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Research Paper

The Market Value of Technology Disclosures to Standard Setting Organizations

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ABSTRACT In light of the increased demand for interoperability, fragmented ownership of intellectual property and high costs for communicating new technologies, open standard-setting activities emerged as an important coordination and diffusion mechanism. Little is known about the value of contributions to standard setting organizations (SSOs) for technology providers. This paper provides a large-scale empirical assessment of the value of disclosures to SSOs for technology sponsors. Our findings show that disclosures referring explicitly to patents are evaluated positively by the market while this is not the case for blanket disclosures. This indicates that the expected benefits of participating in SSOs outweigh potential disadvantages from making patented technologies available to the market under SSO licensing conditions. The market does not appreciate disclosures to SSOs if there is uncertainty about the associated technologies.

KEY WORDS: Open standards, IP disclosures, market value

JEL Classification: O32, O34, L15

Introduction

Standard setting activities have become an increasingly important coordination mechanism in technology markets (Besen and Farrell 1994). Their frequency has grown tremendously during the last decade (Simcoe 2007). This is due to at least two developments. At first, there is an increased demand for interoperability of products and technologies. Telecommunications, computers and electronics industries have made extensive use of new information and communication technologies (ICTs) and share increasingly similar technology bases (Rosenberg 1976; Bresnahan and Trajtenberg 1995). Second,

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ownership of intellectual property (IP) has become more fragmented in the past which raises transaction costs, royalty stacks and the risk of hold-up (Shapiro 2001; Gallini 2014; Grimpe and Hussinger 2014). In such a complex environment, standards define a set of technical specifications which are intended to provide common interface designs for products or processes. Standards can emerge as the result of market competition or from formal and informal coordination in standard setting organizations (SSOs). Standard setting through SSOs has become increasingly important over the past decades (Blind et al. 2011). As public or private non-profit organizations, SSOs provide a legal framework for different technology owners to agree voluntarily and cooperatively on technology standards.

Standards have been shown to contribute to national growth (Acemoglu, Gancia, and Zilibotti 2010; Blind and Jungmittag 2008) and to facilitate international trade flows (Swann, Temple, and Shurmer 1996). Stakeholders value the expected product variety and global outsourcing opportunities (Blind, Gauch, and Hawkins 2010). Consumers can benefit from ongoing competition among providers of standardized products (Koski and Kretschmer 2005), lower downstream prices and increased product variety (Gallini 2014). The increasing evidence for industries' and consumers' benefits from standards notwithstanding, evidence for technology providers' returns to open standard setting activities, is limited so far. On the one hand, technology sponsors can expect high returns from their participation in standard setting activities. Owning a technology that is essential for a standard can secure a stream of future licensing revenues. It can further increase the costs of rivals that are not participating in a standard (Salop and Scheffman 1983) and help maintaining the freedom to operate a technology (Blind et al. 2011).

On the other hand, there are significant financial costs of being involved in SSOs (Chiao, Lerner, and Tirole 2007; Rysman and Simcoe 2008). Chiao, Lerner, and Tirole (2007) report that IBM spent half a billion of dollars in 2005 on standard development which equals 8.5 per cent of their total R&D budget. Standard setting activities further imply the threat that technologies disclosed to the SSO create spillovers to competitors and grant them a competitive advantage on technology and product markets (Dahlander and Wallin 2006; Waguespack and Fleming 2009). This can be especially harmful if disclosures to SSOs involve technical information beyond the details publicly available in patent documents (Blind and Thumm 2004). Moreover, technology sponsors have to waive their exclusive patent rights when their technology is included in open standards. They have to provide licenses on reasonable and non-discriminatory (RAND) terms to everybody, hence limiting royalties. The advantages and disadvantages of standard setting activities render the question on its returns for technology sponsors to SSOs an empirical one.

In this paper, we provide large-scale empirical evidence on the correlation of technology sponsoring to SSOs with companies' market value. We build on prior literature that showed that individual patents once declared as essential for a standard patents receive more citations by future patent applications, suggesting a value increase of the patent in the technology market (Rysman and Simcoe 2008) and an increased citation frequency by members of the consortium (Delcamp and Leiponen 2014). With focus on the firm level, Waguespack and Fleming (2009) show that participation in standard consortia increases the likelihood of a buy-out for start-ups. Blind, Neuhaeusler, and Pohlmann (2014) show that standard essential patents increase firms' returns to assets. We contribute to this literature by showing that the disclosure of potentially standard essential patents correlates positively with the market valuation of companies. The market value is a much broader concept than financial returns since not only immediate financial performance effects are taken into account, but also the future expected value associated with the disclosure event. According to a recent survey by Blind et al. (2011), SSO participation is most valuable because it allows firms to maintain the freedom to operate technologies. The market value approach accounts for this source of value which does not lead to immediate financial returns.

Since there is considerable heterogeneity between SSOs ranging from de jure public bodies[2] to private alliances and consortia (Leiponen 2008; Chiao, Lerner, and Tirole 2007), we focus on a specific type of SSO. First, we only consider open SSOs. Open SSOs are open in the sense that anybody may contribute to and make use of the associated standards, but they are also partially closed by requiring RAND licenses.[3] Second, we only focus on compatibility standards. Such standards define technical specifications which govern the interaction between components of a technical system. Our sample consists of large established companies which have been publicly traded in the USA from 1986 to 2005. All the firms are active in industries in which at least one firm disclosed at least once a technology to one of our standards.

Our results from a market value approach show that technology disclosures to open SSOs are positively correlated with company valuation if they explicitly refer to patents. If technology is disclosed to SSOs without referring to a patent, i.e. blanket disclosures, no market reaction is observed. This suggests that patents reduce information asymmetries about the disclosed technology so that the market can form an opinion about the value of the disclosed technologies and its chances to become part of a standard. The results further suggest that the benefits of disclosing patented technologies outweigh the costs. In the absence of a patent reference, the market faces uncertainty about the disclosure-related IP so that no positive correlation with the market value is observed. Our findings hold when unobserved firm-specific effects are taken into account.

The next section provides a literature review and develops our hypotheses. Section 3 outlines the estimation approach while Section 4 describes our data-set. Econometric evidence is presented in Section 5 and the last section concludes.

Literature Review

Standard Setting Processes

Standards provide technical specifications for a common design of products or processes (Lemley 2002). Compatibility standards specify, in particular, interface designs which govern the interaction of components in a technical system. Furthermore, standards codify technical knowledge which facilitates diffusion and adoption of technical knowledge.

Standard setting processes are quite heterogeneous. The economic literature has predominantly focused on de facto standards. De facto standards result from competition among firms that offer competing incompatible technologies. Network externalities induce consumers to gravitate to one standardization approach (Farrell and Saloner 1985). On the other extreme, standards may be selected by public bodies which impose them by authority on industry participants (David and Greenstein 1990). These are so-called de jure standards. Besides administrative and pure market coordination, standards may result from

[2] De jure standards refer to standards mandated by legal requirements or other types of formal standards.

[3] In the following, if not expressed otherwise, the term SSO refers to these open, voluntary and consensus-based organizations.

a hybrid system of competition and voluntary coordination. Standards from cooperative coordination are likely to be of higher quality than those resulting from market selection; at the cost of a delayed introduction, though (Farrell and Saloner 1988). Leiponen (2008) provides a typology of the various organizational forms of such forums. These may be private alliances, industry consortia or open SSOs (see also Hawkins 1999; Blind and Gauch 2008). We focus subsequently on the latter type of organization.

SSOs develop standards for designated technological fields in an open, voluntary and consensus-based fashion.[4] This ensures that standard setting processes are pro-competitive (Lemley 2007). Openness shall prevent inter-firm coordination while competitors remain excluded. It also refers to the scope of potential standard users. Standards shall be available to anybody without discrimination. Furthermore, openness shall prevent a too narrow focus on technology providers' interests. Governments, users and consumers are consequentially represented in these organizations. Participation in SSOs is voluntary so that technology providers cannot be forced to contribute to standards. Consensus-based decision-making shall guarantee that standards are chosen on technical merits and that diverging interests are respected and incorporated (Farhi, Lerner, and Tirole 2005).

Open licensing does not imply royalty-free licenses (Dahlander and Gann 2010). In general, SSOs discourage intellectual property rights (IPRs). Technology is preferably standardized when it is not patent protected or when non-discriminatory, royalty-free licenses are available. If "technical reasons justify this approach" (American National Standards Institute (ANSI) 2011),[5] patent-protected technology may exceptionally be standardized if and only if licenses will be granted on RAND terms. Thus, valuable royalty demanding technology may be standardized if no adequate royalty-free alternative is available. Prerequisite is that patent owners promise ex ante (i.e. before standards are approved) to charge RAND licensing terms (Baumol and Swanson 2005).

SSOs' IP bylaws reflect their role in resolving the tension between formulating high-quality designs and guaranteeing a wide availability of standards (Farrell et al. 2007). Open SSOs lack formal enforcement power. Exclusive rights of technology providers have accordingly to be respected. SSOs' IP bylaws provide a legal framework that governs the treatment of members' IPRs (Lemley 2002, 2007). SSOs require their members to disclose any known IPR that might be "essential" to a standard before it is approved. Patents are deemed "essential" if it is not possible for goods or services to comply with the technical standard specification without infringing that patent.[6]

Disclosure requirements shall limit patent owner's ability to exploit opportunistically the market power conferred by being included in a standard.[7] Once adopted, standards exhibit a considerable degree of lock-in. Industry-wide specific investments in standard-compliant machinery and equipment have been sunk, development of cumulative, next-generation

[4] A more detailed description of the standard development procedure in SSOs can be found in the Appendix.

[5] "Guidelines for implementation of the ANSI patent policy" (2011), available at: http://publicaa.ansi.org/sites/apdl/Documents/Standards%20Activities/American%20National%20Standards/Procedures,%20Guides,%20and%20Forms/Guidelines%20for%20Implementation%20of%20ANSI%20Patent%20Policy%202011.pdf.

[6] The ETSI Intellectual property rights policy is available at http://www.etsi.org/WebSite/document/Legal/ETSI_IPR-Policy.pdf.

[7] For a discussion of recent legal disputes regarding hold-up within standard setting, see, e.g. Shapiro (2001), Farrell et al. (2007) and Geradin and Rato (2006).

standards may be underway, etc. (Shapiro 2001). Owners of essential patents that have not waived their right on exclusivity could, hence, expropriate substantial rents beyond patent's intrinsic technological value, simply because switching costs are that high.

SSOs' disclosure, licensing and negotiation rules reflect these hold-up risks. Large SSOs typically require their members to license essential IPR on RAND terms, although licensing negotiations take place outside SSOs due to antitrust concerns (Gilbert 2009). Agreeing on RAND licensing terms does not oblige to specific licensing terms. It does, however, oblige to licensing negotiation that are conducted in good faith without deceiving SSO participants into ex-post hold-up. Furthermore, royalty rates should be RAND in view of available technical alternatives and in view of cumulative royalty rates when standards read on multiple, fragmented patents (Baumol and Swanson 2005).

Although IP bylaws impose obligations which are partially implicit, they seem to do a fairly good job in preventing hold-up (Lemley 2002; Geradin and Rato 2006). Providers of essential technology commit themselves to negotiate RAND licensing terms in good faith after the standard has been defined (Merges 1996). Thus, open standards can be regarded as certification that technology users will not be squeezed ex post (Farrell and Gallini 1988).

The Value of Contributing to Open Standards

As technology providers contribute voluntarily to open standards, lost benefits from exclusive access to technology have to be offset by expected benefits from participating in open standards. Licensing revenues from open standards are unlikely the primary motivation to contribute to open standards (Garud and Kumaraswamy 1993; Blind et al. 2011). However, it does not seem accidental that open SSOs proliferated particularly in those industries in which complex technologies offer a multitude of applications and in which demand for interoperability is high (Lemley 2002; Simcoe 2007). When interfaces are standardized, components provided by different suppliers and products from different market segments can be combined to form larger technical systems. Reduced hold-up risks in open standards improves the attractiveness for complementary product suppliers to apply these standards. Customer valuation for one standardization approach increases with the available variety of complementary and compatible products that can be combined in a technical system (e. g. Katz and Shapiro 1985; Gallini 2014). Expanding user bases stimulates the attractiveness of one standardization approach for users and complementary product suppliers even further. A positive feedback is, thus, generated which reinforces and installs increasing market shares. Markets tend to tip to one dominant standard in such industries (Shapiro and Varian 1999). These increasing returns to adoption are a powerful force for an industry to coalesce around a single dominant standard. Establishing a large user base early is crucial for standards to become dominant.

Open standards are more likely to achieve widespread adoption than closed proprietary standards (Simcoe 2007). Giving momentum to technology adoption and initiating a bandwagon of complementary product entry should, thus, be a major motivation to contribute technologies to open standards. On the other hand, open and cooperative standards are subject to intensified competition which renders it harder for technology providers to capture value and sustain competitive advantages. The tension between cooperation and competition is inherent in standard setting processes (Gallini 2014). Although the consensus-driven approach to standardization emphasizes cooperation, participants compete fiercely to align standards with private benefits (Suarez 2004). Cooperation and open licensing is, however, likely when technology offers various applications to differentiated markets (Barnett 1990; Gambardella and Giarrantana 2013). Cooperation among large technology providers, which utilize standards themselves in downstream product markets, is likely to the extent that no single technology provider can block the standard development process because a substitute technology is not available (Layne-Farrar, Llobet, and Padilla 2010; Layne-Farrar and Lerner 2011).[8]

Hence, we expect that financial markets value technology sponsoring positively, on average, since contributions to standard setting activities can be an indication for future profits of the technology sponsor.

> H1: Technology disclosures to open ICT standards are positively valued by financial markets.

The quality of the contributions to SSOs and the likelihood that the sponsored technologies will actually become part of a standard are difficult to judge for the market ex ante though. Investors and other market participants typically face an informational disadvantage as compared to firm insiders with regard to the quality of the proposed technology (Hall and Lerner 2010). Technology disclosures to SSOs can, however, contain "quality signals" such as that the technology disclosure to the SSO explicitly refers to the associated patents. Patents serve as a proof of concept of the submitted technology. The reference to a patent elucidates the technology disclosure's technical value and allows the market to form an assessment of this value and the chance that the technology will become part of a standard.

Technology contributions to standards do not have to indicate specific patent rights. General statements of possession of eventually essential IP and associated licensing intentions suffice to fulfill disclosure requirements. Technology sponsors may make blanket disclosures which means that they indicate the existence of a potentially relevant technology without referring to a specific patent (Bekkers and Martinelli 2013).[9] Blanket disclosures are less costly for technology sponsors because they do not have to investigate their patent portfolio in search for standard-relevant patents. These costs are shifted to third parties interested in the potentially standard-relevant technology (Bekkers et al. 2012). Blanket disclosures come at the potential cost of a lack of transparence and uncertainty about the value and success of a disclosure. They are more difficult to be evaluated by the SSO and the market so that we hypothesize the following:

> H2: Technology disclosures to open ICT standards are more valuable when patent rights are explicitly referred to.

[8] Coordination is especially difficult when technology providers are heterogeneous (Simcoe 2012). Temptations to split off from coordinated standards are high for specialized technology suppliers. As they lack revenues from downstream product markets, their participation has to be rewarded by licensing premiums (Schmalensee 2009; Gilbert 2009). In contrast, vertically integrated incumbents adopt standards themselves in downstream markets. Licensing revenues play only a minor role for them. Coordination among vertically integrated firms should be easier as profits are made downstream.

[9] Bekkers and Martinelli (2013) provide an example for a blanket disclosure in the Appendix of their paper.

Estimation Approach

Publicly traded companies can be regarded as bundles of tangible and intangible assets whose value is determined by financial markets. As market prices for intangible assets are usually not observable, hedonic pricing models are used to assess the contributions of various assets to firm value (Griliches 1981). The market valuation of companies is a forward-looking measure for financial market's expectations on returns from investments in different assets. If financial markets work efficiently, various assets are valued simultaneously according to their discounted value of expected cash flows. We follow Griliches (1981) by assuming a linear market value function that is additively separable in assets. According to Equation 1,

$$V_{it}(A_{it}, K_{it}) = q_{it}(A_{it} + \gamma K_{it})^{\sigma_t} \quad \text{or} \quad \log V_{it} = \log q_{jt} + \sigma_t \log A_{it} + \sigma_t \log\left(1 + \gamma \frac{K_{it}}{A_{it}}\right) \tag{1}$$

the value V_{it} of company *i* in year *t* is given by the sum of physical assets A_{it} and knowledge assets K_{it}. The parameter γ represents the marginal value contribution of an one-unit increase in the ratio of knowledge capital to physical assets. The current valuation coefficient q_{jt} captures factors that affect firm value multiplicatively, like time- and industry-specific effects. σ_t indicates the returns to scale of factor inputs. Following the empirical literature (Hall 2000; Hall, Jaffe, and Trajtenberg 2005), we assume constant returns to scale, i.e. $\sigma_t = 1$. Equation 1 can then be rewritten as

$$\log Q_{it} = \log \frac{V_{it}}{A_{it}} = \log q_{jt} + \log\left(1 + \gamma \frac{K_{it}}{A_{it}}\right). \tag{2}$$

The left-hand side of the Equation (1) is the log of Tobin's Q, defined as the ratio of market value to replacement cost of physical assets. γ represents the shadow value of investors for the ratio of knowledge capital to physical assets. We use different variables to measure firm's knowledge assets K_{it}. First, we use the stock of firm's R&D expenses (Hall 1993). As R&D activities measure the input into highly uncertain activities, we use additionally the stock of patent applications as a measure for successfully finished R&D activities (e.g. Blundell, Griffith, and van Reenen 1999). Since previous literature has shown that the distribution of patent value is highly skewed (Harhoff et al. 1999), we further add patent citations as a patent quality indicator to the specification (Hall, Jaffe, and Trajtenberg 2005). Forward patent citations have been shown to correlate positively with patents' social as well as with its private value (Trajtenberg 1990; Hall, Jaffe, and Trajtenberg 2005). They further reflect the economic and technological importance of patents as perceived by the inventors themselves (Jaffe, Trajtenberg, and Fogarty 2000) and the knowledgeable peers in the technology field (Albert et al. 1991).

Besides these established measures for firm's knowledge stocks, we include the stock of firm *i*'s disclosures of IP at SSOs.

$$\log Q_{it} = \log q_{it} + \log\left(1 + \gamma_1 \frac{\text{R\&D}_{it}}{A_{it}} + \gamma_2 \frac{\text{PAT}_{it}}{\text{R\&D}_{it}} + \gamma_3 \frac{\text{CIT}_{it}}{\text{PAT}_{it}} + \gamma_4 \frac{\text{Disclosure}_{it}}{\text{PAT}_{it}}\right). \tag{3}$$

Proxies for firm's knowledge stock enter the estimation equation in a cascading specification. Each variable is normalized by the preceding one. Accordingly, firm's disclosure activities $Disclosure_{it}$ enter othogonalized by the patent stock. The coefficients in this cascading specification have to be interpreted as a premium or a discount on the variable PAT_{it} / $R\&D_{it}$. Regarding our variable of main interest, the stock of disclosures, the estimated coefficient γ_4 is expected to be positive, showing a value-premium beyond firm's patent stock.

According to H2, an indication of patent rights in technology disclosures should facilitate financial market's evaluation and spur the value of standard-setting activities. We investigate this hypothesis by separating disclosure stocks between those referring to specific patents and blanket disclosures. These distinct stocks will enter Equation 3 separately.

Data

Sample

Our sample consists of yearly firm-level information on 609 publicly traded companies during 1986 and 2005. These companies are traded on US capital markets and are active in industries in which at least one company announced standard-relevant IP to the considered SSOs. These are mechanical and electrical engineering, electronics, instruments, transport equipment, communications as well as holding companies in respective industries. Data on companies' market value, tangible assets and R&D expenditures have been retrieved from the Compustat database. This results in an unbalanced panel of 7,095 observations. Information on US patent applications has been retrieved from the NBER patent and citations data-set (Hall, Jaffe, and Trajtenberg 2001).

Information on technology disclosures to eight SSOs has been gathered. These organizations are the ANSI, the Alliance for Telecommunications Industry Solutions (ATIS), the ETSI, the Institute of Electrical and Electronics Engineers (IEEE), the Internet Engineering Task Force (IETF), the International Organization for Standardization (ISO) and the Telecommunications Industry Association (TIA). All these organizations have installed a formalized IP policy, require disclosure of essential IP and allow royalties to be charged for essential IP in exceptional cases. In the 1990s and 2000s, their activities have been dominated by the digital transition of telecommunication networks and the convergence between ICTs.

SSOs require their members to disclose potentially relevant IPR. This information is published on SSO websites. Disclosures of relevant IP at ANSI, ATIS, IEEE, ITU and TIA have been retrieved from data-set by Rysman's and Simcoe's (2008) data-set.[10] IP disclosures at ETSI, ISO and IETF have been retrieved from the SSOs' websites. Disclosures at ESTI refer predominately to digital telecommunication (GSM, UMTS).[11]

[10] Available at http://www.ssopatents.org.

[11] Unfortunately, information on the standard for which disclosed IP might be essential is only available for ETSI and ISO. Disclosures at TIA should refer predominately to the competing CDMA approach. Sample firms' disclosures to ATIS occur from the midst of the 1990s until the beginning of the 2000s. They should refer accordingly to US standardization efforts for 3G. ISO standards refer overwhelmingly to different MPEG generations. IEEE standards refer presumably in its majority to WiFi technology. In view of ANSI's interface function to international standard bodies, disclosures to ANSI should reflect telecom standards as well as standards for information technologies. ITU standards may, in parts, refer to the discussed US and European telecommunication standards. However, they reflect surely technology contributions to standards in other world regions, too.

Table 1. Sample firms' technology disclosures

SSO	Identified IP disclosed	General disclosures
ANSI	15	53
ATIS	0	11
ETSI	599	196
IEEE	45	0
IETF	30	49
ISO	27	125
ITU	19	103
TIA	6	156
	741	693

We found 1434 disclosures events for our sample firms. Large parts of them accrue at standard setting for digital mobile telecommunication at ETSI (see Table 1).

Some statements might indicate that the IP owner does not agree on licensing at RAND terms. This is the case for 11 disclosures of sample firm. These observations are not included in disclosure stocks as this technology is essentially precluded from incorporation in open and consensus-based standards. The remaining disclosure events indicate RAND licenses if IP gets included into standards.

Figure 1 depicts the evolution of these disclosure events. Increasing disclosure numbers reflect the general trend of surging disclosure rates (Simcoe 2007). Peaking

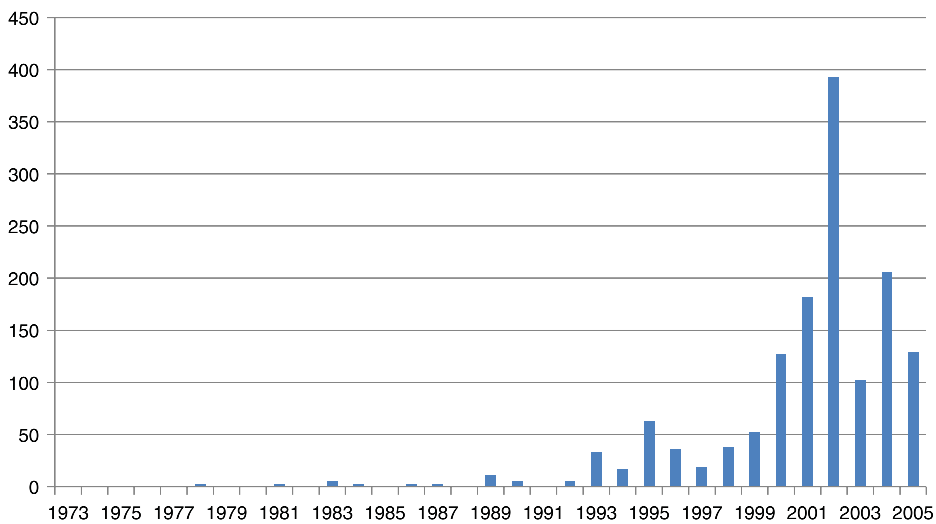

Figure 1. Evolution of sample disclosures

disclosure activities in 1995 reflect intense standardization activities with respect to US CDMA technology. High rates in 1993 and escalating disclosures at the beginning of the 2000s reflect standardization of the second and third generation of digital telecommunication at ETSI.[12]

Disclosures of standard-relevant technology differ in their scope. Some disclosures declare broadly that the disclosing firm might possess relevant IP without specifying single patent rights. Other disclosures reveal specific patent rights which might be standard relevant. In order to take into account their varying scope, IP disclosures have been weighted according to the number of disclosed patent rights. Roughly half of the disclosure events in our sample reveal specific patent rights, the rest are blanket disclosures to which we also refer as general disclosures. Disclosure events indicating specific patents accrue overwhelmingly from ETSI, which blanket disclosures are relatively seldom at ETSI. All disclosures at IEEE indicate specific patents. Blanket or "general" disclosures are more frequent than patent-indicating disclosures at the remaining SSOs.

Variables

The dependent variable Tobin's *Q* is defined as the ratio of firm's market value to the replacement (book) value of its physical assets. Market value is the sum of market capitalization (share price times the number of outstanding shares at the end of a year), preferred stock, minority interests and total debt minus cash. Book value is the sum of net property, plant and equipment, current assets, long-term receivables, investments in unconsolidated subsidiaries and other investments. All explanatory variables of Equation 3 are based on stock variables. Except for tangible assets for which financial stock information is available, we follow Griliches and Mairesse (1981) by calculating the stocks for the remaining explanatory variables as perpetual inventory.

We use the following formula for the R&D stock of firm *i* in year *t*

$$\text{R\&D stock}_{it} = (1 - \delta)\text{R\&D stock}_{it-1} + \text{R\&D}_{it} \quad (4)$$

in which the annual R&D expenditures enter GDP-deflated and a constant depreciation rate (δ) of 15 per cent is assumed.

Patent, citation and technology disclosure stocks are constructed accordingly. Technology disclosure stocks are further distinguished between IP disclosures which explicitly refer to patent rights and general disclosures which do not indicate specific patent rights. The stock of citations which patents disclosed as standard relevant received prior to their first disclosure has been calculated in order to proxy for the importance of contributed technology.

A specialty arises for the calculation of R&D stocks since companies may have conducted R&D before entering our sample. Hence, we calculate a starting equilibrium R&D stock as

[12] Note that since our sample only includes years up to the year 2005, we miss an important increase in disclosures in the later years that has been documented for instance by Blind et al. (2011).

$$\text{R\&D stock}_{i0} = \frac{\text{R\&D}_{i0}}{\delta + g}.$$

This starting value assumes that R&D expenditures prior to the sample have been growing at a constant rate g. Following Hall and Oriani (2006) and Hall, Thoma, and Torrisi (2006), an annual growth rate of 8 per cent is assumed.

Descriptive Statistics

Table 2 shows descriptive statistics for the total sample and the subsample of standard setting firms. They show that our sample includes mostly medium-sized and large companies. All firms in our sample have positive R&D and patent stocks. Average Tobin's *Q* is well above 1. R&D activities, patent portfolio size, citations as well as standard-setting activities are highly skewed in absolute and relative terms. Only 5 per cent of observations have disclosed relevant technology to SSOs.

The righter half of Table 2 provides descriptive statistics for these 334 observations. The distribution of industry sectors appears similar between the total sample and standard setting firms. Technology providers to SSOs are mostly large and very large companies. On average, they have larger stocks of tangibles assets, more R&D investments and larger patent stocks than the control group. The median value for Tobin's *Q* is slightly higher than for the average control firm. Disclosure stocks reach their maximum at 154 disclosures.

Standard-active firms receive for their patent portfolios a share of citations similar to the control group. Firms receive, on average, 12 citations per patent in their portfolio. Rysman and Simcoe (2008) show that technology contributions to standards are selected from the more valuable technologies and patents. In order to take this into account, we include a variable measuring pre-disclosure citations which takes the mean value of 4. Bivariate correlations are presented in (Table A1) in the Appendix.

Market Value Estimations

Table 3 reports coefficients from estimations of Equation (3) using nonlinear least squares. The first panel in Table 3 (models (1)–(4)) shows the effects of the firms' disclosure stock on their market value; the second panel (models (5)–(8)) distinguishes between disclosures with and without IP. The first model of each panel (models (1) and (5)) shows cross-sectional results. The second model of both panels (models (2) and (6)) controls for unobserved firm-specific effects. We follow Blundell, Griffith and van Reenen (1995) and Aghion et al. (2005) by using pre-sample information in order to control for unobserved heterogeneity. Average Tobin's *Q* in the pre-sample period, included as additional regressor, shall control for unobservable firm-specific effects.

The third model of both panels (models (3) and (7)) controls for the pre-disclosure citations that disclosed patents receive. We control for this additional variable since a positive valuation of technology disclosures might reflect a selection of more important technology to be disclosed (Rysman and Simcoe 2008). Furthermore, patents tend to receive more citations after having entered a standard by consortium members (Delcamp and Leiponen 2013). The stock of citations that disclosed patents receive until

Table 2. Descriptive statistics

	Sample					Standard−active firms				
	Mean	Median	SD	Min	Max	Mean	Median	SD	Min	Max
Tobin *Q*	1.22	0.77	1.68	0.00	29.79	1.17	0.78	1.86	0.08	29.49
Market value	2,867	145	11,474	0.00	28,0867	26,664	15,338	38,979	13,651	280,367
Tangible assets	3,088	177	10,749	0.14	137,756	32,581	23,345	3,0781	64.13	126,986
R&D stocks	817	40	3,071	0.01	33,932	9,283	5,547	9,279	35.02	33,932
Patent stocks	289	12	1,171	0.01	18,355	3,540	1,866	3,761	0.85	18,355
Citation stocks	3,005	97	13,936	0	274,483	39,663	17,529	48,618	0	274,483
R&D stocks/assets	1.36	0.65	2.93	0.00	54.69	1.48	0.94	1.50	0.07	9.05
Patent stocks/R&D	0.63	0.33	1.11	0.00	30.85	0.37	0.32	0.28	0.00	1.83
Citation stocks/patents	12.2	8.12	18.67	0	432.63	12.37	10.73	7.31	0	47.94
IP disclosures	0.17	0	3.37	0	153.5	3.54	0.72	15.14	0.00	153.50
General disclosures	0.19	0	1.38	0	26.55	4.11	2.37	4.94	0.00	26.55
IP disclosures/patents	0.00	0	0.002	0	0.16	0.00	0.00	0.010	0.00	0.16
General disclosures/patents	0.00	0	0.09	0	3.17	0.07	0.00	0.4	0.00	3.17
Predisclosure citations	3.92	0	42.27	0	1,125.22	69.41	11.17	17,165	0	1,125.22
Predisclosure citations/patents	0.02	0	0.63	0	32.00	0.4	0.00	2.88	0	32.00
Machinery and computer equipment	0.29	0	0.45	0	1	0.29	0	0.45	0	1
Electric and electronic equipment	0.29	0	0.45	0	1	0.43	0	0.50	0	1
Transportation equipment	0.07	0	0.26	0	1	0.01	0	0.12	0	1
Instruments	0.27	0	0.45	0	1	0.08	0	0.27	0	1
Communications	0.01	0	0.09	0	1	0.08	0	0.27	0	1
Business services	0.06	0	0.24	0	1	0.11	0	0.32	0	1
Observations	7,095					334				

Table 3. Valuation of technology disclosures

Dependent: in (Tobin *Q*)	Full sample							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R&D/assets	0.070*** (0.013)	0.020*** (0.008)	0.070*** (0.013)	0.020*** (0.008)	0.070*** (0.013)	0.020*** (0.008)	0.070*** (0.013)	0.019*** (0.008)
Patents/R&D	0.105*** (0.022)	0.071*** (0.017)	0.105*** (0.022)	0.072*** (0.017)	0.105*** (0.022)	0.072*** (0.017)	0.105*** (0.022)	0.072*** (0.017)
Citations/patents	0.004*** (0.001)	0.001* (0.001)	0.004*** (0.001)	0.001* (0.001)	0.004*** (0.001)	0.001* (0.001)	0.004*** (0.001)	0.001* (0.001)
Disclosure/patents	1.067** (0.536)	0.124 (0.176)	0.076 (0.244)	−0.148 (0.131)				
IP disclosures/patent					8.213** (3.614)	9.011** (3.535)	9.789*** (3.502)	9.372*** (3.473)
General disclosure/ patent					0.979* (0.523)	0.110 (0.172)	−0.08 (0.116)	−0.19 (0.019)
Predisclosure citations/patents			0.227*** (0.081)	0.0655** (0.028)			0.254*** (0.086)	0.074** (0.032)
Presample mean in (Tobin *Q*)		0.403*** (0.014)		0.402*** (0.014)		0.408*** (0.014)		0.402*** (0.014)
Observations	7,095							

Note: ***,**,* indicate a 1, 5, 10 per cent level of significance.

they have been disclosed the first time as standard relevant shall control for the varying importance of technology contributions. In order to avoid double-counting, citation stocks are corrected for pre-disclosure citations when pre-disclosure citations are included in the estimation. The last models of each panel (models (4) and (8)) show the results for a specification that includes both pre-disclosure citations and the pre-sample mean. All specifications include year and industry dummies.

Table 3 shows that disclosures have a positive effect on firms' market value (model (1)) which disappears if we take pre-disclosure citations and/or fixed effects into account (models (2)–(4)). The positive effect of the pre-disclosure citations that renders the disclosure effect insignificant is in line with Rysman and Simcoe, (2008) who argue that better patents are selected for standards. Since also the inclusion of fixed effects renders the coefficient for disclosures insignificant we have to conclude that H1 does not receive support.

Models (5)–(8) in Table 3 present estimation results when technology disclosures are distinguished among IP disclosures that refer to specific patents and blanket disclosures. The coefficient for general disclosures is weakly significant only when unobserved firm-specific effects or the importance of disclosed patents is not controlled for (model (5)). This does not suggest that technology disclosures to open standards contribute to firm value. The coefficients for IP disclosures are, however, positive and statistically significant at the 5 per cent level in all models (5)–(8). The market value of firms is positively correlated with disclosures of standard-relevant patents lending support to H2. Patent rights appear, thus, to facilitate financial market's valuation of technology disclosures.

The finding that blanket disclosures do not lead to an increase in firms' market value suggests that the market values transparency more than a disclosure which is likely to be associated with more technology blocks. If all patents associated with a blanket disclosure would have been declared in the disclosure statement, the likelihood of a positive market reaction is expected to be higher than for disclosures associated with individual patents. However, the results show that this positive effect is outweighed by the uncertainty created by non-disclosure of any specific patents.

With regard to the control observations, our results are robust with regard to the different specifications. The proxies for firm's knowledge stock—R&D, patent and citation stocks—are positively and significantly related to Tobin's *Q*, which is in line with the prior literature (e.g. Hall, Jaffe, and Trajtenberg 2005; Hall, Thoma, and Torrisi 2006).

In order to get an indication of the economic magnitude of estimated effects, Table 4 reports semi-elasticities of Tobin's *Q* with regard to its explanatory variables. The semi-elasticities in columns (1)–(4) are calculated using median values for explanatory variables and coefficients from columns (5)–(8) in Table 3. Estimated semi-elasticities for IP disclosures indicate that an increase from 0 to 1 of the disclosure-patent ratio would increase the log of Tobin's *Q* by a range of 7.4 to 8.9 per cent points. The standard deviation of the disclosure-patent ratio (= 0.23 per cent) provides a more realistic order of magnitude. A 1 standard deviation change yields a change in market value between 1.7 and 2.1 per cent points. Thus, as regard to IP disclosures, the benefits of technology contributions to open standards clearly appear to outweigh the costs, e. g. due to lost exclusivity.

Regarding the control variables, we find lower values for the semi-elasticities of R&D and larger values for patents than Hall, Jaffe, and Trajtenberg (2005). In contrast to Hall, Jaffe, and Trajtenberg's (2005) sample, which refers to manufacturing sectors from 1979 to 1988, our sample focuses on machinery and electronics-related sectors from 1986 to 2002.

Table 4. Marginal effects of technology disclosures

Dependent: in (Tobin *Q*)	Full sample				Low R&D intensity				High R&D intensity			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
R&D/assets	0.063***	0.0019***	0.063***	0.019***	0.264*	−0.115	0.263*	−0.114	0.063***	0.028***	0.063***	0.028***
	(0.012)	(0.007)	(0.012)	(0.007)	(0.157)	(0.138)	(0.157)	(0.138)	(0.012)	(0.009)	(0.012)	(0.008)
Patents/R&D	0.094***	0.068***	0.095***	0.068***	0.006	−0.015	0.006	−0.015	0.328***	0.276***	0.329***	0.277***
	(0.019)	(0.016)	(0.019)	(0.016)	(0.016)	(0.011)	(0.015)	(0.011)	(0.041)	(0.036)	(0.041)	(0.036)
Citations/patents	0.004***	0.001**	0.004***	0.001*	0.014***	0.009***	0.014***	0.009***	0.003***	0.002**	0.003***	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.008)	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)
IP disclosure/patents	7.399**	8.600**	8.819***	8.945***	41.320***	27.874***	27.246*	18.020	6.909*	13.216*	8.136**	13.406**
	(3.252)	(3.372)	(3.151)	(3.314)	(11.597)	(9.595)	(16.360)	(13.950)	(3.695)	(6.822)	(3.442)	(6.681)
General disclosure/ patents	0.880*	0.101	−0.076	−0.185	−20.434***	−16.454***	−13.177	−11.455	0.845*	0.127	−0.05	−0.169
	(0.47)	(0.164)	(0.104)	(0.114)	(4.399)	(4.876)	(8.221)	(7.59)	(0.434)	(0.161)	(0.097)	(0.108)
Predisclosure citations/patents			0.229***	0.070**			−7.547	−5.436			0.215***	0.074**
			(0.077)	(0.030)			(6.562)	(5.763)			(0.070)	(0.030)
Presample mean in (Tobin *Q*) included	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Observations	7,095				2,415				4,680			

Note: ***,**,* indicate a 1, 5, 10 per cent level of significance.

Hall (1993) reports that in those particular industries, the value of R&D declined in the 1980s. As knowledge assets have been found to be of lower values in computing and electrical sectors (Czarnitzki, Hall, and Oriani 2006), it seems not unreasonable that the value of R&D assets has further declined in our sample period.

Tables 5 and 6 re-estimate models (1)–(8) for split samples of firms with low and high R&D intensities. The effect of SSO participation is likely to differ for both types of companies. On the one hand, SSO participation allows firms to monitor technology evolution and to identify particular market opportunities during phases of technological discontinuity (Waguespack and Fleming 2009). SSOs are, thus, important venues for learning, producing, exchanging and promoting technical knowledge (Dahlander and Wallin 2006; Waguespack and Fleming 2009) with learning being more important for small companies (Haeussler, Harhoff, and Mueller 2009; Hsu and Ziedonis 2013; Useche 2014; Greenberg 2013). On the other hand, SSO participation increases the likelihood of knowledge leakages which is an argument that is more important for capacitated companies.

The kernel density for R&D intensities reaches its maximum at 0.44. This value has been chosen to divide the sample into firms of low and high R&D intensities. Overall, technology disclosures do not show significant effects for firms of low R&D intensity (columns (1)–(4) of Table 5). For firms of high R&D intensity, the coefficient of overall technology disclosures is positive and significant (column (1) of Table 6) only when unobserved firm-specific effects or the importance of disclosed patents is not controlled.

Blanket/general technology disclosures do not show positive valuation effects for firms of low R&D intensity (models (1)–(4) of Table 5). Their coefficients show even negative signs when pre-disclosure citations are not included in the estimation. For firms of high R&D intensity, the coefficient for blanket/general technology disclosures is slightly significant in model (5) of Table 6. This positive effect vanishes, again, when unobservable firm-specific effects or the importance of disclosed patents is controlled for.

The estimated coefficients of technology disclosures which refer explicitly to patents are positive and significant for firms of high R&D intensity (models (5)–(8) of Table 6). The estimated coefficients for IP disclosures of firms with low R&D intensities are positive and significant when unobserved firm-specific effects or the importance of disclosed patents is controlled for (models (5)–(8) of Table 5). When both, pre-disclosures citations and firm-specific effects, are controlled for, the coefficient for IP disclosures is not significant for firms with a low R&D intensity any more.

The middle and righter panel of Table 4 reports semi-elasticities for the split sample regressions. Semi-elasticities have been calculated using median values of explanatory variables and estimated coefficients from Table 5 or Table 6, respectively. For R&D intensive firms, estimated semi-elasticities indicate a high correlation between IP disclosures and market value for low R&D companies, but this effect disappears again when both pre-disclosure citations and fixed effects are taken into. For high R&D intensive firms we find a large and significant effect.

Conclusion

Open standards, set by organizations in which technology providers cooperate voluntarily, have gained significant importance over the last decades. These organizations have considerable impact on market and technology evolution and supplanted formal

Table 5. Valuation for firms with low R&D intensities

	Low R&D-intensity							
Dependent: in (Tobin *Q*)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R&D/assets	0.319 (0.202)	−0.116 (0.137)	0.320 (0.202)	−0.114 (0.137)	0.314 (0.201)	−0.118 (0.137)	0.313 (0.201)	−0.117 (0.137)
Patents/R&D	0.007 (0.019)	−0.015 (0.011)	0.007 (0.019)	−0.015 (0.011)	0.007 (0.019)	−0.015 (0.011)	0.007 (0.019)	−0.015 (0.011)
Citations/patents	0.017*** (0.004)	0.009*** (0.003)	0.017*** (0.004)	0.009*** (0.003)	0.017*** (0.004)	0.009*** (0.003)	0.017*** (0.004)	0.009*** (0.008)
Disclosure/patent	1.890 (3.909)	−0.715 (2.489)	0.850 (3.059)	−1215 (2.084)				
IP disclosure/patent					49.081*** (13.679)	28.503*** (9.753)	32.423* (19.381)	18.45 (14.234)
General disclosures/ patent					−24.272*** (5.211)	−16.285*** (4.991)	−15.610 (9.774)	−11.730 (7.759)
Predisclosure citations/ patents			−10.943 (7.167)	−6.761 (5.302)			−8.981 (7.816)	−5.564 (5.907)
Presample mean in (Tobin *Q*)		0.499*** (0.022)		0.498*** (0.022)		0.498*** (0.022)		0.498*** (0.022)
Observations	2415							

Note: ***,**,* indicate a 1, 5, 10 per cent level of significance.

Table 6. Valuation for firms with high R&D intensities

	High R&D intensity							
Dependent: in (Tobin *Q*)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R&D/assets	0.077*** (0.016)	0.032*** (0.010)	0.076*** (0.016)	0.032*** (0.010)	0.077*** (0.016)	0.032*** (0.01)	0.076*** (0.016)	0.032*** (0.01)
Patents/R&D	0.400*** (0.057)	0.313*** (0.045)	0.401*** (0.057)	0.313*** (0.045)	0.400*** (0.057)	0.313*** (0.045)	0.401*** (0.057)	0.313*** (0.045)
Citations/patents	0.004*** (0.001)	0.002** (0.001)	0.004*** (0.001)	0.002** (0.001)	0.004*** (0.001)	0.002** (0.001)	0.004*** (0.001)	0.002** (0.001)
Disclosure/patents	1.901** (0.533)	0.163 (0.187)	0.050 (0.194)	−0.15 (0.129)				
IP disclosure/patents					8.394* (4.492)	14.971* (7.73)	9.887** (4.184)	15.183** (7.569)
General disclosure/ patents					1.031* (0.529)	0.144 (0.182)	−0.061 (0.018)	−0.191 (0.123)
Predisclosure citations/ patents			0.243*** (0.082)	0.077** (0.031)			0.261*** (0.086)	0.084** (0.034)
presample mean in (Tobin *Q*)		0.370*** (0.017)		0.369*** (0.017)		0.370*** (0.017)		0.369*** (0.017)
Observations	4,680							

Note: ***, **, * indicate a 1, 5, 10 per cent level of significance.

public SSOs in many cases. While recent economic studies on cooperative standard setting focus on coordination problems at SSOs (e.g. Schmalensee 2009; Layne-Farrar, Llobet, and Padilla 2010), large-scale empirical evidence on the returns of sponsoring technology to open standards is missing so far. When firms disclose technologies to SSOs, they make tacit technical details public without knowing whether the respective technology will become part of a standard or not. Even in case the technology successfully enters a standard, it cannot be taken for granted that the benefits thereof outweigh the costs, e.g. in terms of giving up exclusive access to the technology at RAND licensing conditions.

We employ a market value approach in order to investigate the valuation of technology disclosures to open standards. The sample consists of large established companies which have been publicly traded in the USA from 1986 to 2005. Information on firm's technology contributions of eight major SSOs has been retrieved. The results show that technology contributions to open standards are positively correlated with company valuation as long as they explicitly refer to the associated patent documents. We do not find a positive value correlation of blanket disclosures. Disclosures of patented technologies to open standards appear, thus, to be valuable despite waiving the right on exclusive access if they include enough information. General and unspecific information create uncertainty and are not positively correlated with firms' market valuation. Our evidence further indicates that especially R&D intensive firms' patent contributions to open standards receive a positive valuation from financial markets.

Our findings provide support for a recent report about patents and standards to the European Commission Directorate-General for Enterprise and Industry in which the authors suggest to limit blanket disclosures to SSOs in order to increase transparence (ECSIP 2014). Our study raises questions about the benefits of blanket disclosures for companies. Further research is required here.

Our analysis is not without limitations. Most important is that while we show correlations between disclosures at SSO, we cannot provide causal evidence. To the extent that the correlation of market value and technology disclosures represents a causal effect, our results show that the benefits from technology contributions to open standards outweigh associated costs, e. g. due to lost exclusivity. Our results could, however, also be explained by the fact that disclosed patents have ex ante characteristics which make them more valuable (Rysman and Simcoe 2008). Our analysis is not able to solve this issue. Furthermore, the reported evidence refers to the valuation of publicly listed companies. Incentives to participate to open standards might be different for specialized technology suppliers. This is an avenue for future research.

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Appendix. Standard Development Procedures

The development process of technical specifications for standardizations is in large parts similar across different consensus-based organizations (Lehr 1995; Layne-Farrar 2011). Figure A1 sketches this process. When a compatibility problem is identified or new technical opportunities have emerged, members may submit a work item proposal to SSO boards.

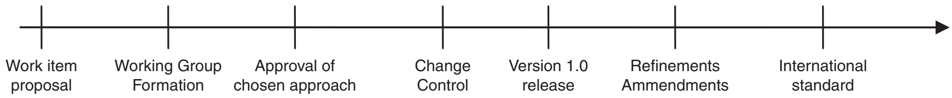

Figure A1. The process of developing standards. *Source*: Authors' own illustration; based on Leiponen (2008), Simcoe (2012) and Layne-Farrar (2011)

When the proposal is approved because it is considered as technically feasible and desirable, the task of developing a technical specification is assigned to appropriate working groups. These consist of technical experts delegated from governments, academia, customers and companies. The Moving Pictures Expert Groups is an example for such a working group formed by ISO boards (http://mpeg.chiariglione.org/).

When internal disagreements regarding the merits of different versions are reconciled, organization's boards have to approve the chosen technical approach. Subsequently, a draft specification is published and interested parties are invited to comment on it. During the process of commenting on draft specifications, SSO participants are obliged to reveal essential proprietary technology of which they are aware. Clarification whether technical specifications read on exclusive patent rights is essential to standardization. Bylaws of SSOs explicitly or implicitly oblige their members to disclose relevant patents and associated licensing intentions (Lemley, 2002). Members' acceptance of these bylaws allows SSOs to act as forum of non-discriminatory coordination. The obligation to disclose IP and its licensing intentions permits standard setting bodies to adjust draft specifications according to the availability of usage rights. Participants shall reveal IP when it may be essential to the adoption of standards. They are, however, not obliged to search their portfolios for eventually infringing patents. General statements that they might possess relevant IP, i.e. blanket disclosures, suffice to comply with disclosure requirements.

Before a draft can be approved, comments have to be responded and reconciled with the draft. This may result in new draft versions. After formal change requests have been responded and consensus is reached, a first standard version can be released. A general technical approach is agreed upon in this early stage of the standardization process. Strategic maneuvering is often intense here as path and direction of further technology evolution are to large extents predetermined by the chosen technical approach in the first standard version (Suarez 2004; Layne-Farrar 2011). Coalitions are restructured to align positions and gain supporters for technical approaches. When the general technological path is agreed upon, working groups define specifications for components of the chosen technical systems. The process of consensus-finding, board approval and change control starts anew for these technical designs. Strategic maneuvering should be less intense in these later stages. Coalitions which gained majority for a general technical paradigm are stable during these phases of incremental change (Rosenkopf and Tushman 1998). Updated standard versions refine or amend technical specifications. User knowledge, created by utilizing standards, is incorporated into standardization, thereby. Market competition selects among various technical approaches proposed by different (supra-) national SSOs. International standard setting starts in the shadow of this competition. International standard bodies often do not propose single standards to solve a compatibility problem. They usually certify important standards in different world regions. When efficiency and effectiveness improvements within a technical standardization approach have reached limits of feasibility, new standard generations begin to loom and the process of strategizing begins anew, although already installed bases may put incumbents at advantage.

Table A1. Correlation matrix

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Tobin *Q*	(1)	1												
R&D stocks/assets	2	0.23**	1											
Patents/R&D stocks	3	0.04***	−0.10***	1										
Citations/patents	4	0.15***	0.19***	−0.07***	1									
IP disclosure/patents	5	0.02	0.00	−0.02**	0.00	1								
General disclosures/patent	6	0.10***	0.04***	−0.02	0.02*	0.05***	1							
Predisclosure citations/patents	7	0.08***	0.03***	−0.02	0.02**	0.00	0.71***	1						
Machinery and computer equipment	8	−0.08***	−0.05***	0.04***	0.01	−0.08**	−0.02*	−0.02*	1					
Electric and electronic equipment	9	−0.05***	−0.05***	0.01	−0.01	0.00	0.05***	0.05***	−0.41***	1				
Transportation equipment	10	−0.06***	−0.09***	0.01	−0.07***	0.00	−0.01	−0.01	−0.18***	−0.18***	1			
Instruments	11	0.12**	0.01	−0.01	0.01	−0.08***	−0.02*	−0.02	−0.39***	−0.40***	−0.17***	1		
Communications	12	0.00	−0.02	−0.04***	−0.03**	0.31**	0.02	0.00	−0.05***	−0.006***	−0.02**	−0.05***	1	
Business services	13	0.07***	0.27***	−0.05***	0.08***	0.00	−0.01	−0.01	−0.17***	−0.17***	−0.007***	−0.16***	−0.02*	1

Note: ***, **, * indicate a 1, 5, 10 per cent level of significance.