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Technology or Exclusion Right? Patent Licensing and Patent Trading

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Patent licensing and trading are the channels for technology transfer. Meanwhile, patents are transacted for patent exclusion rights, which can result in an increasing cost for innovations. In this study, I empirically explore whether and how the patent exclusion right becomes the driver of patent licensing and patent trading, using the traded and licensed U.S.-granted patents from 2000 to 2015. The analysis shows that the enforcement of patent exclusion rights of patent owners is one of the major drivers of the patent licensing agreement. The benefit from the strategic use of patent exclusion rights motivate firms to purchase others’ patents. The conclusion of the present research contributes to the literature on market for technology and recent debates about the social welfare consequences of the market for patents.

Keywords: Market for Patent, Market for Technology, Patent enforcement, Patent policy, Innovation
JEL Code: K11; O34
1. Introduction
Promoting the market for technology is a worthy aim of innovation policymakers. The market for technology provides opportunities for innovators to realize the return of innovation and encourages the division of innovative labor (Arora et al., 2004, Teece, 1986, Gambardella, 2005), which increases the efficiency of the innovation process (Arora, 1997). It also allows firms to take more flexible innovation strategies, such as open innovation (Chesbrough, 2003). Sourcing innovative ideas from the outside helps firms to catch new technological opportunities that could not be captured otherwise (Arora et al., 2016).

The patent is a key facilitator of the market for technology. Since technology used to take the form of patents, the patent becomes an infrastructure for the market for technology (Arora and Gambardella, 2010, Cockburn et al., 2010). The former Intellectual Property Right (IPR) system, such as a patent system, improves the efficiency of the market for technology (Gans et al., 2008, Gans and Stern, 2010, Spulber, 2015) and affects the firms’ innovation sourcing strategy (Veugelers and Cassiman, 1999). This close relationship between patents and market for technology draws the attention of scholars and policymakers about whether encouraging the patent transaction leads to promoting the market for technology.

Some scholars show that the patent transaction is a worthy subject of institutional support for innovation. Kremer (1998) suggests that one way for the government to incentivize innovation is to buy out patents from inventors and allow the non-exclusive practice of the patented technology. Lemley and Myhrvold (2007) highlight institutional efforts to resolve the information asymmetry between patent buyer and seller to improve the efficiency of the patent market and its potential benefits. A study by Kani and Motohashi (2012) suggests that policymakers need to support disseminating the information about the patents that are willing to be licensed, so that licensor and licensees can find each other. Spulber (2015) steps further by arguing that the governmental regulation on patent transactions may reduce the benefit of the market for technology.

However, the patent is not the same as technology. Although the patent is a container for the novel technology, it also includes the exclusive right that it does not necessarily relate to the value of underlying technology. Indeed, the patent can be used as a bargaining chip in the negotiation for the settlement of patent infringement disputes or to block competitors from market entry (Ziedonis, 2004, Cohen et al., 2000, Hall and Ziedonis, 2001). Noel and Schankerman (2013) show that such strategic use of patents is particularly pervasive in the complex technology field, such as computer software. From this perspective, others claim that the patent transaction is not equivalent to the transfer of technology.

A firm may buy a patent to strengthen its patent portfolio. The purchased patent can be used to impose the cost to competitors through patent infringement disputes (Galasso et al., 2013). One can also utilize the purchased patents to obtain the competitors’ technology through patent portfolio sharing instead of
practicing the underlying technology. A study by Ziedonis (2004) shows that the technology firms that face more fragmented patent rights more aggressively engage in patent acquisition. Kelley (2011) also indicates that the emerging market for patents that is driven by the increasing demand for the strategic use of patents rather than the trade of technology. This point of view is further elaborated by the presence of a new patent market players called Patent Assertion Entities (PAEs). They aggregate massive numbers of patents for the purpose of enforcing the exclusion rights of patents against technology firms, which does not contribute to the market for technology (Fischer and Henkel, 2012, Caviggioli and Ughetto, 2016). Likewise, patent licensing can be a consequence of the strategic interaction of licensor and licensee for patent exclusion rights instead of the underlying technology. A patent owner may enforce an unfavorable license agreement to licensees by asserting that the licensees (potentially) infringe upon the patent in question.

In sum, there are two different faces of patent transaction: patent transaction for exclusion rights and for technology (Fischer and Henkel, 2012, Fischer and Ringler, 2014).

These discussions make it less clear that the social welfare consequence of the patent transaction. Indeed, there is growing concern that patent transaction is seemingly driven by the demand for the strategic use of patent exclusion rights instead of the technology transfer (Commission, 2011, Mann, 2004, Lemley and Shapiro, 2006, Galasso and Schankerman, 2010, Galasso et al., 2013). Surprisingly, there are few empirical studies about whether and how the patent exclusion right becomes a driving force of patent licensing and trading. Are the benefits from strategic use of the patent exclusion rights what drives the patent transaction? If so, how does the patent exclusion right come into play for patent licensing and trading agreements?

The present study addresses these questions by capitalizing upon a major patent law reform in the U.S. in 2011. The new patent law includes a revision of the joinder rule and an introduction of new institutions for patent validity examination: post-grant review and inter-parte review. The new joinder rule restricts patent owners’ practice of filing patent infringement lawsuits against multiple dependents in a single case if the defendants are alleged to infringe upon different products or services. As a result, bundling the multiple defendants in a single case becomes significantly restricted, which results in the reduction of the marginal benefit of litigation for patent owners as well as their bargaining power in enforcing patents that have broad technological breadth. The post-grant review and inter-parte review systems allow any third parties to readily challenge the validity of patents of others based on existing prior arts. Accordingly, patent owners face a greater probability of patent invalidation, which encourages them to find ways to cope with the risk. As described above, these two revisions change the environment for enforcement of patent exclusion rights significantly. If the benefit from the strategic use of patent exclusion rights is one of the drivers of a patent transaction, the characteristics of the traded and licensed patents might significantly
change after 2011. Hence, analyzing what patents are traded or licensed before and after the patent reform helps answer the research questions.

I begin with constructing an analytical model that illustrates what patents are likely to be traded over being licensed. From this model, I derive four hypotheses regarding the patent characteristics of traded and licensed patents after the patent law reform in 2011. Next, I test the hypotheses using the dataset. The analysis shows that, before the patent law reform, the broader the technological breadth of the patent, the more likely the patent would be licensed over being traded. Interestingly, this tendency disappears after the patent law reform. I observe similar findings with respect to the legal scope of patents. The findings indicate that the patent reform reduces the bargaining power of the patent owner when exerting the exclusion rights in the patent licensing agreement. For patent trading, the finding shows that the benefits from the strategic use of patent exclusion rights against competitors could drive the firms to purchase others’ patents. Finally, I draw implications for patent policy makers who are interested in promoting patent transactions for innovation. The conclusion of this study also provides insight into the social welfare consequences of the patent transaction.

The remainder of this paper is structured as follows. In section 2, I review literature on the emergence of the market for patents and the patent law reform in 2011. Section 3 illustrates the analytical model. In section 4, I explain the empirical strategy used to test the hypotheses. Section 5 reports the results of the empirical analysis and a crucial test to rule out a rival theory. Section 6 discusses the interpretation of the findings. Section 7 concludes with remarks on the implications and limitations of the present research.

2. Background

2.1. Emergence of the Market for Patents and Patent Exclusion Rights

Recent studies examine how the market for patents helps or discourages innovation. Tsai and Wang (2008) study whether a firm’s external patents acquisition activity enhances the firm’s economic performance. They show that the inward patent licensing and patents purchasing activity of a firm has no direct relationship with the firm’s value added. Their study also reveals that the firm’s internal R&D moderates the benefits of the external patent acquisition activity into improving the firm’s performance. This finding indicates that the patent transaction may be helpful for firms to innovate when the firms have sufficient absorptive capacity (Cohen and Levinthal, 1990).

Monk (2009) focuses on the driver of the rapid growth of the market for the patent in recent years. He argues that the growth of patent trading is fueled by the strategic use of IPR of technology firms and the activity of the new type of patent intermediaries. Firms increasingly seek new opportunities to monetize own IPs. Firms also purchase patents for defensive purposes. By acquiring others’ patents, the firms could
avoid potential patent infringement disputes. Through interviews with patent attorneys and corporate IPR strategists of high-tech firms in Silicon Valley, the author concludes that patent trading can be seen as “weapon-dealing,” and the defensive patent aggregation activity of firms resembles what the U.S. and the Soviet Union did during the Cold War era (developing and acquiring weapons for defensive shields against each other). The author notes that the active market for patents can resolve the tragedy of anti-common arising from the patent thicket because the active patent trading allows firms to proactively reduce the patent thicket problem that they have.

Serrano (2010) explores dynamics in patent trading. He shows that while there is a great difference among technology fields, not a small portion of the U.S. patents had been traded at least once (13.5% of the U.S. granted patents had been traded), which shows presence of a large-scale patent trading market in the U.S. His analysis indicates that the age and technical significance of a patent are positively associated with the likelihood that the patent is traded. Further, a patent that was previously traded is more likely to be re-traded than patents that have not been traded yet. His additional analysis reveals that the major patent sellers are small firms or individual inventors while there was also a significant difference across different technology fields.

Galasso et al. (2013) step further to examine the role of patent trading in patent infringement litigation disputes and social benefits. They show that the patent transaction driven by the comparative advantages in the commercialization of the patent buyer increases the patent infringement disputes. In contrast, the patent trading for patent enforcement reduces the litigation. The additional analyses show that the market for patent can give the following social benefits: (1) the active patent transactions help improve social welfare by allowing the reallocation of innovation to the firms that are more capable of commercialization; (2) the patent transaction reallocates the patents to those who could more efficiently enforce the patent against the infringers. In doing so, the social cost of the litigation could be reduced and helped increase the innovation diffusion speed (Galasso and Schankerman, 2010); and (3) more efficient patent enforcement and benefits from the comparative advantage in commercialization could provide ex-ante incentives for the innovators’ R&D. They suggest the probable negative effect of the patent transaction on the social welfare as well. The patent transaction may worsen the ex-post patent hold-up problem and encourage the concentration of the patents into few large firms that results in decrease of the consumer surplus. For the benefits of the patent transaction, a study by Akcigit et al. (2013) shows that the patent transaction not only helps to correct the misallocation of ideas across firms, but also influence the economic growth of the firms as well as their R&D incentives. Meanwhile, Figueroa and Serrano (2013) indicate that there is no evidence supporting the argument that patent transaction drives the concentration of patents to a few firms.
Fischer and Henkel (2012) focus on a new patent intermediary that is called PAE, and how they capitalize on the patent exclusion rights for their business. The authors argue that PAEs are not interested in the underlying technology in the patent, but solely interested in the patent exclusion rights that can be strategically utilized to extract rent from technology firms through patent enforcement. In this sense, the PAE is the player that is in the “market for patents” and not in the “market for technology.” They also argue that not the small portion of the patent transactions between technology firms (i.e. technology practicing firms) are the “patent-only” transaction, rather than the technology transfer. Based on their findings, they conclude that the concept of the market for patents and market for technology needs to be clearly distinguished.

Fischer and Ringler (2014) explores a way of monetizing patents through patent collateral. They examine whether the underlying technology of a patent or the patent enforcement right matters in the patent collateral decision of the lender. Their findings indicate that the patent with a high technological value is likely to be collateral for a loan while the characteristics of the patent itself are not related to the likelihood that a patent would be used as collateral for small companies. The finding indicates that the lenders value the patent based on if the underlying technology could be re-deployed to small companies, instead of the legal value of the patent.

2.2. America Invents Act in 2011

On September 16, 2011, President Barack Obama signs the new America Invents Act (AIA). This reform majorly changes patent laws in the U.S. The act aims to promote innovation by eliminating unnecessary administrative barriers and costs imposed by the previous U.S. patent system. Another purpose of this act is to curtail abusive patent infringement litigation. While the AIA change multiple provisions in patent law, the following two points from the AIA are particularly related to patent exclusion rights exertion.

First, the AIA changes the joinder rule. Before 2011, a patent owner could file a single case against multiple defendants for patent infringement even if the defendants are not related each other (i.e., infringe upon the patents for different products or services.) This joinder rule particularly helps the patent owner reduce the litigation cost when enforcing a patent that could be used for multiple technological applications. However, under the new joinder rule, this is allowed only if the defendants are alleged to infringe upon not only the same patent, but also the same product or service. This new rule is introduced to reduce abusive patent infringement lawsuits. Cerro (2014) argues that the revision of the joinder rule would be particularly advantageous for small firms in avoiding the litigation of PAEs for patent infringement. The new joinder rule is enacted on September 16, 2011. Multiple studies report that there was a rush to file patent infringement lawsuits just before the new joinder rule was enacted (Bryant, 2011). The data shows that over
50 patent infringement cases against about 800 defendants had been filed on September 15, 2011.\textsuperscript{1} This finding reflects that the new joinder rule significantly reduces the strategic benefits of patent owners in exclusion right exertion.

Second, the post-grant review and inter-parte review are introduced as the new institutions for patent validity examinations (enacted in September 2012). Through the post-grant review, one can request the post-grant review of the Patent Trial Appeal Board (PTAB) on the validity of a patent within nine months from the date of the patent issue if there are any reasonable reasons for challenging the validity of the patent. The post-grant review is applied only for patents that are filed after 2013. The inter-parte review system allows any third party to challenge the validity of a patent if claims of the patent of interest are questionable in terms of novelty and non-obviousness based on the published prior arts. Once the inter-parte review begins, the PTAB should make final judgement regarding the validity of the challenged patents within one year. Unlike the post-grant review, any patents can be the subject of the inter-parte review.

In the next section, I construct a game that allows describing how the AIA affects the patent trading and patent licensing activity of firms.

3. The Analytical Model and Hypotheses

The game is played by a firm S that seeks to generate revenue using an owning patent, and firm X that is willing to use technology related to the firm S’s patent.

3.1. General Setting

Suppose that there is a firm X that operates in a product market and has multiple competitors. Firm X observes the new technological opportunity. Firm S is assumed to own a patent that can be used to obtain the profit from the new technological opportunity. This patent also can be used for making different products. Firm S and firm X play a two-period game for the patent transaction from the beginning of the action of the firm S. The game is illustrated in Figure 1.

\[ \text{[Insert Figure 1 here]} \]

Firm S suggests two options to firm X: patent trade [T] or a license [L]. If firm S suggests [T] and firm X accepts, then firm S and X receive [A, B]. Similarly, firm S and X receive [C, D] as the payoffs when firm S suggests [L] and firm X agrees. If firm S suggests [T] and firm X disagrees but offers [L], then they receive \([C - e, D - e]\) if firm S accepts. The factor \(e\) captures the additional cost for the second-round negotiation.

(t=1) for the transaction. If firm S rejects the offer from firm X, then the payoff $[F - e, G - e]$ is given. If firm S suggests [L] initially but firm X disagrees and counter-suggests [T], then they receive $[A - e, B - e]$ if firm S accepts. If firm S rejects the [T] suggested by firm X, then they receive $[F - e, G - e]$. 

### 3.2. Conditions for Patent Transaction

I search for the Sub-Perfect Equilibria (SPE) through backward induction to find conditions for a successful patent transaction. The constructed game has five subgames. C is bigger than F always by construction.\(^2\) Hence, given the subgame (S→T, X→L), the best response for firm S is to accept [L]. Accordingly, the best response for firm X in the next level subgame (S→T) is [T] if $B > D - e$, [L] otherwise.

For the subgame (S→L, X→T), the value of A is set to F by firm X because firm X will be worse-off if firm S selects [Reject]. I assume that the ability of firm X to estimate the value of F is not perfect. To capture this factor, I introduce an error term ($\epsilon$) that has the normal distribution with a mean of 0 and $\sigma$ as the standard deviation. The value of A offered by firm X is set to $F + \epsilon$, and the expected value of A becomes F. Under this setting, firm X presumes that firm S selects [Accept]. For the upper-level subgame (S→L), firm X will choose to [T] if $B \geq D + e$, [L] otherwise. The value of A is expected to be equal to F and C>F which indicates C>A. Under these conditions, the SPE are:

- **Trade** is the SPE if $B \geq D + e$
- **License** is the SPE if $B < D + e$

The value of B can be decomposed into $\pi^X_T - F - \epsilon$ where $\pi^X_T$ is the expected revenue for firm X from purchasing firm S’s patent. $F + \epsilon$ is the cost for purchasing the patent of interest. According to the SPE condition, $F + \epsilon$ is proportionally set to the opportunity cost of firm S for selling the patent. The value of D is $D = \pi^X_L$, where $\pi^X_L$ is the revenue of firm X if it receives the license of firm S’s patent.

### 3.3. Hypotheses Development

The derived SPE is expressed as the probability of the patent if it is traded over being licensed ($P_T$). It is shown as the following.

$$P_T = Pr(B \geq D + e) = Pr(\pi^X_T - \pi^X_L - F - e \geq \epsilon)$$

Intuitively, the patent will be traded over being licensed only if the net benefit of buying the patent exceeds the net benefit of receiving licensing for firm X, while the benefits of selling the patent exceeds the

\(^2\) In the basic setting, firm S seeks to license or patent the buyer for generating revenue from its patent.
potential benefit of out-licensing for firm S. For simplicity, \( \pi^S_t - \pi^S_t - F - e \) is replaced with \( \omega \). Then, \( P_T = \Phi(\omega) \) where \( \Phi \) is the Cumulative Probability Distribution Function (CDF) of \( \epsilon \) and the increasing function in \( \omega \) by the property of the CDF.

(1) Revision of the Joinder Rule

Before 2011, a patent owner could litigate multiple dependents in a single case even if they are alleged to infringe upon the same patent for different products. Under this rule, the more alleged patent infringers, then the higher the expected marginal benefit for the patent owner from the litigation because it could expect a decreasing marginal litigation cost. Hence, the patent owner could enforce the patent effectively against the multiple firms that may infringe upon the same patents for different products. After the revision of the joinder rule by the AIA in 2011, this benefit is eliminated. The new joinder rule allows the bundling of defendants only if the defendants infringe upon the patent for the same products or service. Hence, this provision is expected to reduce the marginal benefit and the bargaining power for patent owners in enforcing patents that have broad technological breadth. I define the technological breadth of patents as the breadth of technological applications that the patent can be used, and parametrize it with a factor \( R \) in the model.

The difference in the change of \( \omega \) by \( R \) before (pre) and after (post) the reform change can be expressed as:

\[
\Delta_R = \frac{\partial \omega}{\partial R}|_{\text{post}} - \frac{\partial \omega}{\partial R}|_{\text{pre}} = \left( \frac{\partial \pi^X_t}{\partial R}|_{\text{post}} - \frac{\partial \pi^X_t}{\partial R}|_{\text{pre}} \right) - \left( \frac{\partial \pi^X_t}{\partial R}|_{\text{post}} - \frac{\partial \pi^X_t}{\partial R}|_{\text{pre}} \right) - \left( \frac{\partial F}{\partial R}|_{\text{post}} - \frac{\partial F}{\partial R}|_{\text{pre}} \right)
\]

\( \frac{\partial F}{\partial R} > 0 \) because the expected license revenue for the patent owner when it decides to keep the patent is proportional to the range of potential technological applications of the patent (i.e., more potential licensees).

In addition, \( \frac{\partial F}{\partial R}|_{\text{post}} < \frac{\partial F}{\partial R}|_{\text{pre}} \) because the new joinder rule will reduce the marginal benefit of licensing for the patent owner because of the joinder rule revision. Meanwhile, \( \frac{\partial \pi^X_t}{\partial R}|_{\text{post}} = \frac{\partial \pi^X_t}{\partial R}|_{\text{pre}} \) and \( \frac{\partial \pi^X_t}{\partial R}|_{\text{post}} = \frac{\partial \pi^X_t}{\partial R}|_{\text{pre}} \) because the new joinder rule will not affect the benefits of firm X purchasing or receiving license of the patent of interest. Even if the broad range of technological breadth may provide future strategic benefit for firm X, the patent enforcement power of firm X is less likely to be affected by the new joinder rule because firm X will use the patent against its competitors who are in the same product market as firm X. This reasoning gives \( \Delta > 0 \), which implies that the difference in the marginal effect of the technological breadth of patents on the likelihood of a patent being traded over being licensed change in positive direction after 2011.

**Hypothesis 1.** There is a positive directional change in the marginal effect of the technological breadth of patents on the likelihood of the patent being traded over being licensed after 2011.
The rationale explained above also implies that the revision of the joinder rule reduces the expected licensing revenue that the patent owner can expect from the patents with broad technological breadth. The new joinder rule takes out the strategic benefits for patent owners in enforcing the patents that have broad technological breadth in patent licensing negotiation. Accordingly, those patents that could be licensed before 2011 for their broad technological breadth and the strong bargaining power of patent owner cannot be licensed out after 2011.

**Hypothesis 2.** The technological breadth of licensed patents after 2011 is lower than that of licensed patents before 2011.

(2) **Introduction of New Institutions for Patent Validity Examination**

Through the post-grant review system, third parties can request examinations on the validity of a patent within nine months after the patent is issued. The AIA also allows the third party to challenge the validity of patents even after the nine-month window through an inter-parte review. The inter-parte review allows any third party to challenge the validity of a patent based on prior arts that can make the novelty and non-obviousness of the claims of the patent of interest questionable. Three judges in the PTAB start the inter-parte review when the petitioner is believed to prevail on at least one claim that is challenged. Through these new institutions, firms can challenge the validity of competitors’ patents. At the same time, they are also exposed to a greater risk of losing their core patents. Accordingly, firms may become more eager to acquire patents that can be strategically used to cope with the risk of invalidation of their patents (i.e., patents that can be used as bargaining chips to settle the validity dispute\(^3\)). Since the patents that have broad legal scopes have greater strategic values as the bargaining chips while the strategic use of patents is allowed for only the patent owner and not the licensee, firms will desire patents that have a broad legal scope for patent trading than licensing after the reform. I parameterize the legal scope of patents as \(L\) in the model. Then, the difference in the marginal impact of the legal scope of patents on the likelihood of a patent is traded over licensed is expressed as:

\[
\Delta L = \frac{\partial \omega}{\partial L}_{\text{post}} - \frac{\partial \omega}{\partial L}_{\text{pre}} = \left( \frac{\partial \pi^X}{\partial L}_{\text{post}} - \frac{\partial \pi^X}{\partial L}_{\text{pre}} \right) - \left( \frac{\partial \pi^F}{\partial L}_{\text{post}} - \frac{\partial \pi^F}{\partial L}_{\text{pre}} \right)
\]

\[
\frac{\partial \pi^X}{\partial L} > 0 \text{ because the broader the legal scope of patents, the broader the coverage of technological features that firm X can legally practice.}
\]

\[
\frac{\partial \pi^F}{\partial L} > \frac{\partial \pi^F}{\partial L}_{\text{pre}} \text{ because the inter-parte review and post-grant review system will increase the strategic value of the patents that have a broad legal scope.}
\]

\(^3\)http://www.finnegan.com/resources/articles/articlesdetail.aspx?news=e1ff548e-5d17-4b10-8fb3-2a149d128b02
patents can be used to settle the patent invalidation dispute or for challenging the validity of the competitors’ patents. \( \frac{\partial n_L}{\partial L} |_{post} = \frac{\partial n_L}{\partial L} |_{pre} \) because the establishment of institutions of the patent validity examination are unlikely to affect the marginal impact of the legal scope of patents on the expected revenue of the licensee. Meanwhile, \( \frac{\partial F}{\partial L} |_{post} < \frac{\partial F}{\partial L} |_{pre} \) because the patent owner is exposed to a greater patent invalidation risk by the new institutions, and it will decrease the bargaining power of the patent owner in the patent licensing agreement. Accordingly, \( \Delta L \) is expected to have a positive value.

**Hypothesis 3.** There is a positive directional change in the marginal effect of the legal scope on the likelihood of a patent being traded over being licensed after 2011.

Purchasing patents that have a broad legal scope is helpful for firms in coping with or utilizing the increasing patent invalidation risk because the patent with a broad legal scope can be used to challenge the competitors’ patents or be used as a bargaining chip to settle the patent validity dispute. This rationale makes way for the fourth hypothesis:

**Hypothesis 4.** The legal scope of traded patents after 2011 is greater than the traded patents before 2011.

### 4. Empirical Analysis

#### 4.1. Data

I begin with a search of the U.S. granted patents that were licensed or traded from 2000 to 2015 in the patent reassignment database provided by the USPTO.\(^4\) The database contains information about the nature of the patent transaction, name of patent assignor/assignee, identity of the patents (i.e., application number/publication number), and the date of the patent transaction. I find the licensed and traded patents by searching the patents with conveyance type=“license” for licensed patents and conveyance type=“assignment of assignor’s interest” for the traded patents. While the database has provided unique research opportunities for the topics of patent trade (Serrano, 2005, Serrano, 2010, Odasso et al., 2015, Galasso and Schankerman, 2010, Galasso et al., 2013), the comprehensiveness of the dataset has been in question since the patent trading and licensing are self-reported. The patent transaction that the parties do not want to disclose are unlikely to be included in the database. However, reporting ownership change of a patent is incentivized because the subsequent patent assignment can be void if the prior patent transaction fails to be reported (Marco et al., 2015).

The patents’ transaction record can be made for many different reasons that are not within the scope of this study. To filter such cases, I conduct a multi-stage data cleaning processes as follows.

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First, there are many cases where the patent assignor and assignee are the same entity. Such internal patent transactions are excluded from the sample. The transactions that have the assignor’s name and assignee’s name have many common fractions that are identified and excluded from the dataset (i.e., the transaction between Samsung electronics and Samsung electro-mechanics).

Second, the patents that were sold by individual inventors are excluded because the patent transaction by an individual may simply indicate the patent transfer between the employers and employees under the employment contract.

Patents used to be transferred simply because the original patent owner died. The patents traded for this reason are excluded. Many of the licensed patents are transacted under the form of “confirmatory license.” This particular type of licensing agreement, however, is not appropriate to include in the sample. The confirmatory licensing agreement is a legal device that allows the federal funding recipient to conditionally own the rights for the federally funded invention as long as the recipient gives the license to the government. Hence, the confirmatory license does not fall into the typical patent transaction between different business entities that the present study focuses on.

A patent is not necessarily transacted once. Some firms may receive patent licenses for a certain period of time and then decide to purchase the same patents later. Others may purchase the patent and give the license to others. Accordingly, it is possible that the same patents appear in the list of licensed patents as well as on the trade patent list. In this case, I include the earliest transaction into the sample. As a result, the sample contains the non-overlapping list of licensed and traded patents.

Some entities may engage in one type of patent transaction for several reasons. To avoid the biased result by few major players who intensively engage in a particular type of patent transaction, I include the transacted patents by those who received patent licenses as well as purchased patents during the period.

Finally, I exclude the patents that are licensed to or purchased by Non-Practicing Entities (NPEs). To identify the NPEs, I search for the description about the businesses of the patent licensees and buyers in the dataset, using the company profile search engine provided by the LexisNexis Academy. Patents acquired by universities, governmental organizations, and IPR trading companies (including defensive patent aggregators, PAEs, and law firms) are excluded from the sample.

The obtained list of patents is combined with the world patent information database provided by the European Patent Office (PATSTAT, 2016). These processes provide 28,381 patents. Figure 2 depicts the

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5 Patents that have “deceased” in the conveyance field are excluded.
6 https://era.nih.gov/iedison/provide_license.htm
7 http://www.lexisnexis.com/hottopics/inacademic/form_company_profile.asp#
time trend of the number of licensed and traded patents by year and two-year moving averages. The number of traded patents steadily increases while the number of licensed patents is relatively stabilized, except for 2009.

[Insert Figure 2 here]

4.2. Variables
The dependent variable in testing hypothesis 1 and 3 is a binary variable trade that takes 1 for the traded patent and 0 for the licensed patent. The following variables are employed to test the hypotheses.

The first independent variable is for the technological breadth of a patent. This variable is proxy for the breadth of technological applications that the patented invention relates to. Studies use the number of assigned patent classes as an indicator of the breadth of the technical application of patented inventions (Lerner, 1994, Harhoff et al., 2003, Gambardella et al., 2007). Following the prior studies, I use the natural log of the number of unique IPC subclasses assigned to a patent as the proxy of the technological breadth. This variable becomes the dependent variable in testing hypothesis 2.

The second variable of interest is the proxy for the legal scope of a patent. The more new-technical features that the inventor wants to protect through patenting, the more the patent claims are constructed. Indeed, the number of (independent) patent claims is proposed as a good proxy for the legal scope of patents (Marco et al., 2016), and the degree of inventive steps that the patented invention has (Reitzig, 2004). The distribution of the number of patent claims is highly skewed. To take this into account, I use the natural log of the number of independent patent claims as the indicator of the legal scope of patents. This variable becomes the dependent variable in testing hypothesis 4.

I create a binary variable Post2011 that takes 1 if the patent was licensed or traded after 2011 and 0 otherwise. Then, the interaction terms of the Post2011 and two variables of interest are generated (i.e., Legal Scope*2011 and Tech Breadth*2011).

I use a share of the citation from the Non-Patent References (NPL) for the total number of citations made by the patent of interest as a control variable (Science). The NPL citation has been used as a proxy for the science linkage of the focal patented invention. While not all cited NPL are scientific publications or articles (Schmoch, 1993), the share of the NPL over all the cited references still give a good sense about the science linkage of the patented invention in question (Harhoff et al., 2003). Trajtenberg et al. (1997) use a share of the NPL to the total number of citations made by the patent of interest as the indicator of

8 The large scale fluctuation from 2014 to 2015 is because of the delay to the recording the patent transaction in the database.
9 In 2009, there was a large-volume license contract between Walker Digital Gaming Holding (licensor) and International Game Technology Inc. based on their business partnership (http://www.walkerdigital.com/about-us_what-we-do.html)
“basicness” of the patented invention. The basicness of the invention and science linkage may associate with the likelihood of a patent being traded over being licensed (basic vs. applied invention).

The patents that have multiple owners may have difficulty in being sold simply because of a delay among the owners to reach an agreement for selling patent. The multiple ownership on a patent may generate a confounding effect in that multiple entities are more willing to collaborate for an invention that can be used in broad technological applications or many technological features. To control this probable confounding effect, I introduce a dummy variable that indicates whether the patent originally had multiple patent applications (multi-owner).

I also control remained life of patent in the unit of year. In patent trading, the patent buyer should pay a lump sum to purchase the patent whereas the licensee can have the option of terminating the license agreement. Hence, entities that buy younger patents should pay more money for the patent purchase, whereas the patent licensee is less likely to take into account this factor. Meanwhile, the patent age may systematically associate with the technological breadth and the legal scope of the patents in the patent transaction. For instance, one may purchase or receive the license of aged patents because of the patents that have a broad legal scope and technological breadth. Introducing the remained patent life at the moment of patent transaction controls for this potential confounding effect.

The set of dummy variables corresponding to the technological field operationalized by the section code of the primary IPC of the patent are introduced to control for the technological field heterogeneity. Finally, I control for the patent transaction frequency in the given period with a binary variable frequency that takes 1 if the patent was transacted once and 0 if the patent was transacted multiple times. Table 1 summarizes descriptions of the key variables.

4.3. Model specification

I run a probit regression model to test hypotheses 1 and 3 because the dependent variable is a binary variable and the analytical model’s specification fits better to the probit model than the logit model. The following formula illustrates the model specification. The coefficient of interest is $\beta_2$. Hypotheses 1 and 3 expect the positively significant $\beta_2$.

$$ Z_i^* = \beta_0 + \beta_1 X_{1,i} + \beta_2 X_{2,i} \times post2011_i + \beta_3 post2011_i + \sum \alpha_j C_{ji} + u_i $$

where $Z_i^*$ is the z-statistic associated with the likelihood of patent $i$ being traded over being licensed; post2011 is the dummy variable for the patent that was transacted after 2011; $X$ is the technological breadth or legal scope of patent $i$; $C_j$ are the control variables; and $u_i$ an error term.
For the testing hypotheses 2 and 4, I employ the ordinary least square model because the two hypotheses are to compare the expected value of the technological breadth and legal scope of the transacted patents before and after the introduction of the AIA. The following formula illustrates the empirical models:

\[ Y_i = \delta_0 + \delta_1 \ast post2011_i + \sum \theta_j c_{ji} + u_i \]

where \( Y_i \) is the variable for either the technological breadth or legal scope of patent \( i \).

Hypothesis 2 expects a negatively significant \( \delta_1 \) for the licensed patents with the technological breadth of patents as \( Y \), while hypothesis 4 expects a positively significant \( \delta_1 \) for the traded patents with the legal scope of patents as \( Y \).

5. Results

5.1. Descriptive Statistics

Table 2 summarizes the basic statistics of the variables of interest by the patent transaction type. The dataset contains 26,146 (92.1%) traded patents and 2,235 licensed patents (7.9%).

Figure 3 profiles the top 10 patent buyers. About 67% of the traded patents are purchased by the top 10 patent buyers, while the top 10 licensees received 51% of the licensed patents in the sample.

Figure 4 illustrates the distribution of the technological sector—that the traded and licensed patents are related. I map the primary IPC subclass\(^{10}\) of the patent into the five technology fields using the IPC-Technology Concordance Matrix provided by World Intellectual Property Organization.\(^{11}\)

Most of the traded and licensed patents are related to electrical engineering. The electrical engineering sector is known for its complex technology field, which brings about the extensive patent filing activity (Cohen et al., 2000). Hence, it is not surprising that the vast majority of the traded/licensed patents are related to electrical engineering. Chemistry patents take the major share in the licensed patents whereas

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\(^{10}\) I selected the primary IPC subclass appeared most frequently in the IPC subclass.

they take few shares in the traded patents list. This finding shows that the licensing activity is important in the chemical industry (Anand and Khanna, 2000, Arora, 1997).

I check the correlation between the variables of interest. The pairwise correlation matrix shown in Table 3 indicates that the correlation between the variables is sufficiently small.\(^\text{12}\) For a further check on the multi-collinearity issue, I conduct the Variation Inflation Factor (VIF) test. The additional test indicates that the maximum value of the VIF is below the value of two in all regression specifications, which shows that there are a few chances for the multi-collinearity issue.

[Insert Table 3 here]

### 5.2. Regression Analysis

Table 4 reports the regression results. The coefficient of the Tech Breadth in column 1 is negatively significant at the 0.001 significance level (-0.237) while the Tech Breadth*2011 is positively significant at the 0.01 significance level (0.19). This result indicates the marginal effect of the technological breadth of a patent on the likelihood that the patent would be traded over being licensed changed into a positive direction after the patent law reform in 2011. This finding strongly supports hypothesis 1. Columns 2 and 3 report the regression result with the subsample of patents transacted before and after 2011, respectively. The coefficient of Tech Breadth in column 2 is negatively significant at the 0.001 significance level (-0.246). The broader the technological breadth of a patent, the less likely the patent would be traded over licensed before 2011. However, the coefficient of the Tech Breadth in column 3 is statistically insignificant (0.109). The impact of the technological breadth on the likelihood that a patent would be traded over licensed disappears after the patent law reform.

[Insert Table 4 here]

The coefficient of post2011 in the fourth column is negatively significant at the 0.01 significance level (-0.145). This result supports hypothesis 2, stating that the expected value of the technological breadth of the licensed patents after the patent reform is lower than that of licensed patents before 2011.

Columns 5 to 7 report the test results of hypothesis 3. The coefficient of Legal Scope in the fifth column is negatively significant at the 0.001 significance level (-0.128), while the coefficient of Legal Scope*2011 is positively significant at the 0.01 significance level (0.185). This finding indicates that the marginal effect of the legal scope of a patent on the likelihood of the patent being traded over being licensed changed into a positive direction after the patent law reform, which supports hypothesis 3. To

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\(^{12}\) For the patent application year, I introduced the set of dummy variables. The correlation between each application year dummy and the post2011 is below 0.2.
compare the marginal effect of the patent scope on the likelihood of a patent being traded over being licensed before and after 2011, I run two separate regressions with the patents that were transacted before and after 2011, respectively. Columns 6 and 7 present the results. The coefficient of Legal Scope in the sixth column is negatively significant at the 0.001 significance level (-0.12). This indicates that as the legal scope of a patent increases, the probability of the patent being traded rather than being licensed decreases before 2011. However, this pattern disappears after 2011 as the coefficient of Legal Scope in the seventh column is statistically insignificant at the 0.05 significance level (0.001).

Finally, the eighth column reports the test result of hypothesis 4. The coefficient of Post2011 is positively significant at the 0.001 significance level (0.191), which supports hypothesis 4. The expected value of the legal scope of traded patents after 2011 is larger than that of comparable traded patents before 2011.

I conduct two robustness checks. The first robustness check is to partial out the effect of the change of the rule for injunction relief in patent infringement lawsuit cases, after 2006. For the case of ebay Inc. v. MercExchange in 2006, the U.S. supreme court ruled that the injunction for patent infringement lawsuits should be released after strictly applying the four-factor test. Since this decision weakens the patent enforcement power of patentees as well as the patent transaction activity in the U.S. (Aydin, 2015), there might be a systematic change in the patent transaction dynamics thereafter. I limit the sample into transacted patents after 2006. Table 6 reports the results. The findings hold at the 0.05 significance level.

The second robustness check is to find whether there was a significant change in the variables of interest around 2011 within a shorter timeframe. I limit the samples to the transacted patents from 2009 to 2013 (two-year time windows before and after 2011) while excluding the patents transacted in 2011 (in order to eliminate the possibility of patents transacted in 2011 being a mix of transacted patents before and after the actual enactment of the AIA). Table 6 reports the regression result. All the findings hold at the 0.01 significance level.

5.3. Rival Theory and Crucial Test

While the series of empirical tests support all four hypotheses, this does not imply that other explanations can be ruled out. If rival theories can reasonably explain the obtained empirical findings, it

is helpful to conduct crucial tests for finding credibility for the claimed theory over the rival theory (Stinchcombe, 1987).

It is well known that the legal scope indicators are positively correlated with the quality of a patent (see, Reitzig, 2004, Putnam, 1996, Odasso et al., 2015). If the capability of evaluating the quality of a patent increases over time in general while such patents are increasingly preferred for being traded over licensed, the findings for hypotheses 3 and 4 can be reasonably explained.

To test the credibility of this rival theory (hereafter referred to as the Patent Quality Theory), I design a crucial test by rationalizing the difference of the average value of the patent age at the moment of the patent transaction. The rationale for hypotheses 3 and 4 is that the AIA in 2011 drives firms to purchase patents that can be strategically used to cope with the increased patent invalidation risk. The patent invalidation through the new institutions (especially the inter-parte review) becomes possible only if there are prior arts that limit novelty and non-obviousness for the patent in question. Hence, according to the model of the present study, firms will seek the older patents that can be used as the prior arts, which can then threaten the validity of the competitor’s patents or give benefits in settling the patent validity disputes. In contrast, the Patent Quality Theory expects no significant difference in the age of patents between the traded patents before and after AIA. To test these predictions, I compare the changes among the average value of patent age traded before and after 2011. Figure 5 shows the result.

[Insert Figure 5 here]

The result shows that the average patent age for the traded patents after 2011 is greater than the traded patents before, while such pattern is not observed for the licensed patents. These findings reject the Patent Quality Theory in explaining findings from testing hypotheses 3 and 4.

6. Discussion

The present study empirically shows that benefits from the strategic use of patent exclusion rights is one of the main driving forces for patent transactions. To find whether and how patent exclusion rights drive patent licensing and patent trading, I capitalize upon the major patent law reform in the U.S. in 2011, which significantly changed the patent enforcement environment. If the benefit from the strategic use of patent exclusion rights is a driving force for patent transactions, then there should be significant changes in the features of transacted patents after the reform. The constructed analytical model in the present study predicts that the patent reform affects the patent enforcement power for patent owners in patent licensing agreements. Meanwhile, the reform is expected to drive the firms to purchase patents that can give strategic
benefits in coping with the increased patent invalidation risk by the implementation of new institutions for patent validity examination.

Using the traded and licensed U.S. granted patents from 2000 to 2015, my empirical analysis reveals the following. First, before 2011, the likelihood of a patent being traded over being licensed decreases in the technological breadth of patents. However, this relationship disappears after 2011. Second, the technological breadth of the licensed patents after 2011 is significantly lower than that of comparable licensed patents before 2011. These findings indicate that the bargaining power of the patent owner in patent licensing agreements is reduced by the new joinder rule, which further suggests that exertion of the patent exclusion rights of patent owners is one of the driving forces for patent licensing agreements. Before 2011, the bargaining power of the patent owners who have patents with broad technological breadth could be well empowered in patent licensing negotiation because the prior joinder rule allowed the patent owners to take advantage of the decreasing marginal litigation costs against multiple defendants when it comes to the range of technological applications is sufficiently broad. However, the AIA limits such benefits. Accordingly, the patent owners who could successfully license the patents that have broad technological breadth had fewer chances to out-license such patents. This conclusion aligns with the finding of a study by Aydin (2015). According to Aydin’s study, reduction of the patent enforcement power for patent owners after the ebay case in 2006 brings about reduced out-licensing activity for U.S. firms.

Third, before 2011, the likelihood of patents being traded over being licensed decreases in the legal scope of patents. However, after 2011, this pattern disappears. Fourth, the legal scope of traded patents after 2011 is greater than the comparable traded patents before 2011. These findings indicate that those patents having broader legal scopes become more desirable for trading than before 2011.

The crucial test shows that these findings are unlikely to be explained by a rival theory. The comparison of the average age of traded patents before and after 2011 reveals that the establishment of the new institutions for patent invalidation drives entities to seek to acquire the broad-legal scope and older patents that can be used in coping with or utilizing the increased patent invalidation risk by the new institutions. This result implies that the future benefits from the strategic use of patent exclusion rights can drive firms to purchase third parties’ patents.

In summary, the empirical analysis in this study indicates that patent exclusion rights are the driving force for patent licensing and patent trading. Interestingly, exclusion rights come into play differently for patent licensing and patent trading. Patent owners exert the exclusion right to leverage bargaining power in patent licensing negotiations, whereas the future benefit from the strategic use of patent exclusion rights induces firms to purchase others’ patents.
7. Conclusion

The findings of the present study contribute to broad literature on the market for technology and provides empirical grounds for the debate about the social welfare consequences of the emerging market for patents.

The benefit from the strategic use of patent exclusion rights is one of the driving forces for patent transactions. This finding suggests that it is necessary to distinguish the market for technology and market for patent conceptually. While patent transactions can accompany technology transfers (Fischer and Henkel, 2012, Fischer and Ringler, 2014), patent transactions should not be considered as equivalent to technology transactions because some patents may be transacted for the patent exclusion rights instead of underlying technology. The present study shows that the patent owner’s enforcement of exclusion rights against licensees is one of the driving forces for patent licensing. Meanwhile, patent trading is partly driven by the demand of the patent buyer who seeks to benefit from the future strategic use of exclusion rights in the purchased patents.

The findings in this study also provides implications for innovation policy makers who are interested in promoting market for patents. First, policy that aims at promoting the patent transaction based on the belief that benefits of the market for technology for social welfare and innovation can be realized through promoting active patent transactions needs to be carefully discussed. The present study shows that the technology transfer is not the only driving forces for patent transactions.

Second, the finding that a patent policy change can affect the strategic behavior of players in patent transactions provides an empirical implication for the policy makers in designing the next patent policy. The patent policy used to aim at improving the patent system efficiency and providing more incentives for innovation thereafter. However, the present study shows that patent policy (i.e., patent law reform) also affects the patent transaction activity. Accordingly, patent policymakers may need to take into account the potential impact of the new patent policy on the patent transaction dynamics.

The present research adds implications to the conventional discussion about the role of patents in innovation. Since patent system is a institutions that aims to improve the appropriability condition for innovators, it incentivizes the innovation. In contrast, the patent can deter innovation by so-called anti-common problems and accompanied unnecessary costs for innovation (e.g., patent thicket problems). These problems are also observed in patent transactions. Active markets for patents may confer more opportunities for the innovators to gain profit from their innovation and therefore provides innovation incentive. However, as present research shows, patent transaction used to be driven by the benefit from the strategic use of patent exclusion rights, which does not necessarily promote innovations. While the findings in present research do not provide explicit or implicit evidence for the consequence of the patent transaction in innovation, the
findings indicate, at least, that there are two faces of the patent transaction for the innovation in needs of careful consideration.

8. Limitations

First, my empirical findings were obtained by using the traded or licensed patents in the U.S. during a certain period. Hence, the conclusion in the present research is subject to the external validity issue.

Second, there are great variations in contract terms when it comes to patent licensing agreements. In some license contracts, licensees used to be allowed to practice licensed technology for a particular product for certain periods in a designated country or sector. In other license contracts, the licensees can practice the licensed technology without limitations. For royalty payment options, some license contracts require licensees to pay upfront for the license contract or other contract options may require the licensees to pay regular royalty payment only (Anand and Khanna, 2000). All these variations in the license contract term have not been controlled because of the lack of data.

Third, due to the data limitation, the empirical analysis did not take into account the unobserved characteristics of the patent owner and patent buyer (licensee) in the patent transaction. Since the result of patent transaction negotiation is likely to be dependent upon the patent owner’s (licensor’s) and patent assignee’s (licensee’s) characteristics, the obtained results have potential endogeneity issues. It is worthwhile to conduct additional analyses with the panel data that contains detailed information for the patent assignors and assignees, in order to obtain a clearer conclusion.

Fourth, the employed dataset in the present paper does not include all of the licensed and traded patents in the U.S. While reporting the patent trade is de-facto mandatory (the USPTO provides institutional incentive for reporting the patent trade transaction), it is not clear whether the list of the licensed patents is as comprehensive as the traded patents. Indeed, it is not clearly stated whether reporting the patent licensing agreement is incentivized as much as that of the traded patents. Hence, the licensed patent dataset has potentially self-selection bias.
Figures

Payoff \( V, W \): \( V \) for firm S, \( W \) for firm X

Figure 1. The patent transaction game.

Note: Since the dataset has been downloaded at the end of 2016 and there is a 1~2-year delay to recordation, relatively few traded and licensed patents are observed in the 2015 sample.

Figure 2. Number of traded and licensed patents (2000-2015).
Figure 3. Top 10 patent buyers (top) and licensees (bottom).
*Note
Error bar: 95% significance level, controlling for technology field, frequency of the patent transaction, science linkage, multi-owner variables.

Figure 4. Distribution of the technology field of patents.

Figure 5. The average age of transacted patents.
### Tables

#### Table 1. The Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade</td>
<td>1 for traded patents, 0 for licensed patents (dependent variable)</td>
<td>H1,3</td>
</tr>
<tr>
<td>Tech Breadth</td>
<td>Log (Number of unique IPC subclasses)</td>
<td>H1,2 (DV for H2)</td>
</tr>
<tr>
<td>Legal Scope</td>
<td>Log (Number of claims)</td>
<td>H3,4 (DV for H4)</td>
</tr>
<tr>
<td>Tech Breadth*2011</td>
<td>Interaction term of Post2011 and Tech Breadth</td>
<td>H1</td>
</tr>
<tr>
<td>Legal Scope*2011</td>
<td>Interaction term of Post2011 and Tech Scope</td>
<td>H3</td>
</tr>
<tr>
<td>Science</td>
<td>Share of non-patent references to the total number of citation made</td>
<td>Control</td>
</tr>
<tr>
<td>Multi-owner</td>
<td>A dummy variable that takes 1 if the patent was originally assigned to multiple assignees</td>
<td>Control</td>
</tr>
<tr>
<td>Remained life</td>
<td>21 (patent transaction year - patent application year)</td>
<td>Control</td>
</tr>
<tr>
<td>Tech Field Dummies</td>
<td>Set of dummy variables for the section code of the primary IPC code</td>
<td>Control</td>
</tr>
<tr>
<td>Frequency</td>
<td>A dummy variable that takes 0 if the patent is transacted only once</td>
<td>Control</td>
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#### Table 2. Summary Statistics of the Key Variables

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<th>Nature of patent transaction</th>
<th>Traded patent (N=26146)</th>
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<td>Multi-owner</td>
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<td>Remained life</td>
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<tr>
<td>Frequency</td>
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<td>0.2</td>
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#### Table 3. Correlation Matrix

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<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<td>trade</td>
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<td>Tech Breadth</td>
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<td>0.0151</td>
<td>1</td>
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<td>7</td>
<td>Remained life</td>
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# Table 4. Main Regression Result

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<td></td>
<td>(0.023)</td>
<td>(0.023)</td>
<td>(0.087)</td>
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<td>Tech Breadth*2011</td>
<td>0.190**</td>
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<td></td>
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<td>Legal Scope</td>
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<td></td>
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<td>(0.018)</td>
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<td>Remained life</td>
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<td>(0.044)</td>
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<td>(0.070)</td>
<td>(0.204)</td>
<td>(0.079)</td>
</tr>
<tr>
<td>Observations</td>
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<td>20,298</td>
<td>8,083</td>
<td>26,146</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
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<td>Pseudo R2</td>
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<td>After2011</td>
<td>Licensed</td>
</tr>
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<td>Before2011</td>
<td>After2011</td>
<td>All</td>
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<tr>
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*** p<0.001, ** p<0.01, * p<0.05, Robust standard errors in parentheses
Probit Model used for H1 and H3, DV: trade (1 for traded patent, 0 for licensed patent)
OLS for H2 and H4
Legal Scope: ln(number of independent patent claims), Tech Breadth: ln(number of unique IPC subclasses)
MultiApps: number of patent applications filed in US under the same patent family
Post2011: 1 for patent transacted after 2011
Multi-owner: 1 for if the patent was filed by multiple applicants
Science: share of NPL references to the total number of cited references
Frequency: a dummy variable taking 1 if the patent was transacted multiple times during the period
Tech Field Dummy: Dummy variable for the sector code of the primary IPC code
Table 5. Regression with Patents Transacted after 2006

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<tr>
<th>Variables</th>
<th>H1 (Probit)</th>
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<th>H3 (Probit)</th>
<th>H4 (OLS)</th>
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<td></td>
<td>trade</td>
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<td>trade</td>
<td>Tech Breadth</td>
</tr>
<tr>
<td>Tech Breadth</td>
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<td>-0.281***</td>
<td>0.109</td>
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</tr>
<tr>
<td></td>
<td>(0.034)</td>
<td>(0.034)</td>
<td>(0.087)</td>
<td></td>
</tr>
<tr>
<td>Tech Breadth*2011</td>
<td>0.238**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.076)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legal Scope</td>
<td></td>
<td>-0.120***</td>
<td>-0.106***</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.027)</td>
<td>(0.027)</td>
<td>(0.072)</td>
</tr>
<tr>
<td>Legal Scope*2011</td>
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<td>0.190*</td>
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<td>0.075***</td>
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<td></td>
<td></td>
<td>(0.074)</td>
<td>(0.011)</td>
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<tr>
<td>Post2011</td>
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<td>-0.161**</td>
<td>0.470*</td>
<td>0.075***</td>
</tr>
<tr>
<td></td>
<td>(0.062)</td>
<td>(0.050)</td>
<td>(0.218)</td>
<td>(0.011)</td>
</tr>
<tr>
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<td>0.132</td>
<td>-0.491*</td>
<td>-0.127</td>
</tr>
<tr>
<td></td>
<td>(0.117)</td>
<td>(0.135)</td>
<td>(0.199)</td>
<td>(0.095)</td>
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<td>-1.448***</td>
<td>-0.843***</td>
<td>0.305***</td>
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<tr>
<td></td>
<td>(0.084)</td>
<td>(0.094)</td>
<td>(0.215)</td>
<td>(0.083)</td>
</tr>
<tr>
<td>Remained life</td>
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<td>-0.031***</td>
<td>-0.027**</td>
<td>0.013***</td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.009)</td>
<td>(0.004)</td>
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<tr>
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<td>1.138***</td>
<td>1.134***</td>
<td>1.124***</td>
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<tr>
<td></td>
<td>(0.062)</td>
<td>(0.078)</td>
<td>(0.108)</td>
<td>(0.042)</td>
</tr>
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<td>0.815***</td>
<td>0.977***</td>
<td>0.524***</td>
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<tr>
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<td>(0.096)</td>
<td>(0.114)</td>
<td>(0.204)</td>
<td>(0.078)</td>
</tr>
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<td>Observations</td>
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<td>8,083</td>
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<td>R-squared</td>
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<td>-</td>
<td>-</td>
<td>0.065</td>
</tr>
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<td>Pseudo R2</td>
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<td>0.122</td>
<td>0.301</td>
<td>-</td>
</tr>
<tr>
<td>Sample</td>
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<td>After 2011</td>
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<tr>
<td>Tech Field Dummy</td>
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<td>YES</td>
<td>YES</td>
<td>YES</td>
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</table>

*** p<0.001, ** p<0.01, * p<0.05, Robust standard errors in parentheses

Only with transacted patents after 2006

Probit Model used for H1 and H3, DV: trade (1 for traded patent, 0 for licensed patent)

OLS for H2 and H4

Legal Scope: ln(number of independent patent claims), Tech Breadth: ln(number of unique IPC subclasses)

MultiApps: number of patent applications filed in US under in the same patent family

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Frequency: a dummy variable taking 1 if the patent was transacted multiple times during the period

Tech Field Dummy: Dummy variable for the sector code of the primary IPC code
**Table 6. Regression with Patents Transacted from 2009 to 2013**

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<tr>
<th>Variables</th>
<th>H1 (Probit)</th>
<th>H2 (OLS)</th>
<th>H3 (Probit)</th>
<th>H4 (OLS)</th>
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</thead>
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<td>trade</td>
<td>trade</td>
<td>trade</td>
</tr>
<tr>
<td>Tech Breadth</td>
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<tr>
<td></td>
<td>(0.051)</td>
<td>(0.051)</td>
<td>(0.125)</td>
<td></td>
</tr>
<tr>
<td>Tech Breadth*2011</td>
<td>0.445***</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.105)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legal Scope</td>
<td>-0.235***</td>
<td>-0.218***</td>
<td>0.008</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.041)</td>
<td>(0.041)</td>
<td>(0.091)</td>
<td></td>
</tr>
<tr>
<td>Legal Scope*2011</td>
<td>0.278**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.090)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post2011</td>
<td>0.759***</td>
<td>-0.273***</td>
<td>0.204</td>
<td>0.043**</td>
</tr>
<tr>
<td></td>
<td>(0.083)</td>
<td>(0.068)</td>
<td>(0.271)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>Collaboration</td>
<td>-0.221</td>
<td>0.128</td>
<td>-1.090***</td>
<td>-0.020***</td>
</tr>
<tr>
<td></td>
<td>(0.186)</td>
<td>(0.216)</td>
<td>(0.290)</td>
<td>(0.050)</td>
</tr>
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<td>-2.343***</td>
<td>-0.860**</td>
<td>0.049</td>
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<td>(0.117)</td>
<td>(0.140)</td>
<td>(0.286)</td>
<td>(0.103)</td>
</tr>
<tr>
<td>Remained life</td>
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<td>-0.016**</td>
<td>-0.050***</td>
<td>0.022***</td>
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<td>(0.005)</td>
<td>(0.006)</td>
<td>(0.013)</td>
<td>(0.005)</td>
</tr>
<tr>
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<td>1.627***</td>
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<td>(0.129)</td>
<td>(0.144)</td>
<td>(0.064)</td>
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<tr>
<td>Constant</td>
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<td>1.236***</td>
<td>1.185***</td>
<td>0.690***</td>
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<td>(0.137)</td>
<td>(0.168)</td>
<td>(0.314)</td>
<td>(0.099)</td>
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<tr>
<td>Observations</td>
<td>8.022</td>
<td>4.073</td>
<td>3.924</td>
<td>698</td>
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<tr>
<td>R-squared</td>
<td>-</td>
<td>-</td>
<td>0.092</td>
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</tr>
<tr>
<td>Pseudo R2</td>
<td>0.256</td>
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<td>After 2011</td>
<td>licensed</td>
</tr>
<tr>
<td>Tech Field Dummy</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

*** p<0.001, ** p<0.01, * p<0.05. Robust standard errors in parentheses

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References


PUTNAM, J. D. 1996. The value of international patent rights, Yale University Yale.


SCHMOCH, U. 1993. Tracing the knowledge transfer from science to technology as reflected in patent indicators. Scientometrics, 26, 193-211.


