic categories. We also create a continuous variable that measures the number of potential buyers based on therapeutic areas. In particular, we count the number of unique companies that have been the licensee for at least one deal in a particular therapeutic area two years before and two years after the agreement year. Similar to the experience variables, this measure is constructed based on the complete RecapIP database, not just on our analysis sample. The large sample mean is driven by the cancer category. For licenses with unknown therapeutic areas, we use a dummy variable indicating these licenses and replace the number of potential buyers with zero.

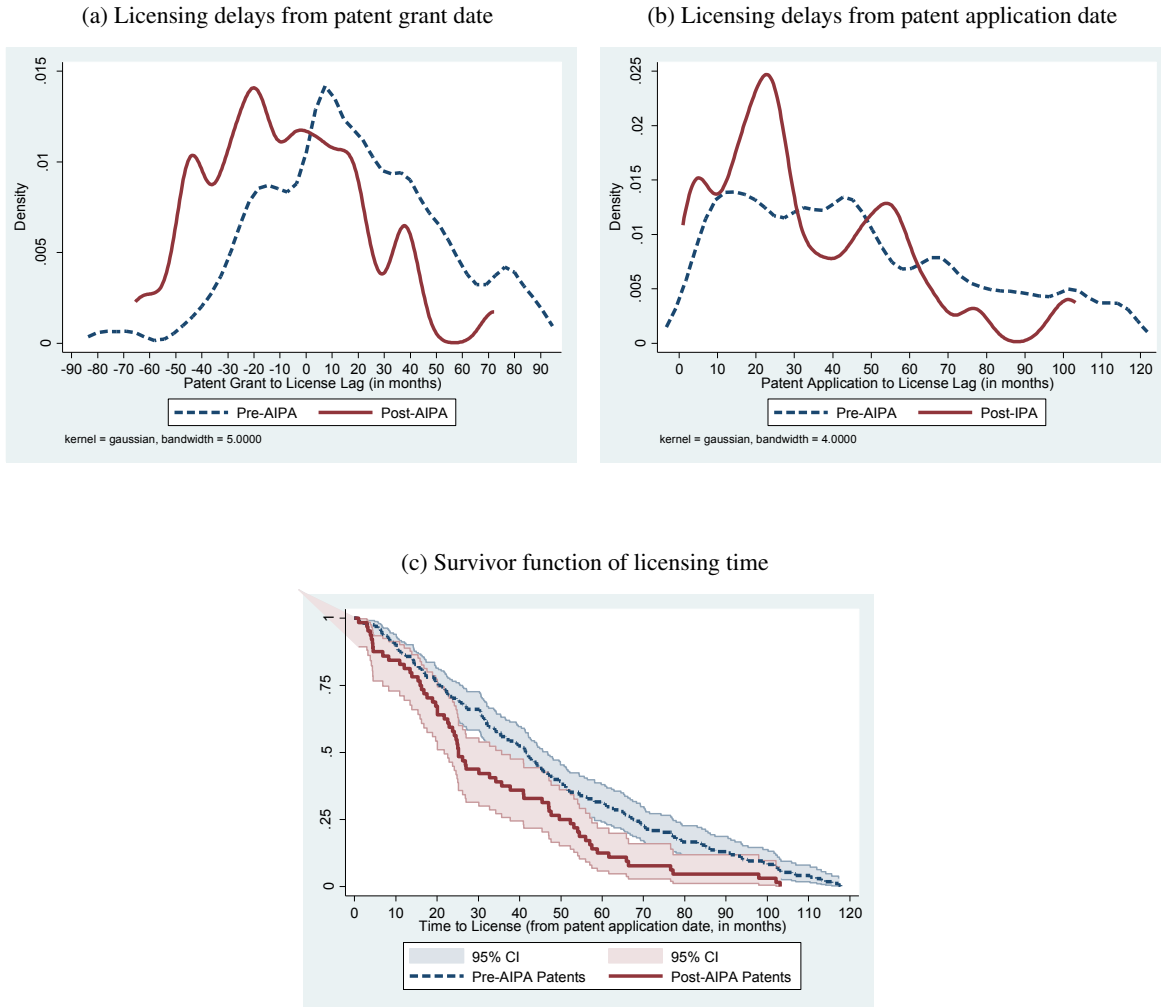
3.5 Descriptive evidence

We focus on comparing licensing timing before and after AIPA for licenses based on US patents without foreign equivalents (the treatment group). Prediction 1 states that the likelihood of licensing after patent grant should decrease after AIPA. Figure 3a plots the density distribution of the difference between the licensing date and the patent grant date in months. The distribution for pre-AIPA licenses appears similar to the one presented in Figure 2 of Gans, Hsu, and Stern (2008), showing a jump in the density of licenses following patent grant. Figure 3a shows that post-AIPA, a much smaller proportion of licenses occur after patent grant. In fact, 56 percent of the pre-AIPA patent applications are licensed after grant, while, after AIPA, only 28 percent delay until grant (see Panel 2 in Table 2).

Prediction 2 states that if patent publication significantly benefits some inventors beyond voluntary disclosure, the likelihood of licensing after 18 months should increase after AIPA. Figure 3b plots the density distribution of licensing lags (between licensing date and patent application date) for applications before and after AIPA. Before AIPA, the density of licensing lags appears to be rather uniform from 10 to 50 months after application and then decreases over time. In contrast, after AIPA, licensing appears to be concentrated around two periods: (i) shortly after 18 months; and (ii) around 55 months after application date. The “bump” shortly after the 18-month publication date is unique to the post-AIPA subsample and provides preliminary evidence for the distinct effect of patent publication.

Figure 3c plots the survivor function of licensing for pre-AIPA and post-AIPA treatment-group patents.

Figure 3: Descriptive evidence for the timing of licensing before and after AIPA



Notes: These figures are based on the treatment-group patents (US patent applications that do not have foreign equivalent applications). Figure (a) plots the kernel density estimates of licensing delay calculated as (patent license date – patent grant date) in months for before and after AIPA, and zero on the horizontal timeline indicates that licensing happened in the same month in which the patent was allowed. Figure (b) plots the kernel density estimates of licensing delays calculated as (patent license date – patent application date) in months for before and after AIPA, and zero on the horizontal timeline indicates that licensing happened in the same month in which the patent was applied for. Figure (c) plots the Kaplan-Meier survivor function of licensing for before and after AIPA.

The graph confirms that post-AIPA patents are licensed sooner, with a clear break in the hazard of licensing for post-AIPA applications shortly after 18 months from application. Post-AIPA licensing occurs, on average, 12.8 months sooner than before AIPA (see Table 3). The Kolmogorov-Smirnov test confirms that the two distributions for licensing lags are statistically different from each other ($p < 0.05$).

The above descriptive analysis provides suggestive evidence that patent publication reduces licensing delays and that the 18-month publication rule after AIPA increases licensing shortly after publication. Still,

the observed patterns could be driven by other factors that may have changed over our study period. For example, patent pendency—the time required to examine and grant patent applications—increased by nine months for post-AIPA applications. In the following section, we estimate regressions that control for other factors that might affect licensing timing and incorporate a number of robustness checks. We also complement the before-and-after AIPA comparisons with DID specifications that use licenses involving foreign patents as the control group.

4 Regression results

In this section, we first report the baseline results on AIPA’s effects on the timing of licensing and then on whether these effects of AIPA are heterogeneous for different types of licensors and inventions. Finally, we discuss the potential effects of AIPA on the overall rate of licensing and patenting.

4.1 Baseline results

A. AIPA’s effects on the likelihood of licensing after patent grant

Table 5 reports estimates obtained from a Probit regression (marginal effects), in which the dependent variable equals one if licensing occurs after patent grant and zero otherwise. We report robust standard errors clustered by therapeutic areas for all license-level regressions in the paper. Columns (1)-(3) report before-and-after AIPA results using licenses involving only treatment-group patents (US patents without foreign applications). Column (1) uses these licenses and controls for only the number of patents and patent pendency. Column (2) uses licenses that take place within six years from application (the 72-month sample) in order to minimize truncation biases caused by our longer period of observation for pre-AIPA patents to be licensed. The specification used in Column (2) also brings in additional controls for the characteristics of the license and the licensing parties, as well as for the market and technology categories. Column (3) further includes the characteristics of the patents and, thus, uses only granted US patents. The estimated coefficients of Post AIPA show that post-AIPA inventions are about 20 percentage points less likely to be licensed after grant than pre-AIPA inventions (the effect is statistically significant at conventional levels).

Columns (4)-(5) in Table 5 present DID results using licenses in both the treatment and the control groups. The control group includes licenses based on foreign patent applications only and US patent applications with foreign equivalents. Although the DID strategy should account for truncation bias, we still report the DID estimates using the 72-month sample in the last column as an additional robustness check. The coefficients of the interaction term between Post AIPA and US patent are both negative and statistically significant. The

magnitudes are also comparable to those of the before-and-after estimates. These results are consistent with Prediction 1 that after AIPA, inventors are less likely to wait until patent grant to license their inventions.

B. AIPA's effects on the likelihood of licensing after (18-month) patent publication

Recall that our theoretical framework suggests that inventors are less likely to delay licensing until grant for two reasons: Some want to expedite licensing to shortly after 18 months because they benefit sufficiently from the reduction in informational frictions post-publication, and some may want to speed up licensing to shortly after the application date because sooner (mandatory) publication lowers the relative downside of information leakage during the search and negotiation process. We are particularly interested in whether the 18-month result is significant because it helps clarify whether public disclosure actively conveys informational benefits beyond what can be achieved through voluntary disclosure. If the speedup in licensing is entirely driven by relative expropriation concerns induced by sooner publication, the incentive to license and the value of patenting may decrease in the long run.

We use two sets of regressions to examine the licensing likelihood in the two earlier licensing windows. First, we use the multinomial logit (MNL) regression, in which the dependent variable equals one if licensing takes place before 18 months from application; two if licensing takes place after 18 months but before patent grant; and three if licensing takes place after grant (the reference outcome). A potentially restrictive assumption of MNL models is Independence of Irrelevant Alternatives (IIA).¹⁵ Conceptually, the IIA assumption may be violated because of the time dependence of licensing likelihood. For example, if licensing after the application date is removed from the licensor's option set, licensors may be disproportionately more likely to choose licensing after the publication date than after the grant date because, other things being equal, the licensor would prefer to license sooner. Empirically, the standard Hausman tests cannot reject the null hypothesis that IIA is a reasonable assumption in our context.¹⁶

The second set of regressions essentially examines the density plot in Figure 3b more formally in a regression framework. Specifically, we reorganize the license-level treatment sample into a month-level panel dataset starting in the month in which the application was filed at the USPTO and ending in the month in which the invention is licensed. Table 7 reports Probit regression results in which the dependent variable equals one for the month in which it is licensed and zero otherwise. The variable Application window equals

¹⁵The literature has used both the MNL and the latent survivor time approaches to estimate competing risk models. The latent survivor model relies on an assumption that is essentially equivalent to the IIA assumption: conditional independence; that is, the latent duration time for risk k is independent of the duration time for risk j , conditional on the controls. We replicate the MNL regressions using a latent survivor time model, which produce qualitatively similar results (not reported here).

¹⁶We use the Stata command 'Hausman' to test for the IIA assumption, and the test statistics cannot reject the assumption. Take the specification in Column (2) in Table 6 for example. The p-value of the Hausman test statistics for excluding the option of licensing after application is 0.97; and the p-value for removing the option of licensing between the publication and the grant dates is 1.00.

one for all months prior to 18 months from application and Publication window equals one for months after 18 months, but within 28, 30 or 32 months after application. The baseline window indicates months later than 28, 30, or 32 months after application. For these regressions, the Publication window does not involve publication for pre-AIPA applications and can, thus, be viewed as a placebo against which to compare the post-AIPA applications. We include the number of months elapsed since application (in logarithm) to control for the time dependence of the licensing likelihood. Because this data structure permits an adequate number of observations for each licensor, we report robust standard errors clustered by licensor.

Table 6 presents MNL regression estimates expressed as relative risk ratios. As in Table 5, we report the before-and-after estimates in the first three columns and the DID estimates in the last two. Across all specifications, the results show a significant 18-month effect: relative to licensing after patent grant, post-AIPA inventions are more than three times more likely to be licensed in the window between 18 months and patent grant. Table 7 presents the Probit results from the panel-structured data. The estimated coefficients of the interaction term, Publication window*Post AIPA, are also positive and significant across all specifications, suggesting that, relative to delaying licensing until later, post-AIPA inventions are more likely to be licensed shortly after the publication date. Overall, both the raw data and the regression results from different specifications show a significant 18-month effect.

The results on the relative likelihood of licensing after application (the earliest time window) are mixed. The MNL results in Table 6 show that, relative to licensing after grant, post-AIPA inventions are also significantly more likely than pre-AIPA inventions to be licensed immediately after application.¹⁷ The estimated coefficients of Application window*Post AIPA in Table 7 are close to zero. Neither specification, however, shows a significant drop in this likelihood. This suggests that imitation concerns are important enough for some inventors/inventions that sooner publication after AIPA makes it less worthwhile to prolong secrecy by delaying the search and negotiation process of licensing.

C. AIPA's effects on licensing delay

We estimate two sets of regressions to investigate AIPA's effects on the magnitude of licensing delay. Panel 1 in Table 8 reports the Tobit estimates, in which the dependent variable is the number of months between the application and licensing dates. The before-and-after estimates in Column (2) and the DID estimates in Column (4) show that post-AIPA inventions are licensed ten months sooner, on average, than pre-AIPA inventions. The effect is economically large (and marginally significant): given that the average

¹⁷Note that, in Table 6, the DID estimates for the increase in the likelihood of licensing after application is much larger than that obtained from the before-and-after regressions. The large estimate is likely to be caused by the fact that, for US patents with foreign equivalents (which are part of the control sample), there are actually no post-AIPA observations that fall into this licensing window.

licensing lag was 46 months before AIPA, the change implies a 22 to 24 percent reduction in the licensing delay. Panel 2 in Table 8 reports the results from a Cox proportional hazard rate regression. The survival analysis estimates a larger increase in the hazard rate of licensing after AIPA—more than 70 percent from the corresponding two columns.

4.2 Robustness checks

Table 9 presents robustness checks using the DID specification reported in the fourth column of Tables 5, 6, and 8. First, Panel 1 reports estimates obtained by restricting the sample to those licenses that specify only one patent (sixty percent of our original sample). Second, 13 percent of the licenses in the original sample were allowed within 18 months of patent application date. In principle, these patents, though enjoying a relatively short examination period, may still be affected by AIPA in expectation because the short patent-grant delay is realized only ex-post facto. Still, we exclude licenses with patents allowed within 18 months and report the results in Panel 2. Third, Panel 3 reports the results excluding licenses that involve US patents with foreign equivalents and, thus, the control group includes only licenses involving pure foreign patents.¹⁸

The estimated coefficients of the interaction terms between Post AIPA and US patent are consistent with the baseline results on magnitude, even though the statistical significance is weaker in some specifications (the p-values of the coefficients of interest are almost all below 0.2). We also conduct the same three sets of robustness checks using the before-and-after specification reported in the second column of Tables 5, 6, and 8. The results (not reported here to preserve space) are consistent with the baseline results and are statistically significant. While some of the robustness results are noisy—likely due to an even smaller sample size—the consistently large estimates of the estimated effects across different specifications and subsamples add confidence to our baseline results.

4.3 Heterogeneous effects of AIPA

Different types of inventors or inventions may face different informational environments before AIPA and, hence, may be affected differently by AIPA. In the following, we explore whether the effects of AIPA are heterogeneous for different subsamples within our treatment group.

A. For-profit versus non-profit licensors

¹⁸The RecapIP database also contains agreements of types that are less likely to be affected by AIPA, such as manufacturing, marketing and distribution agreements. We also use these types of agreements that are based on US patents without foreign equivalents as an alternative control group. The results (not reported here) are consistent with our baseline results on economic magnitude, but with slightly weaker statistical significance.

We first compare the effects of AIPA for non-profit and for-profit organizations. 32 percent of the sample's licensors are non-profit organizations (universities, hospitals, and research institutes), and the rest are for-profit entities (66 percent corporations and 2.2 percent individual inventors). Though likely different in a number of dimensions, the knowledge underlying patents owned by non-profit licensors is more likely to be disclosed in other venues before patent publication (e.g., through academic publications or conference presentations). This difference suggests that AIPA should have a smaller effect for non-profit licensors because the change to their informational environment due to AIPA is smaller.

Panel 1 in Table 10 reports the results including the interaction term between a dummy—indicating for-profit organizations—and Post AIPA. Column (1) shows that, after AIPA, even though both are significantly less likely to license after patent grant, the change is 16 percentage points greater for for-profit than for non-profit licensors, though the difference is not significant. Column (2) shows that, relatively speaking, the 18-month effect is significantly stronger for for-profit licensors. These results are consistent with our expectation that for-profit organizations are more intensely treated than non-profit organizations. Furthermore, for-profit licensors are intuitively more concerned than non-profit licensors about expropriation risks. Thus, finding a stronger 18-month effect for for-profit licensors, despite their greater concern over expropriation, further strengthens the evidence for AIPA's positive impact in reducing information frictions.¹⁹

B. By firm experience

In the pre-AIPA regime, firms with a greater ability to credibly convey the value of their inventions and to protect their inventions from expropriation, such as larger and more-experienced firms, may be less dependent on patent grant to reduce market frictions. Thus, we expect AIPA to have a greater impact on less-experienced firms. In the data, we use the licensor's past number of deals as a seller prior to this particular deal as the measure of the licensor's size. Within the treatment group, 74 percent of the licensors have at least one deal prior to the license, and the median is 3.5 before AIPA and four after AIPA. We define the licensor as less experienced separately for the pre- and post-AIPA periods, if its past number of deals is less than or equal to the respective median.

Panel 2 in Table 10 reports the results including the interaction term between a dummy, indicating less-experienced licensors, and Post AIPA. Column (1) shows that, after AIPA, both are significantly less likely to license after patent grant. The change is slightly greater for less-experienced than for more-experienced licensors (five percentage points but not statistically significant). Column (2) shows that, relatively speaking,

¹⁹Columns (3) and (4) in Panel 1 of Table 10 show that both types of licensors have a shorter licensing lag after AIPA, but the estimates are not significantly different. This is not entirely surprising because the MNL results in Column (2) show that, relatively speaking, post-AIPA inventions by for-profit organizations are less likely to be licensed after application than those by non-profit organizations, though the coefficient is not statistically significant.

the 18-month effect is significantly stronger for less-experienced licensors.

C. By measures of patent value

Before AIPA, because inventors of inventions with a higher ex-ante observable value suffer greater losses from licensing delays, they would have a stronger incentive to license early despite market frictions. Thus, AIPA may have a smaller impact for more-valuable inventions. However, inventors of inventions with a higher ex-ante unobservable value may delay licensing in order not to be pooled with patents of lower value. Thus, if controlling for the observable value, AIPA should have a greater effect on patents that protect inventions of higher, ex-ante unobservable value. Since we are unable to effectively separate observable from unobservable values, it is difficult to hypothesize the relationship between the effect of AIPA and typical measures of patent importance.

Following the literature, we use the number of claims and the number of three-year forward citations to measure patent value. We define a patent as high value if it has more claims or has received more citations than the sample medians separately for the pre- and post-AIPA periods. We group a small number of patents that are not granted as low-value patents. Panels 3 and 4 in Table 10 present the regression results including the interaction terms between a dummy, indicating high-value patents, and Post AIPA. The results show that the effects of AIPA on reducing the likelihood of licensing after grant, as well as the 18-month effect, are both stronger for higher-valued patents. The differences, however, are not statistically significant.

4.4 AIPA and the incentive to license

Our analysis so far has not considered inventors' choice between licensing and other modes of profiting from their inventions. Theoretically, the effect of the pre-grant disclosure required by AIPA on the incentive to license or even to patent is ambiguous. On the one hand, pre-grant disclosure implies a greater risk of inventing around, which may make patenting and participating in the market for ideas less attractive (see, also, Aoki and Spiegel (2009)). On the other hand, as previously discussed, 18-month patent publication may benefit inventors beyond a voluntary-disclosure regime. Aoki and Prusa (1996) also show that pre-grant disclosure could increase firms' incentive to patent because it increases their profits by enabling them to coordinate their R&D investments better. Without good data on inventors' decisions of whether or not to license their patents, we cannot empirically analyze the effects of pre-grant publication on the rate of licensing. Because our sample has a greater number of licenses based on pre-AIPA patents than on post-AIPA patents (341 and 99, respectively), we discuss whether this reflects that the 18-month publication rule has a negative impact on the overall rate of licensing.

First, recall that our analysis relies on agreements for which the actual contracts are disclosed. According to RecapIP, the drop in the number of disclosed contracts in later years is due mainly to a sharp decline in the number of publicly-listed firms (and, hence, the reported contracts) after the burst of the IPO-boom in 2000. Figure A1 in the Online Supplementary Appendix reveals that the decline in licensed patents starts for patents filed in 1998. This is consistent with the decline in the disclosed contracts after the IPO bubble because the average patent is licensed about 40 months after application. Furthermore, for licenses with disclosed contracts and identifiable IP information, the same figure shows that the number of licenses in the treatment group exhibits a time trend similar to that of the control licenses that involve any type of foreign patents and to that of an alternative comparison group including other types of patent-based transactions, such as marketing and manufacturing contracts. Thus, there seems to be no evidence suggesting that the enactment of AIPA caused the drop in the number of licenses observed in our sample.

Second, there also appears to be no evidence that the rate of patenting drops.²⁰ Apart from potential benefits from publication, AIPA also allows inventors to collect royalties from infringers starting from the publication date. This provisional right may compensate inventors for potential losses due to leakages associated with early publication.²¹ Recall that AIPA also created an opt-out provision that allows patentees who agree to forgo equivalent foreign patenting to delay publication until grant. The overwhelming preference for publication, versus opting-out, and the absence of a decline in US patenting after AIPA, documented by Graham and Hegde (2015) suggest that pre-grant disclosure does not seem to harm the majority of patentees.

5 Concluding thoughts

Previous studies have focused on the role of patent rights in resolving the problem of information asymmetry bundled with expropriation risk and, thus, facilitating transactions in the market for ideas. Here, we study the effects of a hitherto understudied function of the patent system—the publication of patent applications—on transactions in the market for ideas. We leverage an important policy change that required US patent applications filed beginning on November 29, 2000 to be published 18 months after application date rather than after

²⁰Putnam (1997); Tepperman (2002) investigate the effects of Canada's 1989 Patent Act reform, which 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. They find opposite results of the reform on the value of patenting and R&D incentives. These studies do not separate out the effects of pre-grant publication from the effects of switching to first-to-file from first-to-invent.

²¹We have argued that the provisional right created by AIPA is a natural consequence of the verifiability of invention disclosures made possible through patent publication. We attempt to theoretically understand the distinct effects of provisional rights on the timing of licensing by adding enforcement to our framework (see Appendix A2 in Online Supplementary Appendix). We find that, in this simple framework at least, the legal right to recoup royalties from the publication date does not affect the timing of licensing. This is because, in the post-AIPA regime, the ability to enforce patent rights starting from the publication date affects the payoffs from licensing in the same way for all timing options; thus, the effects cancel each other out.

grant. Thus, AIPA separated the timing of the disclosure of ideas embedded in patent applications from the certification of inventors' property rights over the idea. We develop a simple framework that incorporates the benefits and risks of public disclosure and helps predict the effects of AIPA on the timing of licensing. We then assess these predictions using a sample of licensing agreements of high-value inventions in the biomedical industry.

We find that post-AIPA patent applications are about 20 percentage points less likely than pre-AIPA inventions to wait until patent grant to be licensed. We also consistently find a significant 18-month publication effect: The likelihood of licensing jumps up significantly after publication for post-AIPA inventions. Overall, post-AIPA inventions, on average, are licensed ten months earlier than pre-AIPA inventions. The shortening of the licensing lag is economically significant, representing a 20-percent decrease in licensing delay.²²

This significant 18-month effect persists across different specifications and suggests that invention disclosure through patent publication benefits at least some inventors beyond what other disclosure mechanisms can achieve. We propose that by providing more information and greater transparency to the market, public disclosure through a centralized, standardized and verifiable repository (such as those used by national patent offices) helps sellers establish the credibility of their ideas and augment potential licensing opportunities. These findings represent a first step towards a deeper understanding of the mechanisms through which parties search and discover each other and how they evaluate ideas, as well as the enabling role of centrally regulated information disclosure mechanisms in this process.

By evaluating the short-term effects of AIPA and patent publication on the market for ideas, our analysis merely scratches the surface of the effects of public disclosure of inventions. In order to gauge the long-term effects of AIPA, future research should investigate the effects of the policy change on outcomes such as knowledge spillovers, the rate of knowledge diffusion, and the duplication of R&D investments. Such investigations could uncover the effects of public disclosure on the rate and direction of follow-on innovation and enable us to better inform disclosure-related strategies and public policy.

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²²Our findings also contrast those in a recent working paper by de Rassenfosse et al. (2013), who find no difference in the probability of licensing for inventions covered by pending Australian patent applications and those without patent applications and interpret this as the absence of a disclosure effect.

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Tables

Table 1: Sample licenses compared to licensing agreements in the RecapIP database

	N	Licensor's prior experience		For-profit licensor	Licensee's prior experience	
		Mean	Median		Mean	Median
<u>Panel 1: All licensing agreements, by whether the contract is available</u>						
Contract not available	5974	13.9	5	0.80	31.2	4
Contract available	1473	13.3	6	0.68	20.4	3
(p-value)		(0.34)	(0.16)	(0.00)	(0.00)	(0.00)
<u>Panel 2: When contracts are available, by whether the contract is redacted</u>						
Non-redacted	440	10.4	3	0.69	24.2	3
Redacted	1033	14.5	7	0.68	29.4	4
(p-value)		(0.00)	(0.00)	(0.82)	(0.09)	(0.08)
<u>Panel 3: Our sample compared to all licensing agreements</u>						
Our sample	440	10.4	3	0.69	24.2	3
All licensing agreements	7447	13.8	5	0.77	29.1	4
(p-value)		(0.00)	(0.00)	(0.00)	(0.10)	(0.10)

Notes: Our sample captures licensing agreements for which (1) the contracts are available and (2) the contracts are not redacted. This table summarizes how the characteristics of the licensing parties compare due to each of the data-availability issues. For all licensing agreements in the RecapIP database between 1995 and 2013, Panel 1 compares licenses for which the contracts are available to licenses for which the contracts are not available. Within licenses with contracts, Panel 2 compares redacted to non-redacted contracts. Finally, panel 3 compares our sample to all licensing agreements.

Table 2: Licensing windows before and after AIPA

	Full Sample	Pre-AIPA	Post-AIPA
<u>Panel 1: U.S. and foreign patents (N=440)</u>			
License before 18 months from application	17.70%	17.00%	20.20%
License b/w 18 months from application & grant	23.60%	17.60%	44.40%
License after patent grant	58.60%	65.40%	35.30%
<u>Panel 2: U.S. patents without foreign equivalents (N=232)</u>			
License before 18 months from application	23.30%	22.00%	26.60%
License b/w 18 months from application & grant	28.50%	22.00%	45.30%
License after patent grant	48.30%	56.00%	28.10%
<u>Panel 3: Foreign patents (N=53)</u>			
License before 18 months from application	13.20%	13.30%	13.00%
License b/w 18 months from application & grant	37.70%	30.00%	47.80%
License after patent grant	49.10%	56.70%	39.10%
<u>Panel 4: U.S. patents with foreign equivalents (N=155)</u>			
License before 18 months from application	11.00%	11.90%	0.00%
License b/w 18 months from application & grant	11.60%	9.80%	33.30%
License after patent grant	77.40%	78.30%	66.70%

Table 3: Licensing lags before and after AIPA

	Patent application to license lag (in months)		
	Full Sample	Pre-AIPA	Post-AIPA
US and foreign patents	48.2 [30.4]	50.7 [30.8]	39.6 [27.6]
US patents without foreign equivalents	43 [30.0]	46.5 [31.1]	33.7 [24.9]
Foreign patents	51.6 [29.8]	55.4 [30.2]	46.6 [29.2]
US patents with foreign equivalents	54.8 [30.0]	54.6 [30.2]	57.5 [29.5]

Table 4: Summary statistics for control variables

Variables	Non-missing observations	Full sample	Before AIPA	After AIPA
<u>Licensing party characteristics</u>				
Number of prior licensee deals	440	24.2	22.2	31.1
Number of prior licensor deals	440	10.4	9.6	13.0
Number of prior joint deals	440	0.2	0.2	0.3
For-profit licensor	440	68.6%	68.6%	68.7%
<u>License characteristics</u>				
Exclusive license	440	60.2%	57.5%	69.7%
Know-how transfer	440	88.6%	88.0%	90.9%
Number of potential buyers	297	348.8	296.4	515.7
<u>Patent characteristics</u>				
Number of patent claims	333	24.8	25.1	23.5
Number of patent citations	333	2.9	3.1	1.9
Number of references to non-patent prior-art	333	6.1	6.0	6.4
Patent pendency in months	440	40.2	38.2	47.2

Notes: The table reports summary statistics for the control variables used in the regressions. Observations are at the license level. For licenses with unknown therapeutic areas, we use a dummy variable indicating these licenses and replace the number of potential buyers with zero in the regressions. Technology categories and top therapeutic areas are not summarized here.

Table 5: Probit estimates of the probability of licensing after patent grant

Sample	US patents (without foreign equivalent)			US and foreign patents	
	(1)	72-month sample (2)	72-month sample & granted patents (3)	(4)	72-month sample (5)
Post AIPA	-0.28 [0.06]**	-0.25 [0.10]**	-0.18 [0.11]+	-0.13 [0.06]*	-0.03 [0.09]
Post AIPA × US patent				-0.21 [0.07]**	-0.26 [0.10]**
US patent				0.02 [0.05]	0.02 [0.06]
Number of patents	0.04 [0.01]**	0.02 [0.01]*	-0.02 [0.01]	0.02 [0.01]*	0.02 [0.01]+
Pendency in months	-0.00 [0.00]	-0.00 [0.00]**	-0.02 [0.00]**	-0.01 [0.00]**	-0.01 [0.00]**
US patent with foreign equivalent				0.17 [0.06]**	0.14 [0.07]+
Number of prior licensee deals		0.00 [0.00]	0.00 [0.00]	0.00 [0.00]	0.00 [0.00]
Number of prior licensor deals		0.00 [0.00]	0.00 [0.00]	0.00 [0.00]*	0.00 [0.00]
Number of prior joint deals		-0.01 [0.05]	0.03 [0.05]	-0.02 [0.03]	-0.01 [0.04]
For-profit licensor		0.11 [0.07]	-0.01 [0.07]	0.18 [0.03]**	0.16 [0.04]**
Knowhow transfer		0.16 [0.10]+	0.34 [0.07]**	0.04 [0.06]	0.09 [0.07]
Exclusive license		-0.10 [0.08]	-0.10 [0.11]	-0.05 [0.04]	-0.08 [0.05]+
Number of potential buyers		0.00 [0.00]**	0.00 [0.00]**	0.00 [0.00]**	0.00 [0.00]**
Potential buyers missing		-0.24 [0.14]+	-0.22 [0.16]	0.01 [0.07]	0.00 [0.10]
Number of scientific references			0.01 [0.01]		
Number of claims			0.00 [0.00]		
3-year citations			0.01 [0.01]		
Therapeutic area dummies	N	Y	Y	Y	Y
Technology category dummies	N	Y	Y	Y	Y
Observations	232	183	129	440	332
Pseudo R-squared	0.09	0.33	0.44	0.35	0.35
Log likelihood	-146	-82	-49	-193	-150

Notes: This table reports the Probit estimates (marginal effects) for licensing after patent grant. US patent equals one for licenses based on US patent applications without foreign equivalents and zero otherwise. All models report robust standard errors clustered by therapeutic areas; ** p < 0.01, * p < 0.05, + p < 0.1.

Table 6: Multinomial logit estimates of the choice of license timing window

Sample	US patents (without foreign equivalent)					US and foreign patents				
	72-month sample		72-month sample & granted patents		Before 18 mos. & grant (3)	72-month sample		72-month sample		
Licensing window	Before 18 mos. (1)	B/w 18 mos. & grant (1)	Before 18 mos. (2)	B/w 18 mos. & grant (2)		Before 18 mos. (3)	B/w 18 mos. & grant (3)	Before 18 mos. (4)	B/w 18 mos. & grant (4)	Before 18 mos. (5)
Post AIPA	2.97 [1.16]**	4.07 [1.55]**	3.98 [3.98]	5.18 [2.77]**	5.33 [9.09]	7.13 [7.06]*	1.62 [0.90]	3.42 [1.97]*	0.63 [0.51]	1.85 [1.22]
Post AIPA × US patent							5.91	3.33	10.03	3.69
US patent							[6.17]+ 0.69	[2.20]+ 0.93	[10.10]* 0.71	[2.75]+ 1.17
Number of patents	0.56 [0.10]**	0.89 [0.04]**	0.53 [0.12]**	0.97 [0.04]	0.83 [0.14]	1.60 [0.17]**	0.57 [0.09]**	0.96 [0.03]	0.58 [0.10]**	1.00 [0.04]
Pendency in months	0.99 [0.01]+	1.01 [0.01]	1.02 [0.01]	1.04 [0.01]**	1.13 [0.04]**	1.19 [0.06]**	1.02 [0.01]**	1.05 [0.00]**	1.05 [0.01]**	1.07 [0.01]**
U.S. patent with foreign equivalent							0.28	0.29	0.32	0.42
Number of prior licensee deals			0.99 [0.01]	1.00 [0.00]	0.96 [0.02]+	1.00 [0.01]	1.00	1.00	0.99	1.00
Number of prior licensor deals			0.97	0.99	0.99	0.95	0.97	0.98	0.98	0.99
Number of prior joint deals			[0.02]	[0.01]	[0.03]	[0.03]*	[0.01]**	[0.01]	[0.01]+	[0.01]
For-profit licensor			1.45 [0.65]	0.79 [0.26]	1.74 [0.99]	0.20 [0.17]+	1.31 [0.35]	1.01 [0.25]	1.25 [0.43]	0.77 [0.24]
Other controls	N		0.55 [0.31]	0.41 [0.30]	6.63 [6.49]+	0.47 [0.43]	0.27 [0.11]**	0.27 [0.08]**	0.32 [0.12]**	0.29 [0.12]**
Observations	232	186	Y	Y	Y	Y	Y	Y	Y	Y
Pseudo R-squared	0.1	0.31	0.52	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Log likelihood	-220	-141	-63	-284	-284	-284	-284	-284	-284	-284

Notes: This table reports the Multinomial logit estimates for the probability of licensing in each of the three mutually exclusive windows: (i) before 18 months from (the first) patent application; (ii) between 18 months and grant; and (iii) after patent grant (the omitted base category). Coefficient estimates are reported as Relative Risk Ratios, with reference to the base category. US patent equals one for licenses based on US patent applications without foreign equivalents and zero otherwise. The control variables included in each of the models (omitted in the interests of space) are the same as that in Table 5: Other controls in Columns (2)-(5) (omitted in the interests of space) include knowhow transfer, exclusive license, number of potential buyers, potential buyers missing (dummy), and dummies for top therapeutic areas and technology categories, and Column (3) also includes number of claims, 3-year citations, and number of scientific references. All models report robust standard errors clustered by therapeutic areas, ** p < 0.01, * p < 0.05, + p < 0.1.

Table 7: Probit estimates of the probability of licensing (panel-structured data)

Def. of the publication window Sample	18-28 months		18-30 months		18-32 months	
	(1)	72-month sample (2)	(3)	72-month sample (4)	(5)	72-month sample (6)
Application window	0.00	-0.01	0.00	-0.01	0.00	-0.01
	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
Publication window	-0.01	-0.02	-0.01	-0.03	-0.01	-0.02
	[0.01]+	[0.01]**	[0.01]+	[0.01]**	[0.01]+	[0.01]**
Post AIPA × Application window	0.00	0.01	0.00	0.01	0.00	0.01
	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
Post AIPA × Publication window	0.02	0.02	0.02	0.03	0.02	0.02
	[0.01]*	[0.01]*	[0.01]*	[0.01]*	[0.01]*	[0.01]*
Post AIPA	0.02	0.01	0.02	0.01	0.02	0.01
	[0.00]**	[0.01]+	[0.00]**	[0.01]+	[0.00]**	[0.01]+
log(Duration)	0.02	0.02	0.02	0.02	0.02	0.02
	[0.00]**	[0.01]**	[0.00]**	[0.01]**	[0.00]**	[0.01]**
Other controls	Y	Y	Y	Y	Y	Y
Observations	9,961	6,043	9,961	6,043	9,961	6,043
Pseudo R2	0.07	0.08	0.07	0.08	0.07	0.08
Log likelihood	-1014	-767	-1013	-767	-1014	-768

Notes: The table presents Probit estimates (marginal effects) for licensing probability using a panel-structured data, containing monthly observations for each license in the treatment-group (US patents without foreign equivalent) starting from the corresponding patent's application date until license date. The dependent variable equals 1 if licensing happens in any given particular month, and 0 otherwise. "Application window" equals 1 if the month is between patent application date and 18 months from application, 0 otherwise. "Publication window" equals 1 if the month is within 10, 12, or 14 months after 18-month publication; that is, 18 to 28, 30, or 32 months from application date. Other controls in all regressions (omitted in the interests of space) include number of patents, pendency, number of prior licensee deals, number of prior licensor deals, number of prior joint deals, for-profit licensor, knowhow transfer, exclusive license, number of potential buyers, potential buyers missing (dummy), and dummies for top therapeutic areas and technology classes. All models report robust standard errors clustered by licensor; ** p < 0.01, * p < 0.05, + p < 0.1.

Table 8: Licensing delay

(a) Tobit model					
Sample	US patents (without foreign equivalent)			US and foreign patents	
		72-month sample	72-month sample & granted patents		72-month sample
	(1)	(2)	(3)	(4)	(5)
Post AIPA	-16.13 [3.21]**	-9.57 [4.98]+	-12.77 [6.49]*	-11.61 [7.83]	-1.69 [6.94]
Post AIPA × US patent				-11.06 [6.19]+	-9.37 [5.51]+
US patent				-0.60 [3.19]	-0.81 [2.96]
Number of patents	1.54 [0.24]**	0.52 [0.28]+	-0.04 [0.23]	0.99 [0.30]**	0.94 [0.36]**
Pendency in months	0.49 [0.07]**	0.25 [0.06]**	0.15 [0.07]*	0.23 [0.04]**	0.11 [0.04]**
U.S. patent with foreign equivalent				7.27 [3.81]+	2.43 [3.56]
Other controls	N	Y	Y	Y	Y
Observations	232	186	132	440	332
Pseudo R-squared	0.0253	0.0588	0.0725	0.0578	0.0336
Log likelihood	-901.6	-743.2	-478.6	-1770	-1546

(b) Cox hazard model					
Sample	US patents (without foreign equivalent)			US and foreign patents	
		72-month sample	72-month sample & granted patents		72-month sample
	(1)	(2)	(3)	(4)	(5)
Post AIPA	1.77 [0.30]**	2.06 [0.61]*	2.74 [1.01]**	1.95 [0.60]*	1.28 [0.49]
Post AIPA × US patent				1.73 [0.46]*	1.75 [0.61]
US patent				1.03 [0.16]	1.15 [0.22]
Number of patents	0.91 [0.02]**	0.98 [0.02]	1.02 [0.02]	0.94 [0.02]*	0.96 [0.03]
Pendency in months	0.98 [0.00]**	0.98 [0.00]**	0.98 [0.01]**	0.99 [0.00]**	0.99 [0.00]**
U.S. patent with foreign equivalent				0.74 [0.16]	0.94 [0.20]
Other controls	N	Y	Y	Y	Y
Observations	232	186	132	440	332
Pseudo R-squared	0.02	0.06	0.07	0.05	0.03
Log likelihood	-1012	-743	-479	-2135	-1546

Notes: Panel (a) reports the Tobit estimates for the licensing delay (the number of months between application and license date), and panel (b) reports the Cox hazard rate model estimates for the licensing delay (hazard ratios are reported). US patent equals one for licenses based on US patent applications without foreign equivalents and zero otherwise. The control variables included in each of the models (omitted in the interests of space) are the same as that in Table 5: Other controls in Columns (2)-(5) include number of prior licensee deals, number of prior licensor deals, number of prior joint deals, for-profit licensor, knowhow transfer, exclusive license, number of potential buyers, potential buyers missing (dummy), and dummies for top therapeutic areas and technology classes, and Column (3) also includes number of claims, 3-year citations, and number of scientific references. All models report robust standard errors clustered by therapeutic areas; ** p < 0.01, * p < 0.05, + p < 0.1.

Table 9: Robustness checks for baseline results

Model	Probit	MNL		Tobit	Cox
DV	License after grant	Before 18 mos.	B/w 18 mos. & grant	License lag	License
	(1)	(2)	(2)	(3)	(4)
<u>Panel 1: Single-patent licenses</u>					
Post AIPA	-0.12 [0.08]	1.83 [1.69]	3.29 [2.13]+	-6.99 [8.88]	1.20 [0.42]
Post AIPA × US patent	-0.24 [0.10]*	5.20 [7.18]	4.12 [3.35]+	-9.66 [8.09]	2.80 [1.05]**
US patent	0.04 [0.09]	0.48 [0.46]	1.14 [0.81]	1.28 [3.97]	0.68 [0.12]*
Other controls	Y		Y	Y	Y
Observations	262		262	262	262
Pseudo R2	0.34		0.33	0.05	0.05
Log likelihood	-120		-182	-1198	-1138
<u>Panel 2: Excluding patents granted within 18 months</u>					
Post AIPA	-0.13 [0.06]*	1.53 [0.80]	3.19 [1.77]*	-11.98 [7.27]+	1.49 [0.45]
Post AIPA × US patent	-0.22 [0.08]**	6.16 [6.52]+	3.43 [2.13]*	-8.94 [5.79]	1.97 [0.54]*
US patent	-0.00 [0.05]	0.69 [0.38]	1.01 [0.45]	-1.18 [3.32]	0.95 [0.13]
Other controls	Y		Y	Y	Y
Observations	380		380	380	380
Pseudo R2	0.33		0.31	0.06	0.06
Log likelihood	-177		-268	-1743	-1778
<u>Panel 3: Excluding U.S. patents with foreign equivalents from the control group</u>					
Post AIPA	-0.21 [0.09]*	4.36 [2.60]*	4.29 [3.19]+	-13.46 [8.60]	1.62 [0.53]
Post AIPA × US patent	-0.14 [0.09]	1.76 [1.65]	2.55 [1.72]	-7.15 [7.26]	1.75 [0.54]+
US patent	-0.05 [0.07]	1.55 [1.00]	1.25 [0.63]	-4.37 [4.03]	1.15 [0.21]
Other controls	Y		Y	Y	Y
Observations	285		285	285	285
Pseudo R2	0.33		0.32	0.06	0.06
Log likelihood	-133		-203	-1297	-1252

Notes: This table reports three sets of regressions for robustness checks. Other controls in all regressions (omitted in the interests of space) are the same as that used in the fourth column in Tables 5, 6, and 8: They include number of patents, pendency, US patent with foreign equivalent, number of prior licensee deals, number of prior licensor deals, number of prior joint deals, for-profit licensor, knowhow transfer, exclusive license, number of potential buyers, potential buyers missing (dummy), and dummies for top therapeutic areas and technology classes. US patent equals one for licenses based on US patent applications without foreign equivalents and zero otherwise. All models report robust standard errors clustered by therapeutic areas; ** p < 0.01, * p < 0.05, + p < 0.1.

Table 10: Heterogenous results of AIPA

Model	Probit	MNL		Tobit	Cox
	License after grant (1)	Before 18 mos. (2)	B/w 18 mos. & grant (2)	License lag (3)	License (4)
<u>Panel 1: By licensor type</u>					
Post AIPA	-0.23 [0.08]**	6.74 [5.99]*	3.37 [2.06]*	-19.75 [5.09]**	3.31 [1.18]**
Post AIPA × For-profit licensor	-0.16 [0.14]	0.81 [0.79]	6.68 [5.99]*	-3.83 [5.54]	0.91 [0.32]
For-profit licensor	0.15 [0.05]**	0.70 [0.39]	0.23 [0.09]**	6.38 [4.43]	0.73 [0.16]
Pseudo R2	0.34		0.32	0.07	0.07
Log likelihood	-107		-165	-1044	-962
<u>Panel 2: By licensor experience</u>					
Post AIPA	-0.32 [0.08]**	10.23 [11.31]*	6.71 [3.41]**	-23.97 [4.43]**	3.74 [1.00]**
Post AIPA × Low experience	-0.05 [0.07]	0.63 [0.75]	2.96 [1.14]**	3.60 [5.05]	0.75 [0.17]
Low experience	0.07 [0.06]	0.47 [0.25]	0.77 [0.39]	0.56 [4.25]	0.85 [0.14]
Pseudo R2	0.34		0.33	0.07	0.07
Log likelihood	-107		-165	-1044	-962
<u>Panel 3: By the number of claims</u>					
Post AIPA	-0.30 [0.10]**	7.58 [7.33]*	9.18 [5.79]**	-20.63 [6.59]**	2.92 [0.89]**
Post AIPA × High number of claims	-0.06 [0.14]	0.71 [0.67]	1.94 [1.81]	-1.47 [7.32]	0.98 [0.37]
High number of claims	0.17 [0.07]*	0.59 [0.37]	0.20 [0.10]**	7.00 [4.98]	0.65 [0.16]+
Pseudo R2	0.36		0.33	0.07	0.07
Log likelihood	-103		-163	-1042	-959
<u>Panel 4: By the number of cites</u>					
Post AIPA	-0.28 [0.07]**	4.70 [4.12]+	7.76 [3.02]**	-16.97 [4.80]**	2.49 [0.61]**
Post AIPA × High number of cites	-0.13 [0.17]	3.02 [6.52]	2.85 [2.91]	-16.71 [10.27]	2.05 [1.11]
High number of cites	0.16 [0.07]*	0.31 [0.25]	0.38 [0.21]+	6.92 [4.25]	0.72 [0.13]+
Pseudo R2	0.35		0.32	0.07	0.07
Log likelihood	-104		-165	-1041	-960
Other controls	Y		Y	Y	Y
Observations	232		232	232	232

Notes: The table presents four sets of regressions for the effects of AIPA on different types of inventors and inventions. Other controls in all regressions (omitted in the interests of space) are the same as that used in the second column in Tables 5, 6, and 8: They include number of patents, pendency, number of prior licensee deals, number of prior licensor deals, number of prior joint deals, for-profit licensor, knowhow transfer, exclusive license, number of potential buyers, potential buyers missing (dummy), and dummies for top therapeutic areas and technology classes. All models report robust standard errors clustered by therapeutic areas; ** p < 0.01, * p < 0.05, + p < 0.1.