Title	The structure and the evolution of essential patents for standards: Lessons from three IT standards
Author(s)	Nagaoka, Sadao; Shimbo, Tomoyuki; Tsukada, Naotoshi
Citation	
Issue Date	2006-09
Type	Technical Report
Text Version	publisher
URL	http://hdl.handle.net/10086/15973
Right	

Hitotsubashi University
Institute of Innovation Research

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

Sadao Nagaoka
Tomoyuki Shimbo
Naotoshi Tsukada

IIR Working Paper WP#06-08

September 2006

Institute of Innovation Research
Hitotsubashi University
Tokyo, Japan
http://www.iir.hit-u.ac.jp

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

Sadao Nagaoka [*], Institute of Innovation Research, Hitotsubashi University
Tomoyuki Shimbo, Graduate School of Commerce and Management, Hitotsubashi University,
Naotoshi Tsukada, Graduate School of Economics, Hitotsubashi University

September 2006

Summary

This paper examines the structure and the evolution of the patents declared 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. Many patents have been applied even after the standard was set. We analyze three important reasons for why the essential patents are many and increase over time: they cover a number of different technology fields, there exist R&D competition even in a narrowly defined technology field and a firm can expand its patent portfolio by using continuations and 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 empirical analysis suggests that a firm with pioneering patents does not obtain more essential patents, using these practices.

Key words: standard, essential patent, continuations
JEL classification: O31, O34

---

[*] Corresponding author: Professor, Institute of Innovation Research, Hitotsubashi University, 2-1 Naka Kunitachi Tokyo, Japan 186-8603 Fax: 81-425-80-8410.
E-mail addresses: nagaoka@iir.hit-u.ac.jp

We would like to thank the participants in a session of the 11th International J.A. Schumpeter Society Conference in June 2006 for their valuable comments. We would like to thank the Japan Patent Office for its financial support to the research project on the essential patents of the standards at Hitotsubashi University. This paper is based on its project report. We would like to thank Hisashi Kato of Mitsubishi Electric, and Yasuo Nishioka and Sadao Suzuki of Toshiba for their help in deepening our knowledge of the standards. Nagaoka would like to thank for excellent research assistance by Kazuyoshi Taniguchi and Wang Tingting.

1. Introduction

This paper examines the structure and the evolution of the patents declared as essential for three technical standards (MPEG2, DVD formats and W-CDMA). Patents have become important in technical standards especially in information technology (IT) area in recent years, since the standards often incorporate cutting-edge technologies and the firms owning the patents on these technologies 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 infringes it[i].While exercising such patent right may enhance the appropriability of R&D investment from the perspective of a single firm, it may cause the inefficiency due to a patent thicket problem when many firms independently try to collect royalty (Heller and Eisenberg (1988), Shapiro (2001), Lerner and Tirole (2002)). The analysis of the structure and the evolution of the essential patents of these standards would provide important clues on how the patent thicket problem might emerge in a standard setting process as well as on appropriate policy responses. As for as we know, a deep empirical study of the patent thicket problem is scarce (an exception is Hall and Ziedonis (2001)) and there is no empirical study on the essential patents of a standard from this perspective.

Let us briefly explain three technical standards which 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. There is a patent pool administered by MPEG LA, which certify essential patents for collective licensing in video technology. It started to license the bundle of the essential patents in September 1997. DVD (Digital Video Disc or Digital Versatile Disc) is optical disc technology and can store a large volume of digital data for full-motion video. The standard for

the player format of DVD was developed by a private consortium (the DVD forum) with its decision on the standard in December 1995. There are two patent pools, 6C group and 3C group, both of which certify and license different parts of the essential patents for DVD. No consensus was struck for the standardization of the recorder format of DVD and these pools also license the essential patents for the recorder formats. 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 exist no comprehensive patent pool (or platform) organization which covers a significant part of the essential patents for collective licensing, although the 3G patent platform was established in 2003, with a small number of the 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 the 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 of these patents have been made (According to one experts evaluation[ii], only 21 % of the patents declared to ETSI are actually essential). In section 2, we analyze who have essential patents to a standard. In section 3 we explore the reasons for why there are so many essential patents. In section 4, we assess the frequency of the patents which a firm has obtained by using the continuations and other applications based on the priority dates of earlier patent applications, and whether a firm with pioneering patents can obtain more subsequent patents, using these practices. 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 are 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. There are 800 licensees in November 2004.Lucent and IBM are the major non-members of the patent pool. The number of the essential patents held by the original 8 members of the patent pool (7 firms and one university) increased from 34 families in July 1997 to 83 families in July 2004 by 49 families. This can be compared to the increase of the essential patents owned by the pool, simply due to the expansion of the members, which amounted to 44 families.

In the case of the DVD formats, there are 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[iii]. There are 7 firms in 6C group and 4 firms in 3C group. Both groups widely license its technology (179 licensees in the case of 3C and 245 licensees in the case of 6C for player). 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 are 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 (the Association of Radio Industries and Businesses of Japan as of November 2004)[iv]. There exist 24 patentees for the standard according to the declaration to the ARIB.

Not only many patents and many patentees are involved in technical standard, but also their membership is heterogeneous. As shown in Table 2, although a manufacturing firm which is both the licensor to the standard as well as the user of the standard is most numerous, it

accounts for 80% of the firms with essential patents. Non-manufacturing user such as an operator firm and pure licensor firms, such as a firm specialized in R&D or in patent portfolio management and a university, are also important, accounting each for around 10 % of the firms with essential patents.

(Table 2)

3. Why so many essential patents?

In this section we examine several reasons why these standards cover so many patents. For this purpose, we have analyzed both the distributions of the essential patents over technology fields defined by IPC (International Patent Classification) as well as their time profile. Table 3 shows such distributions for the DVD format. This shows that the standard covers a large number of different technology areas, reflecting its technological sophistication. As shown in Table 3, the essential patents of the DVD covers the half of 8 IPC sections, that is, physics, electricity, human necessities and performing operations, 11 of 120 IPC classes and 25 of 724 IPC subclasses. Similarly, the MPEG2 covers 2 IPC sections, 4 IPC classes and 8 IPC subclasses.

(Table 3)

Second, a number of firms own the essential patents in the same technology field, even if the latter is relatively narrowly defined by the classification based on IPC subclass, which has more than 720 classifications. As shown in Table 3, more than 10 firms own essential patents in the following two IPC subclasses in the case of DVD. They are G11B: information storage based on relative movement between record carrier and transducer, and H04N: pictorial communication, e.g. television. Moreover, there are 14 IPC subclasses for which more than two firms own essential patents. Similarly, 14 firms own essential patent in IPC subclass H04N in the case of MPEG2, and there are 5 IPC subclass 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 standard is set is also important, as shown in Figure 1. This Figure classifies the essential US patents into the following four categories in terms of their registration, application and priority dates relative to the date of standard determination. The group *R* covers those registered before the month of the first determination of standard specification. The group *P* covers those applied before the month of the first determination of standard but not yet registered before that month. The group *C* covers those applied on or later than the month of the first determination of standard specification, with the priority date before the month of the first determination of standard specification. Finally, the group *A* covers those with the 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: 34 % for MPEG2, 15% for DVD (player) and 25% for W-CDMA. This implies that the standard specification is developed and agreed at the stage when most essential patents are still pending or still to be applied. Thus, as far as the granted patents are concerned, the patents follow a 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 a good sense that the disclosure policy of the standard bodies such as ITU-T covers both granted and pending patents.

(Figure 1)

The time lag between the patent application and the grant is an important reason for why the patents are often granted after the standard is set. As shown in Figure 1, the essential patents which are applied 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 the similar shares of the essential patents as above: 33% for the MPEG2, 17% for the DVD format (player) and 35 % for the W-CDMA. However, it is also true that a significant part of the patents are

applied even 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 the MPEG2, 41% for the DVD and 25% for the W-CDMA. Thus, the number of essential patents can increase long after the determination of the initial standard. These ex-post applications for the essential patents may pose a question of how a firm can satisfy the novelty requirement for a patent once the standards are published. This puzzle can be resolved by the availability of continuation, continuation-in-parts and divisional 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 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 division practices are in fact important in the ex-post expansion of the essential patents granted, as we will see in the following section.

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*). The most likely explanation is the revision of the standards, incorporating new technology. There are four revisions of the standard for DVD (reader) and two revisions for W-CDMA by the end of 2004, which have added new functions. Although there is no systematic information available with respect to how many new patents are added to the revision, 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 patents to the original 83 patents and 4 out of 14 patents have priorities more recent than the month when the standard was initially set[v].

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 its 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 royalty by threatening to hold-up the users of the standard. Such risk gives exactly the reason 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 their essential 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 on the users of the standard is fixed, independent of the number of essential patents. Even given these commitments, an individual firm can still 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 continued use 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 why we see a significant ex-post increase of the essential patents granted for a standard are the use of 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 the 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 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. 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 for MPEG2, 1.2 times per patent for DVD (6C) and 1.3 times for 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 distributing more of the royalty income to such pioneering 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 using these practices in its portfolio of the essential patents acquired ultimately by such firm. For simplicity, let us assume that a firm *k* has n_k essential patents with quality q_k which are applied before the determination of a standard. We assume that a firm does not use the continuation and divisional practices in such 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 increases 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 of the essential patents of firm *k* which have been obtained using these practices in its total essential patents (θ_k) 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 with rich written descriptions to obtain more subsequent patents based on these descriptions, we would observe a positive correlation between the quality of the inventions in the standard development stage (*q*) and the share of the patents which are 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 variables are the share of the US patents obtained using continuations or continuations-in-parts (*contcipy*) or that of using continuations, continuations-in-parts or divisional applications (*contcipdivy*) by firm *k* until 2004 in its total US essential patents for MPEG2 and DVD (player). 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 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 more chance 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 smaller downward bias due to truncation problem in citation. On the other hand, an essential patent applied earlier would have more chance to be 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 larger chance for being used for such objective. We introduce the standard dummy (*mpeg*) controlling the standard fixed effect, which can take into accounts the difference in citation structure among standards, including the degree of truncation bias. 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 diseconomy of scale with respect to *patentsb* in expanding the number of essential patents due to the internal overlap of such patents in patent scope within a firm. 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 is offered in the appendix.

Table 5 provides estimation results. As shown in Table 5, the 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 size of the coefficient of this variable is very close between the basic specification and the extended specification. The firm with high quality early stage patents tends to have a smaller number 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 truncation bias is more important. In addition, there is some evidence for diseconomy of scale with respect to the number of the essential patents in the standard formation stage. In summary, a firm with pioneering patents does not obtain more subsequent essential patents, using these practices, rejecting Proposition 1.

(Table 5)

5. Conclusions

This paper has examined the structure and the evolution of the patents declared 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 rate 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 even after the standard was set. We identify three important reasons for why the essential patents are many and increase over time: they cover a number of different technology fields, there exist a number of firms active in R&D even in a narrowly defined technology field and firms can expand their patent portfolio by using patent applications based on earlier priority dates (continuations, CIP and divisions) in the USA 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 a good 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 the patents to be applied 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 for a standard. 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.

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.

[i] 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 being trivial. The patent pool organization usually hires outside independent experts to evaluate 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.

[ii] Goodman and Myers (2005)

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

[iv] 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.

[v] 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 specifiatio n 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 specifiatio n 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 specifiatio n 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.

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

Figure1 Time profile of the essential patents of three standards

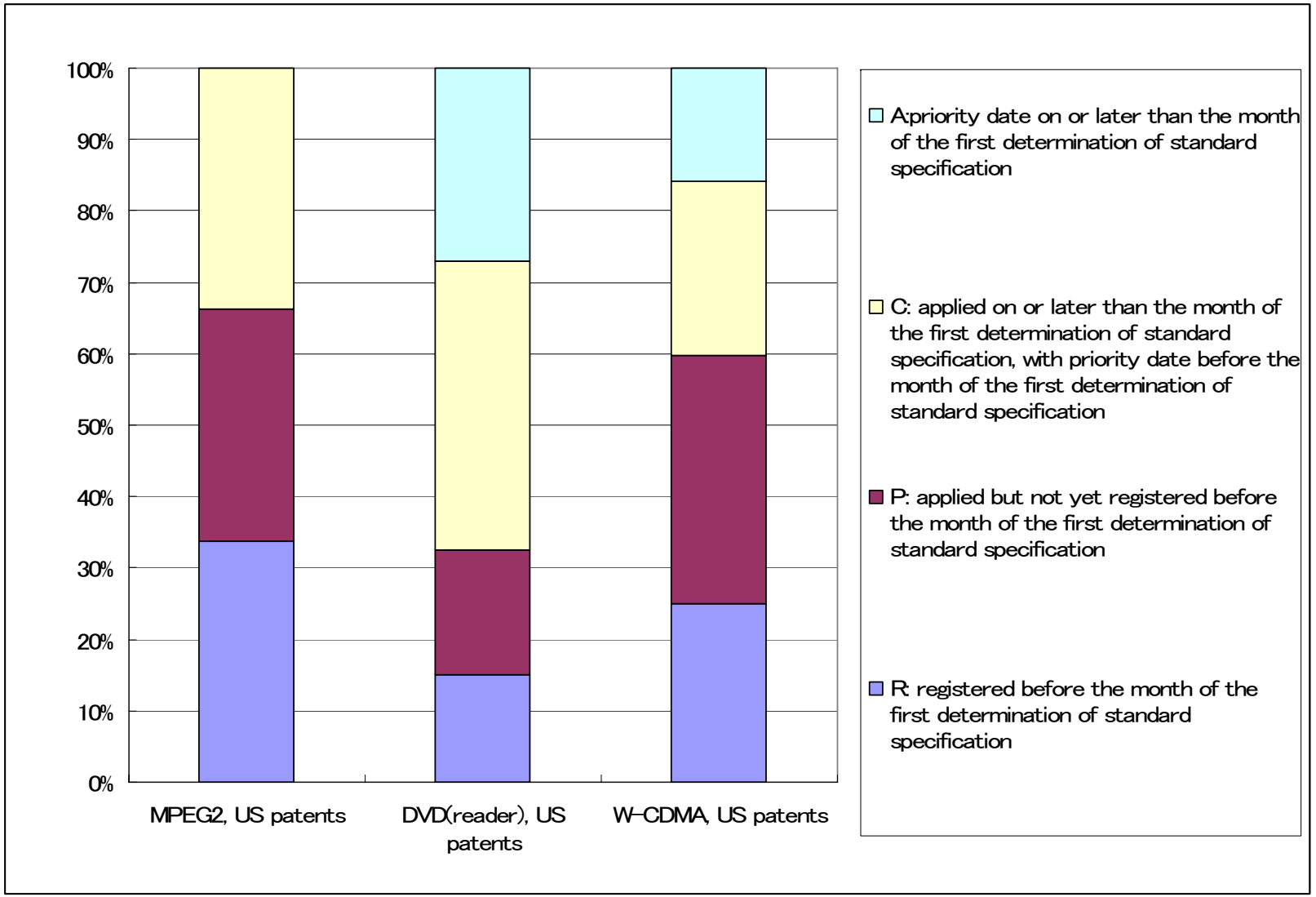

Table 4. The essential patents which were obtained, using divisions, continuations and continuations-in-parts

	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
contcip	21	5.10	5.11	0	22
contcipdiv	21	8.00	8.87	0	38
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* is the number of the essential patents using continuation or CIP, *contcipdiv* is the number of the essential patents using continuation, CIP or division.
Note. The sample focus on the firms with at least three essential patents.