Patent Pools and Litigation*

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Abstract Uncertainty about the quality of intellectual property rights affect the licensing and litigation behavior of firms. I investigate how enforcement behavior, i.e., litigation changes with additional information on a patent's relevance for a technological innovation. By exploiting the institutional setting of patent pools that verify the essentiality of their members for a technological invention, I investigate how litigation probabilities change with pool membership and market structure, e.g., vertical integration. Using U.S. patent litigation data, pool membership, firm classification, and proxies for patent quality, I find that patents in a pool are on average more often litigated. However, vertically separated IP owners tend to litigate less pool patents. The average effect is driven by downstream producers who enforce more pool patents in court and also more low quality pool patents. The findings can be explained with incentives to raise rivals costs of downstream manufacturers.

Key words: intellectual property rights, licensing, patent pools, standard setting
JEL Codes: K41, L22, L24, O32, O34

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1 Introduction

Uncertainty of intellectual property rights shapes the enforcement of patent rights. Litigation arises when technology adapters knowing or un-unknowingly violate the rights of a patent owner and are unwilling to settle the dispute outside of courts (Bessen and Meurer, 2006). Patent owners litigate their patents to seek compensation for their effort to innovate, i.e., they file an infringement lawsuit to enforce intellectual property rights through courts (Lanjouw et al., 1998; Lanjouw and Schankerman, 2001). On the one hand, uncertainty about the validity and scope of a patent induces asymmetric information in the bargaining process over licensing terms. If uncertainty leads to disagreeing views on the relevance and value of an innovation, patent owners file infringement lawsuits in court. On the other hand, infringement lawsuits trigger counter suits that questions the validity of the patent and owners risk to loose their rights. Patent owners might hesitate to turn to courts if uncertainty increases the risk of a validity lawsuit. This paper focuses on the question how additional externally validated information on the relevance of a patent rights affect the enforcement activities of the owner, i.e., litigation. Particularly, I exploit the institutional setting of patent pools for standard essential patents, i.e., complementary patents that are necessary in order to implement a standardized technological innovation, to empirically investigates how a reduction in uncertainty about patent quality affects the enforcement of complementary patent rights.

After obtaining a patent right, the owner has to decide on how to monitor the downstream licensing market. Similar to the transaction of ownership rights, patents can join patent pools due to the competitive advantage in patent enforcement (Galasso et al., 2013). Patent owners can delegate enforcement activities, to patent pools which are agreements of owners of intellectual property to jointly enforce their patent rights by licensing and litigation. For example, *Avanci*, a pool for patents covering the technology of wireless connected devices, sells to manufacturers of cars, household appliances, smart meters, and more (Avanci, 2018). Pools evaluate whether the covered claims are essential for the technology of the standard before inclusion of new patents.[1] By joining a pool, patents reveal information on their essentiality for a specific technological standard. Pool membership validates the claim that a patent is standard essential and reduces the uncer-

[1]For example, patents are considered essential when they are determined to have at least one independent claim that would be necessarily and unavoidably infringed (in the absence of a license) by the practice of the standard (Via Licensing, 2017)

tainty whether a patent is relevant to implement an innovation. Fees for the evaluation of a patent are born by the applicant and are about USD 10,000 per patent (according to discussions with industry members), e.g., USD 10,500 for the pool of AAC standard patents by Via Licensing (2017).

In addition to the uncertainty about a patent's validity and scope (Lemley and Shapiro, 2005), for patents that are declared standard essential, i.e., where the patent owner thinks its patent is necessary to implement a standardized technology, the additional question arises whether a patent is relevant to implement a technological standard. Declarations of standard essentiality are submitted by participating firms during the standard setting procedure. Because standard setting evolves over time and a review of the declared patents is not common, uncertainty about the *true* essentiality of declared SEP remains. Further uncertainty is generated by the fact that more than 70 percent of declared SEP are patent applications and are eventually granted after the finalization of the technological standard. Industry reports suggest that between 10 and 50 percent of all patents that are declared essential are *truly* necessary to implement the technology (Pierre Regibeau and Zenger, 2016; Knut Blind, 2017). I use the information provision by patent pools to estimate how additional verified information affect enforcement behavior. Joint licensing of patent owners in industries with complementary patents owned by different entities decreases double-marginalization and transaction costs for implementer of new technologies, i.e., producers of final consumer goods.[2] Pools of complementary patents are considered as welfare enhancing and antitrust authorities tend to have a lenient view on pools (Shapiro, 2001; Lerner and Tirole, 2004). In the context of standard essential patents, the European Commission suggest costly validations of declared SEP or the setup of patent pools for standard essential patents in order to overcome issues over patent essentiality, to clarify licensing costs, and reduce transaction costs (Commission, 2017). To encourage the set-up of more patent pools for standards, the European Commission suggests to strengthen the relationship between SSO and pools, to provide incentives for participation, and to distribute information (Commission, 2017).

[2]In some industries the final consumer product incorporate thousands of complementary patents, e.g., a mobile phone might involve around 250,000 patent claims (RPX Corp., 2011). Some claim that in 2016 about 25 percent of patents granted by the USPTO are mobile related (while about 8 percent in Europe) (Sharma, 2016). Empirical studies show that the problem of multiple marginalization lead to the accumulation of patents in the software industry (Noel and Schankerman, 2013) and for defensive purposes in industries with potentially overlapping property rights (Arora et al., 2004).

If uncertainty leads to more heterogeneous beliefs in patent quality and more lawsuits (Bessen and Meurer, 2006; Lemley and Shapiro, 2005), patent pools are expected to reduce the number of cases filed in court. However, if uncertainty leads to patent owners that are hesitant to enforce their patents (Choi, 1998), patent pools are expected to increase litigation. Ultimately, the effect of information on litigation, i.e., the effect of patent pools on litigation, is an empirical question addressed in this paper.

My estimations relate the probability of litigation to pool membership, standard essentiality, quality, and several control variables. To analyze the effect of patent pools on litigation of complementary patents, I exploit the institutional setting of pools that emerged from voluntary technological standard-setting by industry members. While standard setting organization facilitate the development of new technologies mainly to promote interoperability between product, e.g., wifi, they do not coordinate licensing activities. Owners can declare their patents as essential to a standard during the development of a new technology and then decide whether to license them in a patent pool or individually. I focus on the information and communications technology (or ICT) industry which comprises 95 percent of all standard essential patents (16,462 patents from the Searle (2016) database). I have information on 38 patents pools that emerged from 3,765 standardizing projects. My sample comprises of all standard essential patents, including 4,110 pool patents, of which 459 were litigated between 2000 and 2015. I add a randomly drawn control group of non-SEP patents with the same characteristics, in particular, with the same vintage, number of claims, and technological sub-field. For the main estimation, I create an unbalanced panel data set of patents for the years 2000 to 2015. Besides patent fixed effects, I address the endogenous selection of firms into patent pool with instrumental variables that proxy for how close a patent is linked to a standard and for the belief of the applicant in the value of the patent at the time of filing the patent application. In particular, I use the number of disclosures per patent, i.e., how often a patent number comes up during standard setting, and the grant lag (time between application and granting of a patent) as instruments for the decision to join a patent pool.

My results show that membership in a pool of complementary patents increases the likelihood of enforcing patents in court. The effect is in addition to the effect of standard essentiallity, a main driver of litigation probabilities. The results hold when controlling for endogenous selection into pools using instrumental variables. Further, I investigate how the quality of essential and pool patents affect litigation and find that patents with more citations end up more likely in court. The finding is consistent with the theoretical findings that more information on patent quality, e.g., on the patent boundaries, increase the attractiveness of litigation. Greater patent refinement, for example, higher quality patents or better monitoring, lead to more lawsuits (Bessen and Meurer, 2006).

Patent pools regularly include patents of vertically integrated firms and non-integrated firms. Next, my work investigates empirically how patent pools affect enforcement behavior and how this depends on market structure of vertically integrated producing entities with a downstream business vs. non-integrated IP owner. Producing entities are manufacturers of products that implement complementary innovation and own (some of) the necessary technology. Vertically separated, non-integrated IP firms do not manufacture, distribute, or sell products. They generate profits through licensing of innovations and patent assertion.[3] Throughout the paper, I use the terms vertically separated IP owners and non-producing entity as well as vertically integrated manufacturer and producing entity synonymous.

On the one hand, pool can become anti-competitive due to vertically integrated pool members that have less incentive to set competitive prices for downstream implementer Reisinger and Tarantino (2018). Further, integrated firms with a downstream presence can avoid mutually destructive litigation by engaging in mutual forbearance to avoid litigation, a strategy that is less attractive for vertically dis-integrated non-producing firms. On the other hand, integrated producer have an incentive to raise rivals costs through enforcing their patents (Schmalensee, 2009; Simcoe et al., 2009). The heterogeneous effect across types to litigate are also driven by two common defenses when a firm faces a litigation lawsuit: challenges of patent validity and infringement counter-lawsuits. While patent validity, i.e., the question whether an invention is novel, nonobvious, and useful, lawsuits can be filed against both vertically integrated and dis-integrated firms, infringement counter-lawsuits can only be filed against vertically integrated manufacturers that produce for the downstream market (Lemus and Temnyalov, 2017). Income from litigation also differs across firm types: patent damages are calculated by juries that are

[3] The analysis by firm type is related to the debate on the role of patent assertion entities, particularly so-called patent trolls, a term for firms that buy patents and aggressively collect revenue from potential infringers. They target firms that have already made investments in new products on the market, thus, leveraging a hold-up situation. In addition to troll, my definition of vertically separated firm includes all non-producing IP owners, for example, universities.

generally more convinced by stories of producing companies that are entitled to lost profits, injunctions are more likely to be granted to practicing entities (see the case *eBay Inc. v. MercExchange, L.L.C.*), and they have a better case to calculate damages (Lemley and Melamed, 2013). Since the expected income and costs of litigation differ across market structures and firm types, I expect that pool membership affects litigation probabilities differently across firm types. The aim of this paper is to find out how they differ.

Particularly, I find a strong positive correlation between litigation and patent pool membership for vertically integrated downstream manufacturers. Patent owner with a downstream business impose costs on their rivals through litigated pool patents. An explanation for the effect are lower litigation costs in pools and the bundle of patents for offensive and defensive lawsuits. Producing entities also tend to enforce pool patents of lower quality in courts.

For vertically separated IP firms, however, I find a negative effect of pool membership on enforcement behavior. Although they file more lawsuits for their standard essential patents, their pool patents are less enforced in court. While vertically separated IP firms have an incentive to monetize patents regardless of the type of licensee, joint licensing of with downstream manufacturers increase the risk of counter-suits in pools and they lack the incentive to impose costs on downstream rivals. Further, I find that higher quality patents from pools are less likely litigated by producing companies. For litigation filed by IP firms, however, quality is positively associated with the number of citations and its interaction with essentiality and patent pool membership.

While the final decision whether to file a infringement suit lies with the patent owner, pools are institutions that by themselves affect incentives to litigate besides reducing uncertainty. Patent pools affect through the following incentives the enforcement of patent rights in court. First, pools manage and consult on litigation strategies, for example, by setting up joint litigation funds to hedge costs between pool members. According to discussions with pool managers, almost all pools set up funds or similar measures to coordinate litigation. If patent owners are risk avers, the hedging effect of the litigation fund might encourage litigation. Second, a bundle of patents provides opportunities for offensive litigation as well as for defensive counter-litigation. Offensive litigation means that patent owners actively enforce their patents in court while defensive litigation means that patent owners file a counter-suit after they have been accused of infringing the patent of another firm. The size and composition of patent portfolios determines the incentives for firms to either engage in intensive litigation or in mutual forbearance where no firm files lawsuits (Lemus and Temnyalov, 2017; Schmalensee, 2009). Third, pools file court cases to create a reputation of a strict enforcer of patents in order to attract pool members. Thereby, they accumulate experience of enforcement in court. Both experience and reputation are favorably associated with court outcomes and, thus, affect initial litigation probabilities (Simcoe et al., 2009; Lanjouw and Schankerman, 2001). Fourth, patent pools itself can discourage patent litigation when members settle disputes through the formation of patent pools (Choi, 2010). Ultimately, the effect of patent pools on litigation is an empirical question addressed in this paper.

For welfare considerations it is important to understand whether the level of litigation is optimal. With too much litigation, patent owner waste resources in unproductive courts while with too little enforcement, they generate not enough revenue from their innovation. My results cannot say much about the optimal level of litigation. This question is left for future research.

The remainder of the paper is structured as follows. Section 2 provides an overview of the literature and works out the contribution of this paper. Section 3 describes the institutional setting of patent pools and standard-setting organizations. Section 4 describes the data and lays out the econometric model of litigation and participation in patent pools. Section 5 presents results and Section 6 discusses the findings and concludes.

2 Literature

With overlapping or blocking patent rights innovators have difficulties to generate revenues from their innovations (Gallini, 2002). Cross-licensing agreements and patent pooling relieve situations of blocking patents, speed up technology transfer processes, and encourage complementary research lines and vertical specialization (Shapiro, 2001). However, the evidence on effects of patent pools on litigation is not clear. One the one side, Lampe and Moser (2010) study descriptively the relationship between litigation, innovation, and patent pool in the the 19th century sewing machine industry. Litigation risk decreases for participants of the patent pool but increased for patent holders outside of the pool. On the other side, Delcamp (2015) finds that patents in nine modern pools from the ICT industry are more likely to be litigated compared to non-pool patents. His results hold even when accounting for an increase in the market size of the patent due to additional exposure from the pool. My study complements previous work by focusing on vertical relations, identifying the effect of pools while controlling for the effect of standard essentiality, one of the main driver of litigation (Simcoe et al., 2009; Lerner et al., 2007), and by addressing endogeneity concerns with instrumental variables. Also, my sample of pool patents is much larger.

Lerner et al. (2007) find that characteristics of patents in a pool determine the licensing contracts, particularly, pools with grantback provisions are less likely to be litigated and are associated with more often with independent licensing. The authors' treat litigation as a measure for for anti-competitiveness and suggest that pools comprise more complementary patents.

Some empirical articles analyze the diffusion of innovation vertically related markets (Alon Eizenberg and Sovinsky, 2018) and how vertical mergers can increase innovation and welfare (Yang, 2017).

Considering vertical integration of pool members is important because there is evidence that pools can hinder downstream industries and implementation of innovation (Lampe and Moser, 2013; Gilbert, 2004). While the theoretical literature finds welfare increasing effects of patent pools due to the elimination of horizontal double marginalization (Kim, 2004; Schmidt, 2014), vertical integration of licensors and downstream manufacturers can offset the gains due to vertical price coordination (Reisinger and Tarantino, 2018). Theoretical evidence of the effect of patent pools on litigation is mixed and depends on the assumptions, e.g., market conduct (Choi and Gerlach, 2017; Lemus and Temnyalov, 2017).

Several authors investigate determinant of litigation rates, , for example, by firm size (Lanjouw and Schankerman, 2004; Simcoe et al., 2009) and reputation (Lanjouw and Schankerman, 2001). Leiponen and Delcamp (2018) investigate how technological capabilities and licensing business model affect litigation rates and find that technological developers are the most aggressive litigants. Vertically dis-integrated non-practicing entities, however, win more judgments and larger settlement than practicing entities (Lemley and Melamed, 2013). By analyzing producing and non-producing, i.e., upstream and downstream firms, this paper also links to the discussion on how patent enforcement differs by firm characteristics.

Simcoe et al. (2009) analyze the litigation strategies of owners of standard essential patents and differentiate between larger and smaller companies. Their calculated litigation rates for standard essential patents are much higher than for similar patents that are not declared essential. Also, my data shows that essentiality is one key driver of patent litigation, e.g., litigation rates are about 3 times higher than in the control group of similar patents. Lerner et al. (2007) analyze the effect of firm size and SSO activity on litigation rates. They finds considerably higher litigation rates for SSO patents. Moreover, for a subsample of patents both disclosed and litigated, they find that small firms litigate more often after disclosure. Small firms may have incentives to litigate more often as they compete mainly through licensing of intellectual property and face a dilemma between standard adoption and rent capture, while large integrated incumbents can seek rents from their participation in the downstream market as well. While NPE outsiders assert numerous unencumbered SEPs, (Contreras, 2016) finds a greater threat of hold-up and excessive royalties from outsiders that are producers. Remedies to patent holders also shape the market outcome, for example, damages (liabilities) from infringers can reward patent holders while injunctions directly restrict infringing conduct (Schankerman and Scotchmer, 2001).

Mazzeo et al. (2013) find a higher success rate of litigation involving patent assertion entities but not significant difference in the award value of infringement across firm types. Assertion entities acquire also patents that are more likely to be infringed and more robust to legal challenges, i.e., of higher quality and larger scope (Fischer and Henkel, 2012). Abrams et al. (2017) find that smaller firms sell more often patents further from their core business and with a high litigation risk to assertion entities because they seem to be better equipped to capitalize and enforce patents. My study complements previous studies with the effect of patent pools on litigation by the type of the litigating firms, e.g., vertical integration.

Llobet and Padilla (2017) introduce litigation in a market for complementary patents and find that the potential invalidation in court does not affect high-quality patent portfolios but incentivizes firms with weak patent portfolios to set moderate royalty rates. The expected gains from patent invalidation with high aggregate royalty rates are less likely to compensate for the cost of the licensee. In one of the estimations, I complement their study by empirically investigating how patent quality, pool membership, and essentiality affect litigation probabilities. Pool membership seems to set incentives for producing firms to more actively enforce their lower quality patents. My results shed light on the discussion how institutions shape market outcomes.

3 Institutional Setting

This study analyzes the relation of litigation of patent assertion entities and pools of complementary patents. Since all pools license patents related to technological standards, this section provides background information on patent pools and on standard-setting procedures.

Patent pools are arrangements of owners of intellectual property rights to jointly license their patents.[4] An important task of pools is to identify potential licensees and patent infringements. Rights' owners can maximize returns from patents by delegating enforcement to pools, if pools are more effective in monitoring, licensing, and litigation. Historically patent pools have been formed in various industries, e.g., for sewing machines railway springs, or dry ice, and contained not necessarily complementary patents (Lampe and Moser, 2015). Most modern patent pools, however, have formed in industries where the final product builds on several complementary patents, e.g., the internet and communication technology industry. All observed pools include patents for a technical specification or a standard. The first modern patent pool has been formed in 1997, after antitrust authorities clarified their stands on patent pools, i.e., the approval of pools with complementary patents (see (Gilbert, 2004; European Commission, 2014; Lerner and Tirole, 2004)). Given the legal uncertainties around patent pools, some pools ensure potential members their accordance with the law, e.g., DVD6C (2017) writes: "The U.S. Department of Justice issued a business review letter expressing that it has reviewed the DVD Patent Joint License and does not intend to take any action against the DVD Patent Joint Licensing Program."

Litigation is costly and for firms only profitable if the questionable patent is commercially important enough (Lemley and Shapiro, 2005).[5] Patent pool administrators support members regularly with litigation strategies and set up litigation funds. According to personal discussions with managers, decisions on infringement lawsuits or counter

[4]Beside the commercialization of IPR, patent pools can improve collaboration on research and development, e.g., in medicines WHO (2018).

[5]Even smaller cases are expensive: median total litigation costs for a patent infringement suit with a value below USD 1m are about 700,000 USD (in 2013-USD, AIPLA, 2013).

suits are made either individually or jointly by the patent owners (sometimes by majority vote) and administrators take the role of consultants for their members.

Policy makers and scholars underline positive effects of patent pools for owners of intellectual property rights and for consumers if the pool patents are complementary or blocking (Lerner and Tirole, 2004). Benefits for complementary patents are the improved information transmission between pool members and a decreased uncertainty of the value of the patent, e.g., due to the evaluation of patents prior to joining a pool.

Similar to patent pools are defensive patent aggregators that also bundle patents (either own or collect patents) for pure defensive purposes in lawsuits. Examples are the firm *RPX* that makes its patents available for use in counterlawsuits against nonmembers of an aggregator who initiate litigation against members (Hagiu and Yoffie, 2013). Some of the defensive aggregators publicly commit to not litigate for the purpose of revenue extraction which differentiates their business model from patent enforcement in court, the topic of this paper.

Standard-setting organizations (SSO) are voluntary membership-based organization that invite industry participants to develop standardized technologies (Baron and Ciaramella, 2017). Standards promote technical interoperability between products or product categories, e.g., Wifi or mpeg2. Standard-setting organization do not coordinate licensing negotiations (Baron and Spulber, 2018).

The definition of a new standard is mainly a technical process whereby often parts of the standard specification are covered by patents – often owned by separate firms. During the standard-setting process participants declare whether they own intellectual property rights that might infringe a future standard. A patent is declared essential if a standard is impossible to implement without the patent. Firms decide which of their patents is declared standard essential. Firms face a trade-off between over-disclosing their patents to avoid litigation and to under-disclose their patents to not reveal their R&D strategies (Schmalensee, 2009). SSO aim at promoting the adoption of new standards, for example, by reducing bargaining costs between members. Thus, many standard-setting organizations promote (publish) intellectual property rights of firms in exchange for their promise to disclose all their patents and license them at reasonable terms (Simcoe et al., 2009). To address excessive royalties, however, standard setting organizations mandate often commitments to moderate royalty rates, e.g., FRAND/RAND licensing terms (for a discussion see Bekkers et al. (2017)).

4 Empirical Analysis

4.1 Data

The final data set focuses on in-force U.S. patents related to the technological field of electrical engineering for the period 2000 to 2015 because much of the innovative activity is carried out in the U.S. Indicators show whether the patent is licensed through a patent pool, whether it is essential for a standard, and whether and by whom it was litigated. For the main empirical specification, I create a panel data set of patents over the years 2000 to 2015. Over time, patent owners enter/leave a patent pool, submit a declaration of standard essentiality, and file cases in court.

First, I use the universe of standard essential patents from the *SEARLE Center* database which comprises 20,153 standard essential U.S. patents which were declared essential to 25 standard setting organizations (Baron and Pohlmann, 2018).[6] I use observations for the U.S. between 2000 and 2015 to overlap with the information on litigation. In my estimations, I use the information whether a patent is essential to a standard and their indicator whether a patent is licensed through a patent pool (1,692 U.S. patents).

Since the *SEARLE Center* database does not have an indicator for all pool patents, in a next step, we complemented their data with self-collected patent numbers entering/exiting pools from Archive of the Internet (2018). My sample consists of 17,542 unique patent numbers (2,418 U.S. patents) in 30 unique pools between 2000 and 2015. The pools license patents for several technologies such as AVC, BlueRay, or DVD.

To identify the patent numbers from all infringement lawsuits filed in U.S. district courts, about 54,000 U.S. patents, I add the *Stanford PAE Litigation Data*. It also comprises the date of filing and categorizes plaintiffs in types, e.g., vertically integrated entities (Miller, 2018). In fact, patent owners are categorized into eleven types, see Table A1.[7] I am interested whether a patent is owned by a firm that is vertically integrated,

[6]Between 1980 and 1997 only 173 patents were declared essential and patent pools were allowed only after 1997. The number of declarations of SEPs are also lower after 2015, partly due to the lag in declaring SEPs. Some firms choose to submit so-called *blanket* disclosures which are unspecific letters of firms that inform the relevant committee at a standard setting organization about patents owned by that firm and potentially relevant for the standard.

[7]The column *litigation (all)* present the distribution for all available observations where most patents are litigated by product companies (50 percent) followed by owners of acquired patents (24 percent). The column *litigation (sample)* presents the classification for observations in the ICT industry. The distribution of litigation across types of patent owners is comparable to the full sample. The column *litigation (sep)* presents the classification for all lawsuits involving a patent classified as standard essential. The most

i.e., is a producing entity. Thus, I identify producers (and their IP subsidiaries) from the *Stanford PAE Litigation Data* and define all firms without a presence in a downstream market as non-producing entity, including startups, universities, and acquired patents.[8] I use a 75 percent sample of 41,667 litigated patents (which was available as of January 2018). Overall, 459 standard essential patents were involved in lawsuits compared to the overall number of 12,467 patents from the ICT industry.

Next, I merge the *OECD Patent Quality Indicators* database (version March 2017) which provides several indicators for the quality of patents capturing the technological and economic value of patented inventions. I use quality measures for USPTO patents, such as forward/backward citations/claims, and non-patent citations. Further, I use indicators for size and scope of the patent (family) and an indicators for breakthrough (top 1% cited patents in each cohort by technology field and year) and radicalness (sum of the weighted fractional counts of IPC 4-digit codes of patent j cited in patent p that are not allocated to patent p, over all backward citations) (Squicciarini et al., 2013). The measures are defined for 7.5m USPTO patents between 1976 and 2015. Patents are classified in 35 technological fields (Schmoch, 2008) and more than 95 percent of the standard essential patents are classified in the technological area of electrical engineering, e.g., semiconductors and telecommunication. To create a homogeneous sample of technologically similar patents, I restrict the sample to 2.9m patents in the technological area of electrical engineering. In a final step, I merge the Historical Patent Data from the *USPTO* (USPTO, 2017) to eliminate abandoned and pending patents.

4.2 Descriptives

I descriptively investigate how litigation rates differ across essential and pool patents and across firm types in Table 1. Litigation rates are the number of patent lawsuits relative to the overall number of patents in the relevant population, i.e., overall, standard essential and pool patents. The figures are interpreted as the rate of litigation in the respective class, e.g., on average 27.88 of $1,000$ standard essential patents are litigated during our

litigated types involve also product companies and acquired patents. However, the distribution across types shows more IP subsidiaries and more inventors involved in lawsuits than in the full sample. More information on the project of the Stanford Law School and on the classification method can be found on the website `https://law.stanford.edu/projects/stanford-pae-litigation-datasetwebsite` [accessed on 15 Aug 2017].

[8] The definition of the firm types follows the classification of the Stanford Law School (Miller, 2018).

observation period. Mean litigation rates are 7.04 for all patents, 27.88 for all standard essential patentsl, and 34.5 for pool patents. The figures indicate a more than 3-fold increase in litigation rates for standard essential and a more than 4-fold increase for pool patents compared to the overall average rate.

Mean litigation rates for patents enforced by vertically non-integrated IP firms are 2.09 overall, 7.59 for standard essential patents, and 3.64 for pool patents. For lawsuits involving only non-producing firms, the litigation rate, again increases about 3-fold from the overall rate to the rate of standard essential patents. For pool patents, however, the rate drops an increase of less than 2-fold compared to the overall rate. It seems that producing companies drive the litigation rate of pool patents, i.e., producers enforce patent rights more in pools.

The overall rates are similar to Lanjouw and Schankerman (2001) (without truncation) for the technology group of electronics. I find also relative higher litigation rates for standard essential patents, like Simcoe et al. (2009).

Figure 2 shows the number of cases differentiated by pool patents, standard essential patents, and patents in the same technological fields over the years 2000 to 2015. The left axis shows overall cases while the right axis shows the number of cases of litigated pool and standard essential patents. The number of overall litigation cases increased and tripled during the observation period. Litigation involving standard essential patents increases over time and occurs in three waves around 2006, 2009, and 2012. Litigation cases involving pool patents are overall lower with a constant trend and a peak in 2009.

In order to investigate the effect of standard essentiality and patent pools on litigation probabilities, I calculate litigation rates before and after the standard essential declaration in Figures 3. The year 0 is the year of the declaration of essentiality and about three years after the declaration litigation rates are more than double the previous rate. Litigation rates are the number of litigation over the number of patents in the random drawn sample.

Figures 4 shows the effect of patent pools on litigation rates before and after joining a patent pool. Litigation rates increase after joining a patent pool. Without claiming causality, the descriptives show that membership in a patent pool and standard essentiality are associated with higher litigation rates. Next, I estimate the effect of patent pools on litigation rates while controlling for standard essentiality.

Table 2 presents summary statistics of the data used in the empirical analysis. In general, litigated patents are of higher quality and are older than patents in the same technological class. While SEP tend to have broader claims, the quality index and the number of citations is highest for litigated pool patents. Overall, pool patents and standard essential patents are younger than other patents in the ICT industry. Litigated patents, however, are older than the comparison group while patents enforced by vertically separated IP firms are younger than the sample average.

4.3 Econometric Model

To test the impact of patent pools on litigation, I relate litigation to patent pool membership, standard essentiality, and a range of control variables. Using a panel data set of standard essential patents and a random control group from the same vintage, number of claims, and technological sub-field over time, I identify the effect of pool membership on litigation probabilities. The approach allows to control for patent fixed effects, e.g., unobserved quality, and reveals separately the effect of becoming a standard essential patent and of joining a patent pool on litigation. Taking into account the binary outcome variable *litigation*, I fit a maximum-likelihood probit model in the following form:

$$Pr(Lit_{jt} = 1) = F(a + \beta pp_{jt} + \gamma sep_{jt} + year_t + FE_j + \epsilon_{jt}) \quad (1)$$

where $Lit_{jt} = 1$ if patent j is involved in a litigation case in year t. A binary indicator for membership in a patent pool is pp and for a standard essential patent is sep, $year$ controls for years, FE controls for patent fixed effects, and ϵ is an error term.

Whether a patent is marketed in a pool is a strategic choice of the patent owner. Unobserved, time-varying characteristics of the patent or its owner might affect the decision to join a patent pool.[9] As an identification strategy, I use two instrumental variables to address the endogeneity problem, namely grant lag and the number of disclosure per patent. First, the decision to join a patent pool is driven by the innovators' experience, beliefs about the value of the patent and beliefs about the complexity of the standard. Experience and belief in the value of a patent can be approximated by the grant lag (Régibeau

[9] For example, Baron and Delcamp (2015) analyze entry of U.S. patents into seven modern patent pools and find that patents that are introduced later are narrower and non-significant. The effect is driven by patents included by incumbent licensors. New licensors tend to include patent of higher quality into existing patent pools. Baron and Pohlmann (2018) investigate how the announcement of a patent pool changes firms' incentives to innovate. They find increasing patenting activities after the announcement of the creation of a patent pool.

and Rockett, 2010). Grant lag measures the time of filing a patent and depends on how careful innovators complete the patent application procedure. I argue that the grant lag stems from behavior of the innovators (or the innovating firm) at the early patent life and is not correlated with the probability of litigation later in the patent life. If I include fixed effects in the estimations, I use the average yearly grant lag of the patent owner. Second, the decision to join a patent pool depends on the individual complexity of each standard and how closely a patent is linked to that standard. I argue that the number of disclosures per patent, i.e., how often a patent number comes up in the development of a standard, is a good approximation for how closely a patent is linked to a standard. Specifically, I count how often a patent shows up each year in the documents collected by the *SEARLE Center Database*. Further, I control for time-invariant characteristics of patents using fixed effects. Since standard setting is a decision of a group of voluntary industry participants, usually by voting, it is difficult for individual firms to steer whether standards develops into the direction of their patent portfolio. I assume that firms observe the development of a standard and declare their patents essential if they are relevant for the implementation of the standard (thus, I abstract from endogeneity issues arising from strategic declaration of standard essential patents). Due to the large number of fixed effects, I estimate the IV model as a linear fixed-effects model of the following form:

$$Lit_{jt} = \delta \tilde{pp}_{jt} + \zeta sep_{jt} + year_t + FE_j + \epsilon_{jt} \tag{2}$$

where $\tilde{pp}$ is instrumented as described above.

Next, I investigate how patent quality is related to litigation behavior using the panel data described above and transform it to a cross-section data set where each observation is one patent. Some have argued that quality can be used as a proxy for demand (Simcoe et al., 2009). Controlling for quality means that my estimates are net of any effects that increase demand for pool patents. The following estimation equation models litigation depending on patent pool membership, standard essentiality, and observed exogenous characteristics, e.g., quality. Again, I account for the endogenous choice of patent pool membership with the two instruments. To overcome the empirical difficulty of the binary depended outcome variable and the binary instrumented variables, I I fit a maximum-likelihood two-equation probit model (seemingly unrelated probit) as follows:

$$Pr(Lit_j = 1) = F(a + \lambda \hat{pp}_j + \mu sep_j + \xi quality_j + tech + cohort + \epsilon_j) \quad (3)$$

where $Lit_j = 1$ if patent j was ever involved in a litigation case. A binary indicator for standard essential patent is *sep*, quality is measured by *quality*, *tech* is a control for technological class, *cohort* for the cohort of the patent, and ϵ is an error term. I predict membership in a patent pool, $\hat{pp}$, with the second estimation:

$$Pr(\hat{pp}_j = 1) = F(a_2 + \rho sep_j + \tau quality_j + tech + cohort + IV + \epsilon_j) \quad (4)$$

where $\hat{pp}_j = 1$ if patent j is member of a patent pool and can take the value 1 or 0. I use instruments to predict membership in a patent pool, denoted IV. Particularly, I use the firms' involvement in standard setting and their beliefs in the value of the patent affects decision how to license, i.e., grant lag and the number of disclosures per patent.

To differentiate effects by firm type, in particular, lawsuits of practicing and non-practicing entities, I estimate the effects separately for lawsuits filed by vertically integrated manufacturers and non-producing IP firms. I use the same estimation strategies and instrumental variables for the estimations but the sample size is smaller for each firm type.

5 Results

Table 3 presents results for the effect of patent pools on litigation. Columns *Probit* present results from the Maximum Likelihood Probit model equation described in 1 and columns *IV* show results from the linear panel fixed-effect IV regression from equation 2. For the total sample, columns 1 and 2 show that pool membership is positively correlated even when controlling for SEP. Column 3 addresses endogeneity issues with IV and finds very similar results.

Firms protect their standard essential patents more by litigation. This finding is consistent with previous literature that patents that form the base of a technologically innovation are more often litigated due to the contractual difficulties to recoup the full rent with cumulative innovation (Lanjouw and Schankerman, 2001; Rockett, 2010).

Another channel that affects litigation probabilities is the fragmentation of patent rights which is reduced by patent pools. While some scholars claim that the fragmentation of ownership rights lead to more complex bargaining procedures (Heller and Eisenberg, 1998), others argue that the fragmentation of ownership rights facilitates negotiations outside court due to the lower value of each of the negotiations (Lichtman, 2006). However, when implementer of a technology with complementary patents need to negotiate with multiple owners, the value of each negotiation is lower to each of the potential licensors. The value added of each patent and expected damages decreases which results in a lower value of litigation (Lichtman, 2006). For example, the European Commission expects an increase in patent conflicts when more firms form traditional industries implement standardized technologies from the ICT industry such as IoT (Commission, 2017). My results show that the reduction in fragmentation leads to more patent conflicts in court.

In columns 4 to 6, we see that the effect is mainly driven by producing entities. Their pool patents end up more often in court when licensed in a patent pool. Non-integrated IP firms enforce more of their SEP in court while the additional effect of patent pools is negative (columns 7-9). Producing firms seem to drive the overall positive effect of pools on litigation behavior. They tend to enforce their patents stricter through pools than outside. This is coherent with the theory of raising rivals costs and with the finding that producing entities produce similarly costly cases than vertically separated IP firms (Lemley and Melamed, 2013). The results are in line with the proposition that patent holder who invest more in R&D and that hold larger patent portfolios are more likely to sue infringers (Bessen and Meurer, 2006). The results how that NPE do not achieve excessive rewards for their innovative contributions (Scott Morton and Shapiro, 2016).

The average marginal effect of the estimated coefficients help to quantify the effect of patent pools and essentiality on litigation (all results are statistically significant, tables not reported). For the total sample I find that patents from patent pools face a .4 percentage points higher probability of litigation. The probability of litigation is larger (.5 percentage points) for producing entities and negative (-.2 percentage points) for non-producing entities.

Table 4 presents the effect of pools, standard essentiality, and patent characteristics, i.e., quality, on the probability to litigate. Estimates from the columns *Probit* originate from a Maximum Likelihood Probit model. The columns *2-Probit* instrument the variable patent pool with *grant lag* and *disclosures per patent* implementing a Maximum-likelihood two-equation Probit model as described in equations 3 and 4. For the total sample, the effect of patent pool membership on litigation is again positive for columns 1 and 2. Further, patent quality measured by forward citations is positively correlated with litigation. Column 3 presents estimates for additional patent characteristics, such as non-patent literature citations and backward citations/claims which are all positively correlated with litigation. The measures for breakthrough and radicalness which originate in the *OECD* data are statistically not significant. Even controlling for a range of patent characteristics, e.g., quality, does not diminish the effects of patent pools on litigation. Columns 4-9 present separate results for vertically integrated producers and non-integrated IP firms. I show that producing entities litigate more often patent pool patents than non-producing entities, similar to the results in table 3. Quality affect litigation probabilities positively across all estimates.

Next, I address the questions how the quality of essential and pool patents affect litigation. Therefore, the estimation relates litigation to an interaction of essentiality and pool membership with the number of citations as a measure of quality. The results are from a Maximum Likelihood Probit model in table 5 show that overall litigation probabilities increase with quality and with the quality of standard essential patents. Regardless of the type of plaintiff, patents with more citations end up more likely in court. Higher quality patents from pools are, however, less likely to be litigated by producing companies (column 2). For litigation filed by IP firms, quality is positively associated with the number of citations and its interaction with essentiality and patent pool membership. The results suggest that producing entities enforce lower quality patents from pools while non-producing entities tend to litigate patents of higher quality from pools.

About 27% of all patents are litigated more than once. The figures are similar for SEPs and pool patents, 27% and 29%. Given the similar numbers of repeated litigation across all types of patents, I argue that a selection of more litigated patents in pools is not likely. As a robustness check, I estimate equation 2 with the number of lawsuits per patent as dependent variable and find similar results for signs and statistical significance (not reported).

6 Conclusion

Access to (prior) knowledge through research-enhancing institutions supports the exploitation, creation, and extension of a knowledge stock, for example, in Life Sciences (Furman and Stern, 2011). Institutions that facilitate low-cost diffusion of knowledge affect the creation of new knowledge, i.e., innovative products. By reducing transaction costs of patent transfers and by diffusing information about standard essentiality, patent pools play a role in transmitting and providing information on essential technologies necessary for the implementation of a standardized technology.

Over the last years, the standard setting process led to the formation of several patent pools to license out bundles of patents, in particular, in the information and communications technology industry. With complementary or blocking patents, patent pools can improve returns for innovators and increase welfare. At the same time, patent rights are probabilistic, subject to disputes, and increasingly litigated over the past decade. I investigate how patent pool patents are enforced in court in light of different market structures.

Using a sample of patents from the ICT industry, including an indicator whether the patent was declared essential or member of a patent pool, I control for quality, age, and technological field to estimate drivers of litigation. This paper finds that pool membership has a positive effect on litigation – even when controlling for standard essentiality, quality, age, and technological fields. I find that membership in a pool of complementary patents increases the likelihood of enforcing patents in court. The effect is driven by vertically integrated downstream manufacturers and in addition to the effect of standard essentiallity, a main driver of litigation probabilities. To address the endogenous selection of firms into patent pool, I use instrumental variables that proxy for the crowdedness of patents in the standard and for the belief of the applicant in the value of the patent. In particular, I use the the grant lag (time between application and granting of a patent) and the number of disclosures per patent as instruments for the decision to join a patent pool. The positive enforcement effect of producing entities prevails after addressing endogeneity issues with the instrumental variables. Vertically separated IP firms, however, enforce fewer pool patents in court although they file more lawsuits for their standard essential patents. I explain my results with the theory that producing entities impose costs of their downstream rivals through patent pool while this is impossible for vertically separated IP firms. The latter seem to face a stronger risk of counter-suits when they join a pool with downstream manufacturers. Overall, litigated patents are of higher quality and litigated standard essential patents are of even higher quality, similar to pool patents.

My analysis also tests the theoretical findings of Choi and Gerlach (2015) and Choi (2010) that predict less litigation with patent pools. I also find less patent enforcement in courts from non-integrated IP firms. They seem to settle conflict more easily within pools. An explanation for my (partially) contradicting findings for vertically integrated firms is that the pools in my sample do not contain many weak patents that needs to be protected from litigation. Particularly, all patents in the pool are essential to a standard and pools evaluated patent with respect to their quality/essentiality.

There are several caveats to the data: first, *blanket* declarations are not part of the data. Second, standard essentiality is defined by the owner of a patent and it is unobserved how relevant the declared patents are for the standard. Third, the market success of a standard or of a part of the standard is unobserved. Thus, the sample of standard essential patents does include some patents that are not relevant for the standard (false positives). Another caveat of the data is that the analysis only includes filed cases and outcomes are unobserved, for example, damages (liabilities) from infringers can reward patent holders while injunctions directly restrict infringing conduct. The form of liability can shape licensing agreement as outcome of negotiations between patent holder and licensee (Schankerman and Scotchmer, 2001). Lanjouw and Schankerman (2001) differentiate their analysis by type of lawsuit, particularly, by cases of patent infringement vs. the challenge of patent validity. The differentiation between lawsuits is not observed in my data and is left for future work.

In industries with a large number of complementary patents royalty rates can be excessive if the holder of a single patent has the power to extract more than her contribution to the final product. In order to exploit their patent individually, firms might be reluctant to join SSOs that require bundled licensing if individual patent owners are able to extract large royalties. Besides the hold-up problem, individual licensing raises transaction costs. Final goods might not come to market if producers face high costs of patent thicket. Therefore, many SSOs mandate some form of fair and reasonable royalty rates from their licensors. Coordination of technology sharing might work better with ex-ante than with ex-post licensing. Therefore, NPE might strategically hide their patents until firms invest in the implementation of a technology.

By analyzing litigation differentiated by firm type, my paper is related to the discussion on the role of non-integrated IP firm (patent assertion entities or non-practicing entities) in the market for patents (FTC, 2016; Contreras, 2016; Abrams et al., 2017). Non-integrated IP firm refer to the business model of acquiring patents from third-parties and asserting them against potential infringers. Non-integrated IP firm do not manufacture, distribute, or sell products and generate profits through patent assertion.

Since information on the patent quality and litigation are positively correlated (Lanjouw and Schankerman, 2001), pool patents are more litigated.

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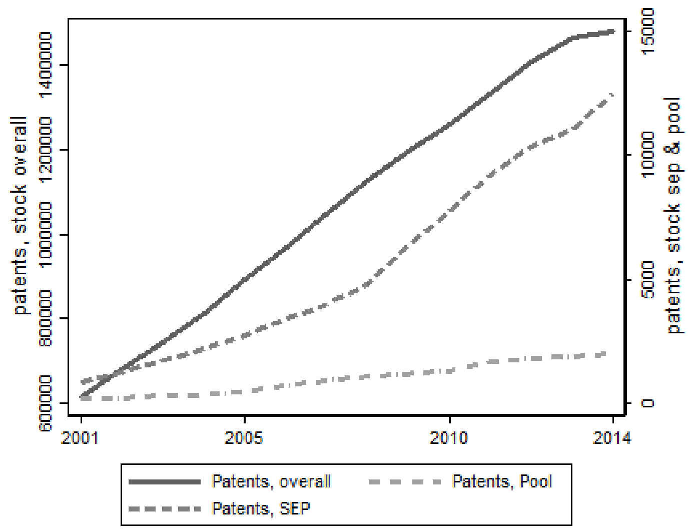
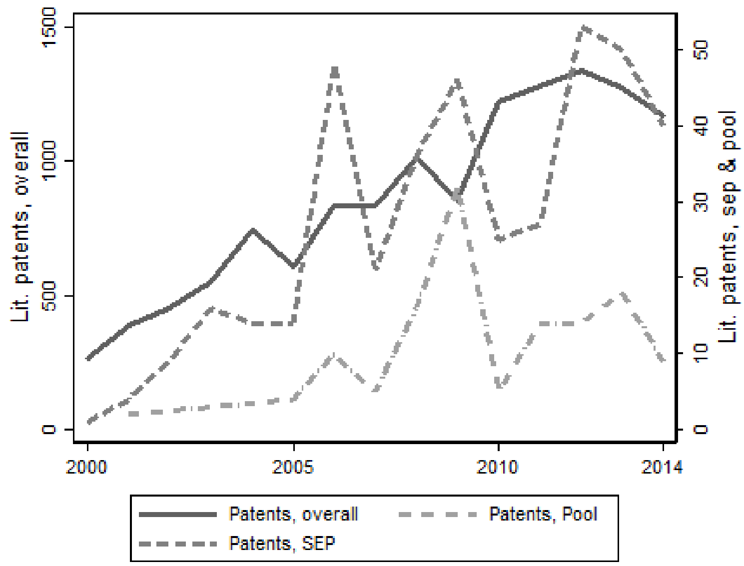
Figures and Tables

Figure 1: Stock of US Patents, SEP, and Pool Patent



Notes: The graph shows the number of patents, SEP, and pool patents over the years 2000 to 2014. The left axis shows overall number of patents and the right axis SEP and pool patents. Own data and data from the *Stanford Law School* and the *SEARLE Center*.

Figure 2: US Patents in Lawsuits by Type Over Time



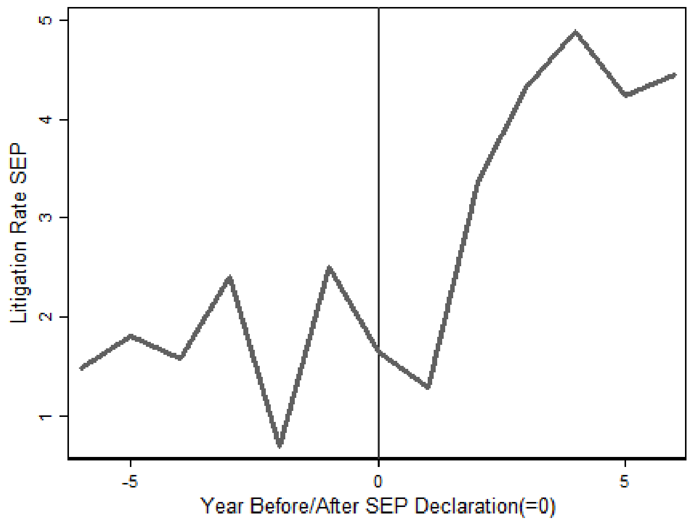
Notes: The graph shows the number of cases involving pool patents, standard essential patents, and patents in the same technological fields for the years 2000 to 2014. The left axis shows overall cases while the right axis shows the number of cases of litigated pool and standard essential patents. Own graph and data complemented by data from the *Stanford Law School*, and the *SEARLE Center*.

Table 1: Litigation Rates by Type of Plaintiff

	All	SEP	Pool
Rate overall, mean	7.04	27.88	34.5
Rate for IP firms, mean	2.09	7.59	3.64

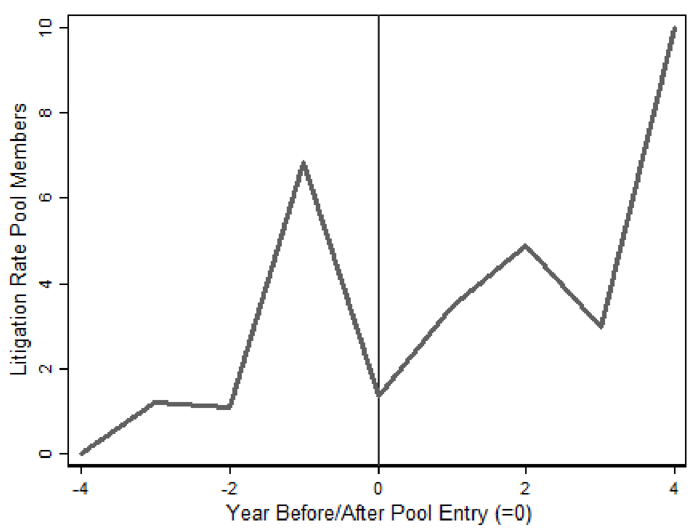
Notes: Litigation rates differentiated by non-vertically integrated IP firms and overall. Litigation rates are patent lawsuits per 1,000 patents relative to the overall number of patents from the same cohort (vintage) in the population of standard essential patents, pools, and overall. The figures are interpreted as the rate of litigation in the respective class, e.g., 27.88 of 1,000 standard essential patents are litigated during our observation period. SEP are standard essential patents and Pool indicates whether a patent is member of a patent pool.

Figure 3: Litigation Rates before/after SEP



Notes: The graph shows litigation rates before and after the declaration of standard essentiality. The year of the declaration of essentiality is zero. Own graph and data complemented with data from the *Stanford Law School* and the *SEARLE Center*.

Figure 4: Litigation Rates before/after Pool



Notes: The graph shows overall litigation rates before and after the entry in a pool for the years 2000 to 2014. Own graph with data from the *Stanford Law School*, the *SEARLE Center*, and the *OECD*.

Table 2: Summary Statistics

Status	Year of Filing	Claims	Quality (index)	Citations
Litigated pool patent	1998	20.85	0.43	52.67
NPE litigated pool patent	2002	23.40	0.53	165.40
Litigated SEP	1999	27.09	0.46	85.76
NPE litigated SEP	2003	25.75	0.46	82.35
Litigated patents	2000	26.60	0.41	54.94
NPE litigated patents	2000	29.64	0.41	58.24
Pool patents	2004	11.48	0.41	67.81
SEP	2005	20.70	0.39	39.04
ICT industry patents	2002	16.81	0.30	14.56
Total	2002	16.89	0.30	15.10

Notes: The table presents mean values by categories. Quality is a composite index that is, as all other measures, described in more detail in (OECD, 2017). Own data complemented with data from the *Stanford Law School*, the *SEARLE Center*, and the *OECD*.

Table 3: The Effects of Patent Pools on Litigation

	Litigation overall			Litigation by Producers			Litigation by IP firms		
	Probit	Probit	IV	Probit	Probit	IV	Probit	Probit	IV
Pool	.27***	.13**	.021***	.33***	.18***	.019***	-.13	-.26***	-1.5***
	(.045)	(.051)	(.0033)	(.046)	(.053)	(.0029)	(.086)	(.094)	(.08)
Essential		.25***	.0023***		.26***	.0036***		.2***	.32***
		(.026)	(.00088)		(.028)	(.00078)		(.044)	(.017)
Pool Patents			.00016***			.00019***			.003***
			(.000021)			(.000018)			(.00017)
Patent FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	326,530	326,530	326,530	324,501	324,501	324,501	320,656	320,656	320,656

Notes: Results of the effect of patent pools on litigation differentiated by the firm types *producer* and *IP firm*. Estimates from the columns *Probit* originate from a Maximum Likelihood Probit model controlling for patent fixed effects. The columns *IV* instrument the variable patent pool with *grant lag* and *disclosures per firm* estimating a panel IV equation controlling for patent fixed effects. Constants are not reported. Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Data from the *Stanford Law School*, the *SEARLE Center*, and the *OECD*.

Table 4: Cross-Section Litigation and Patent Pools

	Litigation			Litigation by Producers			Litigation by IP firms		
	Probit	2-Probit	Probit	Probit	2-Probit	Probit	Probit	2-Probit	Probit
Pool	.34***	.26***	.35***	.49***	.53***	.5***	-.16	-.57***	-.19*
	(.047)	(.087)	(.049)	(.051)	(.096)	(.053)	(.1)	(.11)	(.11)
SEP	.016***	.016***	.015***	.015***	.015***	.015***	.011	.0088*	.0089*
	(.0045)	(.0045)	(.0043)	(.0047)	(.0047)	(.0046)	(.0048)	(.0051)	(.0048)
Citations	.0013***	.0014***	.00093***	.0012***	.0012***	.001***	.0012***	.0015***	.00058**
	(.00016)	(.00017)	(.00021)	(.00017)	(.00019)	(.00023)	(.00018)	(.0002)	(.00024)
Citations (bw)			.0018**			.00068			.0026***
			(.00078)			(.001)			(.001)
Citations (npl)			.0058***			.004*			.0066***
			(.0015)			(.0021)			(.0018)
Claims (bw)			.019***			.02***			.0079
			(.0042)			(.0045)			(.0054)
Breakthrough			.092			.063			.2
			(.1)			(.11)			(.16)
Radicalness			.013			-.02			.11
			(.075)			(.09)			(.11)
Tech Field	yes	yes	yes	yes	yes	yes	yes	yes	yes
Cohort	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	32,858	32,858	32,858	32,673	32,673	32,673	32,435	32,435	32,435

Notes: Results of patent pools on litigation from cross section data. Estimates from the columns *Probit* originate from a Maximum Likelihood Probit model. The columns *2-Probit* instrument the variable patent pool with *grant lag* and *disclosures per patent* implementing a Maximum-likelihood two-equation Probit model (seemingly unrelated). Constants are not reported. Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Data from the *Stanford Law School*, the *SEARLE Center*, and the *OECD*.

Table 5: Litigation of High-Value Patents

	Litigation Probit	Litigation Prod. Probit	Litigation IP firms Probit
Pool	.026***	.62***	-.3**
	(.0038)	(.058)	(.13)
Citations	.00011***	.001***	.00083***
	(.000035)	(.00025)	(.00022)
SEP	.00034	.012**	.0091*
	(.00035)	(.0052)	(.0052)
Citations × SEP	.000086*	.00079***	.00061*
	(.000048)	(.00031)	(.00031)
Citations × Pool	-.00021***	-.0025***	.001*
	(.000047)	(.00054)	(.0006)
Tech Field	yes	yes	yes
Cohort	yes	yes	yes
N	32,858	32,673	32,435

Notes: The cross section probit model estimates the effect of patent pools on litigation. Fixed effects for filing year and for the technological class are included. Standard errors in parentheses. Constants are not reported. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Data from the *Stanford Law School*, the *SEARLE Center*, and the *OECD*.

Appendix

Table A1: Classification of Patent Asserters by Miller (2018)

Category	Litigation (all)		Litigation (ICT)		Litigation (SEP)	
	N	%	N	%	N	%
Acquired patents	9,605	24	2,322	18.63	79	16.42
University heritage or tie	92	0.23	10	.08	0	0
Failed startup	263	0.67	108	.87	0	0
Corporate heritage	270	0.68	142	1.14	0	0
Individual-inventor-started company	5,138	13	1,318	10.57	16	3.33
University/Government/Non-profit	666	1.68	234	1.88	40	8.32
Startup, pre-product	33	0.08	23	.18	0	0
Product company	19,617	49.62	7,171	57.52	221	45.95
Individual	2,989	7.56	504	4.04	8	1.66
Undetermined	16	.04	4	.03	0	0
Industry consortium	36	.09	74	.59	4	.83
IP subsidiary of product company	627	1.59	405	3.25	61	12.68
Corporate-inventor-started company	183	.46	152	1.22	52	10.81
Total	39,535		12,467		481	

Notes: Plaintiffs of patent litigation are classified in 13 distinct categories of which all but product companies and it's IP subsidiaries are non-producing entities. The column *Litigation (all)* presents the distribution for all available observations, the column *Litigation (ICT)* for all observations in the ICT industry, and the column *Litigation (SEP)* for all standard essential patents. Classification according to Miller (2018).