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Research on Management of Patent Applications about Long Life-Cycle Electric Appliances

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***Abstract*--a lot of patent rights are used for producing assembled products like electric appliances. And electric appliances like digital cameras have very long product life-cycle. High-ranking Japanese electronics companies file several thousands of patent applications each year for protecting own products. In view of the product life-cycle, the sales of long product life-cycle products tends to be flat after the mature phase and each company cannot get enough sales and profits. However, some companies continue to file excess patent applications after the mature phase. This kind of patent applications will not be contributory to corporate profitability. We think this is the reason why each company pays careful attention to other competitor's number of patent applications and don't consider own financial indicators (for example, sales, income, and R&D expense) which are related to corporate performances.**

Therefore, in this study, we took up some Japanese electronics companies and analyzed correlations among these companies' accumulated number of patent applications and correlations between each company's accumulated number of patent applications and its financial indicators. From the result of analyses, we propose IP management for reducing useless patent applications after the mature phase.

I. INTRODUCTION

A. Background and Objective

The total number of Japanese patent applications is about 400,000 each year [1]. Almost half of TOP 10 companies are Japanese electronics companies. The ratio of patent applications from residences in Japan is about 80% of 400,000, despite Japanese companies are promoting the internationalization of corporate activities [2]. High-ranking Japanese electronics companies continue to file several thousands of patent applications each year. We speculate these companies have filed excess and ineffective patent applications about long life-cycle electric appliances such as digital camera, cell phone, etc. Especially, patent applications filed after mature phase of product life cycle will not be contributory to corporate profitability too much.

Therefore in this study, we took up digital camera which is one of long life cycle products in Japanese electronics companies and analyzed the correlations among each company's patent applications as external factor and the correlations between patent applications and financial indicators as internal factor. We found out each company's financial factors for deciding the number of patent applications and would like to present recommendations for improvement for decreasing patent applications noncontributory to corporate profitability of each company and the industry-wide profitability. This will lead to reduce useless cost and time on patent applications not linked to product life cycle and financial indicators. Each company will be able to concentrate management resources on future important research and development. This IP (Intellectual Property) management largely contributes to the development of each company's technology management.

B. Existing Literature

It is an important factor to diffuse products to the market for corporate sales. Rogers set up the theory of diffusion of innovations by observing diffusion of agricultural instruments in United States. The mechanism of diffusion of innovations is described in the literature of Rogers [7]. This diffusion curve is expressed by the ratio of annual intakes and has five phases (innovator, early adopter, early majority, late majority, and laggard).

In marketing field, Levitt proposed the marketing action plan based on the steps of product life-cycle [6]. These steps consist of four phases (development, growth, maturity, and decline). This product life-cycle curve is expressed by annual sales.

Generally, it was difficult to predict the diffusion curve and the sales curve precisely. As to mathematical approach, Bass came up with product growth model for consumer durables [3]. Bass model is a simulation model for diffusion process of consumer durables. However, it requires parameters such as accumulated diffusion ratio, innovation coefficient, and imitation coefficient. It is difficult to collect these data about certain product fully and predict the latter half of diffusion curve precisely.

As to IP fields, for example, there is a study of IP management in pharmaceutical firms about the relation between patents and product life cycle [4]. In this study, the literature describes IP management for maximizing the profit from drug discovery research over long periods by some different types of patents. Pharmaceutical companies can directly protect their drugs by substance patents. Therefore the number of patent applications in the pharmaceutical industry is low compared with electronics companies.

On the other hand, we can't find out existing literatures about IP management for decreasing useless patent applications of products after the mature phase of product life cycle in the electronics industry in terms of financial indicators.

By the way, there are plenty of definitions about product life-cycle. In this study, we define product life-cycle in terms of annual sales. This sales curve is generally expressed by S-curve and four phases (development, growth, maturity, and decline). The development phase indicates the beginning of launch. The growth indicates high demand. The mature phase indicates stagnant demand. The decline phase indicates

downturn in demand. Especially, we focus on the start point of mature phase which is defined by the start point where the sales (S-curve) begin to be flat.

C. Summary of the history of digital cameras

Next we provide a brief explanation of the history of digital cameras in Japan. The emergence of digital cameras was in 1981. It is said that Mavica made by Sony Corporation was the first digital camera in Japanese market. This digital camera adopted a method of storing images on a floppy disk without films and an analog-type recording method of video camera for recording images. The first digital-type digital camera was FUJIX DS-1P made by Fuji Photo Film Co., Ltd. in 1988 [5].

And Canon Inc. released RC-701 as a SLR (single-lens reflex) camera with interchangeable Lens in 1986. However, this camera was for professionals and business use and very expensive. The rapid spread of SLR camera began from 2003 when Canon released EOS KISS DIGITAL. The marker price of the body of camera at the time in Japan was about 120000 yen [5].

Therefore, it has been over 25 years since the emergence of digital cameras in Japan. Digital cameras are very long life cycle products. On the other hand, film cameras had high demand at that time. However, the demand of film cameras gradually started to reduce as digital cameras become increasingly popular. Next we get a grasp of the start point of mature phase in digital cameras product life- cycle by using various statistical data about digital cameras.

D. Spread of digital cameras

According to statistical data compiled by CIPA (Camera & Imaging Products Association, URL:http://www.cipa.jp/english/index.html) which is a Japanese industry organization about camera & imaging products, the penetration volume of main consumer durables (general households) about digital cameras was 32% in 2003, 53.7% in 2006, 69.2% in 2009 [8]. We think that the commoditization of digital cameras occurred at a fast pace for several years. Hereinafter, we consider the diffusion trends in digital cameras using statistical data compiled by CIPA.

Figure 1 shows the trends of value of shipments to Japan about digital cameras with built-in lens and digital SLR cameras with interchangeable lens [8]. Digital cameras with built-in lens which holds a majority of value of shipments to Japan continued to grow rapidly from 1999 and reached a peak in 2003 and turned flat after that. Therefore, it is highly possible that the start point of mature phase is 2003.

Figure 2 shows the trends of quantity of shipments to Japan about digital cameras with built-in lens and digital SLR cameras with interchangeable lens [8]. Digital cameras with built-in lens which holds a majority of quantity of shipments to Japan continued to grow rapidly from 1999 and turned flat from around 2003. In addition, one US dollar is about equal to 100 yen.

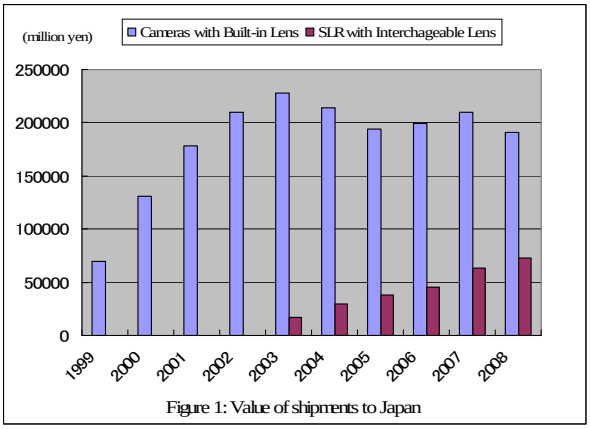

Figure 1: Value of shipments to Japan

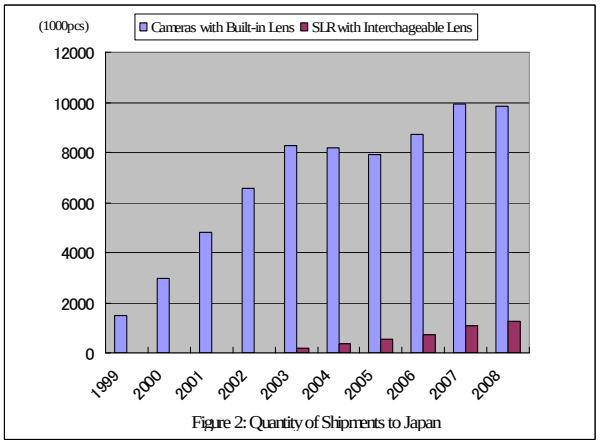

Figure 2: Quantity of Shipments to Japan

Figure 3 shows the trends of average unit price shipments to Japan about digital cameras with built-in lens and digital SLR cameras with interchangeable lens [8]. The unit price of digital cameras with built-in lens took a big dip by 2003 and decreases very gradually after that. The unit price of digital SLR cameras with interchangeable lens which began to spread rapidly in 2003 decreases rapidly from 2003 to the present.

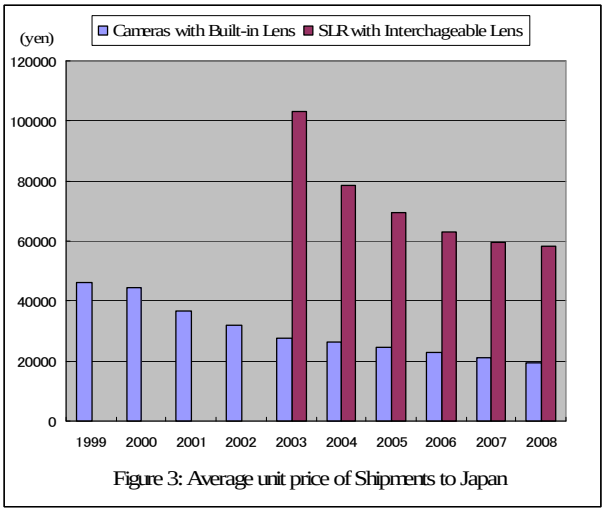

Figure 3: Average unit price of Shipments to Japan

The quantity of shipments to Japan about digital cameras with built-in lens turned flat from 2003 and the average unit price of shipments to Japan continued to fall as Figure 3 illustrates. It turns out that it is difficult for each company to get big profits from the market after 2003. Considering Figure 2 and Figure 3, it is highly possible that the sales carve shown in Figure 1 will continue to be flat after 2003. Therefore, we can estimate that digital cameras went into the mature phase of product life cycle from 2003 and 2003 is the start point of mature phase.

II. RESERCH METHODOLOGY

Next we provide a brief overview of our research methodology.

A. Analysis of patent applications

We figure out the annual trends of patent applications and the cumulative numbers of patent applications about 6 companies which participate in CIPA. We form hypothesis 1 and test hypothesis 1 by using correlation analysis about their cumulative number of patent applications.

B. Patent applications and financial indicators

Next we form hypothesis 2 about the relations between each company's cumulative number of patent applications and financial indicators, and test hypothesis 2 by using correlation analysis about them.

C. Classification of 6 companies

We analyze the main determinant of each company according to financial indicators based on the verification result and classify these 6 companies by the main determinants.

D. Conclusions

We make a proposal for decreasing useless patent applications noncontributory to corporate profitability which are not linked to financial indicators. Lastly we give an explanation of future subjects about this study.

III. ANALYSIS OF PATENT APPLICATIONS ABOUT DIGITAL CAMERAS

A. Extract of patent applications about digital cameras

We extracted the annual number of patent applications and the cumulative number of patent applications about the Top 6 companies which filed a lot of patent applications in Japan from 1983 to 2007 (TABLE 1). These 6 companies are Olympus Corporation, Canon Inc., Sony Corporation, FUJIFILM Corporation, Panasonic Corporation, and SEIKO EPSON CORPORATION. All of them are the members participating in CIPA Statistical Research.

TABLE 1: PATENT APPLICATIONS DATA OF 6 COMPANIES (*:CUMULATIVE NUMBER)

Calendar year	Olympus	Olympus*	Canon	Canon*	SONY	SONY*	FUJIFILM	FUJIFILM*	Panasonic	Panasonic*	SEIKO EPSON	SEIKO EPSON*
1983	4		1		13		1		23		1	
1984	13	17	6	7	27	40	9	10	29	52	0	1
1985	21	38	20	27	48	88	121	131	35	87	2	3
1986	24	62	40	67	75	163	194	325	28	115	1	4
1987	69	131	61	128	50	213	164	489	34	149	1	5
1988	132	263	97	225	31	244	232	721	32	181	0	5
1989	104	367	87	312	61	305	166	887	41	222	6	11
1990	90	457	108	420	51	356	162	1049	48	270	9	20
1991	90	547	92	512	72	428	166	1215	24	294	5	25
1992	68	615	101	613	67	495	119	1334	13	307	0	25
1993	85	700	52	665	43	538	73	1407	7	314	1	26
1994	29	729	49	714	24	562	87	1494	6	320	0	26
1995	25	754	82	796	18	580	71	1565	9	329	2	28
1996	34	788	167	963	55	635	108	1673	35	364	20	48
1997	90	878	283	1246	110	745	244	1917	67	431	60	108
1998	198	1076	441	1687	183	928	374	2291	94	525	106	214
1999	220	1296	624	2311	239	1167	556	2847	123	648	171	385
2000	256	1552	695	3006	320	1487	596	3443	198	846	172	557
2001	360	1912	851	3857	386	1873	758	4201	289	1135	240	797
2002	300	2212	1105	4962	405	2278	1656	5857	234	1369	485	1282
2003	386	2598	1133	6095	600	2878	1202	7059	444	1813	904	2186
2004	548	3146	1467	7562	714	3592	1248	8307	578	2391	938	3124
2005	468	3614	1617	9179	708	4300	1426	9733	584	2975	998	4122
2006	471	4085	1302	10481	861	5161	1052	10785	570	3545	967	5089
2007	483	4568	1214	11695	1119	6280	876	11661	507	4052	929	6018

We used JP-NET of Japan Patent Data Service Corporation (URL: http://www.jprom.co.jp/) as the patent search system. Data sources are based on data of Japan Patent Office [9]. The search conditions are the following ones from 1 to 4. In addition, we removed some noise applications after this search.

Condition 1

partial match retrieval by applicant name (company name)

Condition 2

keyword retrieval from full text including claims and patent specification

keywords: digital camera or digital still camera or electronic still camera

Condition 3

IPC (international patent classification): G or H

Condition 4

period subject to retrieval: patent applications and utility model applications filed in Japan Patent Office from January 1st, 1983 to December 31st, 2007. Application date is based on actual filing date. In addition, hereinafter referred to as patent applications including utility model applications

Figure 4 shows the annual trends of patent applications about Olympus, Canon, SONY, FUJIFILM, Panasonic, and SEIKO EPSON. Each company rapidly increased the number of patent applications from around 1997. On the other hand, it turns out that some companies increased the number of patent applications and other companies decreased the number of patent applications after 2003 as shown in Fig. 4. It was difficult to find out characteristic tendency from Fig. 4. Next, we considered the trends of cumulative numbers of patent applications about these 6 companies.

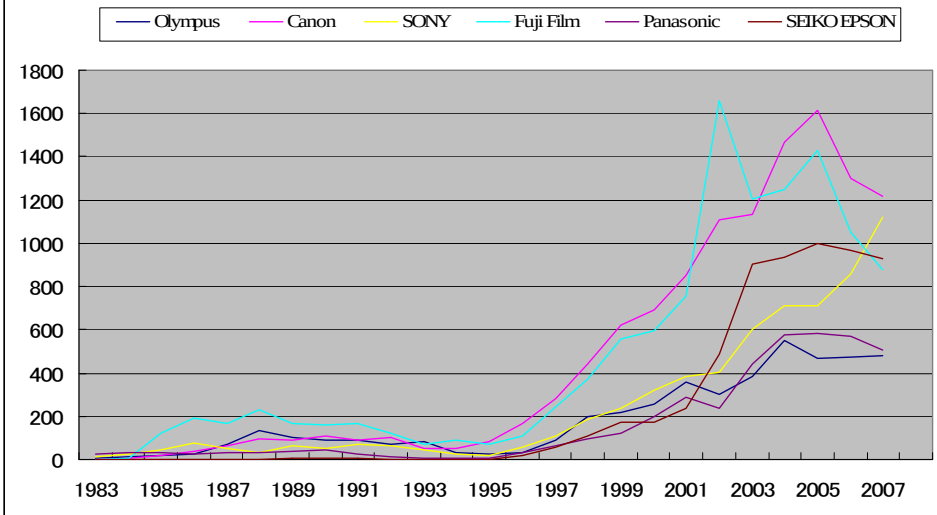

Figure 4: Trends of patent applications from 1983 to 2007

Figure 5 shows the annual trends of cumulative numbers of patent applications about 6 companies. There are the first group including FUJIFILM and Canon and the second group including SONY, SEIKO EPSON, Panasonic, and Olympus. FUJIFILM and Canon in the first group have the similar curves. And the curve of SONY in the second group is about half level of FUJIFILM or Canon. Some kinds of relations among each company's curve will be expected from Fig. 5.

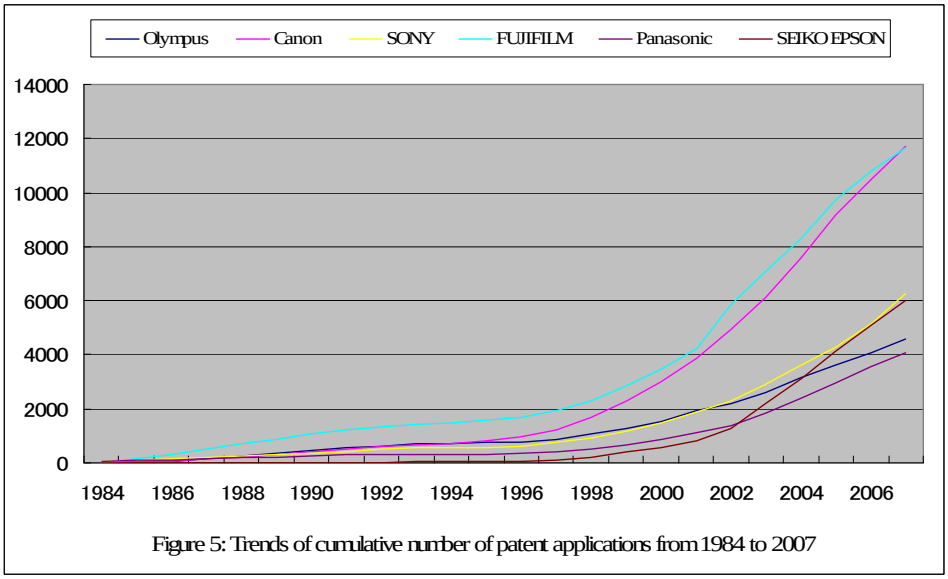

Figure 5: Trends of cumulative number of patent applications from 1984 to 2007

B. Hypothesis 1

Generally, a lot of patents are used in one electronics product. Therefore, each electronics company tends to file a lot of patent applications for protecting own products from the competitors. As diffusion of products comes down, some new companies go into the same market and each company faces confused fight in patent field. Therefore, it is difficult for each company to avoid all patents which other companies have. This is why each company tends to enter into cross license in case of IP license in electronics industry. Each company must increase own patent volume and power for making good cross license. One of main sources for getting advantageous cross license is a cumulative number of patent applications from the past to the preset about the target product. So we formed Hypothesis 1.

Hypothesis 1*: Each company of digital cameras decides own cumulative number of patent applications considering other's cumulative number of patent applications.*

C. hypothesis testing

We tried to test hypothesis 1 by correlation analysis among 6 company's cumulative number of patent applications from 1984 to 2007. We calculated kinds of data by SPSS (IBM SPSS statistics) which is statistical software. We use correlation analysis because we predict each company considers other competitive company's patent applications.

TABLE 2 shows the results of correlation analysis. Each company cumulative number has a high correlation with the others. Therefore, we concluded that each company controls and decides own cumulative number of patent applications considering other companies' cumulative number(s) as external factor. Therefore, it can be said that hypothesis 1 was tested.

TABLE 2: CORRELATION AMONG CUMULATIVE NUMBERS OF PATENT APPLICATIONS (*:CUMULATIVE NUMBER)

Company	Correlation	Olympus*	Canon*	SONY*	FUJIFILM*	Panasonic*	SEIKO EPSON*
Olympus*	Pearson's correlation coefficient	1	.994**	.990**	.997**	.984**	.957**
	significance probability (two-sided)		0	0	0	0	0
Canon*	Pearson's correlation coefficient	.994**	1	.996**	.997**	.995**	.979**
	significance probability (two-sided)	0		0	0	0	0
SONY*	Pearson's correlation coefficient	.990**	.996**	1	.991**	.998**	.986**
	significance probability (two-sided)	0	0		0	0	0
FUJIFILM*	Pearson's correlation coefficient	.997**	.997**	.991**	1	.989**	.967**
	significance probability (two-sided)	0	0	0		0	0
Panasonic*	Pearson's correlation coefficient	.984**	.995**	.998**	.989**	1	.993**
	significance probability (two-sided)	0	0	0	0		0
SEIKO EPSON*	Pearson's correlation coefficient	.957**	.979**	.986**	.967**	.993**	1
	significance probability (two-sided)	0	0	0	0	0	

In addition, single asterisk shows significance probability of below 5%, double asterisk shows significance probability of below 1% in all Tables.

IV. ANALYSIS BETWEEN EACH COMPANY'S CUMULATIVE NUMBER OF PATENT APPLICATIONS AND FINANCIAL INDICATORS

A. Hypothesis 2

There are high correlations among each company's cumulative number of patent applications. However, we predict that determining factors of filing patent applications are related to financial indicators as internal factor as well as other cumulative number of patent applications. On the other hand, it is possible that some companies decide the number of patent applications not linked to own financial indicators if we consider Figure 4. Such companies may file useless patent applications noncontributory to corporate profitability at least in the short-term future. Then we made the following hypotheses 2. In addition, we mainly define financial indicators as sales, income, and R&D expense because we predict IP budget in each company will be decided according to these indicators.

Hypothesis 2*: There is a company which decides the cumulative number of patent applications not linked to own financial indicator (especially, income).*

B. hypothesis testing

We tried to test hypothesis 2 by correlation analysis between cumulative numbers of patent applications and financial indicators about 6 companies. We collected financial indicators of each company from each company website [10] [11] [12] [13] [14] [15]. In addition, there are the differences in conditions among individual companies about a number of items and years of financial indicators. The cumulative number of patent applications is shown in calendar year. The financial indicators are shown in financial year. Generally, companies decide the budget based on the performance of the previous year. Thus, in our analysis, we shifted financial indicators to the previous year ones like the cumulative number of patent applications in FY1999 and the financial indicators in calendar year 2000.

Hereafter, we explain the results of correlation analysis between cumulative numbers of patent applications and financial indicators about 6 companies.

TABLE 3 shows SONY's correlation between the

cumulative number of patent applications and the financial indicators. The financial indicators were retrieved from SONY's web page [10].

Sony's cumulative number of patent applications has a high correlation with sales and operating revenue (Total sales). And Sony's cumulative number of patent applications has a very high correlation with R&D expenses. On the other hand, Sony's cumulative number of patent applications has a negative correlation with "operating income".

TABLE 3: SONY'S CORRELATION BETWEEN THE CUMULATIVE NUMBER OF PATENT APPLICATIONS AND THE FINANCIAL INDICATORS

	Sales and operating revenue(Total sales)	Operating income	Net income	R&D expenses
Pearson's correlation coefficient	.779(*)	-0.666	0.221	.959(**)
Significance probability (two-sided)	0.013	0.05	0.567	0

TABLE 4 shows Canon's correlation between the cumulative number of patent applications and the financial indicators. The financial indicators were retrieved from Canon's web page [11]. Canon's cumulative number of patent applications has very high correlations with sales (camera), operating profit (camera), R&D expenses, sales (Japan), operating profit (Japan), and net income, etc.

TABLE 4: CANON'S CORRELATION BETWEEN THE CUMULATIVE NUMBER OF PATENT APPLICATIONS AND THE FINANCIAL INDICATORS

	sales(camera)	operating income(camera)	oprating income to sales	R&D expenses	R&D expenses to sales	sales(Japan)	operating income(Japan)	oprating income to sales(Japan)	sales(Japan)
Pearson's correlation coefficient	.995(**)	.961(**)	.951(**)	.992(**)	0.432	.982(**)	.994(**)	.970(**)	.847(**)
significance probability (two-sided)	0	0	0	0	0.285	0	0	0	0.008

	sales(total)	gross operating profit	operating income(total)	oprating income to sales(total)	net income before tax	net income before tax ration	current net income	current net income ratio
Pearson's correlation coefficient	.986(**)	.994(**)	.996(**)	−0.073	.998(**)	0.36	.996(**)	0.61
significance probability (two-sided)	0	0	0	0.864	0	0.382	0	0.109

TABLE 5 shows FUJIFILM's correlation between the cumulative number of patent applications and the financial indicators. The financial indicators were retrieved from FUJIFILM holdings' web page [12].

FUJIFILM's cumulative number of patent applications has very high correlations with sales (Japan), sales (worldwide), and R&D expenses. On the other hand, FUJIFILM's cumulative number of patent applications has a negative correlation with operating income, net income before taxes and other adjustments, and net income.

TABLE 5: FUJIFILM'S CORRELATION BETWEEN THE CUMULATIVE NUMBER OF PATENT APPLICATIONS AND THE FINANCIAL INDICATORS

	Sales(Japan)	Sales(world)	Operating income	Net income before tax	Current net income	R&D expenses
Pearson's correlation coefficient	.816(**)	.905(**)	-0.508	-0.514	-0.654	.919(**)
significance probability (two-sided)	0.007	0.001	0.163	0.157	0.056	0

TABLE 6 shows SEIKO EPSON's correlation between the cumulative number of patent applications and the financial indicators. The financial indicators were retrieved from SEIKO EPSON's web page [13]. SEIKO EPSON's cumulative number of patent applications has a high correlation with sales. On the other hand, SEIKO EPSON's cumulative number of patent applications has negative correlations with operating income, current profit, net income before taxes and other adjustments and net income, and net income, etc.

TABLE 6: SEIKO EPSON'S CORRELATION BETWEEN THE CUMULATIVE NUMBER OF PATENT APPLICATIONS AND THE FINANCIAL INDICATORS

	sales	gross operating profit	Operating income	Current profit	Net income before tax	Current net income	Sales (Japan)	Operating income (Japan)	Sales (department)	Operating income (department)
Pearson's correlation coefficient	.773(*)	-0.083	-0.263	-0.144	-0.303	-0.214	.803(*)	-0.285	0.72	-0.341
significance probability (two-sided)	0.042	0.859	0.568	0.758	0.509	0.645	0.03	0.535	0.068	0.454

TABLE 7 shows Panasonic's correlation between the cumulative number of patent applications and the financial indicators. The financial indicators were retrieved from Panasonic's web page [14]. Panasonic's cumulative number of patent applications has a very high correlation with sales. And Panasonic's cumulative number of patent applications has high correlations with operating income, sales (location), and income (location).

TABLE 7: PANASONIC'S CORRELATION BETWEEN THE CUMULATIVE NUMBER OF PATENT APPLICATIONS AND THE FINANCIAL INDICATORS

	sales	Operating income	Operating income to sales	Net income before tax	Net income before tax ration	Current net income	Current net income ratio	Sales (department)	Sales (department, Japan)	Sales (location)	Income (location)
Pearson's correlation coefficient	.882(**)	.750(*)	0.675	0.581	0.509	0.513	0.466	.976(**)	0.936	.783(*)	.779(*)
significance probability (two-sided)	0.004	0.032	0.066	0.131	0.197	0.193	0.244	0.001	0.228	0.037	0.039

TABLE 8 shows Olympus' correlation between the cumulative number of patent applications and the financial indicators. The financial indicators were retrieved from Olympus' web page [15]. Olympus' cumulative number of patent applications has very high correlation with sales and R&D expenses. Olympus' cumulative number of patent applications has a high correlation with R&D expenses (department).

TABLE 8: OLYMPUS' CORRELATION BETWEEN THE CUMULATIVE NUMBER OF PATENT APPLICATIONS AND THE FINANCIAL INDICATORS

	sales	Current profit	Current net income	R&D expenses (total)	R&D expenses (department)
Pearson's correlation coefficient	.976(**)	0.601	0.542	.951(**)	.749(*)
significance probability (two-sided)	0	0.087	0.132	0	0.033

From correlations shown in Figure 2 to 7, it turns out that Sony, FUJIFILM, SEIKO EPSON, and Olympus don't decide cumulative numbers of patent applications by considering own income. The tendency is especially true in Sony, FUJIFILM, and SEIKO EPSON because they have negative correlations about income. Therefore, it can be said that hypothesis 2 was tested.

V. RESULT AND CONSIDERATION

A. correlations between cumulative number of patent applications and main financial indicators

We put main results shown in above-mentioned TABLE 3 to 8 together in TABLE 9. These financial indicators can be classified into 3 groups (sales, income, and R&D expenses). We think these three indicators are linked to each company's IP budget. The company's way of thinking about IP budget will be reflected in these there indicators. So we classified 6 companies into 3 groups as shown in TABLE 9. The first group includes Sony, FUJIFILM, and Olympus. These companies in the first group are thought to consider sales and R&D expenses for deciding cumulative numbers of patent applications. The second group includes Canon and Panasonic. These companies in the second group are thought to consider sales and income mainly for deciding cumulative numbers of patent applications. The third group includes SEIKO EPSON. This company in the third group is thought to consider only sales for deciding cumulative numbers of patent applications. In addition, because the cumulative numbers of patent applications in Sony, FUJIFILM, and SEIKO EPSON have negative correlation with income as shown in TABLE 9, the tendency that each cumulative number of patent applications is not linked to corporate profitability is strong.

TABLE 9: CORRELATIONS BETWEEN CUMULATIVE NUMBER OF PATENT APPLICATIONS AND MAIN FINANCIAL INDICATORS

Company	sales	income	R&D expenses
SONY	○	—	○
Canon	○	○	○
FUJIFILM	○	—	○
SEIKO EPSON	○	—	
Panasonic	○	○	
Olympus	○		○

B. Relation between patent applications and product life cycle

It can be said that product life cycle of digital cameras in Japan went into the mature phase from 2003 as explained in Introduction. And patent applications of digital cameras began to appear from 1983 and a lot of patent applications have been filed in Japan for long term over 25 years. Because the life of patent is 20 years in principle, it is expected that patents which supports the basic techniques of digital cameras will expire one after another in the near future. Thus we think that it will be difficult to turn a corporate profit even if the company files excess patent applications after 2003.

By the way, each company's number of patent applications maintains the high levels after 2003 as shown in Fig.4. It can be said that Canon and Panasonic continuously file patent applications according to the corporate profit from the result of TABLE 8.

On the other hand, it is highly possible that Sony, SEIKO

EPSON, and FUJIFILM are filing excess patent applications noncontributory to corporate profitability after 2003. Therefore, we think these 2 companies should have reduced the number of filing new patent applications after 2003.

In addition, we took up digital cameras as an example. When you apply this research approach to other industry's patents, you have to be careful of the differences of product life cycle and patent applications. Moreover, it is possible that the number of patent applications change irregularly because of particular internal factors in the company.

C. Proposals

In the industry with a lot of cross license, it is necessary for each company to have a large number of patent applications for the purpose of maintaining competition against other competitors. There was a high correlation between one company's cumulative number of patent applications and other's one as described in hypothesis testing of hypothesis 1. However, it is thought that some companies decide own cumulative number of patent applications not linked to financial indicators as described in hypothesis testing of hypothesis 2. Therefore, it is important to implement IP management that promotes IP activities to file patent applications linked to financial indicators in each company. This IP management will lead to yield high corporate profitability.

Moreover, it is a waste of time and cost for each company to keep a large number of patent applications for warning against other company in IP field without considering financial indicators. Also, it is wasteful for the industry. Thus, it is necessary for each company to reduce wasteful time and cost related to useless patent applications by implementing patent applications activity linked to financial indicators in terms of long period as well as short period. For linking to financial indicators, IP department in each company should cooperate with other departments such as sales, marketing, corporate planning further.

Finally, we propose the detailed actions that each company should adopt as IP management.

Action 1

Each company should reduce new patent application after the mature phase of product life-cycle. Especially it is good not to file defensive applications and tiny improved applications. And it should consider its own financial indicators and decide the number of patent applications based on the financial indicators.

Action 2

Each company should do continuous inventory after the start point of mature phase and control to abandon useless pending patent applications and useless patent rights, considering the remaining period of basic patent rights after the start point of mature phase.

Implementing the above IP management, each company will be able to focus corporate resources on their intended areas or R&D so that it can get more profitability through this IP activity. This will lead to better technology management and revitalization of each company.

In addition, in this study we took up Japanese companies which filed a lot of patent applications. However, it seems very possible that this tendency will emerge in other countries such as United States and China that have a huge number of patent applications. Our approach will help to these countries.

D. Future issues

In this study, we mainly dealt with macro data such as cumulative numbers of patent applications in digital camera industry. However, we could not consider technical contents and strength of patent applications, influences of other patent data such as patent-holding period, foreign applications, a number of patent rights, etc., and more precise prediction of product life cycle. We would like to study each company's annual determinant of deciding a number of patent applications in the future.

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