The structure and the emergence of essential patents for standards: Lessons from three IT standards

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Summary

This paper examines the structure and the evolution of the patents judged as essential for three major recent technical standards in information technology (MPEG2, DVD and W-CDMA). We have found that these standards have many essential patents, which are owned by many firms with different interests. The number of essential patents has increased significantly over time since the standard was set. We identify three reasons for why the essential patents are many and increase over time: they cover a number of different technology fields, there exists R&D competition even in a narrowly defined technology field, and a firm can expand its patent portfolio by using continuation and the other practices based on the priority dates of its earlier filed patent applications in the USA. Around 40% of the essential US patents for MPEG2 and DVD standards have been obtained by using these applications. However, our analysis does not support the view that a firm with a pioneering patent can obtain more essential patents, using these practices.

Key words: standard, essential patent, continuations
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1. Introduction

This paper examines the structure and the evolution of the patents judged as essential for three recent major technical standards (MPEG2, DVD formats and WCDMA). Patents have in recent years become important in technical standards, especially in the information technology (IT) area, since the standards often incorporate cutting-edge technologies and the firms owning the patents are not willing to contribute them to a standard for royalty free. A patent is essential to a standard, if making a product or using a method, complying with the standard, requires use of the patent[1].While exercising the patent right may enhance the appropriability of R&D investment from the perspective of a single patentee, it would cause inefficiency due to a patent thicket problem, when many firms independently try to collect royalties (Heller and Eisenberg (1988), Shapiro (2001), Lerner and Tirole (2002)). The analysis of the structure and the evolution of the essential patents would provide important clues to how the patent thicket problem might emerge in a standard setting process, as well as on appropriate managerial and policy responses.

As for as we know, empirical studies of the patent thicket problem in the context of a standard setting are scarce[2]. Bekkers, Duysters and Verspagen (2002) analyzed how the firm ownership of the essential patents of the GSM (the global system for mobile communications), were related to its position in the alliance network and to its market share position. They also found a significant variation of a strategy toward patenting across firms, reflecting the different attitudes of the US and European firms for the patents in the late 1980s. Bekkers and West (2006) also analyzed the essential patents of the third generation mobile telephone and pointed out that the number of essential patents as well as the number of firms owning these patents had increased significantly from the 2nd to 3rd generation. These studies do not offer detailed structural analysis of the emergence of essential patents in the standards, including the effect of

the use of continuations in obtaining the essential patents.

Let us briefly explain the three technical standards we focus on (see Table 1 for a summary). MPEG2 is the second set of flexible compression standards created by the MPEG (Moving Pictures Experts Group) and was adopted as the ISO/IEC 13818 international standard in December 1994. It is widely used for encoding and decoding the audio and video in digital format. The patent pool administered by MPEG LA certifies the essential patents for collective licensing in video technology. It started to license the bundle of the essential patents in September 1997. As shown in Table 1, there are 23 organizations in the pool and there were 800 licensees as of November 2004. DVD (Digital Video Disc or Digital Versatile Disc) is an optical disc technology and can store a large volume of digital data including full-motion video. The standard for the player format of DVD was developed by a private consortium (the DVD forum) in December 1995. There are two patent pools, 6C group (covers seven firms) and 3C group (covers three firms), both of which certify and license different parts of the essential patents for DVD (See Table 1 for the membership). No consensus was struck for the standardization of the recorder format of DVD. Both groups widely license the technology (179 licensees in the case of 3C and 245 licensees in the case of 6C, see Table 1). W-CDMA (Wideband Code Division Multiple Access) is one of the 3rd generation wireless technologies (3G) as approved by the ITU in November 1999. While W-CDMA is most likely to have many essential patents, judging from the number of the patents declared to be essential with respect to standard bodies such as ETSI (The European Telecommunications Standards Institute) and the ARIB (Association of Radio Industries and Businesses, Japan), there exists no patent pool (or platform) organization which covers a significant part of the essential patents for the certification and collective licensing, although the 3G patent platform was established in 2003, with a relatively small number of members.

(Table 1)

We analyze the structure and the evolution of the essential patents, based on the information made public by the patent pool organizations for MPEG2 and DVD formats, and a standard body (ARIB) for W-CDMA. Note that the patent list of the ARIB is likely to contain many non-essential patents, since no third-party certification has been made. According to one experts evaluation[3], only 21 % of the patents declared to ETSI as "essential" for W-CDMA were actually essential. In section 2, we analyze the holders of essential patents to a standard. In section 3, we explore the reasons there are so many essential patents. In section 4, we assess the frequency of the patents granted, based on the continuations and other applications using earlier priority dates and whether a firm with pioneering patents can obtain subsequent patents. Section 5 concludes.

2. Structure of the essential patents

The numbers of essential patents for a standard are many and are owned by many organizations. As shown in Table 1, there were 127 patent families of essential patents owned by 23 patentees as of July 2004 in the case of MPEG2. This covers only those owned by the members of the patent pool which is administered by the MPEG LA., which covers around 90% of the essential patents, according to an industry expert. Lucent and IBM are the major non-members of the patent pool. The number of the essential patents held by the original eight members of the patent pool (seven firms and one university) increased from 34 families in July 1997 to 83 families in July 2004. The rest of the increase from 34 patent families to 127 patent families is due to the expansion of the patent pool members, which had 44 patent families.

In the case of the DVD formats, there were 311 (=180+131) essential US patents for players and 272 (=166+106) essential US patents for recorders, as of December 2004, which are covered by two patent pools[4]. There are 7 firms in 6C group and 4 firms in 3C group. Both

groups widely license the technology (179 licensees in the case of 3C and 245 licensees in the case of 6C). Thomson is a major non-member firm of the pools, although it was a member of the DVD forum. In the case of W-CDMA, there were no substantial third party evaluations of the essentialities of the patents. 954 patents in terms of the number of US patents have been declared by the patentees as essential for the W-CDMA technology to the ARIB as of November 2004[5]. There exist 24 patentees for the standard according to the declaration to the ARIB.

Not only are many patents and many patentees involved in the technical standard, but their membership is heterogeneous. As shown in Table 2, a manufacturing firm which is both the licensor to the standard as well as the users of the standard accounts for 80% of the firms with essential patents. Non-manufacturing users of the standard such as a telecommunications operator firm as well as pure licensors such as a firm specialized in R&D, a firm specialized in patent portfolio management, and a university are also important, accounting for around 10 % of the firms with essential patents respectively.

(Table 2)

3. Why so many essential patents?

In this section, we explore several reasons why these standards cover so many patents. For this purpose, we have developed the distributions of the essential patents over technology fields defined by IPC (International Patent Classification). Table 3 shows such distributions for the DVD format. This shows that the standard covers a relatively large number of different technology areas, reflecting its technological sophistication and complexity. The essential patents of the DVD cover four of the eight IPC sections (physics, electricity, human necessities and performing operations), 11 of the total 120 IPC classes, and 25 of the total 724 IPC subclasses. Similarly, the MPEG2 covers two sections, four IPC classes, and eight IPC subclasses.

(Table 3)

Second, more than one firm owns the essential patents in a number of specific technology fields, even if the technology field is relatively narrowly defined by the classification based on IPC subclass, which has more than 720 classifications in total. As shown in Table 3, more than 10 firms own essential patents in the following two IPC subclasses in the case of DVD: G11B for information storage based on relative movement between record carrier and transducer and H04N for pictorial communication, (e.g. television). Moreover, there are 14 IPC subclasses for which more than two firms own essential DVD patents. Similarly, 14 firms own essential patent in IPC subclass H04N in the case of MPEG2, and there are five IPC subclasses for which more than two firms own essential patents. These indicate the severity of R&D competition in terms of the number of participants.

The ex-post increase of the number of essential patents after the adoption of a standard is also important, as shown in Figure 1. This figure classifies the essential US patents into the following four categories, by dates of registration, application and priority, relative to the date of standard determination. Group *R* covers those registered before the month of the first determination of standard specification; Group *P* covers those applied for before the month of the first determination of standard but not yet registered; Group *C* covers those applied for on or later than the month of the first determination of standard specification, but with the priority dates before the month of the first determination of standard specification; finally, Group *A* covers those with priority dates on or later than the month of the first determination of standard specification. As shown in Figure 1, only a minority of the patents (group *R*) are registered before the first determination of standard specification, around 34 % for MPEG2, 15% for DVD (player) and 25% for W-CDMA. This implies that the standard specification is developed and agreed upon at the stage when most essential patents are still pending or still to be applied for.

Thus, as far as the granted patents are concerned, the patents follow the standard rather than vice versa, and the number of the essential (granted) patents increases after the standard is set. In light of this finding, it makes good economic sense that the patent policy of the standard bodies such as ITU-T requires not only the disclosure of granted patents but also those of pending patents.

The time lag between the patent application and the registration accounts partly for why patents are often granted after the standard is set. As shown in Figure 1, the essential patents which are applied for but not yet registered before the initial determination of a standard, i.e. the pending patents when the standard was being negotiated (group *P*), account for a substantial proportion of the essential patents as above: 33% for the MPEG2, 17% for the DVD format (player) and 35 % in the case of W-CDMA. However, it is also true that a significant part of the patents are applied for after the standard is set, even though the priority dates of these patents are before the initial specification of a standard (group *C*): 34% for MPEG2, 41% for DVD and 25% for W-CDMA patents. Thus, the number of essential patents can increase substantially after the determination of the initial standard.

The ex-post applications for the essential patents may pose a question of how a firm can satisfy the novelty requirement once the standards are published. This puzzle can be partially resolved by the availability of continuation applications by which a firm can get a new patent, using the priority and the disclosure of earlier filed patent applications. That is, in these continuation applications, a firm can use the priority date of earlier filed patent applications to secure the novelty. (See Lemley and Moore (2003) and Quillen and Webster (2001) for the details of continuation applications in the US.) The continuations, continuation-in-parts and divisional application practices are in fact important for the ex-post expansion of the essential patents granted, and we will see in the following section how frequently these practices are used

for the acquisitions of essential patents.

In the case of DVD and W-CDMA, there are a fairly large number of essential patents, the priority dates of which were more recent than the month when the standard was initially set (group *A*). These patents are based on the inventions more recent than the standard. The most likely explanation is the revision of the standards, incorporating new technology. There were four revisions of the standard for DVD (reader) and two revisions for W-CDMA by the end of 2004, which added new functions. Although there is no systematic information available with respect to how many new patents were added, due to the revisions of these standards, the 3G patent platform provides information on which essential patent is relevant to which version of the standard for the essential patents of its member firms. According to this information, the first revision prepared from March 2000 to March 2001 (*v.4* of the standard specification) added 14 new patents to the original 83 patents, and four out of these 14 patents have priorities more recent than the month when the standard was initially set[6].

Finally, we would like to discuss the economic incentive for ex-post application for essential patents, by using continuation and other practices based on the priority dates of the earlier filed patent applications. If a firm can acquire an essential patent after the standard is set, such firm can potentially collect a significant amount of royalties by threatening to hold-up the users of the standard. Such risk explains why standard bodies require the participants in standard setting to disclose the essential patents as well as to commit to the royalty free licensing of these patents or to their licensing under RAND (Reasonable And Non-Discriminatory) conditions, including those found after the standard is set. In addition, the patent pool makes a commitment to the maximum royalty for the bundle of the patents of its member firms. That is, the total royalty rate charged by the pool to the users of the standard is fixed, independent of the number of essential patents. An individual firm can increase its share

of royalty income by increasing the number of its essential patents, if the royalty income is distributed among the patentees according to the number of the essential patents owned by these firms as in the case of the patent pools of MPEG2 and DVD (6C). In addition, a firm with a strong patent position would be able to affect significantly the future evolution of the standard, since the backward compatibility requires the consistency with the technologies of the existing essential patents. Thus, a firm has a clear incentive to expand its patent portfolio for a standard.

4. Does a firm with pioneer patents make more use of the patent applications based on earlier priority dates?

One important reason for the significant ex-post increase of the essential patents granted for a standard is that firms use the continuation and other applications based on the priority dates of the patent applications made earlier. Table 4 summarizes how the patentees of the essential patents have used these practices, including continuations, continuations-in-parts and divisions, in acquiring essential US patents. The ratio of the patents which were obtained by using these practices amounts to 44% of the essential patents for MPEG2, 46% for DVD (6C) and 36% for DVD (3C). Thus, the patent applications taking advantage of earlier priority dates are extensively used for obtaining the essential patents of these standards. The fact that these practices are more heavily used in DVD(6C) than in DVD(3C) seems to be consistent with the pattern of incentives of these two patent pools. The royalty is distributed according to the number of essential patents for 6C, while such is not the case for 3C.

(Table 4)

Among the three practices using the earlier filed patent applications, continuations are most often used, which account for 47% of the practices, followed by divisions (44%) and continuation-in-parts (9%). These practices are used 2.3 times per patent, among the patents using these practices in the case of MPEG2, 1.2 times per patent in the case of DVD (6C) and

1.3 times in the case of DVD (3C), where the denominator refers to the patents using these practices.

If a firm with more pioneering patents for the development of the standard can use more of these practices, it would help in distributing more of the royalty income to such firm. If this is the case, we would expect that a firm with high quality patents in the early stage would have a higher ratio of the patents acquired through these practices in its portfolio of the essential patents. For simplicity, let us assume that firm *k* has n_k essential patents with quality q_k which are applied for before the determination of a standard. We assume that a firm does not use the continuation and divisional practices in this stage. We further assume that such firm can obtain additional essential patents using the continuation (including continuation-in-parts) and/or divisional practices, the number of which is proportional to n_k with the coefficient $f(q_k)$, which may increase with q_k. Thus, denoting the number of such patents by m_k, we have

$$m_k = n_k f(q_k) \qquad (1)$$

Given these assumptions, the share (θ_k) of the essential patents of firm *k* which have been obtained using these practices in its total essential patents is given by

$$\theta_k = m_k /(n_k + m_k) = f(q_k)/(1+ f(q_k)) \qquad (2)$$

Thus, if the above view holds, we would observe the positive correlation between θ and q.

Proposition 1

If the main effect of the availability of continuations, continuations-in-parts and divisional patent applications is to allow a firm with pioneering patents to obtain more subsequent patents based on them, we would observe a positive correlation between the quality of the inventions in the standard development stage (*q*) and the share of the patents obtained using these practices (θ).

In order to test the above proposition, we implement a simple estimation based on the following equation:

$$contcipy_k\,(contcipdivy_k) = \beta_0 + \beta_1 \ln(citedness)_k + \beta_2 age_k + \beta_3 mpeg + \varepsilon_k \qquad (3)$$

The dependent variable *contcipy* is the share of the US patents obtained using continuations or continuations-in-parts by firm *k* until 2004 in its total US essential patents for MPEG2 and DVD (player). The dependent variable *contcipdivy* is the share for adding those obtained using divisional applications to the numerator. The explanatory variable is the quality of the essential US patents of firm *k* in the standard formation stage. We use the average forward citations of the US essential patents applied for before the initial standard determination as a variable representing such patent quality (*citedness*), which excludes self-citations in order to control the endogeneity of the forward citation variable (a patent obtained by a continuation practice is likely to cite the original patent).Forward citations are up to September 2006 for MPEG2 and September 2004 for DVD. We introduce the difference between the average application year of the essential patents in the standard formation stage and 2005 as a control (*age*). An essential patent applied earlier would have a greater chance of being cited for a given patent quality. In this context, we expect a negative coefficient of the variable *age*, since an older patent has a larger forward citation due to a smaller truncation bias in citation. On the other hand, an essential patent applied for earlier would have a greater chance of being used for generating patents based on continuation and other practices. In this context, we expect a positive coefficient of the variable *age*, since an older patent has a greater chance of being used for such are objective. We introduce a standard fixed effect or a dummy (*mpeg*), which can take into account the difference in citation structure among standards. In addition to the above basic specification, we also estimate the following extended specification (equation (4)). It

incorporates the number of the essential patents of firm *k* applied in the standard formation stage (*patentbs*) and the square of *age* as additional controls. There may be diseconomies of scale with respect to *patentsb* in expanding the number of essential patents due to the within firm overlap of such patents in the technology scope. In addition, the effect of *age* may be nonlinear.

$$contcipy_i(contcipdivy_k) = \beta_0 + \alpha_1 \ln patentsb_k + \beta_1 \ln(citedness)_k + \beta_2 age_k + \alpha_2 age_k^2 + \beta_3 mpeg_k + \varepsilon_k \quad (4)$$

The sample for estimation focuses on the firms with at least three essential patents. The descriptive statistics are offered in the appendix.

As shown in Table 5, the independent variable *lncitedness*, which represents the quality of early-stage patents, has a negative and significant coefficient (5% or 10% level) in both the basic specification and the extended specification. The estimated coefficients of this variable are very close to each other between the basic specification and the extended specification. The firm with high quality early stage patents tends to have a smaller share of essential patents obtained through continuations and other practices which take advantage of earlier priority dates. This is the case for both the share of the essential patents using continuations or CIPs and for the share of the essential patents using continuations, CIPs or divisions, although the explanatory power is larger for the latter specification. As for the other independent variables, *age* has a significantly negative coefficient, implying that a truncation bias is more important for the opportunities being cited than for the opportunities for using the continuations and the other practices for increasing the number of essential patents. In addition, there is some evidence for diseconomies of scale with respect to the number of the essential patents in the standard formation stage. In summary, the estimation results are reasonable as a whole, and a firm with pioneering patents does not obtain more subsequent essential patents using these practices, rejecting the precondition for Proposition 1.

(Table 5)

5. Conclusions

This paper has examined the structure and the evolution of the patents judged as essential for three major technical standards in information technology (MPEG2, DVD and W-CDMA). These standards have many essential patents, which are owned by many firms with different interests. The fact that there are numerous patentees suggests that the benefit from cooperation through the patent pool in avoiding the tragedy of anti-commons is large, while at the same time there can be a big coordination problem, since an individual firm (especially a firm specialized in research) may prefer higher royalty rates at the expense of others (Aoki and Nagaoka (2004, 2005)). We have also found that the number of essential patents has increased significantly over time, and many patents have been applied for even after the standard was set. We identify three important reasons for why the essential patents are many and increase over time: (1)they are complex, so that they cover a number of different technology fields; (2) there exists a number of firms active in R&D even in a narrowly defined technology field; and (3) firms can expand their patent portfolios by using the patent applications based on earlier priority dates (continuations, CIPs and divisions) even after the standard specification is set. Around 40% of the essential US patents for these standards are obtained by using these applications. However, our analysis does not support the view that a firm with pioneering patents obtains more subsequent patents, using these practices,.

There may be two important policy implications. First, it makes good economic sense that the disclosure policy as well as the licensing commitment required by a standard body covers not only granted patents, but also pending patents as well as patents to be applied for in the future with respect to the standard. Second, the case for the reform of the continuations and related application practices in the US (see Lemley and Moore (2003)) may be strong from the

perspective of efficient use of patented technologies. Our results indicate that these practices are not used more by a firm with pioneering inventions, suggesting that the success of obtaining patents based on continuations and related practices may depend more on the patenting strategy of a firm than on the quality of its inventions.

Reference

Aoki Reiko and Sadao Nagaoka, 2005, “Coalition formation for a consortium standard through a standard body and a patent pool: Theory and evidence from MPEG2, DVD and 3G”, *Working paper05-01 of the Institute of Innovation Research*, Hitotsubashi University (http://www.iir.hit-u.ac.jp/file/WP05-01aoki,%20nagaoka.pdf)

Aoki Reiko and Sadao Nagaoka, 2004, “The Consortium Standard and Patent Pools,” *The Economic Review* (Keizai Kenkyu), 55(4):345-356.

Bekkers Rudi, Geert Duysters, and Bart Verspagen, 2002, “Intellectual property rights, strategic technology agreements and market structure: The case of GSM”, Research Policy , Vol. 31, 1141–1161

Bekkers Rudi and Joel West, 2006, “The Effect of Strategic Patenting on Cumulative Innovation in UMTS Standardization,” *DIME (Dynamics of Institutions and Markets in Europe)* Working Papers No.9

Goodman David and Robert A. Myers, 2005, “Analysis of intellectual property for third generation cellular technology,” *Infocom* March 17 (http://dawn.cs.umbc.edu/INFOCOM2005/goodman-sl.pdf)

Hall H. Bronwyn and Rosemarie Ham Ziedonis, 2001, “The Patent Paradox Revisited: An empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995,” the RAND journal of Economics, Vol. 32, No.1

Heller, M.A. and R. S. Eisenberg, (1998), “Can Patents Deter Innovation? The Anticommons in Biomedical Research,” *Science*, 280, 698-701.

Lemley A. Mark & Kimberly A. Moore, 2003, “Ending Abuse of Patent Continuations”, *LAW AND ECONOMICS WORKING PAPER SERIES*, George Mason University SCHOOL of LAW

Lemley, Mark A., 2002, "Intellectual Property Rights and Standard-Setting Organizations,", California Law Review, Vol. 90, p. 1889-2002

Lerner Joshua and Jean Tirole (2004), “Efficient Patent Pools,” *American Economic Review*, Vo. 94, No. 3, 691-711

Quillen D. Jr.Cecil, and Ogden H. Webster, 2001, “CONTINUING PATENT APPLICATIONS AND PERFORMANCE OF THE U.S. PATENT OFFICE”, *Federal Circuit Bar Journal*, Vol. 11, No. 1 (August, 2001), pages 1-21

Shapiro Carl (2001a),“Navigating the Patent Thicket: Cross License, Patent Pools and Standard-Setting,” in *Innovation Policy and the Economy, Volume I*, Adam Jaffe, Joshua Lerner, and Scott Stern, eds., MIT Press, 2001.

[1] ETSI (The European Telecommunications Standards Institute) defines the essentiality of a patent as follows: “ESSENTIAL" as applied to IPR means that it is not possible on technical (but not commercial) grounds, taking into account normal technical practice and the state of the art generally available at the time of standardization, to make, sell, lease, otherwise dispose of, repair, use or operate EQUIPMENT or METHODS which comply with a STANDARD without infringing that IPR.” The evaluation of the essentiality of a patent is far from trivial. The patent pool organization usually hires outside independent experts for evaluating such essentialities, so as to avoid including substitute patents in a pool which might raise an antitrust concern and to ensure the fair distribution of royalty income among the member firms.

[2] See Hall and Ziedonis (2001) for an empirical study in the context of semiconductor industry.

[3] Goodman and Myers (2005)

[4] 3C does not classify the essential patents according to patent families. This forces us to use the number of US patents as a measure of the number of essential patents.

[5] Some firms specify only Japanese patents to the ARIB which is a national body. We have identified the corresponding US patents by using the Derwent families.

[6] More detailed analysis is available from the author.

Table 1 Three technical standards and patent pools

Standard	Pool Admin., Year	Members of the pool licensors	Essential patents	Non-members	Licensees
MPEG 2 (standard specifiation in December 1994)	MPEG LA, 1997	Originally (July 1997) 7 firms, 1university; 22 firms, 1 univ. as of April 2004	Originally 125 patents (34 families); currently(July 2004) 644 patents (127 families)	Lucent , IBM	800 (November 2004)
DVD (standard specifiation in December 1995)	6C,Toshiba, 1998	Toshiba, Matsushita, Mitsubishi Electric, Time Warner, Hitachi, Victor Company of Japan, IBM	180 US patents for player, and 166 US patents for recorders (December 2004)	Thomson	245 firms for hardware (decoders and encoders) 157 firms for discs
	3C, Philips, 1998	Philips, Sony, Pioneer,LG	131 US patents for DVD players, 106 US patents for recorders (December 2004)		179 firms for hardware (decoders and encoders) 216 firms for discs
3G (standard specifiation in November 1999)	3G Patent Platform, 2003	7 firms for W-CDMA	no significant third-party evaluations (954 W-CDMA related patents (in terms of US patents) and 857 cdma2000 related patents submitted to the ARIB as "essential" by December 2004)	Many, including Qualcomm, Motorola, Ericsson, and Nokia	

Source: based on http://www.3gpatents.com; http://www.mpegla.com; DOJ Review Letter from Joel Klein to Carey R. Ramos, June 10, 1999; DOJ Review Letter from Joel Klein to Gerrard R. Beeney, December 16, 1998; http://www.dvd6cla.com/index.html ; http://www.ip.philips.com/.

Table 2 Types of firms which own essential patents (Number of firms)

	MPEG2	DVD (reader)	3G (WCDMA)	Total	%
Manufacturing firms (licensor and licensee)	17	10	19	46	79.3%
Non-manufacturing user	3	1	2	6	10.3%
Pure licensor	3	0	3	6	10.3%
Total	23	11	24	58	100.0%

Note 1. Pure licensor includes a firm specialized in R&D, a firm specialized in patent portfolio management and a university.

Note 2. Based on the firms belonging to patent pools for MPEG2 and DVD. Based on the firm which declare the ownership of essential patents to the ARIB for 3G.

Table 3 The number of firms owning the essential patents for DVD (player and recorder)

Section	IPC Class		IPC Subclass	Number of firms owning essential patents	Number of essential patents
Physics	G01	Measuring; Testing	G01D	2	3
	G02	Optics	G02B	1	1
	G06	Computing; Calculating; Counting	G06F	7	15
	G06		G06K	4	13
	G06		G06T	1	1
	G09	Educating; Cryptography; Display; Advertising; Seals	G09B	1	1
	G09		G09G	1	1
	G10	Musical instruments; Acoustics	G10H	2	3
	G10		G10L	2	4
	G11	Information storage	G11B	12	236
	G11		G11C	2	3
	G11		G11D	1	1
	G11		G11G	1	1
Electricity	H03	Basic electronic circuitry	H03K	1	1
	H03		H03M	5	11
	H04	Electric communication technique	H04B	2	6
	H04		H04H	2	4
	H04		H04K	1	1
	H04		H04L	6	10
	H04		H04N	10	124
	H04		H04R	1	1
	H04		H04S	1	2
Human necessities	A63	Sports; Games; Amusements	A63H	1	1
Performing operations; Transporting	B11	Other	B11B	2	2
	B32	Layered Products	B32B	2	3

Figure 3 Time profile of the essential patents of three standards

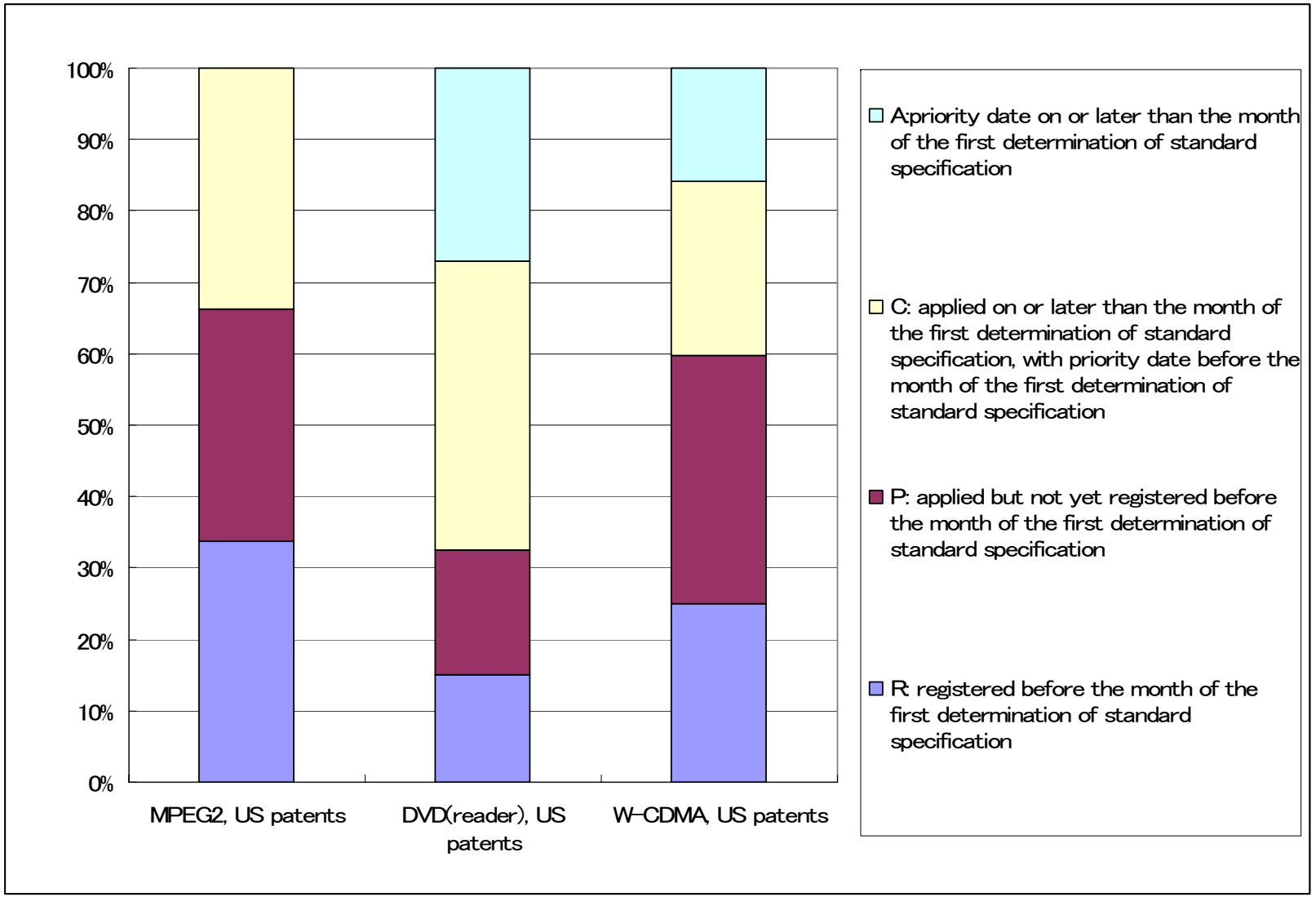

Table 4. The essential patents which were obtained, using divisions, continuations and continuations-in-parts

	Number of essential patents		Frequency of continutations, CIP and divisions				
	Total	those which enjoy earlier filing dates	Continuations	CIP	Divisions	Total	per patent
MPEG2 (10 firms)	85	37	44	9	32	85	2.30
		44%	52%	11%	38%		
DVD (6C)	180	83	34	5	62	101	1.22
		46%	34%	5%	61%		
DVD (3C)	131	47	38	9	15	62	1.32
		36%	61%	15%	24%		
Total	396	167	116	23	109	248	1.49
		42%	47%	9%	44%		

Note 1. 10 firm for MPEG2 include Sony, Philips, Thomson licensing, Mitsubishi, Matsushita, GE technology, General instrument, JVC, Samsung. And Toshiba.

Note 2. There are some overlaps between continuations, CIP and divisions.

Table 5 Testing proposition 1(dependent variable: the share of the essential patents using continuations, CIPs or divisions)

		Basic specification						Extended specification					
		Share of essential patents using continuations or CIPs			Share of essential patents using continuations, CIPs or divisions			Share of essential patents using continuations or CIPs			Share of essential patents using continuations, CIPs or divisions		
		contcipy			*contcipdivy*			*contcipy*			*contcipdivy*		
		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.	
size of essential patents in the standard formation stage	*lnpatentsb*							−0.133	0.074	*	−0.125	0.067	*
quality of early stage patents	*lncitedness*	−0.188	0.085	**	−0.166	0.077	**	−0.199	0.084	**	−0.161	0.076	*
difference between application year and 2005	*age*	−0.021	0.022		−0.044	0.020	**	−0.065	0.312		0.130	0.285	
	age^2							0.002	0.011		−0.006	0.010	
MPEG dummy	*mpeg*	0.132	0.088		0.083	0.080		0.040	0.105		−0.020	0.096	
		Number of obs=21			Number of obs=21			Number of obs=21			Number of obs=21		
		R-squared = 0.2828			R-squared = 0.3897			R-squared = 0.4208			R-squared = 0.5049		
		Adj R-squared = 0.1563			Adj R-squared = 0.2821			Adj R-squared = 0.2278			Adj R-squared = 0.3398		

*** 1% significance, ** 5% significance, * 10% signigicance

Appendix: Descriptive statistics of the essential patents by firm

Variable	Obs	Mean	Std. Dev	Min	Max
patents	21	18.86	18.58	3	66
patentsb	21	7.62	4.94	2	22
contcipy	21	0.31	0.20	0	0.8
contcipdivy	21	0.43	0.20	0	0.8
citedeness	21	29.97	19.53	11.9	95.2
age	21	13	1.9	11.0	17.9
mpeg	21	0.52	0.51	0	1
c6	21	0.33	0.48	0	1
c3	21	0.14	0.36	0	1

Note. *Patents* represents the number of essential parents held by a firm, *patentsb represents that at the standard formation stage, contcip*y is the share of the essential patents using continuation or CIP, *contcipdiv*y is the share of the essential patents using continuation, CIP or division.
Note. The sample focus on the firms with at least three essential patents.