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Competing on Standards? Entrepreneurship, Intellectual Property and the Platform Paradox

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Abstract: *This paper studies the intellectual property strategy of firms that participate in the formal standards process. Specifically, we examine litigation rates in a sample of patents disclosed to thirteen voluntary Standard Setting Organizations (SSOs). We find that SSO patents have a relatively high litigation rate, and that SSO patents assigned to small firms are litigated more often than those of large publicly-traded firms. We also estimate a series of difference-in-differences models and find that small-firm litigation rates increase following a patent's disclosure to an SSO while those of large firms remain unchanged or decline. We interpret this result as evidence of a "platform paradox"— while small entrepreneurial firms rely on the openness in standards to lower the fixed cost of innovation and market entry, these firms are contrastively more likely to pursue an aggressive IP strategy that can undermine the openness of the standard.* JEL Codes: L0, O32, M13.

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1. Introduction

New technologies are often designed to be part of a platform – a system of independently supplied yet inter-operable components governed by shared technical standards. Many successful platforms, such as the Internet, the personal computer, and the cellular telephone, are based on *open standards*, meaning that any firm can access key components and interface technologies at little or no cost. These open standards are typically developed by voluntary Standard Setting Organizations (SSOs), which offer their members a quid pro quo: in return for the opportunity to promote their proprietary technology, and perhaps have it endorsed as an industry standard, firms agree to disclose relevant intellectual property (IP) and license it broadly (Chiao, Lerner and Tirole 2005).

While both large platform leaders (Gawer and Henderson 2007) and small entrepreneurs play an important role in the formal standards process, SSO intellectual property rules can present smaller firms with a conundrum. While small specialized technology firms are often anxious to see a standard emerge — especially if it will complement (or rely on) their proprietary technology —they typically cannot pursue the competitive strategy favored by large firms because they lack the downstream marketing, manufacturing and distribution capabilities needed to "cooperate on standards and compete on implementation" (IBM 2007). In fact, many small firms view the formal standards process as an attempt by other firms to secure cheap access to their proprietary technology. Large systems vendors generally take a different view. Many suspect that small players manipulate the standards process, and respond by accumulating a large stock of patents for defensive cross-licensing (Hall and Ziedonis 2001). We label this broad conflict faced by small firms over standards-related IP the *platform paradox*; open standards create favorable conditions for innovation by technology entrepreneurs while simultaneously providing them incentives for opportunistic behavior that can undermine a platform's openness.

This paper examines the intellectual property strategy of SSO participants and finds evidence of a platform paradox; specifically, large firms pursue a more liberal licensing policy than small ones following the creation of standard. Our evidence is based on patent litigation, which indicates that a patent-holder tried to assert its IP and that licensing negotiations were unsuccessful. To link individual patents to the formal standards process, we created a unique data set of 949 U.S. patents listed in the intellectual property disclosure archives of thirteen influential SSOs.

We find that SSO patents have a very high litigation rate (roughly six times that of a random sample from the same vintage and technology class), and that patents assigned to small firms are more likely to be litigated. However, we interpret these results as selection effects: firms disclose their most important patents, and a large firm's marginal disclosure is less important simply because they have a larger IP portfolio.

Our evidence for the platform paradox is based on changes in the litigation rate following disclosure. Specifically, we estimate difference-in-differences models that use patent-level fixed-effects to control for any time-invariant unobserved heterogeneity, such as differences in disclosure strategy. We find that litigation rates increase following the creation of a standard for patents assigned to small firms, but remain unchanged (or even decline) for patents assigned to large public firms. We find no comparable change in the relative citation rate of the small- and large-firm patents following disclosure, which suggests that our main results are driven by changes in licensing or litigation strategy, rather than unobserved shifts in demand (or infringement) that favor small-firm patents after the new standard is created.

The remainder of the paper proceeds as follows: Section 2 describes the standard setting process – particularly the importance of IP disclosure and "reasonable and non-discriminatory" (RAND) licensing rules – and develops a simple model of patent litigation. Section 3 describes our empirical methods. Section 4 discusses the construction of our data set and presents a number of summary statistics. Section 5 presents our main results – including the difference-in-differences models that show a significant divergence in the litigation rate for large and small firm patents after disclosure – along with several robustness checks. Section 6 concludes.

2. Formal Standards and Intellectual Property Strategy

Standards are an important part of the competitive landscape in information technology markets. This section describes several ways that formal standards are used, explains why firms are willing to contribute IP to these standards, and develops a simple model of patent litigation to motivate our empirical work.

2.1 The Role of Compatibility Standards

At a basic level, standards exist to promote inter-operability. For example, consumers expect any DVD player to work with a wide variety of television sets and to play DVDs released by any studio. Matutes and Regibeau (1988) were among the first to analyze the positive externalities associated with this type of "mix and match" compatibility, which is central to the basic idea of a platform.

Standards can also help firms or consumers make a coordinated transition between successive technology generations. In theory, markets with strong network effects might converge on inferior solutions or take "too long" to make a Pareto-improving switch (Arthur, 1989; Farrell and Saloner 1985). In practice, SSOs work to solve these problems by seeking the best available technology, and issuing a formal endorsement that serves as a focal point for consumers, perhaps leading to bandwagons in the adoption process. For example, Greenstein and Rysman (2007) describe how the ITU helped break a standards deadlock that slowed the adoption of 56K modems. Similarly, affixing the "Wi-Fi" label to the IEEE's 802.11g standard helped reassure end-users that new products would be compatible with the installed base of 802.11b equipment.

Standards are also used to lower the cost of innovation. By specifying a set of boundaries or "modules," standards reduce opportunities for differentiation in some dimensions of product design and promote experimentation in others (Baldwin and Clark 2000). For example, widespread adoption of the Internet's core transport protocols (TCP/IP) led to a proliferation of new technologies at the underlying physical or delivery layer.[1] Similarly, when IBM opened up the personal computer architecture, there was a great deal of entry and experimentation in the design of both PCs and peripheral devices (Bresnahan and Greenstein 1999). This experimentation corresponds to the first half of the platform paradox: by facilitating component-level innovation, standards promote entrepreneurship and an increased division of innovative labor.

However, standards can also be used to create or reinforce a position of market power. One such anti-competitive strategy is to delay or withhold important technical information from competitors. Mackie-Mason and Netz (2007) suggest that this strategy was used by members of the consortium that developed the USB 2.0 standard. Firms can also create market power by inserting patents into an industry standard. The most vivid example of this strategy comes from the Rambus case (Farrell et al 2004; Graham 2004).

Rambus participated in an SSO called JEDEC that was developing an open standard for memory chips. The evidence suggests that Rambus used information gained through its participation to ensure that its patents would cover the standard, but withdrew from JEDEC when the work was nearly complete (possibly to avoid any disclosure obligations). When Rambus sought to license its IP to firms using the JEDEC standard, there was a wave of public and private anti-trust litigation. Much of the litigation focused on Rambus' obligation to disclose its patent applications to JEDEC and subsequently license them on "reasonable and non-discriminatory" terms. Eventually, a

[1] These physical-layer protocols include ATM, DSL, Frame-relay, PPP, and several wireless standards.

unanimous ruling by the U.S. Federal Trade Commission found that Rambus violated JEDEC's membership rules, and placed royalty caps on the relevant patents.

2.2 Standards and Proprietary Technology

While Rambus' "submarine" strategy and the resulting litigation attracted a great deal of attention, it is important to note that JEDEC and most other SSOs do not prohibit IP in standards or the licensing of essential patents. Rather, these groups encourage *ex ante* disclosure of relevant IP, so members can evaluate the potential trade-off between technical quality and implementation cost. Most SSOs also seek a promise to license on "reasonable and non-discriminatory" (RAND) terms, which promotes widespread adoption of the final specification.[2]

In practice, the meaning of RAND and its European equivalent FRAND ("Fair" reasonable and non-discriminatory) is unclear. Lemley (2002) suggests that RAND represents a commitment to refrain from exclusive licensing and the use of injunctions during patent litigation. However, the question of "reasonable" pricing is murkier, and in some cases the courts are becoming involved.[3] One solution to this problem might be to encourage IP owners to commit to specific royalty rates before choosing standard. However, most SSOs prohibit any prospective discussion of licensing terms – generally citing fears of antitrust litigation.[4] Thus, while bilateral negotiations may take place on the side, the formal standards process does not typically produce common knowledge about expected IP prices. In fact, a standard RAND commitment seems to leave SSO participants with considerable flexibility to pursue an aggressive licensing strategy.

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[2] For a detailed discussion of how these IP rules fit into the broader process of standards creation see, for example, Cargill (1997), Lemley (2002), or Farrell and Simcoe (2007).

[3] *Nokia Inc. vs. Qualcomm Inc. Civ. A. No. 2330-N (Delaware).*

[4] This is changing. Some SSOs, such as the IEEE, now allow for *ex ante* disclosure of royalty caps as part of the IP disclosure process. Some of the SSOs' antitrust concerns were also addressed by the Standards Development Organization Advancement Act of 2004 (H.R. 1086), and recent statement from various antitrust agencies: see e.g. Majoras (2005) or the discussion in the FTC's unanimous Rambus opinion (FTC 2006, page 36).

Nevertheless, disclosure and the inability to grant exclusive licenses are a real cost for any firm that owns IP essential to the standard. What causes these firms to join an SSO? We suggest there are two types of private incentive: some firms join an SSO to promote *their own* technology, while others join to promote the creation of a standard based on *anyone's* technology. That is, firms can either "compete on standards" or "compete on implementation." For small firms, the incentive to compete on the former formula is, we contend, stronger: lacking the complementary assets necessary to compete downstream on implementation, small firms will seek profits upstream, around the standard itself.

Firms that compete on standards (within SSOs) can profit in a number of ways if their proprietary technology becomes a *de facto* standard. The most obvious is licensing, which can be extremely lucrative, even under a RAND policy. For example, Qualcomm's portfolio of CDMA cellular telephony patents generates several billion dollars of licensing revenue annually. There is also a "defensive" version of this strategy, where firms try to prevent an IP-rich company from controlling the standard, or contribute their own IP to ensure access to a less costly cross-licensing arrangement.

Firms may also compete on standards even if they do not expect to make money on licensing. In some cases, companies will give away the IP – usually via a royalty-free license or non-assertion covenant – in order to have a proprietary technology endorsed by the SSO. These firms typically hope to benefit from product development lead times, backwards compatibility, or the existence of proprietary complements. For example, Henderson (2003) describes how Ember hoped to create an advantage for its proprietary wireless networking systems by contributing to the IEEE 802.15.4 standards process and the ZigBee alliance.

While "competing on standards" clearly creates an incentive to participate in formal standards development, some firms (often those with interests in "implementation") join SSOs even if they do not have a specific technology to promote. Such firms naturally place more emphasis on the emergence of a high-quality standard. Often, they are large customers, systems vendors or "platform leaders" with a strong position in complementary markets. For example, Thomson (1954) describes the role of the major auto manufacturers in the standardization of a wide variety of parts and sub-assemblies. Similarly, Intel participates in a broad array of standards activities that could lead to new applications for its micro-processors, and IBM's increasingly co-operative patent licensing strategy reflects a broad move into computing services.

Though we refer to this strategy as competing on implementation, it is analogous to the principle of "internalizing complementary efficiencies" (or ICE) described by Farrell and Weiser (2003). They discuss a monopoly platform provider's incentive to promote the efficient organization of vertically-related complements markets (calling it a variation of older Chicago-style "one monopoly rent" arguments). In our setting, standards based on cheap and widely-accessible technology will be attractive to large systems vendors because such openness mitigates the "patent thickets" problem (i.e., complementary upstream monopolies) and promotes investment by reducing the threat of hold-up (Shapiro 2001; Farrell, Hayes et al 2007).[5]

We expect that the distinction between competing on standards and competing on implementation generates variation in firms' IP strategies. Longitudinal variation will be driven by the creation of new standards and technology life-cycles. Cross-sectional variation will be driven by differences in size – especially where it is related to manufacturing, marketing or distribution capabilities, or a presence in complementary markets that make it more attractive for large firms to compete on implementation. A natural place to look for evidence of these broad differences in intellectual property strategy would be data on patent licensing. Unfortunately, it is very difficult to collect

[5] Farrell and Simcoe (2007) also suggest that "vendor neutral" participants can also improve the efficiency of the formal standards process. Gawer and Henderson (2007) offer an interesting discussion of how Intel may commit not to compete too hard in complementary product markets – a problem that is analogous to pursuing a liberal licensing policy.

licensing data, as most firms hold these agreements in strict confidentiality (often because of legal restrictions). As a result, we use data on patent litigation.

2.3 Patent litigation: a simple model

There are two necessary conditions for a patent lawsuit to be filed. First, the patent-holder must try to assert its IP, and second, the bargaining process must fail. There is often some confusion on the first point, since some patent suits are filed by the accused infringer and focus on the issue of patent validity. However, until the *Medimmune* case in 2007, the law was clear that a non-patentee could not initiate an invalidity suit unless it faced "an explicit threat or other action by the patentee [suggesting an imminent] infringement suit."[6] Therefore, no suit in our data could arise unless the patentee was actively enforcing the patent. The second point raises a question that has received a great deal of scholarly attention: why couldn't the two parties bargain to a more efficient outcome?[7] This sub-section addresses that question using a simple model based on the discussion in Lanjouw and Lerner (1998).

Consider a two-period bargaining game played between a patent-holder i and potential infringer j. If the players reach an agreement in the first period, the game ends, otherwise the dispute goes to court. If the patent-holder wins in court, the infringer will be forced to pay damages of $\$D$, with no payment in the event of a loss. The total expected cost of litigation is $\$C$ and that the plaintiff and defendant place the probability of winning a trial at b_i and b_j respectively. We assume that first-period bargaining is costless, and that an agreement will be reached as long as the first-period surplus exceeds the players' joint payoff from going to court. Given these (very stylized) assumptions, the two parties will enter litigation if and only if

[6] Sierra Applied Scis., Inc. v. Advanced Energy Indus., Inc., 363 F.3d 1361, 1373 (Fed. Cir. 2004) (quoting BP Chems. Ltd. v. Union Carbide Corp., 4 F.3d 975, 978 (Fed. Cir. 1993)). Overturned by MedImmune, Inc. v. Genentech, Inc.,127 S. Ct. 764 (2007).

[7] The American Intellectual Property Law Association (2007) provides some estimates of the direct costs of patent litigation. They suggest that suits between $1-25 million in patent value cost litigants on average a total of $2.5 million through discovery, and $5 million through trial.

$$D(b_i + b_j - 1) > C \qquad (1)$$

The logic is straightforward. Litigation is only observed when the total expected value of going to trial, $Db_i - D(1-b_j)$, exceeds the total cost, because otherwise there must be some side-payment less than C that will make both players better off. This model is a simplified version of the well-know divergent expectations hypothesis; litigation occurs only if $b_i+b_j > 1$, which implies that one or more players over-estimates its chance of winning.

A variety of incomplete information models relax the assumption of inconsistent posterior beliefs, and generate litigation based on inconsistent priors (e.g. Nalebuff 1987; Spier 1992). These models typically place more structure on the bargaining process, and allow the players' to reveal private information about D or C as part of the litigation (e.g. during discovery). However, compared to other types of litigation, the parties in a patent suits are sophisticated, and have detailed knowledge of the relevant technology. Thus, we focus on an alternative story – based on the idea that litigation is not necessarily a zero-sum game.

Suppose the plaintiff's expected value of going to court in our model is actually αD (where α could be greater or less than one). In patent litigation, the potential loss of a monopoly will frequently lead to α greater than one. Going to trial might also help a patent-holder establish a reputation for "tough" bargaining, or to win a validity ruling that would increase the value of their IP. On the other hand, litigation can generate negative externalities – particularly for large systems vendors – by destroying goodwill, inducing wasteful efforts to invent around a patent, and perhaps reducing the long-run levels of entry and innovation in complementary markets. There may also be asymmetries in the expected cost of litigation. For example, practitioners often suggest that asset-intensive firms are hesitant to litigate because they fear that counter-suits could lead to costly injunctions.

Whatever the cause, if litigation creates positive externalities (α>1) for a plaintiff, the negotiation surplus shrinks and the likelihood of settlement becomes smaller.[8] In particular, our simple model predicts litigation whenever

$$D(\alpha b_i + b_j - 1) > C \qquad (2)$$

How, then, do standards influence the propensity to litigate? In general, there are two possible channels: demand and litigation incentives. Suppose that X_{ikt} is a vector of observable characteristics for patent k (owned by firm i) at time t, including an indicator variable s_{ikt} which equals 1 if the patent is essential to implement an industry standard. We model demand as the total number of potential infringers $N(X,s)$. Litigation incentives are the probability that Equation (2) is satisfied. To simplify matters, we make the (standard) assumption that D is proportional to C, and let b_j be an independently distributed random variable, so the average litigation propensity can be written as $P(X,s)$.[9] Thus, when N is large and P small, the total amount of litigation for patent k can be approximated by a Poisson distribution with mean:

$$E[Suits_{ikt} \mid X,s] = P(X,s)N(X,s) \qquad (3)$$

Equation (3) provides the basis for our empirical tests, which measure the impact of disclosure on litigation, and perhaps more importantly, examine whether this effect is larger for specialized entrepreneurs who "compete on standards" than for large systems vendors that "compete on implementation." The central empirical challenge will be to control for unobservables that correlate with both disclosure and litigation, and distinguishing between the demand effects (changes in N) and incentive effects (changes in P) created by standardization. Our basic strategy is to estimate difference-in-

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[8] Farell and Shapiro (2007) point out countervailing externalities that may encourage a defendant to settle. In particular, fighting to invalidate the plaintiff's IP is akin to providing a public good and we naturally expect some free-riding.

[9] For example, if b_j has a Gumbel distribution $P(X,s)$ will be logistic with mean $exp\{C/D+1-b_i\} / (1+exp\{C/D+1-b_i\})$. Of course, this formulation abstracts from a number of potentially interesting complexities, such as the endogeneous ordering of potential targets for litigation.

difference models that contain patent-level fixed effects and exploit the time-series variation associated with standards creation.

3. Methods

An ideal approach to measuring the impact of formal standards on litigation would be to identify a significant coordination problem, along with a feasible set of substitute technologies, and randomly assign one technology to be the standard. Given a large number of these random trials, we might compare the subsequent litigation rates for large and small IP-holders. Unfortunately, we have neither a controlled experiment nor an instrumental variable that will exogenously cause SSOs to favor a particular technology as the standard. So, we turn to non-experimental methods that exploit variation over time caused by the standards process itself.

We begin by specifying the probability of litigation $P(X,s) = exp\{\beta_1 X_{ikt} + \theta s_{ikt}\}$ and demand for the intellectual property $N(X,s) = exp\{\beta_2 X_{ikt} + \eta s_{ikt}\}$.[10] Equation (3) then suggests the following linear model:

$$Log(Suits_{ikt}) = X_{ikt}\,(\beta_1+\beta_2) + s_{ikt}\,(\theta+\eta) + \varepsilon_{ikt} \qquad (4)$$

This equation highlights the two main issues we confront below. First, in a cross-sectional regression, s_{ikt} is very likely to be correlated with unobserved variables that enter a firm's litigation decision through ε_{ikt}. And second, the data do not separately identify standards' impact on litigation incentives θ from their impact on demand η.

We address the first issue by restricting attention to SSO patents and examining changes in litigation rates. In particular, we add patent fixed effects to equation (4) to capture any time-invariant unobserved heterogeneity.[11] In these models, our estimate of the

[10] The exponential is a convenient functional form for $P(X,s)$ and provides a reasonable approximation to the logistic for small litigation probabilities.

[11] In practice, we estimate Poisson quasi-maximum likelihood models with conditional fixed-effects, so only litigated patents actually enter the estimation sample.

standards effect $(\theta+\eta)$ will be identified by comparing changes in the litigation rate of disclosed patents to changes in the litigation rate of undisclosed patents that will eventually be revealed to an SSO. If the timing of the formal standards process were exogenous, we could interpret these estimates as the causal impact of standardization on the litigation rate of disclosed patents (i.e., the impact of the treatment on the treated). However, the creation of new standards is likely correlated with time-varying shocks in the importance of particular technologies. Thus, our interest will center on a different question: do large and small firms respond to these standards-related technological shocks differently?

To answer this question, we create an indicator variable E_i that equals one for small firms (entrepreneurs) and interact it with the time-varying standardization dummy s_{ikt}. This leads to the following specification, where γ_k are patent fixed-effects, λ_t a set of time-period effects, α captures the small-firm incentive effect, δ reflects the small-firm demand effect, and ε_{ikt} is a patent-specific time-varying error component that is uncorrelated with the explanatory variables:

$$Suits_{ikt} = \gamma_k + \lambda_t + X_{ikt}(\beta_1+\beta_2) + s_{ikt}(\theta + \eta + E_i(\alpha + \delta)) + \varepsilon_{ikt} \quad (5)$$

By including patent fixed-effects, we control for time-invariant factors that might lead to differences in the litigation rate across firms (e.g. systematic differences in patent quality driven by disclosure strategies). By focusing on the interaction effect $(\alpha + \delta)$ we turn our attention from identifying a causal standards effect to a test of our informal platform paradox hypothesis.

While we might like to include a set of patent-age effects in equation (5), these are not separately identified in a linear model with a full set of time-dummies and patent fixed-effects, since age equals calendar-year minus grant-year (which will be absorbed in the patent fixed-effects). However, it is possible to examine correlations between a patent's age and the *difference* between large- and small-firm litigation rates. We are particularly interested in showing that there is no secular trend in this difference prior to disclosure, which would raise questions about the exogeneity of disclosure-timing. We test for a difference in pre-disclosure litigation trends by interacting a time-trend with a pre-disclosure dummy and the small-firm indicator E_i.

Finally, equation (5) shows that our identification strategy can only identify the joint impact of changes in litigation incentives (α) and demand (δ) for standards-related IP. Without more data, it is not possible to dis-entangle these effects. So, the last step in our analysis uses patent-citation data as a proxy for demand to test the hypothesis that $\delta > 0$. Specifically, we estimate (5) using citations as the dependent variable and test whether the interaction between disclosure and the small-firm indicator variable is positive. If we reject the null-hypothesis that $\delta > 0$, any heterogeneity in the demand effects of standardization will create a downward bias for our estimates of the difference between large and small-firm litigation incentives. In other words, $(\alpha + \delta)$ would be a lower bound on the size of the platform paradox.

4. Data

Our data were collected from publicly available SSO IP disclosure archives, the NBER US patent database (Hall, Jaffe and Trajtenberg 2001), the Derwent LIT/ALERT patent litigation database, the U.S. Federal Judicial Center, CompuStat and Venture Economics. This section discusses our main data sources and presents a series of firm and patent-level summary statistics.

3.1 Standard Setting Organizations and IP Disclosures

We began by identifying fourteen SSOs (listed in Table 1) with publicly-accessible IP disclosure archives. The scale and scope of these institutions varies substantially, with two large umbrella organizations, the American National Standards Institute (ANSI) and the International Organization for Standards (ISO), at one end of the spectrum and several small consortia such as the DSL Forum, ATM Forum and Multi-Service Switching Forum (MSSF) at the other.

Collectively, these fourteen SSOs have developed a large number of commercially significant standards. Prominent examples include Ethernet (IEEE), the 802.11 or Wi-Fi protocols for wireless networking (IEEE), core Internet protocols such as TCP/IP (IETF), cellular telephony protocols such as CDMA and TDMA (ATIS and ETSI) and various modem protocols (ITU and DSL Forum). While several of the larger SSOs (e.g., ISO and ANSI) develop safety and quality standards, nearly all of the patent disclosures are related to compatibility standards used for information and communications technologies.[12]

For each SSO, we collected all disclosures made through July 2006. A disclosure is typically a letter or e-mail message indicating that a firm owns relevant IP that it is willing to license on RAND terms. While each disclosure contains a firm name and date, not every disclosure lists a specific piece of intellectual property. In particular, there are a number of "blanket" disclosures that do not mention any specific patent or application numbers. (Figure A.1 in the Appendix reproduces two letters from our sample to provide a sense of the heterogeneity in disclosure practices.)

We pause here to offer several caveats about the disclosure data. First, we do not observe whether a given standardization effort was successful or a particular piece of IP was actually essential to the final specification. Thus, our sample of disclosed patents is likely to contain a number of false positives (i.e. disclosures where the standard failed or the SSO chose an alternative technology). We expect these patents to bias estimates of the standards effect downwards. This issue could present a problem for our analysis if large firms' non-essential IP was more likely be litigated before disclosure. However, if

[12] Table A.1 in the Appendix contains a short description of the fourteen SSOs in our study. Table A.2 in the Appendix shows that ninety-nine percent of U.S. patents in our data have a primary (3-digit) technology classification of Computing, Communications, Electrical or Electronic technology.

this effect were large, we would expect it to become evident in our tests for a difference in the pre-disclosure litigation trends.

Second, disclosure is clearly not exogenous. We expect disclosed patents to be among the most important in a firm's IP portfolio, and disclosures to be concentrated in the most important and commercially relevant standards efforts. Thus, when we compare SSO patents to various "control" samples below, the controls are meant to provide a measure of the average patent, rather than a true counter-factual. And finally, since our results are based on patents that were specifically identified in a disclosure letter, they are not likely to reveal anything about the prevalence of "hold-up" strategies – where a patent-holder pushes for a particular standard while keeping its IP secret, as in the Rambus case.

Figure 1 shows the increase in IP disclosure over time and Table 1 presents a number of summary statistics for our sample of disclosures. The first two columns in Table 1 indicate that we reviewed 2,558 disclosure letters, of which 969 were blanket disclosures. There is substantial variation across SSOs in the number of IP documents listed per disclosure. For instance, the average ETSI disclosure listed 42 separate patents or application numbers (many from international jurisdictions), while the average TIA disclosure listed 0.2 pieces of IP. Our review identified 2,049 U.S. patents and 224 application numbers that matched to a U.S. patent.

The evidence in Table 1 suggests that disclosure norms at ETSI are quite different from the rest of the sample. In particular, many firms appear to have "dumped" their patent portfolios into the standards process. For this reason, we exclude ETSI from the remainder of our analysis. However, we have run all of the regressions with ETSI included in the sample and find qualitatively similar results.[13]

[13] These results are available from the authors upon request.

3.2 SSO Patents

We matched all of the U.S. patents in our sample of disclosure letters to the Derwent LIT/Alert database as well as an augmented version of the NBER U.S. patent database.[14] The Derwent litigation data are based on court records provided to the USPTO, and their strengths and weaknesses are discussed in Lanjouw and Schankerman (2003). Table 2 compares a series of sample means for the SSO patents to several sets of matched controls.

The left-most panel in Table 2 compares all SSO patents (excluding ETSI) to a randomly selected control sample that matches on grant year, three-digit technology classification, and assignee country.[15] The first eight rows examine litigation patterns. SSO patents have a substantially higher litigation rate than an average patent (9.4 versus 1.7 percent) and this difference increases with a patent's age (e.g. the difference is 14.2 versus 2.0 percent for patents granted before 1994). This age effect may reflect truncation, since older patents are exposed to the risk of litigation for a longer period of time, or a selection effect, since past litigation may increase the probability of disclosure to an SSO. Conditional on litigation, there is little difference in the number of lawsuits or named defendants per patent. However, the SSO patents are roughly 2.5 years older than the controls when first litigated. Finally, we find that 28 percent of the SSO patents are involved in litigation *before* they are disclosed to an SSO. Since lawsuits tend to attract a great deal of attention, this last fact may suggest that some disclosures are less about revealing the existence of essential IP than signalling the strength of a firm's patent portfolio.

The next six rows in Table 2 examine a number of patent quality measures that have appeared in the empirical literature. These measures are forward-citations (i.e. cites received), backwards citations, citations to non-patent prior art, the number of claims,

[14] Since many of the data elements are available in the NBER database are available only through 1999, and none after 2002, we found it necessary to update the data.

[15] Our assignee countries are really continents – i.e. either the US or the rest of the world.

and the "generality" index of Jaffe, Trajtenberg and Henderson (1993), which indicates that a patent is cited by a more diverse array of future inventors. Not surprisingly, we find that SSO patents score substantially higher than an average patent along almost all of these quality dimensions.

The last five rows in Table 2 compare the SSO and matched control patents in terms of assignee characteristics. While it is not surprising that the SSO and control samples are indistinguishable (this was the point of the matching exercise), it is worth noting that 11 percent of the SSO patents are assigned to individual inventors, universities, governments or other non-corporate entities.

The central panel in Table 2 (columns 4 through 6) pairs each SSO patent with a matched control patent having the same grant year, technology category[16] and assignee. This panel contains a smaller number of patents, since we could not obtain matched controls for unassigned patents and some of the smaller firms. Overall, the results confirm our intuition that the disclosure process selects for important patents. Once again, the SSO patents are more likely to be litigated – especially as they get older – and score higher on all of the quality measures (except for non-patent prior art cites).

Finally, the right-most panel in Table 2 (columns 7 through 9) compares the SSO patents to a set of matched controls with the same grant-year, technology category, assignee-country and cumulative citation count.[17] Our goal in this matching exercise was to determine whether forward cites – perhaps the most widely used measure of patent quality – would capture a substantial amount of the variation in litigation rates. They do

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[16] In order to generate more matches, we expanded the technology classifications to the NBER sub-category level.

[17] Since it was difficult to draw an exact match when cumulative citations are large, we simply drew the control patent that matched on all other characteristics and had the next highest citation count (after the focal SSO patent). We had to drop 9 patents from the SSO sample in the matching process because they were the most highly cited patent in a particular grant-year technology-class cell, so that no comparable control patent could be identified.

not. While the litigation rates in this control sample are slightly higher, they do not approach those of the SSO patents – in spite of the fact that the controls score slightly higher on all of the citation-based quality measures by construction. Once again, these results highlight the idea that disclosure is correlated with unobserved patent characteristics that influence the litigation process. For this reason, we discard any pretence of constructing a matched control sample and focus on the SSO patents in our main analyses.

3.3 Entrepreneurs and Systems Vendors

Identifying individual firms represents a major challenge in any research that relies on patent data. We use the assignee codes contained in the NBER patent data as our starting point.[18] Unfortunately, many patents are assigned to subsidiaries or related entities, and ownership can change over time. As a result, we undertook an extensive effort to identify the parent firm for every assignee in our data, using a variety of corporate directories as well as the Internet. Through these efforts, we identified 190 unique parent-firms that disclosed one or more SSO patents.

For 126 parent-firms that were traded on a public stock-exchange at some point in time, we also obtained CUSIP numbers, and (whenever possible) CompuStat data on Employees, Assets, and R&D expenditures.[19] While we would like to track changes in patent ownership over time, this did not prove feasible. Thus, a potential weakness of our analysis is that each patent retains its affiliation with the original assignee. We did experiment with measures that might capture significant changes in ownership (e.g. dummy variables for entering or leaving the CompuStat database) and found that it produced no changes in our results.

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[18] These data have been updated and can be found on Bronwyn Hall's web site. We also used the Compustat name matching programs created by Bronwyn Hall and Megan MacGarvie as the starting point for our own name matching algorithms.

[19] Wherever possible, these data are for the application year of a given patent, though we settled for the closest available year in several cases.

Since our empirical tests focus on the difference between large and small firms – where size serves as a crude proxy for vertical specialization – we constructed a binary size measure that plays a central role in the analysis. Specifically, we define as "small" vertically specialized entrepreneurs a set of 72 firms that were either privately-held or were public but had fewer than 500 employees (averaged over all available years). The remaining 118 public firms we defined as "large" systems vendors. While the cutoff at 500 employees is arbitrary, our results do not change if we choose a random threshold anywhere between 50 and 3,000 employees. The main point is to separate the small publicly traded firms with a relatively small number of employees from the large enterprises with several thousand.

Table 3 compares sample means (at both the firm and patent level) for the large and small firms in our data set. The first two rows in this table show that small firms disclose patents to fewer SSOs and have a smaller cumulative patent portfolio. By comparing sample-sizes in the top and bottom-half of the table, we can also see that small companies disclose fewer US patents per firm. The third and fourth rows in the top panel of Table 3 report our use of a Herfindahl measure of patent technology classes to show that small-firm patent portfolios are more concentrated.[20] The final rows in the top panel show that large systems vendors are older, have more employees (compared to publicly-traded small firms), and are less likely to have received venture capital funding (i.e. appear in the Venture Economics data).

The bottom panel of Table 3 presents patent-level summary statistics. The first row shows that patents disclosed by small firms have a significantly higher litigation rate – particularly those granted before 1998. We find little difference in the numbers of lawsuits or named defendants per litigated patent. And while the large-firm patents are five percent more likely to be litigated before disclosure, this difference is not

[20] This measure is based on 10 years of patent data and was constructed using the 3 digit U.S. patent classification scheme.

statistically significant. While small- and large-firm patents receive a similar number of forward cites, the small firm patents have later grant years, and so are cited slightly more often per year. Finally, the small firms are more likely to use the continuation procedure – potentially a method for "hiding" a patent inside the USPTO – when acquiring a disclosed patent (Graham and Mowery, 2004). Overall, the comparisons in Table 3 suggest that the entrepreneurs in our data set are in fact smaller and more vertically specialized than the large systems vendors.[21]

5. Results

This section begins with a set of descriptive probit regressions before turning to our main difference-in-differences analysis. After presenting the difference-in-differences results, we perform a series of robustness checks, including the patent/citation analysis described above.

5.1 Descriptive Probits

We begin by estimating a series of probit regressions in order to characterize the cross-sectional litigation patterns in our sample. These results are primarily descriptive, since firm- and patent-level (unobserved) heterogeneity presumably play an important role in the litigation process. In Table 4 we report marginal effects from these probit models, along with robust standards clustered by disclosure, and a baseline litigation rate calculated at the means of the independent variables. (For a complete set of variable definitions and summary statistics, see Table A.4 in the appendix.)

The first column in Table 4 emphasizes variation in the size of the "selection effect" (i.e., the difference between SSO and matched control patents) across SSOs. For this model, the estimation sample includes all patents in the first panel of Table 2, and we create five SSO categories; one each of the four largest organizations (ANSI, IEEE, IETF, ITU) and a

[21] Table A.3 in the appendix lists the top-ten entrepreneurs and systems vendors based on a count of disclosed patents. Several of the entrepreneurs clearly fit into the vertically specialized category. For example, Interdigital earns all of its revenue from licensing, and Verisity Design is a "fabless" semiconductor company. The second half of table A.3 lists the most common plaintiffs and defendants in our litigation data.

composite group ("Other") that includes the remainder. The specification includes an unreported set of "main effects" to capture between-SSO variation in the control patent litigation rates (e.g. from differences in technology), a full set of interactions to measure the SSO-specific selection effects, and a full set of assignee-type effects.

The results in the first column of Table 4 show that small-firm patents are substantially more likely to be litigated (an increase from 3.4 to 9.2 percent). Not surprisingly, all of the SSO effects are substantial, though not all statistically significant. ANSI has the largest selection effect – almost 30 percentage points – and the body with the smallest SSO effect (ITU) still increases the baseline litigation rate by 200 percent (a Wald test does not reject the hypotheses that all of the SSO effects are equal). While we do not report those assignee-type effects that are not statistically significant, it is worth noting that SSO patents assigned to individual inventors and universities are litigated somewhat more often than those assigned to firms.

In the second column of Table 4, we drop the matched control patents from our estimation sample (noting that the baseline litigation rate nearly doubles) and add a series of patent level control variables. Once again, the marginal effect for a small-firm dummy is large and statistically significant. We find no correlation between the litigation rate and a patent's age at disclosure or disclosure year, though it is possible that secular trends in the overall litigation rate are picked up by the grant-year effects. We do find a significant positive correlation between litigation and forward citations. Litigation is also correlated with the continuation procedure (one interpretation of this result is that lawsuits select for patents with an early priority date). Finally, the SSO coefficients at the bottom of column 2 show that while ASNI patents have the highest litigation rate, none of the between-SSO differences are statistically significant.

In the third and fourth column of Table 4, we divide the sample into small- and large-firm patents and re-estimate the model of column 2. This exercise reveals several interesting observations. First, the correlation between litigation and use of the continuation procedure is primarily driven by large-firm patents. This result is not surprising in light of Table 3, which shows that the continuation rate for small-firm patents is almost 80 percent. For small-firm patents, there is a strong negative correlation between non-patent prior art citations and litigation. Finally, it is interesting to compare the SSO effects across columns 3 and 4 (noting that ANSI is the omitted category and the baseline litigation rates are similar). While large firm patents are more likely to be litigated at the ITU, there is a substantial (though imprecise) increase in litigation among small-firm disclosures in the "Other" group.

The last column in Table 5 adds firm-size and financial variables for a sub-sample of 626 patents that could be matched to CompuStat.[22] These patents are concentrated among the large firms by construction, since CompuStat contains only publicly-listed firms. Once again, the results suggest a negative correlation between firm size and litigation. In particular, the coefficient on the log of assets per employee is negative and significant, while patenting intensity (patents per R&D dollar) produces the opposite sign. Moreover, when these measures are excluded, the coefficient on the log of employees becomes more negative and statistically significant. Interestingly, there is a weak positive correlation between litigation and disclosure year in this specification, suggesting that the largest firms are becoming somewhat more litigious over their IP in standards over time.

5.2 Difference-in-differences models of patent litigation

Overall, the descriptive probit regressions suggest that small-firm SSO patents are more likely to be litigated. Of course, this could easily reflect differences in disclosure strategy. In particular, since large firms own and disclose more patents, the marginal disclosed patent may be less important, and therefore less likely to be litigated. This effect may be further exacerbated by a tendency in small firms, with relatively fewer resources, to

[22] Wherever possible, these data are taken from the patent's grant-year.

focus their patenting activity only on those technologies that are necessary to the firm's business model. In this sub-section we address these selection problems using patent fixed-effects.

Figures 2.a and 2.b provide a graphical intuition for our identification strategy and the main results. These figures compare the litigation rate (i.e. lawsuits per patent) for patents assigned to small and large firms over a 20 year window, centered on the year of disclosure (Figure 2.a shows the litigation rate for all patents; only litigated patents enter the denominator in Figure 2.b). In both graphs, there is a sharp increase in the litigation rate for small-firm patents in the disclosure-year, followed by a substantial increase over the next five or six years. In contrast, the large-firm litigation propensity seems to increase slightly before disclosure, remains unchanged in the period immediately surrounding the disclosure year, and then tails off again. The result is a large increase in the relative litigation rate of small-firm patents in the period immediately following disclosure. This graphical display represents our main evidence of the platform paradox.

In Table 5, we present a series of regression results that capture the basic pattern seen in Figure 2 while controlling for calendar effects and other sources of potentially confounding variation. Our basic specification is a Poisson quasi-maximum likelihood model with conditional fixed effects (Wooldridge 1999). Like the more common negative-binomial fixed-effects model, the coefficients have an elasticity interpretation. However, this estimator is preferable because it is consistent under a weaker set of assumptions, robust to arbitrary forms of hetero-skedasticity and does not suffer from the fixed-effects serial correlation issues highlighted by Betrand, Duflo and Mullainathan (2004). Because the conditional fixed-effects specification discards all unlitigated patents, the sample sizes in Table 5 are quite small.[23] However, we obtain similar results using OLS fixed-effects models that retain all unlitigated patents.

[23] Figure A.2 plots the number of large- and small-firm observations by age-relative-to-disclosure.

The first two columns in Table 5 tell the main story. For the 26 patents assigned to small-firms that were litigated, there is a substantial increase in litigation following disclosure. For the 46 litigated patents assigned to large firms, there is a large but statistically insignificant decline in the litigation rate following disclosure. Each of these models includes a fourth-order polynomial in time (i.e. calendar year minus 1995) to control for secular trends in the litigation rate. While we would have preferred a complete set of calendar-year dummies, the presence of several years with no litigation makes this approach infeasible.[24]

The third column in Table 5 pools the small- and large-firm patents to estimate the model specified in Equation (5), in which disclosure is interacted with a small-firm dummy variable. The coefficient on this interaction term is large but statistically significant only at the 90% confidence interval. This result suggests that the calendar-year effects differ in the large and small-firm sub-samples (since the coefficient on this interaction term in a fully-interacted model would equal the sum of the disclosure coefficients in the first two columns). Since the calendar-year polynomial also captures correlations between patent age and the litigation rate – which could easily differ for large and small firms – we consider several models that provide some additional flexibility in these age effects.

In the fourth column of Table 5, we test for a difference in the pre-disclosure litigation trend. Specifically, we interact a time-trend (Age) with the small-firm dummy and an indicator for the pre-disclosure period. The coefficient on this variable is small and not statistically significant, indicating no difference in pre-disclosure litigation trends between the large and small firms. This result is reassuring evidence that any difference in the post-disclosure litigation rates is not driven by the standards process, rather than by pre-existing differences in the underlying trends.

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[24] We experimented with various ways of aggregating calendar-year dummies and found that they produce the same results.

The next column in Table 5 includes a differential time-trend in both the pre- and post-disclosure periods. While we continue to find no difference in the pre-disclosure trends, the post-disclosure trend difference is both negative and statistically significant. Moreover, there is a sharp increase in the disclosure effect. An explanation for this effect can be seen in Figure 2. While there is a sharp increase in small-firm litigation rates during a five to six years period following disclosure, the relative increase in litigation disappears by years seven and eight. This leveling may reflect technology life-cycles, reversion to the mean, firm-level age processes or negative state-dependence (e.g., litigation reveals information about patent-quality that leads to more negotiated settlements). Whatever the cause, the result is a "bump" in the relative litigation rate of small-firm patents immediately after disclosure. In our regressions, this bump in the litigation rate is captured by a large positive coefficient on the interaction between the "Small-firm" and "Disclosure" dummy variables and a negative coefficient on the post-disclosure interaction between firm size and patent age.

The last column in Table 5 shows that it is also possible to generate the small-firm "bump" described above by including a set of interactions between the small-firm indicator variable and a quadratic in patent age. Once again, there is a large statistically significant coefficient on the interaction term corresponding to the sum $(\alpha + \delta)$ in Equation (5).

In Table 6 we consider a variety of robustness checks. One potential concern with our difference-in-differences analysis is that it is sensitive to outliers – particularly since the dependent variable is a litigation count that equals zero for most patents in most years.
We address this question by estimating a series of fixed-effects logit models, in which the dependent variable is a dummy taking the value unity only if a new lawsuit was filed (i.e., the maximum value in a given year is one). The results are presented in the first four columns of Table 6. Interestingly, we find that the disclosure effect for large-

firm patents is negative and statistically significant in this specification. However, the overall findings upon which our main findings are based do not change meaningfully.

The fifth column in Table 6 uses a count of defendants (rather than lawsuits) as the dependent variable. While this empirical approach may pick up differences in the propensity to file multi-party lawsuits, it does not produce a meaningful change in our main results. Finally, the last column in Table 6 presents estimates from a negative binomial regression.[25] Not surprisingly, the point estimates are quite similar to the Poisson coefficients.

To summarize, we consider a variety of different models and find a persistent increase in the relative litigation rate of small-firm patents following disclosure. We obtain the same results in a variety of less conservative models (firm fixed-effects and pooled cross-sectional regressions) that are not reported here. These consistent findings suggest that entrepreneurs and systems vendors respond differently to the creation of a new standard in which their IP is essential. In the next sub-section we ask whether these differences in intellectual property strategy are driven by variation in demand or by divergent litigation incentives.

5.3 Citation models

The simple model developed in Section 2 suggests that our difference-in-difference estimates will capture the joint impact of an increase in demand along with any change in the incentive to litigate patents following the creation of a new standard. Thus, if standardization has a larger impact on the demand for small-firm IP, it would be inappropriate to interpret the difference-in-differences results as evidence of a platform paradox (i.e., a divergence in litigation incentives). In this sub-section, we use patent-citations as a proxy for demand, and argue that our previous estimates actually provide a lower bound on the true incentive effects.

[25] Because we could not cluster the standard errors on disclosures for this model, the standard errors may be inappropriately small.

There is a large literature that uses forward citations to measure a patent's economic or technological significance (e.g. Hall, Jaffe and Trajtenberg, 2005; Harhoff et al 1999). Thus, while cites are an admittedly crude proxy for demand, they should provide a reasonable picture of changes in the perceived importance of a patent near its SSO-disclosure date. We estimate a series of citation models similar to those presented in Rysman and Simcoe (2006).

The regressions focus on a 13 year window that includes the five years prior to disclosure, along with the seven post-disclosure years, and include a complete set of age-relative-to-disclosure dummies (excluding the dummy in the year prior to disclosure). We also include a set of non-linear Age (since grant) variables to capture well-documented non-linearities in the citation age-profile. In this specification, changes in the counterfactual citation rate are estimated using undisclosed SSO patents with the same age. Once again, we use a Poisson specification with individual-patent (conditional) fixed effects and robust standard errors clustered on disclosures.

We are primarily interested in measuring the difference between large- and small-firm citation rates following disclosure. We do this in two ways: first by including a simple interaction between a *Small Firm* and *Disclosure* dummy variable, which we report in Table 7; and second, by including a complete set of age-relative-to-disclosure interactions for the small-firm patents, which we present in Figures 3.a and 3.b.

The first column in Table 7 shows the coefficient for the small-firm disclosure interaction in the sample of litigated patents (i.e., the sample used to generate our main results). While the point estimate suggests that small-firm patent citations drop by 3 percent relative to those of large-firms following disclosure, the upper bound of the 95 percent confidence interval corresponds to a 60 percent increase. In the second column we add a post-litigation dummy and its interaction with the small-firm indicator. The results are not meaningfully different. The third and fourth columns in Table 7 repeat this exercise for the full sample of disclosed patents. For this broader sample, the point estimates indicate a 30 percent decline in the relative citation rate of small firm patents after disclosure, with the upper bound corresponding to an 18 percent increase.[26]

Figure 3 presents a similar set of results in graphical form. In particular, we estimated the model used in Table 7, including a complete set of interactions between the *Small Firm* dummy and the *Age* (relative to disclosure) coefficients – again omitting the dummy for the year before disclosure. This approach allows for a very flexible citation response to disclosure in both the small- and large-firm sub-samples. We then plotted the coefficients on these interaction terms (along with a 95 percent confidence interval). The top panel shows the results for the full set of disclosed patents. We observe a distinct small negative break just before disclosure. In the second panel, which includes only litigated patents, there is neither an apparent trend, nor a break in the relative citation rates.

These results provide some assurance that our main findings are not driven by heterogeneity in the demand shock produced by standardization. While we find that patent citations increase following disclosure, there is essentially no difference in the response of small- versus large-firm citation rates. If we believe the negative point estimates obtained in the full sample of disclosed patents, then our difference-in-differences results provide a lower bound on the actual divergence in litigation incentives produced by the standards process (i.e., the platform paradox). We do offer two caveats to interpreting these results too broadly. First, citations are a crude proxy for the level of infringement. And second, while the point estimates in our citation

[26] The unreported baseline age coefficients in these regressions are very similar to the results presented in Rysman and Simcoe (2006); there is a 15 to 20 percent increase in the citation rate in the year before disclosure, followed by a upward trend that adds another 20 percent over the next three to five years.

models are close to zero, these estimates are not precise enough to reject the null hypothesis of a moderate positive shock to the relative demand for small-firm IP.

5.4 Litigation patterns

As a last stop in our exploration of SSO patent litigation, we use data from the Federal Judicial Center (FJC) to compare trial outcomes for SSO patents to those in a matched control sample. We formed the control sample by selecting a random patent case filed in the same court within 10 days of each SSO patent-suit filing (with replacement). However, because the FJC data are collected at case termination (while the Derwent data are reported at filing), there is a substantial truncation problem in the matching process. So, for this exercise, we re-introduced the ETSI patents, and were able to match 102 out of 151 total lawsuits.

Table 8 shows a series of univariate tests for differences in litigation outcomes between the SSO and control samples. In general, the results show the processes to be quite similar. The average case duration – from filing to termination – is 61 days (14 percent) shorter for the SSO patents, but that difference is not statistically significant. The share of cases that terminate during *discovery* (the initial phase of the suit in which parties are permitted to collect information, including documentary and depositional) is 31 percent for SSO patents and 36 percent in the control (non-SSO) sample, but again this difference is not statistically significant.[27] We do find that SSO patent suits are more likely (significant at the 5% level) to end with a settlement order (i.e., an order requested and agreed upon by both parties). This difference may indicate that SSO patent litigants desire added institutional support for their settlement agreements.

We observe too that lawsuits in the SSO and control sample have an identical likelihood of reaching trial (4.9 percent). However, we find a large disparity in plaintiff win rates. In particular, plaintiffs win 54 percent of the SSO-patent cases compared to 24 percent in

[27] Note that the outcome shares are not intended to sum to unity (for instance, the "reached trial" share is a subset of the "final verdict" share of cases).

the control sample (significant at the 10% level). The SSO cases appear less likely to end in a defendant victory or a shared victory.[28] However, it is difficult to interpret these findings since the patent holder might be either a plaintiff or defendant in these cases (depending on whether it is an infringement or validity suit). Overall, we interpret the summary statistics in Table 8 as evidence that SSO patent lawsuits are not particularly different from other types of patent litigation.

6. Conclusions

This paper examines the intellectual property strategy of firms that participate in the formal standards process. Using data on patents disclosed to a group of influential SSOs, we show that small firms are more likely to litigate their standards-related IP after a new standard is created, while large-firm litigation rates remain unchanged or perhaps decline. These findings suggest to us that standardization causes a divergence in the litigation incentives faced, on the one hand, by small entrepreneurs and, on the other, by large systems vendors. One explanation for this divergence is that small vertically-specialized firms do not have the presence in complementary markets or the downstream manufacturing, marketing and distribution capabilities that allow their large firm rivals to cooperate on the standards while competing on the implementation.

While these results shed some new light on important questions related to IP strategy and the emergence of open platforms, we acknowledge that it is very difficult to draw clear welfare implications from our findings. In particular, we have little to say about the impact that SSO intellectual property policies may have on long-run innovation incentives. Our results suggest that patents are truly important to entrepreneurs, and thus play an important role in promoting the division of innovative labor. At the same time, they suggest that large firms are willing to sacrifice some of the value in their IP for the benefits of a more "open" technology input market. While this trade-off between the

[28] A shared victory may occur, for instance, when a defendant is found to be infringing some of the patent claims, but the plaintiff's patent is found to have other claims that are invalid.

dynamic benefits and static costs of IP protection is well known, our results suggest that large and small firms will have different views about the optimal policy – particularly in markets where the innovation process is vertically dis-integrated.

It is somewhat ironic that we find very high litigation rates for standards-related technologies, since the goal of most SSOs is to promote "openness" in the form of widespread access to standardized components at relatively low prices. Of course, such litigation is presumably the price of success, since increased use of a patented technology will inevitably lead to more infringement, more incentives to enforce the IP, and a resulting higher probability of litigation. Nevertheless, we believe our findings suggest the need to re-examine the RAND standard currently used by most SSOs. The lack of a clear definition of "reasonable" pricing – combined with the proliferation of open platforms and increased vertical dis-integration in many technology markets – seems likely to send an increasing number of cases into the legal system. Some SSOs, including IEEE and ANSI, are exploring the idea of allowing firms to state an *ex ante* royalty cap as part of their IP disclosure. This approach strikes us as a reasonable policy. However, it is important to recognize that any move towards stronger IP rules will cause some SSO participants to opt out of the formal standards process, which may lead to more standards wars and an increased use of the submarine-patent or hold-up strategies.

Finally, our results raise a number of questions about the organization and dynamics of open-platform development that call for further research. In particular, what strategies can platforms leaders adopt to encourage entry by entrepreneurs (who may be better poised to provide critical complements) while preserving the benefits of platform openness? Will competition between SSOs working on similar problems lead to a more efficient set of IP policies, or will it produce technical fragmentation and coordination failures? How do SSOs compare to patent pools (Lerner, Strojwas and Tirole 2003) as a mechanism for contracting around the problem of complementary upstream monopolists (i.e., the patent thicket)? We are hopeful that the increasing availability of data on patents and the formal standards process will lead to further empirical work on these issues.

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Table 1: Disclosure summary statistics by SSO

A blanket disclosure contains no patent or application numbers that would identify a specific piece of intellectual property. Total IPR is a count of all patents (US and foreign) and application numbers listed in a disclosure. A large firm is publicly traded or has more than 500 employees.

SSO	Total Discs	Blanket Discs	Total IPR	US Patents	US App's	Min Disc Year	Mean Disc Year	Mean Disc Age*	Large Firms*
ANSI	278	177	278	127	15	1971	1996	3.08	0.87
ATIS	58	38	51	20	2	1986	1996	2.68	0.82
ATM Forum	25	1	90	45	1	1995	1998	4.22	0.92
ETSI	324	0	13,684	1,164	160	1990	2002	3.77	0.93
IEEE	390	239	966	278	12	1983	2000	3.35	0.89
IETF	353	188	351	101	6	1995	2003	3.26	0.95
ITU	643	0	1,175	200	18	1983	1999	4.12	0.89
TIA	126	117	23	19	0	1989	1998	3.16	0.99
DSL Forum	8	0	32	3	1	2000	2004	0.75	0.86
ISO	24	8	44	16	1	1980	1995	3.59	0.73
ISO/IEC JTC1	217	194	61	13	7	1992	1998	4.05	0.96
MSSF	13	7	15	3	0	1999	2002	0.33	1.00
OMA	44	0	185	53	1	1999	2004	3.63	0.72
VESA	55	0	62	7	0	1995	2001	1.14	0.88
Pooled Sample	2,558	969	17,017	2,049	224	1971	2000	3.66	0.91

* The unit of observation for these statistics is a disclosed patents rather than a disclosure.

Table 2 : Sample means for SSO and matched control patents

This table presents sample means and t-tests for SSO patents and three different one-to-one matched control samples. Each control patent has the same grant year and technology class as its SSO twin. Firm matches have the same assignee and Cite matches the same number of forward cites.*

	SSO Patents	*Random Match*	*P-value*	*SSO Patents*	*Firm Match*	*P-value*	*SSO Patents*	*Cite Match*	*P-value*
Litigation Rate (percent)	9.38	1.69	0.00	7.16	1.26	0.00	9.15	1.91	0.00
Lit Rate (grant pre-94)	14.24	1.99	0.00	11.66	1.79	0.00	13.85	2.70	0.00
Lit Rate (grant 94-98)	7.11	1.55	0.00	5.11	1.02	0.00	6.99	1.55	0.00
Lit Rate (grant post-98)	4.46	0.96	0.01	4.53	0.41	0.00	4.46	0.96	0.01
Lawsuits (count)**	1.97	2.06	0.87	1.76	1.67	0.79	1.95	1.94	0.98
Defendants (count)**	2.69	2.56	0.90	2.63	2.00	0.21	2.66	3.00	0.75
Litigation Age (years)**	6.20	3.75	0.02	6.10	5.44	0.65	6.12	5.11	0.41
Pre-disclosure (percent)**	28.09			29.41			27.91		
Forward Cites 63-06	33.88	16.84	0.00	30.86	17.05	0.00	31.64	32.32	0.70
Backward Cites	10.75	10.36	0.56	9.89	10.08	0.77	10.79	11.48	0.32
Non-patent Cites	9.07	4.69	0.00	8.54	8.33	0.89	8.97	7.39	0.22
Claims	22.24	17.89	0.00	22.02	17.67	0.00	22.12	20.31	0.05
Continuation	0.43	0.31	0.00	0.40	0.28	0.00	0.43	0.30	0.00
Generality	0.51	0.44	0.00	0.50	0.45	0.02	0.50	0.50	0.60
US Firm	62.17	61.54	0.78				62.45	60.85	0.48
US Other	2.42	2.53	0.88				2.13	3.30	0.12
Non-US Firm	26.87	27.82	0.64				27.02	28.09	0.61
Non-US Other	2.53	1.58	0.15				2.55	1.49	0.10
Unassigned	6.01	6.53	0.64				5.85	6.28	0.70
Patents	949	949		712	712		940	940	

*See text for additional description of the matching process. **Statistics in these cells are conditional on litigation.

Table 3 : Sample Means for Small and Large Firms

This table presents sample means and unpaired two-sample t-tests that examine differences between the large firms (systems vendors) and small firms (entrepreneurs) disclosing one or more patents to an SSO in our sample.

Firm-Level Means	*Large Firms*	*Small Firms*	*P-value*
SSO Count	1.69	1.06	0.00
Patent Grants (67-06)	4899.40	39.40	0.00
HHI 1995	0.12	0.34	0.00
HHI 2000	0.13	0.38	0.00
Public Firm	100.00	11.11	0.00
IPO Year	1980.34	1990.89	0.01
log Employees	9.80	5.36	0.00
VC Match	27.12	36.11	0.20
Total Firms	118	72	

Patent-Level Means	*Large Firms*	*Small Firms*	*P-value*
Litigation Rate (percent)	6.67	17.31	0.00
Lit Rate (grant pre-94)	10.09	37.93	0.01
Lit Rate (grant 94-99)	4.98	12.6	0.02
Lit Rate (grant post-98)	4.57	4.23	0.90
Lawsuits*	1.98	2.11	0.82
Defendants*	2.67	2.59	0.90
Litigation Age*	6.11	4.78	0.20
Pre-disclosure Litigation*	32.61	25.93	0.55
Disclosure age (since grant)	3.44	3.16	0.45
Forward Cites 63-06	31.14	33.68	0.46
Backward Cites	10.46	12.80	0.10
Non-patent Cites	8.33	13.54	0.11
Claims	22.07	24.31	0.21
Continuation dummy	0.36	0.78	0.00
Generality	0.51	0.49	0.62
Forward Cites / Year	3.07	3.80	0.04
Cites / Claim / Year	0.21	0.24	0.38
Backward Cites / Claim	0.78	0.93	0.28
Non-patent Cites / Claim	0.53	1.42	0.14
Total Patents	690	156	

Table 4: Cross-sectional probit models of patent litigation

This table presents marginal effects from patent-level probit regressions. Column 1 compares SSO to control patents. Columns 2 through 5 exclude all patents not assigned to a US or foreign firm.

Unit of Observation = Patent *DV = Litigation Dummy*					
Sample	**All SSO & Match**	**All SSO Firms**	**Small Firms**	**Large Firms**	**Public Firms**
Baseline Probability	**0.0338**	**0.0593**	**0.0402**	**0.0495**	**0.0423**
Small Firm	0.058	0.076			
	(0.02)***	(0.03)**			
US Firm	0.014	-0.008	0.046	-0.017	-0.019
	(0.01)*	(0.03)	(0.03)*	(0.03)	(0.03)
Disclosure Age		0.002	0.009	-0.001	-0.004
		(0.00)	(0.01)	(0.00)	(0.00)
Disclosure Year		0.002	-0.001	0.002	0.009
		(0.00)	(0.01)	(0.00)	(0.00)*
Continuation Dummy		0.074	0.025	0.075	0.054
		(0.03)***	(0.03)	(0.03)**	(0.02)**
Log (Claims)		0.011	0.002	0.012	-0.004
		(0.01)	(0.02)	(0.01)	(0.01)
Log (Forward Cites)		0.041	0.047	0.034	0.030
		(0.01)***	(0.02)***	(0.01)***	(0.01)***
Log (Backward Cites)		0.005	0.014	-0.000	0.001
		(0.01)	(0.02)	(0.01)	(0.01)
Log (Non-patent Cites)		-0.003	-0.037	0.005	0.005
		(0.01)	(0.01)***	(0.01)	(0.01)
Log (Employees)					-0.007
					(0.00)
Log (Assets / Employee)					-0.046
					(0.02)**
Log(Patents / Employee)					0.025
					(0.01)**
ANSI	0.293				
	(0.12)**				
IEEE	0.096	-0.041	-0.038	-0.024	-0.065
	(0.04)**	(0.02)*	(0.03)	(0.03)	(0.02)***
IETF	0.120	-0.037	-0.046	-0.020	-0.028
	(0.10)	(0.03)	(0.02)**	(0.03)	(0.02)
ITU	0.062	-0.016	-0.050	0.001	-0.033
	(0.03)*	(0.03)	(0.02)**	(0.03)	(0.02)*
Other	0.122	-0.019	0.098	-0.027	-0.036
	(0.05)**	(0.02)	(0.09)	(0.02)	(0.02)**
Grant Year Effects	Y	Y	Y	Y	Y
Assignee-type Effects^	Y				
SSO Main Effects^	Y				
N (Patents)	1848	846	156	690	626
Pseudo R-square	0.1367	0.1399	0.4013	0.0968	0.1827
Chi-square	84.48	69.90	53.68	39.42	58.95

* 10% significance; ** 5% significance; *** 1% significance. (Robust SEs clustered on disclosure)
^See text for a discussion of the specification in column 1.

Table 5: Difference-indifferences models of patent litigation

This table presents coefficients and robust standard errors (clustered by disclosure) from Poisson quasi-maximum likelihood regressions with patent (conditional) fixed effects. These models exclude all un-litigated patents. All specifications contain a fourth-order polynomial in calendar years to control for common unobserved time-trends.

Unit of Observation = Patent-Year *DV = Count of new lawsuits*						
Sample	Small Firms	Large Firms	All Firms	All Firms	All Firms	All Firms
Specification	*Poisson*	*Poisson*	*Poisson*	*Poisson*	*Poisson*	*Poisson*
Disclosure	1.570***	-0.831	-0.278	-0.276	-0.693	-0.906
	(0.58)	(0.59)	(0.52)	(0.52)	(0.58)	(0.66)
Small Firm * Disclosure			1.216*	1.310	2.478**	2.189**
			(0.73)	(0.94)	(0.99)	(0.98)
Small * Age * Pre-Disc				0.0395	-0.114	
				(0.19)	(0.23)	
Small * Age * Post-Disc					-0.205**	
					(0.093)	
Small Firm * Age						0.0760
						(0.37)
Age squared						-0.00652
						(0.0053)
Small * Age squared						-0.0276
						(0.028)
log (Cites, t-1)						-0.299
						(0.22)
Year Effects (Chi2, 4 d.f.)	7.52	8.23*	12.54**	12.47**	17.75***	13.16**
Patent Effects	Y	Y	Y	Y	Y	Y
Patents	26	46	72	72	72	72
Observations	317	588	905	905	905	905
Log-likelihood / N	-0.334	-0.311	-0.202	-0.328	-0.328	-0.322

*10% significance; ** 5% significance; *** 1% significance. (Robust SE's clustered on disclosures).

Table 6: Difference-in-differences robustness checks

This table presents models similar to Table 5 with variations in the specification and dependent variable. These models exclude all un-litigated patents. All specifications contain a fourth-order polynomial in calendar years to control for common unobserved time-trends. Note that it is not possible to cluster the standard errors by disclosure for the fixed-effects logistic or negative-binomial model.

	Unit of Observation = Patent-Year *DV = New Lawsuit (Dummy) or Defendants (Count)*					
Sample	Small Firms	Large Firms	All Firms	All Firms	All Firms	All Firms
Dependant variable	*Dummy*	*Dummy*	*Dummy*	*Dummy*	*Count*	*Count*
Specification	*Logistic*	*Logistic*	*Logistic*	*Logistic*	*Poisson*	*Neg Bin*
Disclosure	2.029***	-0.966**	-0.278	-0.803*	-0.682	-0.540
	(0.67)	(0.48)	(0.44)	(0.47)	(0.63)	(0.40)
Small Firm * Disclosure			1.389*	3.214***	2.902***	2.184***
			(0.80)	(0.97)	(1.09)	(0.61)
Small * Age * Pre-Disc			0.051	-0.149	-0.127	-0.159
			(0.18)	(0.20)	(0.24)	(0.17)
Small * Age * Post-Disc				-0.309***	-0.259**	-0.227***
				(0.091)	(0.11)	(0.071)
Year Effects (Chi2, 4 d.f.)	11.60**	7.14	11.14**	12.62**	11.30**	11.86**
Patent Effects	Y	Y	Y	Y	Y	Y
Patents	26	46	72	72	72	72
Observations	317	588	905	905	905	905
Log-likelihood / N	-0.227	-0.231	-0.239	-0.231	-0.412	-0.306

*10% significance; ** 5% significance; *** 1% significance.

Table 7: Disclosure and patent citations

This table presents coefficients and robust standard errors (clustered by disclosure) from Poisson quasi-maximum likelihood regressions with patent (conditional) fixed effects. These models exclude all un-cited patents. All specifications contain a full set of age-since-disclosure effects.

	Unit of Observation = Patent Year			
	DV = Forward Citation Count			
Sample	*Litigated SSO Patents*	*Litigated SSO Patents*	*All SSO Patents*	*All SSO Patents*
Small Firm * Disclosure	-0.0278	-0.0420	-0.278	-0.363*
	(0.32)	(0.29)	(0.23)	(0.22)
Litigation Dummy		-0.310		-0.00350
		(0.20)		(0.17)
Litigation * Small Firm		0.0489		0.425*
		(0.24)		(0.25)
Patent Fixed Effects	Y	Y	Y	Y
Age-since-disc Effects	Y	Y	Y	Y
Patents	70	70	803	803
N (Patent Years)	892	892	8994	8994

* 10% significance; ** 5% significance; *** 1% significance. Robust standard errors.

Table 8: Litigation Outcomes

This table provides descriptive statistics for outcomes of SSO patent lawsuits and a matched sample of non-SSO patent lawsuits drawn from the same court within 10 days of the SSO lawsuit filing date.

	SSO Lawsuits	*Non-SSO Lawsuits*	*Difference*	*P-value*
Duration: Filing to termination (days)	449.99	511.52	-61.53	0.34
Outcome Shares (N=102)				
Terminated during discovery	0.314	0.363	-0.049	0.46
Settlement order	0.431	0.294	0.137	0.05
Reached trial	0.049	0.049	0.000	1.00
Final verdict (after trial or motion)	0.127	0.167	-0.040	0.43
Final verdict (N=13 SSO, 17 Non-SSO)				
Plaintiff victory	0.538	0.235	0.303	0.09
Defendant vicory	0.231	0.412	-0.181	0.31
Shared victory	0.231	0.353	-0.122	0.49

Figure 1 : Annual IPR Disclosure at Thirteen Standard Setting Organizations

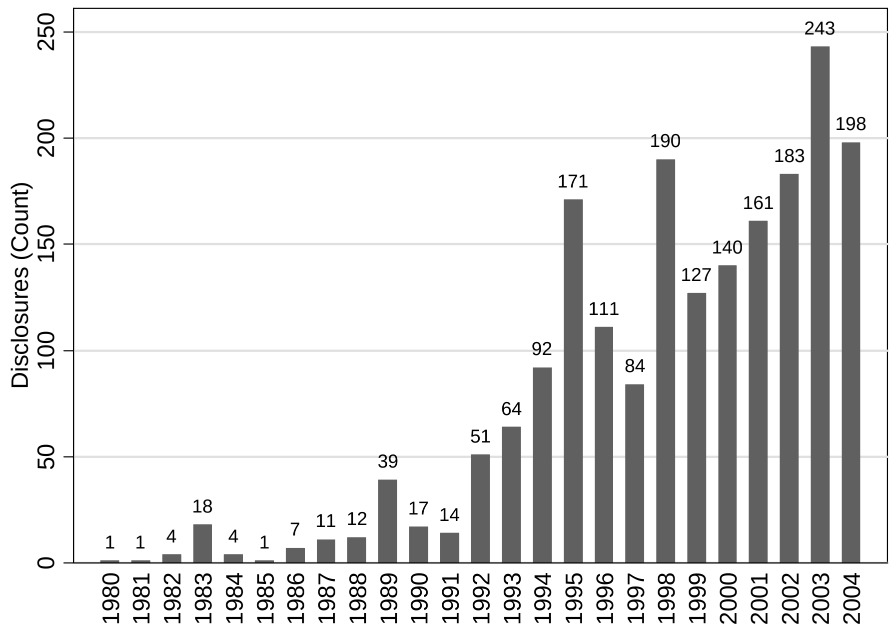


Figure 2a: Pre/Post-disclosure litigation rates by firm size (all patents)

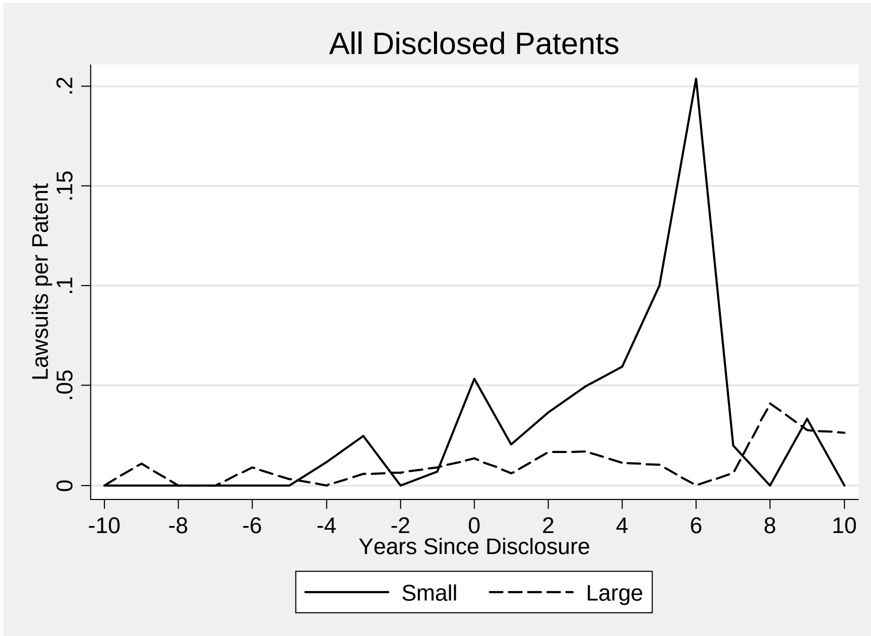


Figure 2b: Pre/Post-disclosure litigation rates by firm size (litigated patents)

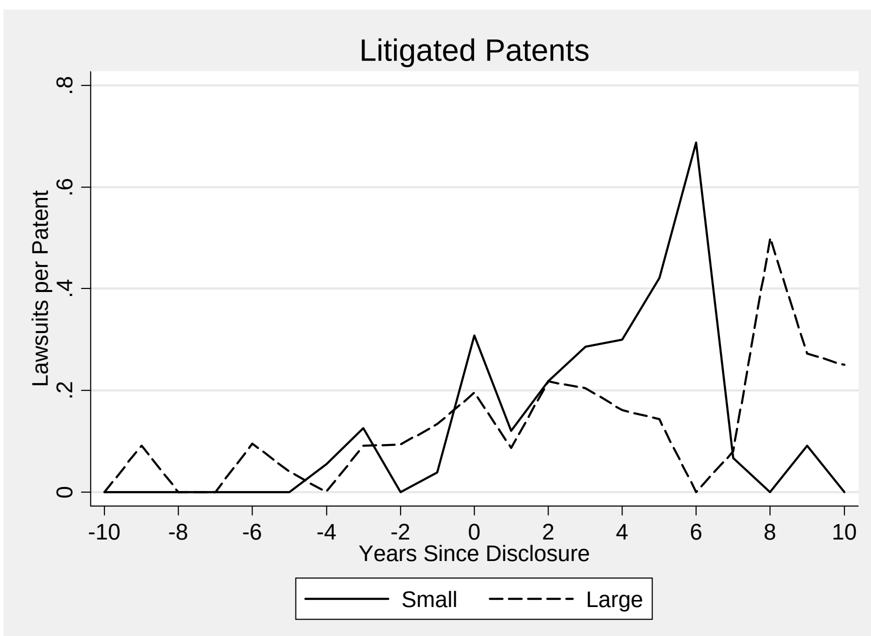


Figure 3a: Citation rate differences (small firm interactions, all patents)

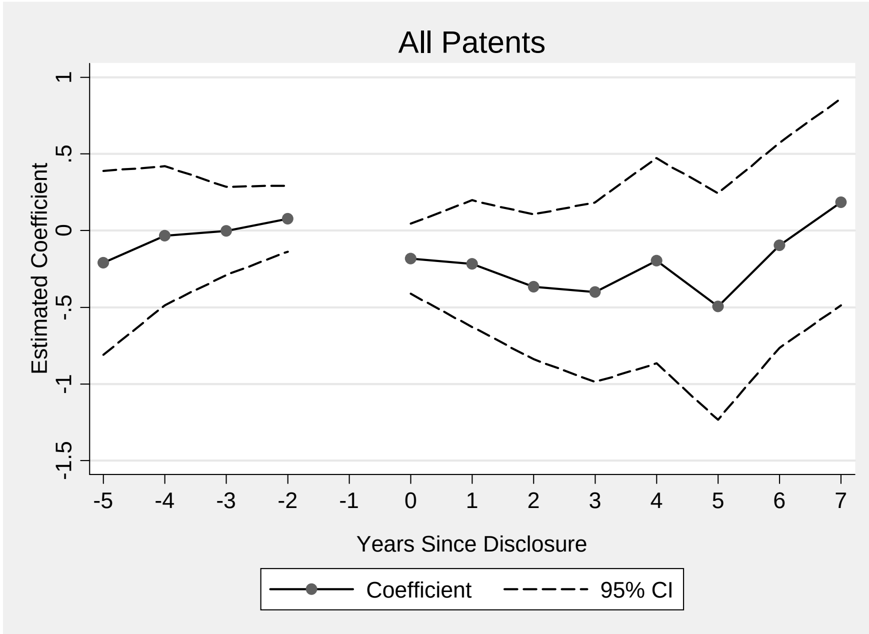
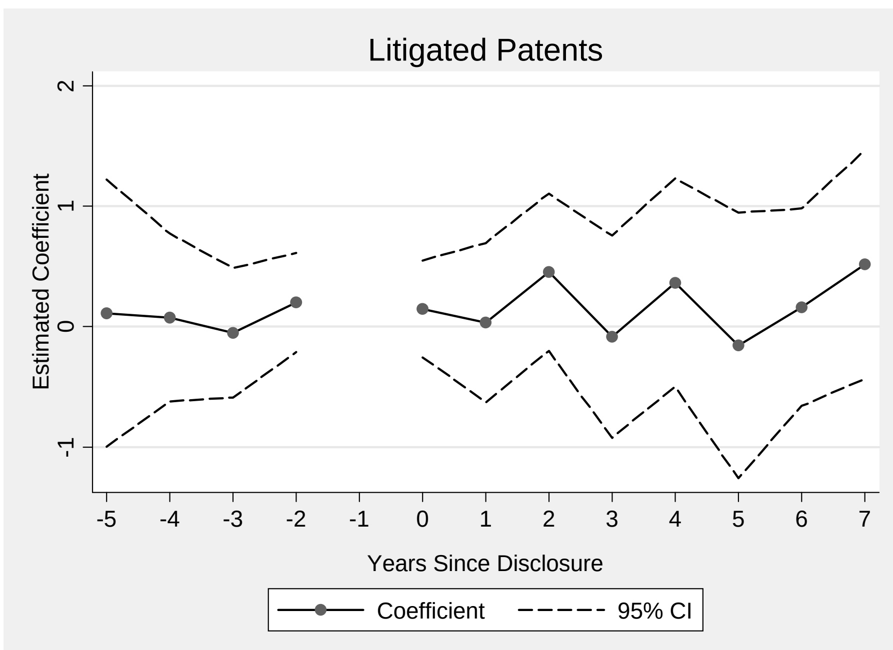


Figure 3b: Citation rate differences (small firm interactions, litigated patents)



Appendices

Table A.1 : Short SSO Descriptions

Acronym	Description
ANSI	American National Standards Institute: The umbrella organization that certifies US Standards Developing Organizations.
ATIS	Alliance for Telecommunications Industry Solutions: ANSI accredited US SDO that develops telecommunication standards
ATM Forum	Asynchronous Transfer Mode Forum: Consortium promoting a high-speed Internet switching technology
ETSI	European Telecommunications Standards Institute: Develops cellular telephony standards, including GSM and CDMA protocols used widely in Europe.
IEEE	Institute of Electrical and Electronic Engineers: Engineering trade groups that also sponsors ANSI accredited standards activities for a variety of information technologies, including the 802.x series of computer networking standards.
IETF	Internet Engineering Task Force: Large independent SSO that develops core Internet protocols for applications, routing and transport.
ITU	International Telecommunication Union: The primary international organization for voluntary governance and standardization of the public switched telephone network.
TIA	Telecommunications Industry Association: ANSI accredited US SDO that develops telecommunications industry standards, particularly for wireless/cellular applications
DSL Forum	Digital Subscriber Line Forum: A consortium for high speed modem standards.
ISO	International Organization for Standards: Large umbrella organization for international standards development.
ISO/IEC JTC1	Joint committee of ISO and the International Electrotechnical Commission (IEC) where all ISO sponsored work on information technology standards occurs.
MSSF	Multiservice Switching Forum. Consortium for "next generation" networking standards.
OMA	Open Mobile Alliance. Consortia to promote mobile telephone application interoperability.
VESA	Video Electronics Standards Organization: Promotes industry-wide interface standards designed for the PC, workstation, and other computing environments.

Table A.2 : Technology Classification of Disclosed Patents

This table shows the distribution of patents in our sample over a set of broad technology areas, whose definitions are based on the US Patent and Trademark Office's technology classification scheme. These patents primarily cover information and communications technologies.

Technology Category	*SSO Patents*	*With ETSI*
Chemical	3	9
Communications	426	1,500
Computers (HW/SW & Other)	377	563
Drugs & Medical	4	5
Electrical & Electronic	98	121
Mechanical & Other	34	68
Total Patents	942	2,266

Table A.3: Common Firms

This table provides the names of the top ten Large and Small firms in our data set (ranked by the number of disclosed patents). It also lists the most frequent plaintiffs and defendants out of 206 total lawsuits.

Top 10 Large Firms	Pat Discs	Employees*	**Top 10 Small Firms**	Pat Discs	Employees*
Ericsson	276	71,981	Interdigital Technology	170	185
Nokia	181	44,780	Snaptrack	33	
Qualcomm	172	5,949	Int'l Mobile Machines	30	87
Motorola	105	87,656	Tecsec, Inc.	12	
AT&T	77	108,953	Hybrid Networks	11	65
IBM	66	312,643	Verisity Design	10	190
Toshiba	46	147,217	Stac Electronics	9	
Alcatel	45	143,744	Netergy Networks	8	113
Apple Computer	41	10,477	SCS Mobilecom	5	
Philips	41	299,382	Digital Theater Systems	5	

Top Plaintiffs	Lawsuits	**Top Defendants**	Lawsuits
Elonex IP Holdings	13	Interdigital Technology	5
U.S. Philips	7	Acer Inc	2
RSA Data Security	5	Broadcom Corp	2
Lucent Technologies	5	Ciena Corp	2
Qualcomm Inc.	5	Compal Electronics	2
Interdigital Technology	3	Dallas Semiconductor	2
Compression Labs	3	Dell Computer	2
Agere Systems	3	Ericsson, Gateway, Microsoft, Motorola, Novell	2

Table A.4 Variable Definitions and Summary Statistics

	N	Mean	S.D.	Min	Max	Definition
Small Firm	949	0.21	0.40	0	1	Dummy: Private firm or public company with less than 500 employees (in year of patent grant).
US Firm	949	0.70	0.46	0	1	Dummy: Parent firm located in the United States.
Disclosure Age	949	3.50	3.87	-5	33	Years between patent grant and first disclosure.
Disclosure Year	949	1999.23	5.03	1974	2006	Calendar year of first disclosure.
Continuation Dummy	949	0.27	0.45	0	1	Dummy: Patent application filed as a continuation or Continuation-in-part.
Claims	949	22.24	17.90	0	199	Count of individual claims contained in the patent.
Forward Cites	949	33.88	45.11	0	500	Cumulative citations received from other US patents.
Backward Cites	949	10.75	14.97	0	198	Count of citations made to other US patents.
Non-patent cites	949	9.07	31.83	0	565	Count of citations made to non-patent materials (e.g. scientific papers).
Employees (000's)	635	101	111	0	430	Compustat employees of parent firm in patent grant-year.
Assets ($M's)	635	30,234	33,534	4	164,863	Compustat assets of parent firm in grant-year ($millions).
Patents	892	2,587	3,689	1	23,038	Five-year stock of granted patents.
Generality	807	0.51	0.33	0	1	One minus a Herfindahl measure based on the 3-digit US patent classification of citing patents.

Figure A.1a: Sample disclosure letter 1

Mark T Starr
Staff Vice President and
General Patent & Technology Counsel

Unisys Corporation
PO Box 500
Blue Bell PA 19424-0001

Telephone
215 986 4411

PL 242

UNISYS

VIA FACSIMILE (202) 663-7554
CONFIRMATION BY REGULAR MAIL

December 12, 1995

RECEIVED
DEC 15 1995
ABA ST...

Ms. Cynthia Fuller
ASC X9 Secretariat
American Bankers Association
1120 Connecticut Avenue, N.W.
Washington, DC 20036

Re: United States Patent 4,107,653

Dear Ms. Fuller:

This is to advise you that Unisys Corporation is willing to grant to any requesting party a non-exclusive license under the claims of Unisys U.S. Patent No. 4,107,653, the infringement of which is recommended to properly make, use or sell Magnetic Signal Level Measuring Instruments used for the manufacture and/or calibration of secondary reference documents which are used to carry the signal level reference for the calibration of production signal level measuring equipment as referenced in ANS X9.27 - 1995, when approved and published. Please forward a copy of this letter to ANSI for their use. .

Each grant will be under separate agreement, at a royalty rate of one percent (1%) applied to the net selling price or fair market value of the equipment sold. Also, each requesting party must be willing to grant Unisys Corporation an option to a license of the same scope on similar terms, conditions and charges under the requesting party's patents.

Upon adoption of the ANSI standard, parties who wish a license should contact my office.

Sincerely,

Mark T. Starr

Mark T. Starr

MTS/cdt

Figure A.1b: Sample disclosure letter 2 (blanket disclosure)

Page 1 of 1

Heather Benko

From: smontgomery@tiaonline.org
Sent: Wednesday, January 12, 2005 4:18 PM
To: hbenko@ansi.org
Cc: smontgomery@tiaonline.org
Subject: IPR/Patent Holder Statement

Document Information

Reference Doc. No.	PN-3-3972-UGRV.SF1 (refer to Project Number, Standards Proposal Number or title--one form per document. Note, may fill one statement for a document with multi-parts.)
Publication ID	TIA-733-A [SF1]
Document Title	Software Distribution for TIA-733-A - High Rate Speech Service Option17 for Wideband Spread Spectrum"

General Information

Your Name	Michael Wang
Your Title	
Company	Nortel Networks
Company Phone	972-684-2848
IPR Contact	Michelle Lee
Address1	Mail Stop 036NO151
Address2	8200 DIXIE ROAD SUITE 100
City	BRAMPTON
State	ONTARIO
Zip	L6T 5P6
Country	CANADA
Phone Number	905-863-1148"
Fax Number	
Email	mleelaw@nortelnetworks.com

Nortel Networks states:

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3a. The commitment to license above selected will be made available only on a reciprocal basis. The term 'reciprocal' means that the licensee is willing to license the licensor in compliance with either (2a) or (2b) above as respects the practice of the TIA Publication.

1/12/2005

Figure A.2a: Observations by age and firm size (all patents)

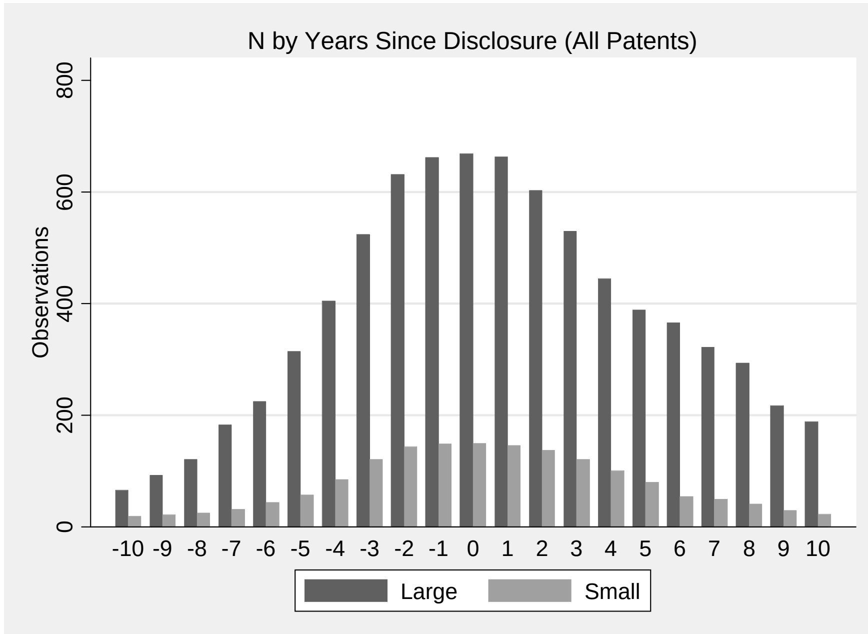

Figure A.2b: Observations by age and firm size (litigated patents)