

R&D strategy analysis using Patent Database

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Abstract—The patent strategy including evaluation of patents has recently been considered as an important technique for the technology management. This paper proposes a citation analysis as a method providing the patent strategy. A citation analysis is a method that examines the value of a patent on the basis of the number of citations of references. While the citation analysis is of great interest as a method of evaluation, this analysis has not been fully examined and does not define any framework for the patent strategy. Therefore, we enhance the conventional citation analysis and propose new frameworks for the patent strategy.

Index Terms—Management of Technology, Patent Strategy, Patent Evaluation, Citation Analysis

I. INTRODUCTION

THE purpose of this paper is to propose and analyze frameworks for the patent strategy using a citation analysis. The A citation analysis was originally applied in scientific literature and was used so as to measure the relationship between two scientific documents (H.G. Small (1973) [1]). Furthermore, the citation analysis was applied to couple patents and was used for determining the patent value by counting the number of citing patents and then calculating the ratio of the self-citing patents to the total citing patents, including the self-citing and other-citing patents (Mary Ellen Mogee & Richard G Kolar (1999) [2]). Hereafter, “self-citing patents” is defined as citing patents that are granted by the same assignee of a cited patent. On the other hand, “other-citing patents” is defined as citing patents that are granted by an assignee other than that of the cited patent.

Numerous prior researches have analyzed usefulness of the citation analysis (Trajtenberg (1987) [3], Carpenter (1981) [4], Narin (1989) [5], Mogee (1990) [6]). However, these researches merely evaluate the value but do not analyze and provide the patent strategy.

The citation analysis in this paper is enhanced for the patent strategy, by means of (1) a criterion for competitiveness, (2) a citation route connecting patent portfolios, each of which is a collection of related patents, and (3) frameworks for analyzing the patent strategy.

II. METHODOLOGY

A. Patent Portfolio

In this paper, each of the patent portfolios consists of related patents that are linked through both of a common citing patent and a common cited patent. Fig. 1 illustrates that the common citing patent cites patents 1 and 2. Therefore, the two patents 1 and 2 compose the same patent portfolio. Furthermore, Fig. 1 illustrates that the common document is cited by patents 2 and 3. Therefore, patent 3 also forms part of the same patent portfolio as patents 1 and 2. Eventually, patents 1, 2, and 3 compose the patent portfolio.

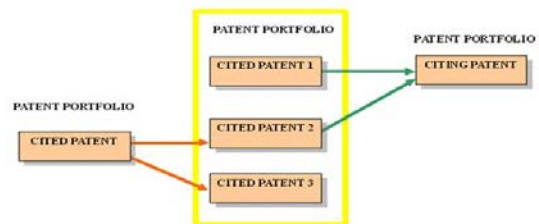


Fig. 1. Patent Portfolio

B. Criterion of Competitiveness

This paper provides a criterion to determine competitiveness so as to distinguish between

superior and inferior patent portfolios from the point of view of the citation analysis. The criterion is defined by —“gross self-citing patent ratio”—which is the ratio of the gross amount of self-citing patents to the gross amount of self-citing and other-citing patents. For example, in Fig. 2, there are three patent portfolios, PP 1 to 3. Fig. 2 illustrates that PP 1 is cited by 7 self-citing patents and 75 other-citing patents; PP 2, by 2 self-citing patents and 24 other-citing patents; and PP 3, by 0 self-citing patents and 9 other-citing patents. The gross self-citing patent ratio is calculated by dividing the gross amount of self-citing patents, i.e., $7 + 2 + 0 = 9$, by the gross amount of self-citing and other-citing patents, i.e., $7 + 2 + 0 + 75 + 24 + 9 = 117$. Therefore, the gross self-citing patent ratio, as can be seen by the results in Fig. 2, is $9 / 117 = 7.7\%$. The gross self-citing patent ratio that determines competitiveness is illustrated in Fig. 2. The self-citing patent ratio of PP 1, $7 / (7 + 75) = 8.5\%$, is larger than the gross self-citing patent ratio and is considered superior competitive patents. Similarly, PP 2, which is near the gross self-citing patent ratio, is considered medium competitive patents. PP 3, whose ratio is above the gross self-citing patent ratio, is considered inferior competitive patents.

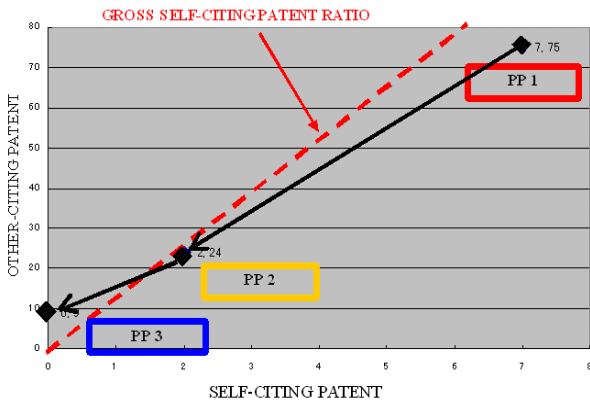


Fig. 2. Criterion of Competitiveness

C. Citation Route

This paper provides a concept termed as “citation route,” connecting the patent portfolios, which indicates the technology transition.

In Fig. 1, the patent portfolio including the patents 1, 2, and 3 has a citation connection with the common citing patent and the common cited patent, as mentioned above.

The citation connection illustrated as an arrow in Fig. 1 is the “citation route” connecting patent portfolios. The citation route are also shown in Fig. 2 as an arrow connecting the patent portfolios PP 1 to 3. The arrows mean that the patent in PP 1 is cited by the patent in PP 2, and it follows that the patent in PP 2 is cited by that in PP 3.

In this paper, the citation route is considered as a technological transition between the patent portfolios connected with each other. The Patent Office refers to the cited patent as a prior art in the process of patent prosecution. After prosecution, the patent office grants the citing patent under the conditions that the invention has novelty, inventive step, etc. Therefore, the citing patent is an invention that is an improvement to the prior art, i.e., the cited patent. For example, in Fig. 2, PP 2 is an improved invention of the patent in PP 1. Similarly, the patent in PP 3 is an improved invention of in PP 2. The citation routes are linked continuously, indicating the technology transition based on improvement.

The citation route is categorized into three types: (1) a one-on-one type, (2) a merger type, and (3) a division type. The one-on-one type connects one patent portfolio to the other (one-on-one), such as the citation route shown in Fig. 2. The merger type and division type are shown in Fig. 3. The merger type is defined as the citation route that connects plurality of patent portfolios to one patent portfolio; an example of this citation route, merging PPs 1 and 4 into PP 2, is shown in Fig. 3. The division type is defined as the citation route that connects one patent portfolio to plurality of patent portfolios; an example of this citation route, dividing PP 2 into PPs 3 and 5, is shown in Fig. 3.

The citation route that is categorized as the merger type may indicate that the citing patent is a generic technology for the cited patents, because the citing patent is invented based on the plurality of the patent portfolios belonging to different technical fields and improves all of them. For example, the citing patent in PP 2, shown in Fig. 3, suggests the generic technology for the cited patents in PPs 1 and 4. On the other hand, the citation route categorized as the division type may indicate that the cited patent is a basic technology for the citing patents, because the cited patent generates the plurality of patent portfolios belonging to various technical fields. For example, the cited patent in PP 2, shown in Fig. 3, suggests the basic technology for the citing patents in PPs 3 and 5.

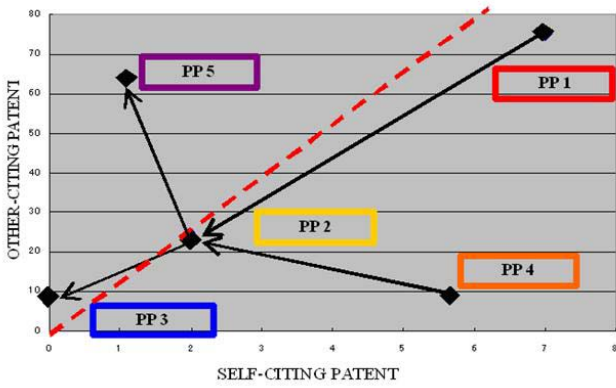


Fig. 3. Merger Type and Division Type

D. Patent Strategy Frameworks

We propose (1) a Patent Strategy Matrix (PSM), (2) a Citation Route Analysis (CRA) and (3) a Time-series Citation Analysis (TCA), as frameworks for the patent strategy.

1) *Patent Strategy Matrix (PSM)*: The PSM proposed to determine the patent strategy is shown in Fig. 4. The horizontal axis indicates the self-citing patent ratio that presents the competitiveness. The vertical axis indicates the number of other-citing patents that presents the value of the patent. The PSM is divided into four phases—introduction phase, growth phase, maturity phase, and decline phase—with boundaries of the gross self-citing patent ratio and the mean number of other-citing patents.

In the introduction phase, a patent obtains a high ratio on the horizontal scale and a small number on the vertical scale. This implies that the patent has superior competitiveness and a low value, because competitors have not yet started developing the technology in the introduction phase. At the beginning of R&D activities in the introduction phase, the patent strategy involves establishing an exclusive position with the patent rather than licensing out the patent to competitors. Establishing this exclusive position means being dominant and acquiring leverage in the market.

In the growth phase, a patent obtains a high ratio on the horizontal scale and a large number on the vertical scale. This implies that the patent has superior competitiveness and a high value because competitors are interested in carrying out R&D activities and developing the technology in the growth phase. In case the competitors have started developing the technology, the patent strategy involves maintaining the exclusivity of position by buying patents or licenses from competitors.

Another strategy is to pervade the market with products by enhancing brand recognition.

In the maturity phase, a patent obtains a low ratio on the horizontal scale and a large number on the vertical scale. This implies that the patent has inferior competitiveness and a high value because the competitors have matched competitiveness in R&D activities in the maturity phase, and the patent is losing competitiveness. In case the competitors have matched competitiveness, the patent strategy involves negotiating with the competitors for a license in order to avoid patent infringement. Yet another patent strategy is to maintain the market share.

In the decline phase, a patent obtains a low ratio on the horizontal scale and a small number on the vertical scale. This implies that the patent has lost both competitiveness and value because of a shrinking market in the decline phase and a decrease in the number of patents by competitors. In the case of market shrinking, the patent strategy involves selling out or licensing out the patent in order to exit the market. An alternative strategy is to select and concentrate on a competitive product so as to increase productivity.

2) *Citation Route Analysis (CRA)*: The CRA is a framework for analyzing the citation routes that indicate the technology transition by using the PSM to determine the patent strategy. In other words, the CRA analyzes linkage patterns of the citation routes, which are shown in the PSM. There are two patterns of the citation routes proposed in this paper: “life cycle pattern” and “investment pattern.”

The life cycle pattern is illustrated in Fig. 5. The arrows in Fig. 5 represent the citation routes from the cited patents to the citing patents. In general, in the PSM, a technology life cycle undergoes the abovementioned four phases in turn, i.e., introduction, growth, maturity, and decline. In accordance with the technology life cycle, the citation routes go through the four phases in turn. This pattern is referred to as the “life cycle pattern.” According to the life cycle pattern, the citation routes appear in the form of arrows, starting from the introduction phase through to the decline phase, as shown in Fig. 5.

The investment pattern is illustrated in Fig. 6. Generally, the sales of products increase in the growth and maturity phases and decrease in the decline phase. Therefore, a profit that is earned in the growth, maturity, and decline phases should be invested in an advanced technology. The citation routes are indicated

in accordance with the investment, as shown in Fig. 6. These citation routes refer to the “investment pattern.” According to the investment pattern, the citation routes are indicated, starting from the three phases through to the introduction phase.

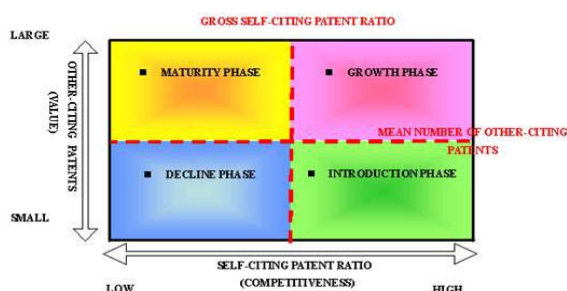


Fig. 4. Patent Strategy Matrix (PSM)

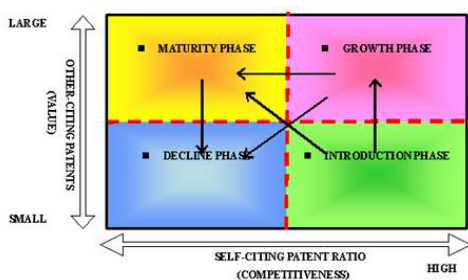


Fig. 5. Life Cycle Pattern

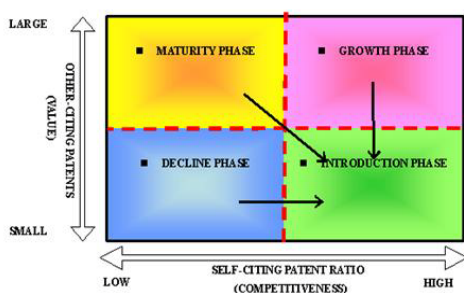


Fig. 6. Investment Pattern

3) *Time-series Citation Analysis (TCA)*: The TCA shown in Fig. 7 is a framework for analyzing the competitiveness, the value of patent, and the focus on R&D in chronological order. According to the TCA, the number of self-citing patents, the number of other-citing patents, and the self-citing patent ratio are counted and calculated each year.

The number of self-citing patents chronologically indicates the focus and progress on R&D activities. When a company focuses and progresses on R&D activities, the number of self-citing patents tends to increase because the vigorous R&D activities results in creation of many related inventions and applications of many patents. Therefore, by observing when the number of self-citing patents increases or decreases, it is found when and how the decision of R&D activities is made.

The number of other-citing patents chronologically indicates the value of patents and R&D activities of competitors. When competitors are keen to catch up with the technology which is previously developed, the number of other-citing patents tends to increase because the competitors devote efforts to R&D activities involving many related patents. Therefore, by observing the number of other-citing patents, it is implied when and how much the competitors are interested in the technology and involved in R&D activities. Furthermore, since the number of other-citing patents indicates the value of patents according to the citation analysis, the transition of value in chronological order can be analyzed.

The self-citing patent ratio chronologically indicates the transition of competitiveness. When the ratio surpasses the gross self-citing patent ratio, the patent has superior competitiveness in that period. In contrast, when the ratio drops below the gross self-citing patent ratio, the patent has inferior competitiveness in that period. Therefore, by observing fluctuation of the ratio compared with the gross self-citing patent ratio, it is implied when and whether the competitiveness is superior or inferior to competitors.

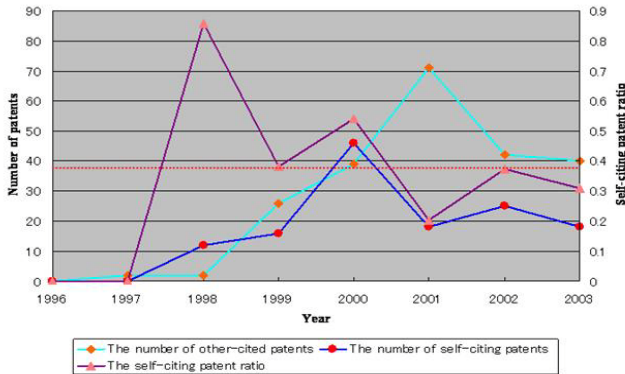


Fig. 7. Time-series Citation Analysis

III. IMPLEMENTATION

The frameworks proposed in this paper are implemented based on the patents granted in the United States by Toshiba Corporation, a giant Japanese electric equipment maker. For the analysis, we selected two technologies for which Toshiba has sufficient patents to be observed. These are (1) an ultrasonic diagnostic technology and (2) an imaging (i.e., DVD) technology.

A. Ultrasonic Diagnostic Technology

In Fig. 8, the patent portfolios related to the ultrasonic diagnostic technology are shown as lozenges. The numbers beside the lozenges indicate the United States patent numbers for the patents at the center of the patent portfolios. The citation routes are illustrated with arrows, in the direction from the cited patents to the citing patents. The lozenges are located in the PSM and are divided into the four phases mentioned earlier by the gross self-citing patent ratio and the mean number of other-citing patents.

The citation route begins from patent 4785402 in the growth phase, which is depicted as the starting point in Fig. 8. Patent 4785402 is separated into three citing routes, patents 5231573, 5669387, and 4911171. These three citation routes indicate the citing routes that are categorized into the type of division. This implies that patent 4785402 may be a basic technology for patents 5231573, 5669387, and 4911171. Normally, the basic technology that is applied to many patents generates high-valued technologies. In fact, patents 5231573 and 5669387 are positioned in the high value area, such as the maturity phase. The citation route from patent 4911171 proceeds to other high-valued patents, such as patents 5669387, 5224482,

and 5515875.

According to the PSM, patent 4911171 is located in the growth phase. Therefore, the patent strategy for this patent involves maintaining an exclusive position and investing profits in an advanced technology. In fact, the citation route, which extends from patent 4911171 to patent 4785402, is in accordance with the investment pattern. For the same reason, the citation route from patent 5515857 extends to patent 5785654.

By undergoing the life cycle pattern, patents 5224482, 5231573, 5515857, 5622174, 5669387, and 5673700 reach the maturity phase. These patents were granted for the period between 1993 and 1997. Consequently, during this period, Toshiba would have been likely to prosper in the ultrasonic diagnostic device market because many patents that go through the life cycle pattern earn profits. In fact, according to the press release published in 1996, Toshiba won the Prime Minister's Award in Japan in 1995 and accounted for the largest percentage of the market both domestically (35%) and globally (18%) in 1996. Furthermore, in this year, Toshiba completed 100,000 cumulative shipments of their ultrasonic diagnostic device. In total, there were 38,000 domestic shipments and 62,000 global shipments.

Furthermore, according to the PSM, the patent portfolios are spread in all phases. Therefore, Toshiba has strong position of the ultrasonic diagnostic technology, developing not only seeds of new technologies but high value technologies. Additionally, since there are observed many numbers of the life cycle pattern and the investment pattern, Toshiba continuously performing vigorous R&D activities. The press release published in 2004 announced that Toshiba remained as a leading company of ultrasonic diagnostic technology, achieving 150,000 cumulative shipments.

The TCA of the ultrasonic diagnostic technology for Toshiba is shown in Fig. 9. Observing the number of self-citing patents, it has increased continuously. This shows that R&D activities have been continuously performed except the year of 2000. This indicates that Toshiba has been dedicated to R&D activities from the early stage of seeds technology. Especially, the period between 1993 and 1997, the number of self-citing patents significantly increases. During the period, it is consider that Toshiba had made efforts on the R&D. Simultaneously, the number of other-citing patents has increased during the period. This indicates that

competitors against Toshiba were following Toshiba, filing many applications of related inventions of the ultra diagnostic technology. Consequently, during the period, the value of Toshiba patents had been growing and Toshiba had operated in highly competitive circumstances.

Fig. 10 showing a transition of the self-citing patent ratio having increased until the year of 1997 indicates that Toshiba had been obtaining strong position of the ultrasonic diagnostic technology until 1997. Then, the self-citing patent ratio had been decreasing until 2000 because Toshiba the faced highly competitive circumstances. However, the self-citing patent ratio has increased again after 2000. This indicates that Toshiba struggles to remain in the strong position and establishes patents portfolio superior to competitors. The press release of 2004 proves that Toshiba remains in the strong position.

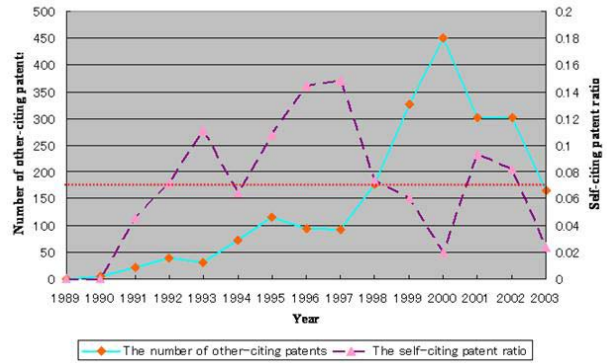


Fig. 10. The TCA of Ultra Sonic Diagnosis Technology

B. Imaging Technology

The PSM of Toshiba's imaging technology is shown in Fig. 11. The citation routes extend from patent 4620199 to patent 4777533 in the investment pattern. Patent 4777533 is divided into patents 5270841 and 4893196 in the investment and life cycle patterns, respectively. Then, patent 4893196, which is in the maturity phase, undergoes the life cycle pattern and is divided into patents 4989099, 5038227, 5079635, and 5119212, in the direction of the decline phase.

Fig. 11 shows the technology transition. Both patents 4620199 and 4702613 are inventions that are related to a thermal transfer printer. The technique of patent 4702613 is applied to patent 4777533, which is related to an image forming apparatus. In particular, the technique involving the miniaturization of the size of the printer was introduced from patent 4702613 to patent 4777533. In fact, patent 4777533 is the invention that miniaturizes the image forming apparatus by changing the structure. Furthermore, the miniaturization technique is introduced in patent 5270841 in the form of the technical field of the scanner. On the other hand, instead of miniaturization, the technique of changing the structure of patent 4777533 is applied to patent 4893196, which is a scanner with two light sources. Fig. 11 proves the technology transition from the thermal transfer printer to the scanner, thus rendering the thermal transfer printer obsolete. In fact, according to Fig. 12, which shows the product share of printers in the market in 1997, the thermal transfer printer accounts for only 2.8%.

In Fig. 11, the citation routes end with patents 4989099, 5038227, 5079635, and 5119212, in the direction of the decline phase. According to the PSM, the patent strategy in the decline phase involves selling out or

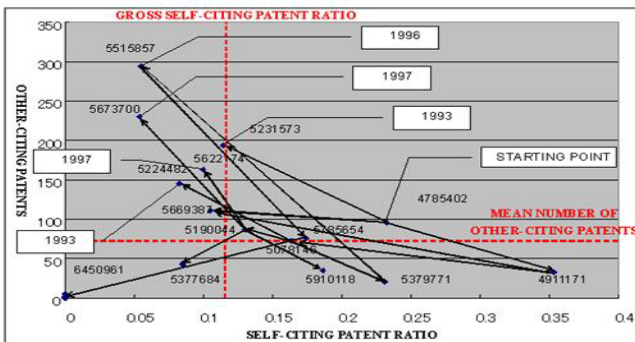


Fig. 8. The PSM and CRA of Ultra Sonic Diagnosis Technology

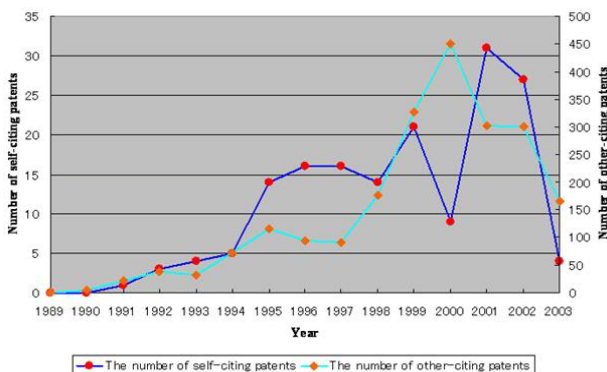


Fig. 9. The TCA of Ultra Sonic Diagnosis Technology

licensing out the patent in order to exit the market. In fact, Fig. 13 shows Toshiba's share in the scanner market in Japan in 1999. The top three manufacturers in that year were CANON, EPSON, and FUJITSU PERSONALS. According to Fig. 13, Toshiba appeared to select the strategy that involved exiting the scanner market. Furthermore, the press release published 1998 announced that Toshiba was going to completely transfer a business operation of the imaging technology.

The TCA of the imaging technology for Toshiba is shown in Fig. 14 and Fig. 15. Observing the number of self-citing patents, it increases until 1992. This shows that R&D activities had been continuously performed until 1992. Notwithstanding, the self-citing patent ratio was gradually decreasing until 1994. This indicates that while Toshiba had kept filing patent applications between 1986 and 1992, Toshiba was losing its competitiveness. In other words, Toshiba's R&D activities do not lead to achievement of strong position for the imaging technology. In such a case, Toshiba should exit the market. The number of self-citing patents was relatively low in 1993 and 1994. This indicates that Toshiba slowed R&D activities. However, the number of self-citing patents increased again from 1995, reaching to the peak in 1996. Toshiba resumed R&D activities of the imaging technology.

In Fig. 15, while the number of self-citing patents was relatively low in 1993 and 1994, the number of other-citing had patents continuously increased until 1995. This indicates that Toshiba had inferior competitiveness and high value patents. In such a case, Toshiba should sell out the business operation of imaging technology. As mentioned above, the press release of 1998 said that Toshiba was going to completely transfer a business operation of the imaging technology. Then, after 1999, it is considered that Toshiba exit the market because the number of self-citing patents is "0".

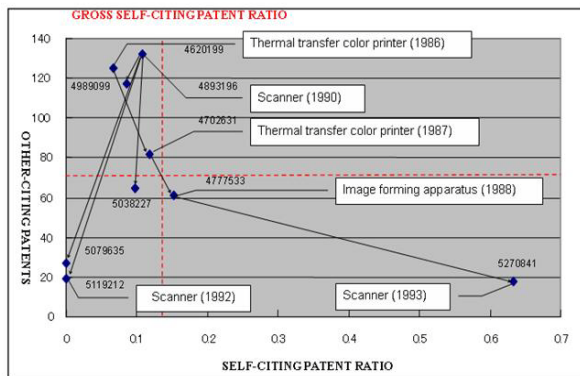


Fig. 11. The PSM and CRA of Imaging Technology

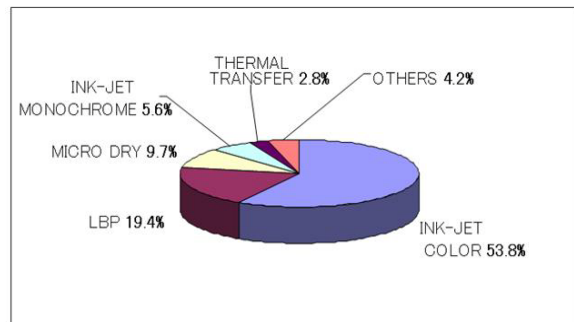


Fig. 12. Product share of Printers

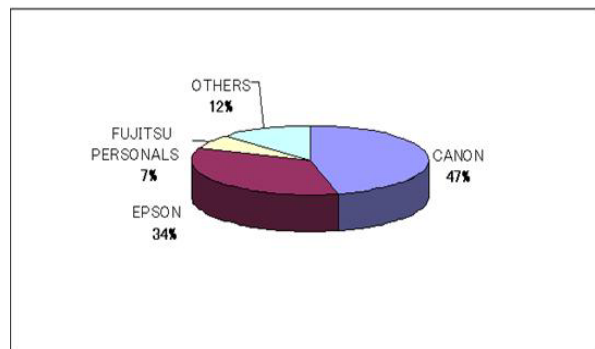


Fig. 13. Company Share in Scanner Market

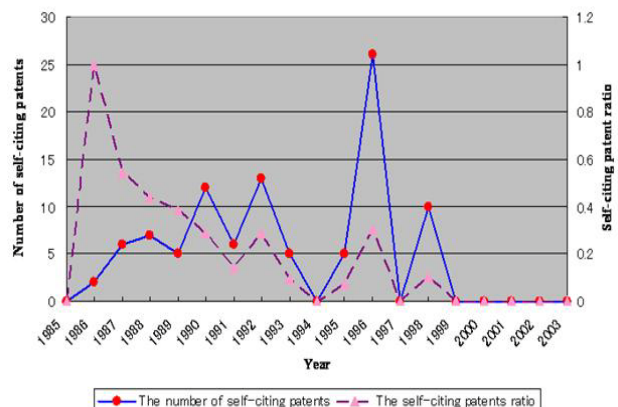


Fig. 14. The TCA of Imaging Technology

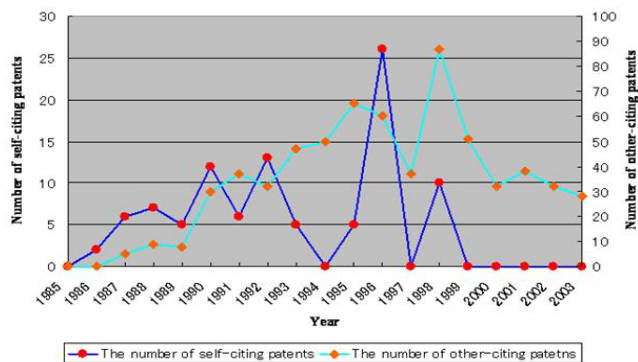


Fig. 15. The TCA of Imaging Technology

IV. CONCLUSION

In this paper, we introduced the concept of citation routes and presented the types of citation routes. As can be seen from Figs 8 and 11, we proved the citation routes and types of merger and division. Furthermore, we proposed the PSM, the CRA, and the TCA as frameworks for analyzing the technology transition and patent strategy. Then, we implemented these frameworks. The TCA was proposed for analyzing chronological transitions of the patent value and the competitiveness by observing the number of self-citing patents, the number of other-citing patents, and the self-citing patent ratio. We discovered that the PSM, the CRA, and the TCA were useful for analyzing the profitable patents and investments as the patent strategy.

This paper has improved the citation analysis by providing the following: (1) a criterion for competitiveness, (2) a citation route connecting patent portfolios, each of which is a collection of related patents, and (3) frameworks for analyzing the patent strategy. Furthermore, this paper provided (1) a Patent Strategy Matrix (PSM), (2) a Citation Route Analysis (CRA) and (3) a Time-series Citation Analysis (TCA), as frameworks for the patent strategy. The PSM, the CRA, and the TCA were used to analyze the technology transition and patent strategy.

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