# Intellectual Property and the Standardization Committee Participation in the U.S. Modem Industry

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## Abstract

We take a preliminary look at the interaction between patenting and standardization committee participation in the U.S. modem industry. Both involve a much wider set of firms than the downstream modem manufacturers themselves. Not surprisingly, the two activities are highly correlated across firms. Using five year periods, Granger causality tests show that while patenting is predicted by participation in earlier standardization meetings, meetings participation is not predicted by earlier patenting. We interpret these results as reflecting the timing of standard setting relative to innovation.

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## Introduction

The last two decades have witnessed a proliferation of high-tech consumer electronic products with exhibit network effects. Successful diffusion of these products is often contingent on a single product winning a battle of market standards or firms achieving compatibility among competing standards.[2]

The benefit to consumers from purchasing a network good depends on the number of other consumers who eventually purchase that, or a compatible good. This has two main implications for competition in network markets, with competing standards:

I: Consumers' expectations regarding the future size of a network are critical in the adoption decision. Thus the expectation that one technology will become a standard may be self-fulfilling. On the other hand, fragmented expectations may lead to a battle with no winner. Postrel (1990) attributes, in part, the failure of quadraphonic sound in the 1970s to competing standards.

II: When network effects are relatively strong, long-term co-existence of competing incompatible standards is unlikely. A small initial advantage will likely influence consumer expectations about the adoption of a particular standard, which, in turn will lead to more consumers adopting the standard. Thus an early lead can be transformed into an advantage that is difficult to overcome.

[2] This section draws from Gandal (2002).

Thus competition in network goods markets without a previously agreed upon standard will often entail suboptimal demand and high risks for firms. Hence, firms may be willing to have a single standard set "outside" of the marketplace. Broadly speaking, there are three ways that can happen: (I) Standards imposed by National Standards Bodies, such as the U.S. Federal Communications Commission. (II) Standards agreed upon by official standards development organizations (SDOs).[3] An SDO is as an accredited standards development organization that can trace its accreditation to a governmental body. The American National Standards Institute (ANSI) is the only U.S. representative to both the International Organization for Standardization (ISO) and the International Electromagnetic Commission (IEC); it accredits more than 270 public and private SDOs that follow ANSI policy in developing voluntary (consensus) standards. These standards are non-proprietary. (III) Other voluntary industry agreements, where standards are jointly developed by industry trade groups, consortia, other standard setting organizations (SSOs) etc.[4] These standards are also typically non-proprietary.[5]

[3] Examples of SDOs include the International Telecommunications Union (ITU), the oldest international standards body in the world, and the International Electrotechnical Commission (IEC). Given the importance of compatibility among international phone networks, the standards set by the ITU are done so by international consensus.

[4] See Caplan (2003).

[5] The DVD (digital video disc) industry provides an example of a jointly developed standard. Throughout the 1990s, video hardware and software manufacturers sought a digital format to replace videocassettes. In order to avoid another Beta/VHS format war, hardware manufacturers led by Sony, Toshiba, and Panasonic, and movie studios, led by Warner and Columbia (a division of Sony), worked together to establish a single standard. The result was the non-proprietary or "open" DVD standard.

There is by now a very large economics literature on the economics of compatibility and standardization.[6] Although the literature is primarily theoretical, there is a growing empirical literature as well. Despite the increasing importance of SDOs and SSOs in achieving standards, there is surprisingly little systematic economics research, either theoretical or empirical, on the topic.

Firms in oligopoly markets interact strategically in many different dimensions. In the case of industries where standardization and compatibility are important, the firms meet in standardization organizations in addition to competing in both research and development and the product market. Indeed, firms have come to recognize the strategic importance of participating in standard setting organizations and hence increasingly send strategic decision makers, in addition to technical staff to these meetings.[7]

There are several reasons why firms participate in standards meeting. As mentioned above, in industries in which interoperability is important, competing incompatible standards may lead to the market failure of the technology itself. An additional reason to participate in standards meetings is that firms profit from getting their intellectual property into the standard. Most standards committees allow firms to earn "reasonable and non-discriminatory" (RAND) royalties if their intellectual property is part of the standard. In many cases, this may be the best way for firms to earn revenues from intellectual property. Although economic models of standard setting typically envision two firms with complete and proprietary incompatible technologies,

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[6] We will not provide a detailed survey here. See David and Greenstein (1990) for a comprehensive survey of earlier work, and Farrell and Klemperer (forthcoming, 2005) for a detailed survey of more recent work. Gilbert (1992), Katz and Shapiro (1994), Gandal (1995), and Matutes and Regibeau (1996) provide selective reviews of the literature. See Gandal (2002) for a discussion of policy issues and Stango (2004) for a survey of the literature on standards wars.
[7] See "Standardization, the Necessary Luxury," by Carl Cargill, Director of Standards, Sun Microsystems, available at http://www.geoplace.com/gw/2004/0403/0403ogc1.asp.

many firms are often involved, and no single one owns a full set of patents covering the essential components of the technology. In such cases, no single firm can credibly threaten to develop its own standard unilaterally.

Another reason for participating in standards committees is that that knowledge diffuses through the meeting process. Firms may gain key incites that will contribute to future intellectual property or help improve their competitive position in the product market.

In this paper we focus on modems.[8] Network effects arise in modem markets because compatible modems are required to transfer data between the sending and receiving parties, e.g., between consumers and Internet service providers (ISPs). Consumers benefit from a modem standard because this enables them to change their ISP without having to change modems. Additionally, a standard enables consumers to travel to other geographic areas and connect to the Internet through the local ISPs.

In 1996 there were two competing incompatible technologies in the 56K analog modem market. If a consumer used one standard while her Internet Service Provider used a different standard, the data transmission speed did not approach 56 Kilobits per second, but rather was that of the previous technology 33 Kilobits per second.[9] The incompatibility in the market led to confusion among consumers and reduced sales. As one industry analyst wrote somewhat colorfully, "Back in 1996, for example, there was the heated, worldwide standards battle involving 56 Kbs analog modem technology that dragged on for a couple of years. Consumer confusion soared, modem sales declined

[8] The word modem comes from modulation-demodulation. An analog modem takes digital data from a computer and converts (modulates) it into analog data; thus the information can be transferred via the telephone line. At the other end, the data is converted back (demodulated) back to the original digital form for the receiving computer. See http://www.wiu.edu/users/miart/web%20syl/handouts/timeline.html.
[9] See Ageureau, Greenstein, and Rysman (2003).

dramatically, and the modem industry in general received a strong punch in the stomach."[10] The standards war featured efforts by both sides to influence the expectations of adopters, with exaggerated claims of dominance. However, the consensus is that, rather than tip the market, the standards war instead caused confusion among consumers and ISPs, delaying adoption.

In this paper, we empirically examine the interaction between intellectual property and participation in standardization committee meetings. We employ "meeting" data from the Telecommunications Industry Association, the SDO responsible for developing voluntary (consensus) standards in the analog modem market in the U.S. The paper proceeds as follows. The remainder of this section contains a literature review (1.1). In section 2, we discuss the modem market. We chose this market because the product is well defined. Section 3 presents our data on patents and section 4 presents our data on participation at standardization committee meetings. We report basic correlations and Granger causality tests in section 5. Our major finding is that while participation in standards meetings predicts future intellectual property (both un-weighted and citation weighted patents), the reverse is not true: patents and citations are not good predictors of future meeting attendance. We interpret these results primarily as reflecting the timing of standard setting relative to innovation, although we also consider the effects of knowledge diffusion at the meetings. Section 6 concludes.

## 1.1 Literature

[10] Garen, Craig, "Analog Modems Take Center Stage - Industry Trend or Event," Electronic News, August 7, 2000. Available online at http://www.findarticles.com/cf_dls/m0EKF/32_46/65023364/p1/article.jhtml, accessed April 8, 2004.

The seminal theoretical paper about the economics of standards committees finds that standards committees have desirable properties. In Farrell and Saloner (1988), each firm has a proprietary (incompatible) standard. There are network effects, so both firms prefer to use the same standard, but each prefers its own standard to that of the rival firm. In this setting, they examine the incentives for firms to achieve coordination via standardization committees and compare committees to (i) to a pure market process in which there is no communication among firms and firms can make unilateral standardization choices and (ii) a hybrid committee/market process in which firms meet in committees and yet can also make unilateral standardization decisions. They find that committees can better set standards in the sense that committees are more likely than market processes to achieve coordination, i.e., standardization (which is efficient in their model). Nevertheless, there is a tradeoff here since the committee process will typically take longer than if standardization choices were left to the market. Perhaps, not surprisingly, the hybrid process outperforms the other two mechanisms.

Several recent empirical papers are a welcome addition to a small, primarily case study literature. Lemley (2002) examines the intellectual property policies of standardization organizations, Ageureau, Greenstein, and Rysman (2003) examine the modem standards war of 1996-1998; they claim that the failure to reach standardization in the market was due to Internet service providers' incentives to differentiate their product. Simcoe (2004) examines the standard setting process of the Internet Engineering Task Force and finds that increased levels of commercial participation are associated with an increase in the time to reach agreements on standards. Meidan (2004) examines a “standard setting race” between two SSOs: an official standardization development organization (SDO) and a commercial SSO for the case of cable modems. Using event study methodology and stock market returns, she finds that the commercial consortium’s standardization decisions created increased competition in the retail market.

## 2. Modems

Modems were invented in the 1950s.[11] The modem was significantly improved by John Van Geen in 1966.[12] The first modem for personal computers was invented by Dennis Hayes in 1977. He founded Hayes Associates, Inc. in 1978, and Hayes shipped the first PC modem in 1979. Hayes became the industry standard, achieving a 60 percent of the world's modem market in 1985.[13] Hence many competing vendors marketed their modems as Hayes-compatible. The PC modem changed the industry from one that worked via leased lines to one that worked via dial-up connections.

Early modem speeds were very slow by today’s standards. In 1981, modems ran at speeds of 1.200 kilobits per second (kbs). In 1983, Hayes released the Smartcom II which ran at modem speeds of 2.400 kbs. By 1996, the maximum speed had increased to 56kbs/sec. See table 1.

Early modems were prohibitively expensive as well. In 1981, the average price of a (1.200 kbs) modem was approximately $1500, i.e., more than a dollar for each bit per second. By 1997, the price of an (analog) modem with a speed of 56 kbs had fallen to

[11] See http://inventors.about.com/library/inventors/blmodem.htm.
[12] See http://www.computerhistory.org/timeline/timeline.php?timeline_year=1966.
[13] Source: http://gtalumni.org/StayInformed/magazine/win99/high.html

less than $300, or $0.005 for each bit per second.[14] That translates into a more than 30% decline in "speed" adjusted prices per year for the fifteen year period from 1981-1996.[15]

| Maximum Speed in kbs/second | Year | Average Price | ITU standard |
|---|---|---|---|
| 9.6 | 1984 | 1,167 | V.32 |
| 14.4 | 1991 | 653 | V.32bis |
| 33.6 | 1994 | 505 | V.34, V.34+ |
| 56 .0 | 1996 | 350 | V.90 |

Table 1: Analog Modem Timeline

The ITU standards shown in Table 1 were typically developed before competition developed in the market.[16] Nevertheless, there was a standards war in this industry over the 56K standard. In September 1996, US Robotics (3COM) submitted the first V.90 56K proposed standard to the ITU. In November 1996, Lucent and Rockwell agreed to make their chipsets interoperable, using the so-called KFlex standard. The Kflex and U.S. Robotics standards were incompatible. Because of the incompatibility, sales to consumers and Internet Service Providers were lower than expected. Hence, the industry appealed to standardization agencies to establish a standard.

[14] Prices in this table come from Bob Kenas. The document is available at http://www.nric.org/fg/fg2/sc1/fg2-sc1-modems-final.doc. Original sources include the Information Technology Industry Council and the Data Analysis Group.
[15] In comparison, quality adjusted computer prices fell by about 15% in the 1980s and early 1990s and only reached rates of decline of about 30% in the second half of the 1990s. See Gordon (2000) and Oliner and Sichel (1994).
[16] There were often precursor modems from individual vendors before the ITU standards, but their numbers were low.

In April 1997, the ITU set up special committee to determine a 56K (V.90) standard.[17] In February 1998 the V.90 standard was approved by the ITU. The relatively short time between the first submission and the setting of the standard was apparently a record for the ITU.[18] Following the introduction of the standard, all **(new)** Kflex and U.S. Robotics modems were produced according to the V.90 standard and hence were interoperable. Hence even when a standards war broke out, the standard was eventually resolved through a committee process.

## 3. Patent Data

We obtained all 604 patents issued between 1976 and 1999 with the word modem in the title.[19] We then matched the patent numbers using the NBER patent data, which is publicly available at http://www.nber.org/patents/. From the latter, we obtained data on the grant year, the assignee, and the number of citations received. Figure 1 shows that until 1982 there were less than 10 patents issued per year with the word modem in the title. During the 1982-1999 period, the number of "modem" patents per year increased steadily, reaching 80 in 1999.

[17] Since the Telecommunications Industry Association (TIA) TR-30 committee was the US technical advisory group (TAG) to the ITU during this period, it was also actively involved in the process. Indeed, the chairman of the TIA TR-30.1 subcommittee at the time, Les Brown, was listed on the ITU press release announcing the standard. See http://www.itu.int/newsarchive/press_releases/1998/04.html.
[18] See http://www.itu.int/newsarchive/press_releases/1998/04.html
[19] Nearly half (44.5%) of these patents are to be found in the 3-digit patent class 375 "Pulse or Digital Communications"). Another 18.5% are in 379 ("Telephonic Communications")and another 12% in 370 ("Multiplex Communications"). The remaining 25% are to be found in more than 30 other classes.

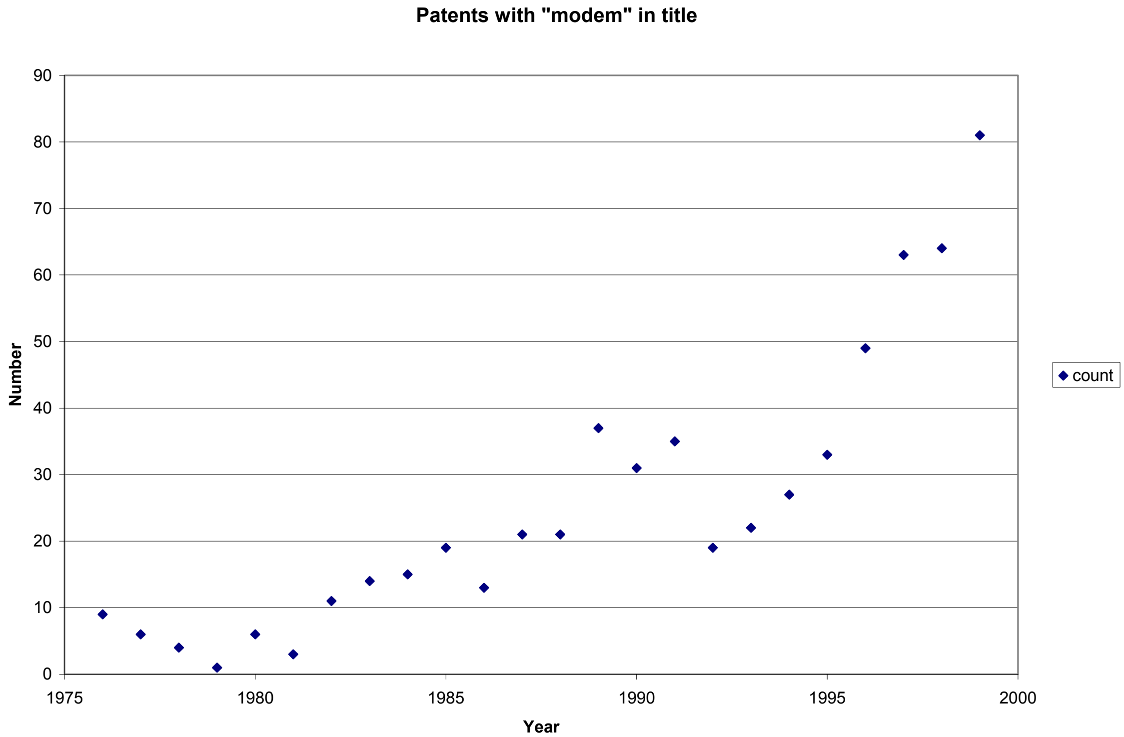


Figure 1: Patents with the word "modem" in the title: 1976-1999

194 firms received patents with the word modem in the title during the 1976-1999 period. Table 4 shows the number of "modem" patents and citations to these patents by firm for the 1976-1999 period, as well as for the 1976-1989 and 1990-1999 sub periods. (The citations are dated by the year of the receiving patent.) Motorola, the leader in cable modems from its introduction in 1997 on, had the most patents overall, as well as the largest number during the 1990-1999 period. Hayes, the first and initially dominant firm in the industry, was ranked high in the 1976-1989 period, but fell in the rankings during the 1990-1999 period. U.S. Robotics, the current market leader in dial-up analog modems, is absent from the early top 15, and is ranked only twelfth in the second period.

The list of firms include not only modem manufacturers, but producers of both modem inputs and complementary products as well, as the fourth column in the table indicates.

| Patents granted 1976-1999 | | | Products[20] | Patents granted 1976-1989 | | | Patents granted 1990-1999 | | |
|---|---|---|---|---|---|---|---|---|---|
| Firm | Patents | Citations | | Firm | Patents | Citations | Firm | Patents | Citations |
| MOTOROLA | 27 | 122 | D,U | PARADYNE | 13 | 156 | MOTOROLA | 21 | 86 |
| PARADYNE | 24 | 180 | D | HAYES | 10 | 186 | IBM | 18 | 74 |
| IBM | 23 | 119 | U,I | UNIV. DATA | 9 | 171 | INTEL | 15 | 43 |
| HAYES | 18 | 334 | D | CODEX | 8 | 131 | MULTITECH | 13 | 101 |
| UNIV. DATA | 16 | 220 | D | RACAL | 8 | 122 | FUJITSU | 13 | 63 |
| CODEX | 15 | 262 | D | HYCOM | 6 | 103 | AT&T | 12 | 166 |
| AT&T | 15 | 199 | C | MOTOROLA | 6 | 36 | COMPAQ | 12 | 74 |
| FUJITSU | 15 | 78 | C | IBM | 5 | 45 | NEC | 11 | 42 |
| NEC | 15 | 77 | C | TEXAS | 5 | 20 | PARADYNE | 11 | 24 |
| INTEL | 15 | 43 | U | TELEBIT | 4 | 129 | LUCENT | 11 | 13 |
| RACAL MILGO | 13 | 180 | D | NCR | 4 | 48 | HAYES | 8 | 148 |
| MULTI-TECH | 13 | 101 | D | NEC | 4 | 35 | U.S.ROBOTICS | 8 | 106 |
| COMPAQ | 12 | 74 | C | AMP | 4 | 14 | CODEX | 7 | 131 |
| LUCENT | 11 | 13 | I | AT&T | 3 | 15 | UNIV. DATA | 7 | 49 |
| TEX. INS (TI) | 10 | 31 | U,I | PHILIPS | 3 | 33 | CODEX | 7 | 131 |

[20] Firms products' are coded as follows: "downstream" modems (D), upstream inputs into modems (U), infrastructure for modems (I), Complementary Products (C), or other (O).

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |
| Total top 15 | 232 | 2002 | 2002 | Total top 15 | 89 | 1211 | Total top 15 | 167 | 1120 |
| Other Firms | 372 | 2893 | 2893 | Other Firms | 91 | 1344 | Other Firms | 257 | 1220 |

Table 2: Patents with word “Modem” in title.

## 4. Standardization Meetings

In the U.S., the Telecommunications Industry Association (TIA) is the primary association that sets voluntary standards in this area. During this period the TIA TR-30 committee was the US technical advisory group (TAG) to the International Telecommunications Union (ITU), the organization that sets international telecommunications standards. The TIA was formed as the result of a merger of the United States Telecommunications Suppliers Association (USTSA) and the Information and Telecommunications Technologies Group of the EIA in 1988.

The TIA is accredited by the American National Standards Institute (ANSI) to develop voluntary telecommunications standards.[21] Since TIA is an ANSI accredited SDO, its intellectual property policy is consistent with that of ANSI: Any essential patent in a U.S. standard must be licensed according to "reasonable and non-discriminatory" terms.

We focus on the TIA TR-30 committee, which is responsible for setting analog standards in data transmission systems and equipment. One of the key responsibilities of the TIA TR-30 committee is to set analog modem standards.[22] This committee has three subcommittees:

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[21] Additional information is available at the TIA website: http://www.tiaonline.org/. Annual Reports from 1994-2002 on the various TIA are committees available at: http://www.tiaonline.org/standards/star/

[22] There is a separate standards committee for digital modems, hosted by the Alliance for Telecommunications Industry Solutions (ATIS).

TR-30.1 Modems

TR-30.2 DTE-DCE[23] Interfaces and Protocols

TR-30.3 DCE Evaluation and Network Interfaces

Table 3 shows that the committee and the subcommittees meet on a regular basis, with approximately five to six meetings per year. The committee and subcommittee meetings are typically held jointly. Occasionally a subcommittee will hold an additional separate meeting.

| Committee | TR30 | TR30.1 | TR30.2 | TR30.3 |
|---|---|---|---|---|
| Meetings 1990-1999 | 56 | 57 | 55 | 60 |
| Meetings 1990-1994 | 29 | 26 | 27 | 29 |
| Meetings 1995-1999 | 27 | 31 | 28 | 31 |

Table 3: Summary of Meetings Data: TR 30 and the subcommittees

Our data consists of participation records of the 56 TR-30 meetings that took place between 1990-1999.[24] The TR-30 subcommittees show that the committee is responsible for more than just modems. However, participation data for the subcommittees are not complete and only available for a few of the years. Nevertheless, the main committee meeting and the subcommittee meetings are held at the same time at the same location and most participants who attend the main committee meetings attend

[23] Data Communications Equipment (DCE) and Data Termination Equipment (DTE).

[24] We do not have attendance data for five of the meetings during this period, three meetings during the 1990-1994 period and two meetings during the 1995-1999 period.

the subcommittee meetings as well. Indeed, there is a very high correlation (0.92) between participation at TR-30 standardization meetings during the 1993-1999 period and TR 30.1 committee meetings during the same period.[25] Hence, it seems quite reasonable to use TR-30 participation data.

Figure 1 shows the average attendance at TR-30 meetings over the 1990-1999 period. The figure shows a steady increase from approximately 35 participants per meeting during 1991 meetings to 58 in 1993. Attendance remains relatively high, peaking in 1997 at 62 participants per meeting during the standards war over the 56K modem. Afterwards attendance falls to slightly more than 40 per meeting during 1998-1999, perhaps in part due to resolution of the standards war and the advent of the digital modems.

Overall, 177 firms participated in at least one TR-30 meeting during that period. However, Table 4 shows that four firms -- Motorola, AT&T, Rockwell, and General Datacom -- accounted for 25 percent of the meeting participants during the 1990-1999 period and that the top 15 firms accounted for approximately 54 percent of the participants during that time

The Table also shows that while the top 15 firms[26] accounted for more than 66 percent of the participants during the 1990-1994 period, the top 15 firms accounted for just 51 percent of the participants during the 1995-1999 period. This suggests that an increasing number of firms believe that there are benefits from participating in the meetings.

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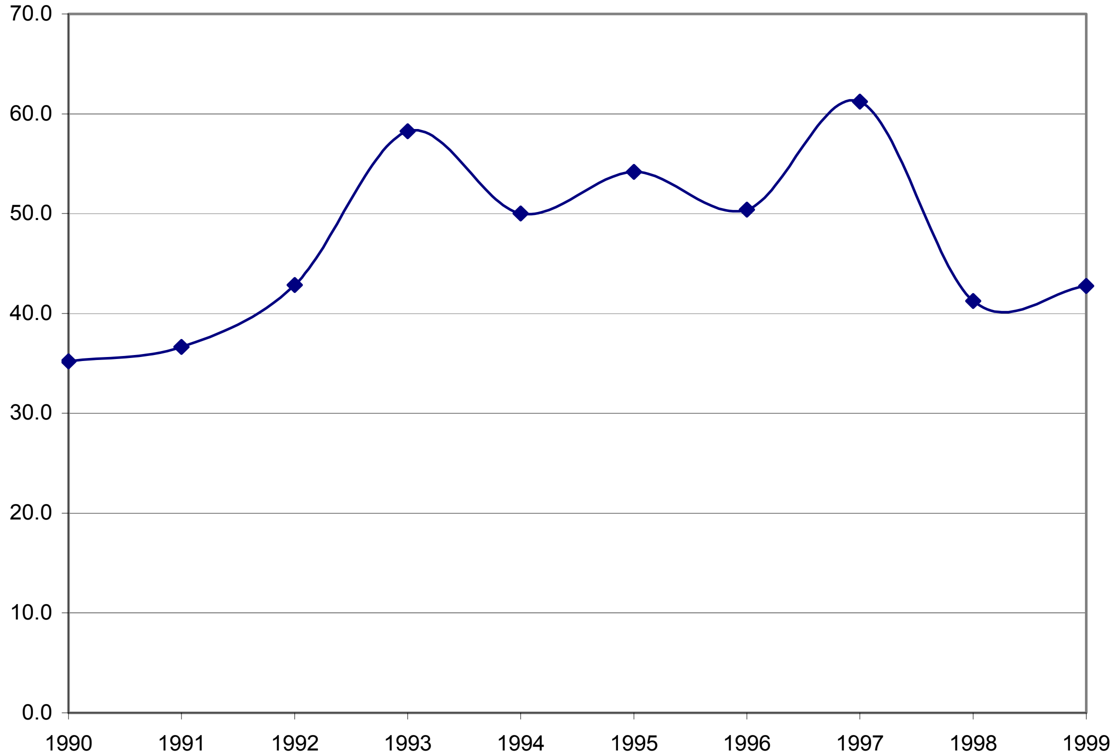
[25] The 1995 and 1998 participation data are missing for the subcommittee. Hence, we use the equivalent data for the full TR-30 committee. This calculation is made for the 45 firms that hold patents and attended meetings.

[26] The top 15 firms in the sub-periods are, of course, not the same top 15 firms that appear in table 4.

**Figure 2: Average Attendance Per TR-30 Meeting: 1990-1999**



| Firm | Attendees 1990-99 | Attendees 1990-94 | Attendees 1995-99 | Products[27] |
|---|---|---|---|---|
| MOTOROLA, INC. | 209 | 122 | 87 | D,U |
| AT&T CORP. | 190 | 136 | 54 | C |
| ROCKWELL SEMICONDUCTOR | 141 | 53 | 88 | U |
| GENERAL DATACOMM, INC. | 106 | 71 | 35 | I |
| U.S. ROBOTICS, INC. | 74 | 37 | 37 | D |
| INTEL CORPORATION | 69 | 39 | 30 | U |
| SATCHELL EVALUATIONS | 67 | 44 | 23 | O |
| HAYES MICROCOMPUTER | 66 | 40 | 26 | D |
| 3COM CORPORATION | 58 | 0 | 58 | D,U |
| TELECOM ANALYSIS SYSTEMS | 55 | 33 | 22 | O |
| RACAL MILGO | 54 | 38 | 16 | D |
| Db CONSULTING | 47 | 25 | 22 | O |
| TEXAS INSTRUMENTS | 46 | 7 | 39 | U,I |
| IBM | 44 | 15 | 29 | U,C |
| NATIONAL SEMICONDUCTOR | 40 | 24 | 16 | U |
| **Participation top 15 (1990-1999)** | 1266 | 682 | 584 | |
| **Total Participation** | 2355 | 1136 | 1219 | |

Table 4: Participation at TR-30 Meetings

[27] Firms products' are coded as follows: "downstream" modem (D), upstream inputs into modems (U), infrastructure for modems (I), Complementary Products (C), or other (O).

## 5. Patenting and Meeting Participation

Approximately 194 firms received patents with the word modem in the title during the 1976-1999 period. Similarly, 177 firms attended TR-30 standardization meetings during the 1990-1999 period. The Herfindahl index (HHI) for patents during the 1990-1994 period is 378 and 225 during the 1995-1999 period. Similarly, the HHI for the standardization meetings is 448 for the 1990-1994 period and 262 for the 1995-1999 period. Hence both intellectual property and standard meeting "competition" have become less concentrated over time. These concentration figures are extremely low relative to what the modem product market concentration figures are likely to be, but, as we saw, both meeting participants and patentees are drawn from a much wider set of firms. However, the modem patent HHI is not so much greater than the average 3-digit patent class HHI of 314, which is quite striking considering that the average number of assignees in a 3-digit class is almost 2400 – an order of magnitude greater than our set of patent modems.[28]

When we merge the two data sets (by assignee number), we find that only 45 firms both attended TR-30 standardization meetings during the 1990-1999 period and held patents with the word modem in the title. (Thus 326 firms, either held at least one patent or attended at least one meeting.)

Nevertheless, as Table 5a shows, these 45 firms accounted for more than 47 percent of the total patents issued between 1976-1999, and 41 percent of the citations

[28] The average 3-digit HHI and number of assignees is calculated on the NBER data for 1976-1999 patents only.

received in the same period. Table 5a also shows that 55% of the firms with patents attended standardization committee meetings during the 1995-1999 period, up from the 41% during the previous period. Table 5b shows that 64 percent of the attendees at the TR-30 standardization meetings between 1990-1999 held relevant modem patents.

| | Patents total | patents 76-89 | patents 90-94 | patents 95-99 | citations |
|---|---|---|---|---|---|
| | | | | | |
| Attended meetings | 281 | 65 | 56 | 160 | 2027 |
| Didn't attend meetings | 324 | 115 | 78 | 130 | 2868 |
| Total | 604 | 180 | 134 | 290 | 4895 |

Table 5a: Patent and Citation Data Summary by Meeting Participation

| | Attendees Total | Attendees 90-94 | Attendees 95-99 |
|---|---|---|---|
| | | | |
| Have Patents | 1519 | 725 | 794 |
| Don't Have Patents | 836 | 411 | 425 |
| Total | 2355 | 1136 | 1219 |

Table 5b: Meeting Summary Data by Patents

An interesting question is whether there are participants who regularly attend standard committee meetings but do not hold patents (or vice-versa). Of the 15 firms with the most participants (Table 4), only three firms did not hold patents. Two of the three, Satchell Evaluations (67 participants) and Telecom Analysis Systems (55 participants), test modems and other telecommunications equipment. The third, Db Consulting (47 participants), provides information on relevant standards to the disabled community.[29] These three firms clearly had no intellectual property, even nascent, to promote in attending these meetings. They attended for informational reasons (and perhaps for user advocacy reasons in the case of the third firm).

Of the 15 firms with the most modem patents during the 1976-1999 period, only Fujitsu, a major provider of electronics and communications products, did not attend any standardization meetings. Of the 15 firms with the most patent citations, only 3 did not attend standardization meetings: Fujitsu, Hycom Data Communications, and ITT. ITT Industries is a global engineering and industrial manufacturing company with important products in communications and networking. Hycom is a Korean firm that integrates data/voice network infrastructures. As Table 4 shows, the firm received most of its citations in the 1976-1989 period. According to a former chief scientist, one of its primary sources of income was the licensing of modem designs to such companies as Phillips, Racal Milgo, ITT and Sharp Corporation.[30] We do not know why these firms did not participate in the meetings. A reasonable conjecture is that their patents covered elements of the technology for which there was no competing standard, or add-on components that did not require standardization. In the case of Hycom, it is possible that some of its licensees essentially functioned as proxies at the meetings. Whatever the case,

[29] See: http://tap.gallaudet.edu/rerc_uta.htm.

[30] see: http://www.hycom.com/eng/about/greeting.html & http://www.astdesign.com/dm.htm. http://www.findarticles.com/p/articles/mi_m0BFP/is_1999_July_12/ai_55129529.

this informal analysis suggests that nearly all key players in the modem industry both participated in standardization meetings and held relevant patents.

**5. Empirical Analysis:**

We now use the merged data set to conduct a more formal analysis. We first define the following variables at the firm level:

| | |
|---|---|
| Patents: | Total number of patents issued during the 1976-1999 period |
| Citations: | Total number of citations received during the 1976-1999 period |
| Meetings: | Total number of meeting participants for the 1990-1999 period |
| Meetings1: | Total number of meeting participants for the 1990-1994 period |
| Meetings2: | Total number of meeting participants for the 1995-1999 period |
| Patents1: | Total number of patents issued during the 1990-1994 period |
| Patents2: | Total number of patents issued during the 1995-1999 period |
| Citations1: | Total number of citations received during the 1990-1994 period. |
| Citations2: | Total number of citations received during the 1995-1999 period |

Descriptive statistics appear in the appendix. Table 6 presents correlations for the following three variables: Total patents for the 1976-1999 period, total citations for the 1976-1999 period, and TR-30 meeting participation for the 1990-1999 period. In table 6a, the data are for all 326 firms that have at least one patent or attended at least one meeting.   Table 6b presents the same summary data for the 45 firms that had patents and attended meetings.

These tables show that there is a very high degree of correlation between patents and citations.  This, of course, is not surprising.  The interesting result is the relatively high degree of correlation between patents and meetings. Tables 6a and 6b show that the correlations are similar for both data sets.

| | Patents | Meetings | Citations |
|---|---|---|---|
| Patents | 1.00 | | |
| Meetings | 0.52 | 1.00 | |
| Citations | 0.80 | 0.39 | 1.00 |

Table 6a: Correlation among Variables: All 326 firms

| | Patents | Meetings | Citations |
|---|---|---|---|
| Patents | 1.00 | | |
| Meetings | 0.55 | 1.00 | |
| Citations | 0.75 | 0.45 | 1.00 |

Table 6b: Correlation among Variables: 45 firms who attended meetings and held patents

Table 7a (full data set) and Table 7b (45 firms) present correlations using the period 1 and period 2 variables.  We first compare the correlations across periods (1) and (2) for the same variable.  In the case of all 326 firms, the correlation between the period (1) meeting participation and period (2) meeting participation is 0.72, while the same correlation is 0.68 for the smaller data set.

The correlations in patents across periods and citations across periods are lower than the correlations across meeting attendance. The correlation between Patent1 and Patent2 is 0.35 for the full data set and 0.27 for the smaller data set. Similarly, in the case of citations, the correlation across the two periods is 0.30 for the full data set and 0.27 for the smaller data set.

When we look across different variables and different periods for the full data set, we find that the contemporaneous correlation between citations and meetings is higher in period two than it is in period one. Similarly, the correlation between patents and meetings is higher for period two. Perhaps the most striking result is the relatively high correlation between Citation2 and Meetings1 (0.60 for the full data set and 0.63 for the smaller data set.)

| Full Data Set | | | | | |
|---|---|---|---|---|---|
| | Meetings1 | Meetings2 | Patents1 | Patents2 | Citations1 |
| Meetings1 | 1.00 | | | | |
| Meetings2 | 0.72 | 1.00 | | | |
| Patents1 | 0.36 | 0.28 | 1.00 | | |
| Patents2 | 0.42 | 0.56 | 0.35 | 1.00 | |
| Citations1 | 0.33 | 0.27 | 0.89 | 0.35 | 1.00 |
| Citations2 | 0.60 | 0.45 | 0.31 | 0.60 | 0.30 |

Table 7a: Correlations among Patents and Meetings: Full Data Set

| 45 firms who attended meetings and held patents | | | | | |
|---|---|---|---|---|---|
| | Meetings1 | Meetings2 | Patents1 | Patents2 | Citations1 |
| Meetings1 | 1.00 | | | | |
| Meetings2 | 0.68 | 1.00 | | | |
| Patents1 | 0.46 | 0.27 | 1.00 | | |
| Patents2 | 0.39 | 0.55 | 0.27 | 1.00 | |
| Citations1 | 0.39 | 0.25 | 0.90 | 0.25 | 1.00 |
| Citations2 | 0.63 | 0.41 | 0.25 | 0.54 | |

Table 7b: Correlations among Citations and Meetings: 45 firms

### 5.1 Granger Causality

The relatively high correlations in Tables 7a and 7b between intellectual property and meeting participation data begs the question whether there is a causal relationship between these variables. That is, does increased participation in standard committee meetings lead to increases in intellectual property, or does increased intellectual property holdings lead to greater participation at standards meetings?

Given the limitations of our data, we can test for causality only in the narrow, technical sense formalized by Granger (1969) and Sims (1980).[31] In this interpretation, a variable *X* causes *Y* if lagged values of X are significant in explaining Y in a regression in which lagged values of Y are also explanatory variables. It is, of course, possible that causality can exist in both directions. This test is performed using vector autoregessions (VARs). We are not estimating a structural model when performing these tests; nevertheless, we believe that this type of analysis is useful for an initial examination of these variables.

Since it typically takes on average 2-3 years to receive a patent, it seems sensible to use two periods that correspond to periods for which we have data on standard committee participation: 1990-1994 and 1995-1999. Since there is there is only a single lag for the standard participation data we employ the following specification.

$$Yt = \beta_0 + \beta_1 Y_{t-1} + \beta_2 X_{t-1}.$$

[31] This section draws from Gandal, Greenstein, and Salant (1999), who conducted a similar type of analysis.

Formally X causes Y if $X_{t-1}$ is significant in explaining Y, after controlling for $Y_{t-1}$. Tables 8a and 8b present results from VAR regressions of intellectual property on meeting participation and vise-versa.

| Full Data Set | Dependent Variable | | | |
|---|---|---|---|---|
| N=326 | Patents2 | Citations2 | Meetings2 | Meetings2 |
| Independent Variables | | | | |
| Constant | 0.50 | 0.27 | 1.68 | 1.66 |
| | (4.45) | (1.23) | (3.93) | (3.95) |
| Patents1 | 0.45 | | 0.24 | |
| | (4.32) | | (0.59) | |
| Citations1 | | 0.08 | | 0.027 |
| | | (2.50) | | (0.94) |
| Meetings1 | 0.057 | 0.44 | 0.57 | 0.56 |
| | (6.48) | (12.02) | (16.99) | (17.12) |
| Adjusted R-squared | 0.22 | 0.37 | 0.51 | 0.51 |

Table 8a: Granger Causality Analysis: All firms (*t*-statistics in parentheses).

| 45 firms included | Dependent Variable | | | |
|---|---|---|---|---|
| N=45 | Patents2 | Citations2 | Meetings2 | Meetings2 |
| Independent Variables | | | | |
| Constant | 2.44 | 3.37 | 10.28 | 9.96 |
| | (3.11) | (0.34) | (3.56) | (3.51) |
| Patents1 | 0.26 | | -0.64 | |
| | (0.73) | | (-0.46) | |
| Citations1 | | -0.03 | | -0.02 |
| | | (-0.26) | | (-0.19) |
| Meetings1 | 0.05 | 0.52 | 0.51 | 0.49 |
| | (2.11) | (4.90) | (5.63) | (5.67) |
| Adjusted R-squared | 0.12 | 0.36 | 0.45 | 0.44 |

Table 8b: Granger/Sims causality tests: All 45 firms (*t*-statistics in parentheses).

In the case of all 326 firms, the first column of Table 8a shows that early patents predict later ones; every additional early patent is associated with about half of an additional late patent. Even controlling for this effect, early participation in standards meeting predicts later patents. An additional participant at each of the 29 meetings in the first half of the 1990s would predict an additional 1.7 patents in the second half. The second column of Table 8a similarly shows that early citations predict later citations. Likewise, after controlling for the lagged dependant variable, early participation in standards meetings explains the later citations as well. Table 8b restricts the sample to the 45 firms that both patented and attended at least one meeting. Now, the lagged dependent variable has no predictive power in either of the first two columns. Yet participation in the early standards meetings still predicts the late patents and citations.

The obvious explanation for this finding is that firms with pending, but not yet granted, patents attend the committee to have the standard incorporate their intellectual property. However, as there is typically a lag of only two to three years between patents applications and patent grants, it is possible that firms lobby to introduce innovations for which there have not yet applied for a patent – although there are obvious risks in doing so. Another possible explanation is that the information garnered at these meetings help advance firms' intellectual property portfolio. Another type of knowledge diffusion may be relevant to the effect of early meetings on citations; firms may cite patents of other firms attending standard meetings. We hope to discriminate among these various explanations in future research.

The third and fourth columns of Tables 8a and 8b show that past participation in early standardization meetings is a good predictor of participation in later ones. With our limited data, we can not hope to discriminate between a heterogeneity explanation for this correlation, and a state-based explanation – e.g., that firms who participate in standardization meetings realize the benefits from doing so and continue to participate in the future. More interesting is the finding that neither early patents nor early citations predict participation in the later standardization meetings. This finding indicates that only recent innovations are the subject matter of these meetings. Innovations covered by patents that are four to five years old must either no longer be technology relevant, or have had their standardization decision already made – they are either already in the standard, or out.

## 6. Conclusion

We empirically examined the interaction between patenting and participation in standardization committee meetings. We showed that while many firms obtained "modem" patents and many firms participated in standardization meetings, only a small subset of 45 firms both obtained patents and participated in the standardization meetings. These firms accounted for a significant percent of the patents received and the total number of meeting attendees. For the 45 firms that both obtained at least one patent and attended at least one standardization meeting, we find a fairly high correlation among the intellectual property and meeting participation data. Using Granger-causality tests, we also find that although participation in standards meetings is predicts future intellectual property (measured by both patents and citations), early patents or citations do not predict later participation in the meetings. We interpret these results primarily as reflecting the timing of standard setting relative to innovation, although we also consider the effects of knowledge diffusion at the meetings.

Missing from this analysis is a formal consideration of firms' importance in the product market. This third element is difficult to add not only because there are various modem product markets (dial-up, faxes, etc.), but also because both meeting participants and patentees are often not modem producers at all, but input suppliers or users, as we have seen. Furthermore, market share data are difficult to obtain. Nevertheless, understanding the three way interaction of meeting participation, patenting and product market competition is surely essential to a full understanding of the role of standardization committees in the modem market, and in markets more generally. We hope to address this issue it in future research.

## References:


Augeureau, A., Greenstein, and M. Rysman, Coordination vs. Differentiation in a Standards War: 56K Modems, 2003 mimeo.

Caplan, P., "Patents and Open Standards," National Information Standards Organization, 2003, available at http://www.niso.org/press/whitepapers/Patents_Caplan.pdf.

David, P., and S. Greenstein, 1990, "The Economics of Compatibility Standards: An Introduction to Recent Research," *Economics-of-Innovation-and-New-Technology*, 1: 3-41.

Farrell, J., and P. Klemperer, forthcoming 2005, Handbook of Industrial Organization.

Farrell, J., and G. Saloner, 1988, "Coordination through Committees and Markets," Rand-Journal-of-Economics; 19(2): 235-52.

Gandal, N., 1995, "A Selective Survey of the Literature on Indirect Network Externalities," *Research in Law and Economics,* 17: 23-31.

Gandal, N., 2002, "Compatibility, Standardization, & Network Effects: Some Policy Implications," Oxford Review of Economic Policy, 18: 80-91.

Gandal, N., Greenstein, S., and Salant, D., 1999 "Adoptions and Orphans in the Early Microcomputer Market." *Journal of Industrial Economics*, Vol. XLVII: 87-105.

Gilbert, R., 1992, "Symposium on Compatibility: Incentives and Market Structure," *Journal of Industrial Economics*, 40: 1-8.

Gordon, R., 2000, "Does the New Economy Measure up to the Great Inventions of the Past, *Journal of Economic Perspectives*, 14: 49-74.

Lemley, M., 2002, Intellectual Property Rights and Standard-Setting Organizations, *California Law Review*, 90: 1889.

Matutes, C., and P. Regibeau, 1996, "A Selective Review of the Economics of Standardization: Entry Deterrence, Technological Progress, and International Competition," *European Journal of Political Economy*, 12: 183-206

Meidan, M., The Effects of the Standardization Process on Competition: An Event Study of the Standardization Process in the US Cable Modem Market, 2004, Stanford University mimeo.

Merges, R., 1998, Institutions for Intellectual Property Transactions: The Case of Patent Pools, UC-Berkeley mimeo.

Oliner, Stephen D., and Daniel E. Sichel, 'Computes and Output Growth Revisited: How Big is the Puzzle?", Brookings Papers on Economic Activity 1994 (2), 273-317.

Simcoe, T., Committees and the Creation of Technical Standards, 2004 University of California-Berkeley mimeo.

Stango, V., 2004, "The Economics of Standards Wars, *Review of Network Economics*, 3: 1-19.

## APPENDIX

### Descriptive Statistics

| Variable | Mean | Std. Dev. | Minimum | Maximum |
|---|---|---|---|---|
| Meetings | 7.22 | 21.48 | 0 | 209 |
| Patents | 1.76 | 3.63 | 0 | 27 |
| Citations | 14.03 | 37.00 | 0 | 334 |
| Meetings1 | 3.48 | 12.87 | 0 | 136 |
| Meetings2 | 3.74 | 10.30 | 0 | 88 |
| Patents1 | 0.37 | 1.07 | 0 | 8 |
| Patents2 | 0.87 | 2.14 | 0 | 18 |
| Citations1 | 4.22 | 14.61 | 0 | 148 |
| Citations2 | 2.45 | 10.06 | 0 | 132 |

Table A1: Full Data Set, N=326

| Variable | Mean | Std. Dev. | Minimum | Maximum |
|---|---|---|---|---|
| Meetings | 33.76 | 46.83 | 1 | 209 |
| Patents | 6.24 | 6.98 | 1 | 27 |
| Citations | 45.04 | 70.64 | 0 | 334 |
| Meetings1 | 16.11 | 29.72 | 0 | 136 |
| Meetings2 | 17.64 | 21.19 | 0 | 88 |
| Patents1 | 1.24 | 1.93 | 0 | 8 |
| Patents2 | 3.56 | 4.32 | 0 | 18 |
| Citations1 | 15.27 | 27.45 | 0 | 148 |
| Citations2 | 11.31 | 24.24 | 0 | 132 |

Table A2: Firms that have at least one patent and attended at least one meeting, N=45.