© Universiti Tun Hussein Onn Malaysia Publisher's Office

IJIE

Journal homepage: http://penerbit.uthm.edu.my/ojs/index.php/ijie
ISSN : 2229-838X e-ISSN : 2600-7916

The International Journal of Integrated Engineering

A Study of Identifying Trends in Projector using F-Term Codes from Japanese Patent Applications

Yoshie Ishii[1*], Ken Kaminishi[2], Shigeyuki Haruyama[3]

[1]Graduate School of Science and Technology for Innovation,
Yamaguchi University, 2-16-1, Tokiwadai, Ube-shi, Yamaguchi-ken, 755-0097, JAPAN

[2,3]Graduate School of Innovation and Technology Management,
Yamaguchi University, 2-16-1, Tokiwadai, Ube-shi, Yamaguchi-ken, 755-0097, JAPAN

*Corresponding Author

DOI: https://doi.org/10.30880/ijie.2021.13.07.037
Received 8 January 2021; Accepted 26 April 2021; Available online 30 September 2021

Abstract: It is important for companies to understand technological trends when developing technologies and products. Based on Utterback and Abernathy's theory of the emergence of dominant design, we investigate a method of obtaining technological trends using patent information. In a previous study, we visualised the innovation state and obtained the emergence of dominant designs using FI and theme codes, which are original patent classification codes of Japanese patents, as well as F-terms. However, there has not been sufficient research conducted on how to obtain patent applications and how to select FIs, theme codes, and F-terms, which are the preconditions for the analysis. In this study, we discuss a procedure for obtaining patent applications, selecting FIs, theme codes and F-terms, visualising the innovation state, and predicting the emergence of dominant designs, and report the results.

Keywords: Technological trends, Japanese patents, F-terms, projectors

1. Introduction

It is important for companies to understand technological trends when developing technologies and products. Based on Utterback and Abernathy's theory of the emergence of dominant design [1], we investigate a method of obtaining technological trends using patent information. In previous studies, patent information was used in order to obtain technological trends [2]-[6]. In our previous study, we visualised the innovation state and predicted the emergence of dominant designs using FIs, theme codes and F-terms, which are patent classification codes that are unique to Japanese patents [7]. Applied patents from all Japanese patents that had been granted FI on the target items were searched for and obtained. For the state of innovation, we classified the number of patent applications with FI for the items under analysis as product innovation and process innovation, and calculated the annual number of applications. We also proposed a method of visualising the rate of change from the previous year based on the number of cases per year. In addition, when classifying a patent application into product innovation and process innovation, the F-term assigned to the patent application was used to determine in advance the F-term code for the target item by using the F-term codes for product innovation and process innovation. In this study, we categorise the annual number of patent applications that have been granted to the items for analysis, and visualise the annual rate of change for each. Then, we predict the timing of the emergence of the dominant design based on the visualised state of innovation. Thus, the selection of FIs, theme codes, and F-terms in the patent classification codes for the target item under analysis is an important element of our proposed method for obtaining technological trends. However, two problems have attracted insufficient research attention in the literature: selecting these patent classification codes, and classifying F-terms into

*Corresponding author: i001wc@yamaguchi-u.ac.jp

product innovation and process innovation. In this study, we discuss a procedure for obtaining technological trends, including the selection of FIs, theme codes and F-terms, obtaining patent applications, visualisation of innovation status, and prediction of the emergence of dominant design. The target item of this study is projectors. A projector is basically a product that is used alone and not incorporated as a part of another product. In the case of a single item that is used alone, the associated FIs and theme codes are considered not to be spread across multiple product areas.

1.1 Japanese Patent Codes

In this study, we use the following patent classification codes: FIs, theme codes and F-terms. As shown in Fig. 1, the classification of Japanese patents is based on the IPC. In Japan, the IPC is subdivided into a number of subdivisions and assigned a classification code called an FI code. In addition, in order to enable research from various viewpoints, some FI codes are compiled into a theme code. Within one theme code, there are F-term codes, which provide researchers with multiple viewpoints. One theme code has an F-term, consisting of multiple viewpoints. One patent is assigned multiple F-terms for each theme code. As shown in Fig. 2, an F-term consists of a theme code, a viewpoint and a number. Furthermore, as shown in Table 1, the F-term is marked with a "." (dot). The dots indicate detailed content within a viewpoint; a greater number of dots indicates a more detailed description.

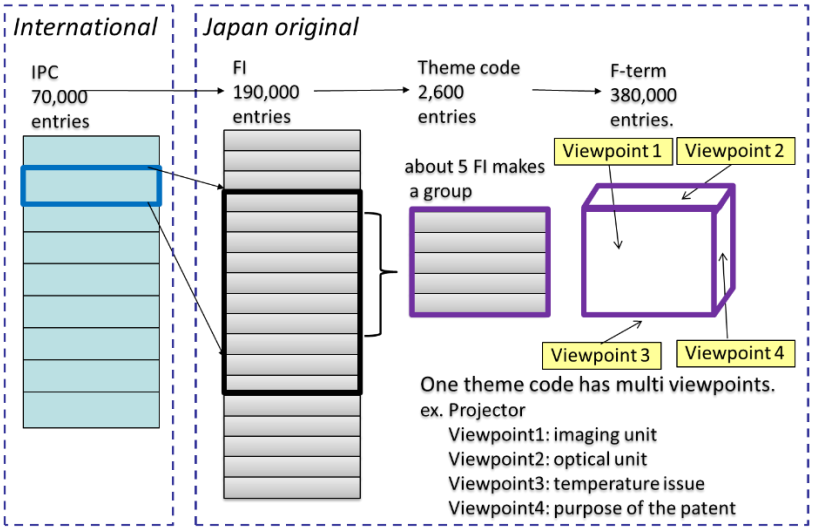

Fig. 1 - Relationship of IPC, FI, theme codes and F-term codes

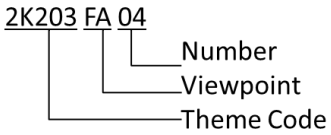

Fig. 2 - F-term code

Table 1 - Example of F-term codes and their explanation

F-term
FA00 MODEL 1 (DRAWINGS PROBLEMS OF THE WORKING EXAMPLES)
FA01 . Image generation methods
FA02 . . Secondary electronic space light modulator
FA03 . . . Displays the multiple colors at the same time.
FA04 . . . Displays the color by splitting.
FA05 . . . . Optical means to generate one color at one time
FA06 . . . . . Color wheel

2. Patent Search Tool

In this study, we use the Yamaguchi University Patent Search System "YUPASS", which contains information that is synchronised with the patent database of the Japan Patent Office. We search patents with specifying keywords, patent classification codes, and periods of time. We can obtain searched patent applications as textual data. The textual data contains the following 36 items: "Type of publication, application number, application date, international application number, international filing date, publication/publication number, publication/publication date, patent/registration

number, registration date, title, applicant, inventor, technology area, F-term, FI, IPC, publication path, abstract, effect, subject matter, solution, claims, keywords, national classification, representative drawing path, request for examination, number of claims, examination record, record of appeal, registration record, country of issue, arrangement number, full text, publication number, date of publication, company classification, agent".In this study, patents with FIs on the target item from the patent application information, obtained from the text data, are defined as the patents to be analysed. In addition, the state of innovation is assessed in terms of the F-term assigned to the patent applications to be analysed.

3. Research Methodology

In this study, we study the procedures for obtaining patent applications, selecting FIs, theme codes, and F-terms, classifying F-terms into product innovation or process innovation, visualising the innovation state, and predicting the emergence of dominant design.

3.1 Step 1: Obtaining Patents Filed on The Target Item

First, we obtain the patent application for the target item. We use "YUPASS" to search for a Japanese patent that includes the product name in the abstract and obtain the search results as textual data.

3.2 Step 2: Confirmation of The Duration and Number of Patents Filed

We then obtain the total number of applications from the textual data obtained in Step 1. We check whether there are a sufficient number of patent applications for the analysis. In addition, we examine the application period and the number of applications filed per year to see if there are any ongoing applications for the target item.

3.3 Step 3: Selection of FIs, Theme Codes and F-terms for The Target Item

After obtaining the textual data of patent applications for the target item, and confirming the period and number of applications for each, the patent classification codes (FIs, theme codes, and F-terms) for the target item are selected.

In order to obtain the major FI codes, we examine the types of FI and the number of FIs included in the patent application information obtained in Step 1 as well as the number of FIs per year. The codes with a particularly large number of FIs among the requested FIs were selected as the main FIs of the target item.

Next, the theme code is obtained from the main FI. The theme code is a code that provides a common theme through the grouping of multiple FIs, so theme codes may not be related to the target item. Then, we read the description of the theme code, determine whether it relates to the target item, and select it.

When we select the theme code of the target item, we can obtain the F-term. The F-term obtained shows the evaluation of the items under analysis from multiple viewpoints.

3.4 Step 4: Visualizing The State of Innovation

We classify the F-terms selected in Step 3 by judging whether they are related to product innovation or process innovation. The decision is made by reading the description of the F-term, provided by Japan Patent Office, and judging whether the content is related to the product or process. Whether a patent is classified as "process innovation" or "product innovation" is evaluated by comparing multiple F-terms assigned to a patent with the previously determined F-term classification. The number of dots is of importance; for example, if a patent application has two F-term viewpoints in one patent application, one with a single dot and the other with two dots, then the latter has been granted to the applicant. The F-term with more dots is selected for the innovation classification. This is because we can interpret an F-term with many dots as representing the latest evaluation, considering the fact that the number of dots increases as more and more F-terms are added to the system. In this way, we classify patent applications into product innovation and process innovation, and calculate the percentage changes from the previous year for each product innovation and process innovation, which are then visualised graphically.

3.5 Step 5: Predicting The Timing of Dominant Design Emergence

In this paper, we predict the emergence of dominant design from the state of innovation visualised in Step 4. We assume that dominant design emerges when the innovation rate increases. From the graphical visualisation of this theory, we predict the emergence of dominant design.

4. Analysis

Analysis of the projector was carried out according to the above procedure.

4.1 Step 1: Obtaining Patents Filed on The Target Item

Application patents that included "projector" in the abstract were searched by “YUPASS”, and the search results were obtained as textual data. The number of patent applications was 15,677.

4.2 Step 2: Confirmation of The Duration and Number of Patents Filed

Fig. 3 shows the annual number of patent applications and the cumulative number of patent applications obtained in Step 1. The number of applications peaked in 2004, and after 2004, the number of applications continued to decline each year. Looking at the cumulative number of applications per year, we can see that there is an S-curve from 1990 to 2016, and the number of applications has since been decreasing. Projectors are considered to be in the third stage of maturity or the fourth stage of decline as a product. The number of applications is on a downward trend, but applications continue to be filed. From these findings, it is observed that the number of patents applied for, and the duration of the patent applications for projectors obtained in Step 1 are sufficient for the analysis of the innovation status, and that applications continue to be filed.

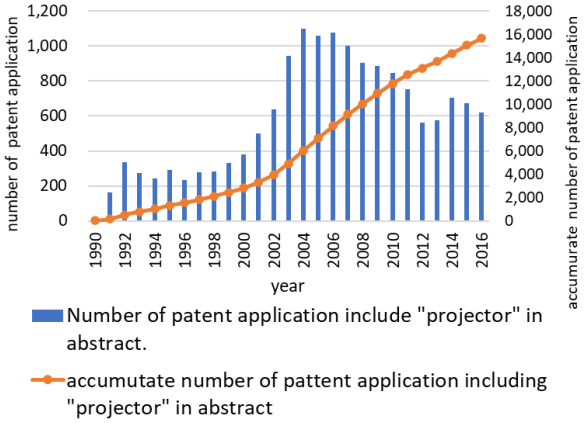

Fig. 3 - Number and cumulative number of patent applications including projector in the abstract

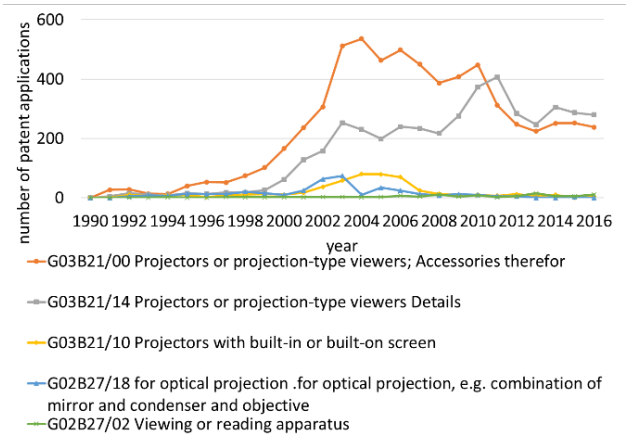

Fig. 4 - Number of FIs applied for each year including projector in the abstract

4.3 Step 3: Selection of FIs, Theme Codes and F-terms for The Target Item

After Step 2, the patent classification codes, FIs, theme codes, and F-terms were obtained from the patent applications obtained in Step 1 in order to understand the innovation status and the time of appearance of the dominant design. The total number of patent applications obtained in Step 1 was 15,677, which included 103 FI codes. The annual change in the number of these FI codes is shown in Fig. 4. There were 6,339 FI codes for G03B21/00, 4,311 for G03B21/14, 524 for G03B21/10, 1 for G03B21/132, and 1 for G03B21/28, and the total number of G03B21 codes was 11,374, accounting for 93.6% of the total. The next largest number was G02B27, 395 in G02B27/18 and 106 in G02B27/02, for a total of 501 in G02B27, accounting for 4.2% of the total. Therefore, G03B21 was considered to be the main FI of the projector.

As shown in Table 2, we selected the theme codes for the projector. Then, 25 theme codes were obtained from the 103 FIs of the patents applied for the projector. Then, based on the contents of the description, we selected items related to the projector. As a result, the theme code 2K203 was found. In order to confirm that the selected theme code was the

main theme code for the product, we surveyed the annual number of applications for each theme code. The total number of patents was 8,434, of which 2K203 accounted for 7,578 or 89.9%. Thus, 2K203 was considered to be the major theme code for the product.

The next step is to narrow down the number of patents. From the 15,677 patent applications obtained in Step 1, 7,922 patents with the theme code 2K203 are used for the following procedure, which is to identify the state of innovation. The 7,922 patent applications related to the projector include 10 different viewpoints as shown in Table 3, among which there were a total of 510 F-term codes. As shown in Table 4, each viewpoint is marked with dots. In this study, in order to evaluate the F-term in dots, we assigned an Internal Block number to each feature within a viewpoint. This is defined as a block with a single dot underneath it. Then, for all F-terms, we define whether it constitutes product innovation or process innovation. Based on this definition, a comparison is made between the F-term assigned to the patent and the definition of F-term innovation in Table 4 for each patent application. The judgement and classification flow is shown in Fig. 5.

Table 2 - FI list with an indicator of whether it is related to the projector or not

Themecode	Descriptions	Related to the projector
2K203	PROJECTION APPARATUS	✓
2H199	OTHER OPTICAL SYSTEMS OR APPARATUS; INTERFERENCE OR CONTROL OF THE COLOUR	
2F065	LENGTH MEASURING DEVICES BY OPTICAL MEANS	
5G445	Advertisements other than illuminations	
2H087	Lenses	
2C028	Electrically operated instructional devices	
2F041	Indicating measured values	
2H057	Talkies	
5E353	SUPPLY AND INSTALLMENT OF ELECTRICAL COMPONENTS	
5D040	Combinations of recording and playing devices and other equipment	
3F303	INDICATING AND SIGNALLING DEVICES FOR ELEVATORS	
5B068	POSITION INPUT DEVICES	
3K243	NON-PORTABLE LIGHTING DEVICES OR SYSTEMS THEREOF	
5C087	ALARM SYSTEMS	
5D028	Accessories for record carriers (e.g. containers)	
2H021	Overhead projectors and projection screens	
2H055	Slide changers	
2H109	LIGHT SOURCES AND DETAILS OF PROJECTION-PRINTING DEVICES	
2H098	Photographic processing devices using wet methods	
2H117	Color separation and correction and screen methods in phototype processes	
5B013	Forestry	
4C316	EYE EXAMINATION APPARATUS	
4C093	APPARATUS FOR RADIATION DIAGNOSIS	
3C049	Grinding and polishing of tertiary curved surfaces and surfaces with complex shapes	
2H026	HEAT SENSITIVE COLOUR FORMING RECORDING	

Step 4: Visualizing the State of Innovation

As shown in Fig. 6, the rate of change in product innovation and process innovation is calculated and visualised graphically for each product innovation and process innovation. As shown in Fig. 6, 2002, 2010, and 2015 show changes in innovation.

4.4 Step 5: Predicting The Timing of Dominant Design Emergence

Fig. 6 predicts the emergence of dominant design in 2002, 2010, and 2015. Based on the state of projector innovation during the study period 1999-2016, the first emergence of the dominant design was in 2002. The "fluid phase" was around 2002, the "transitional phase" was around 2003-2004, and the "specific phase" came after 2004. The second emergence of the dominant design was in 2010. The "fluid phase" was around 2010, the "transitional phase" was around 2011, and the "specific phase" came after 2011. In addition, the third emergence of the dominant design was in 2015. This indicates that the "fluid phase" began around 2015.

Table 3 - F-term viewpoints I list

Code	Description
FA00	MODEL 1 (DRAWINGS, PROBLEMS OF THE WORKING EXAMPLES)
FB00	MODEL 2 (DRAWINGS OF WORKING EXAMPLES AND PROBLEMS)
GA00	LIGHT SOURCE SECTION OR ILLUMINATION SECTION (SCOPE OF CLAIMS)
GB00	IMAGE SECTION (SCOPE OF CLAIMS)
GC00	PROJECTION SECTION OR PROJECTION PLANE (SCOPE OF CLAIMS)
HA00	OPTICAL SYSTEM 1 (SCOPE OF CLAIMS)
HB00	OPTICAL SYSTEM 2 (SCOPE OF CLAIMS)
KA00	COMPONENTS OTHER THAN OPTICAL SYSTEMS (SCOPE OF CLAIMS)
LA00	TEMPERATURE (SCOPE OF CLAIMS)
MA00	PURPOSE (SCOPE OF CLAIMS)

Table 4 - In-view point block classification and product/process innovation classification for each F-term (excerpt)

Description	Fterm 4digits	Fterm 2digits	Inner-block No.	number of dots	Product, Process kind
FA31 . Number of display panels	FA27	FA	3	1	Product
FA32 . . One piece of display panels	FA28	FA	3	2	Product
FA33 . . Two pieces of display panels	FA29	FA	3	2	Product
FA34 . . Three pieces of display panels	FA30	FA	3	2	Product
FA35 . . Four pieces of display panels	FA31	FA	3	2	Product
FA36 . . More than five pieces of display panels	FA32	FA	3	2	Product
FA41 . Types of light sources	FA41	FA	4	1	Product
FA42 . . White heat light sources	FA42	FA	4	2	Product
FA43 . . Gas discharge light sources	FA43	FA	4	2	Product
FA44 . . LED or laser light sources	FA44	FA	4	2	Product
FA45 . . LED or laser light sources	FA45	FA	4	3	Process

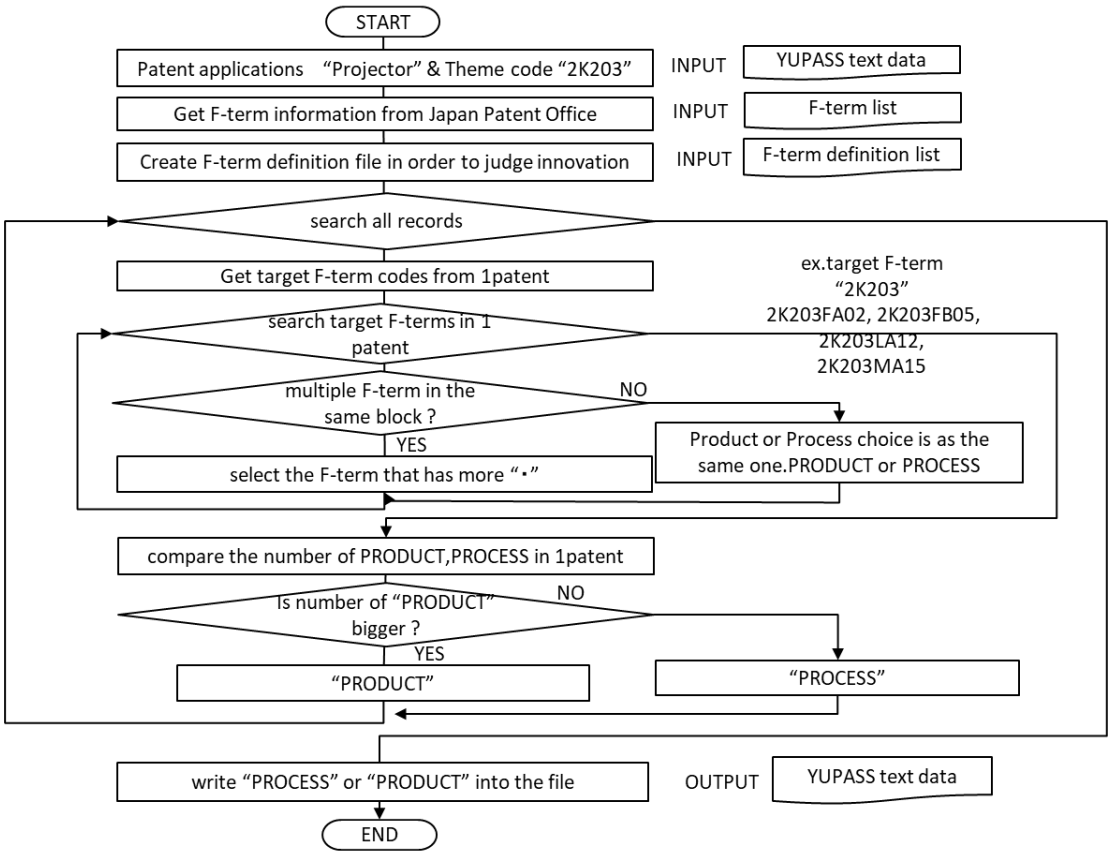

Fig. 5 - Procedure to judge the patent innovation by F-terms (Product/Process) timing of the emergence of dominant design

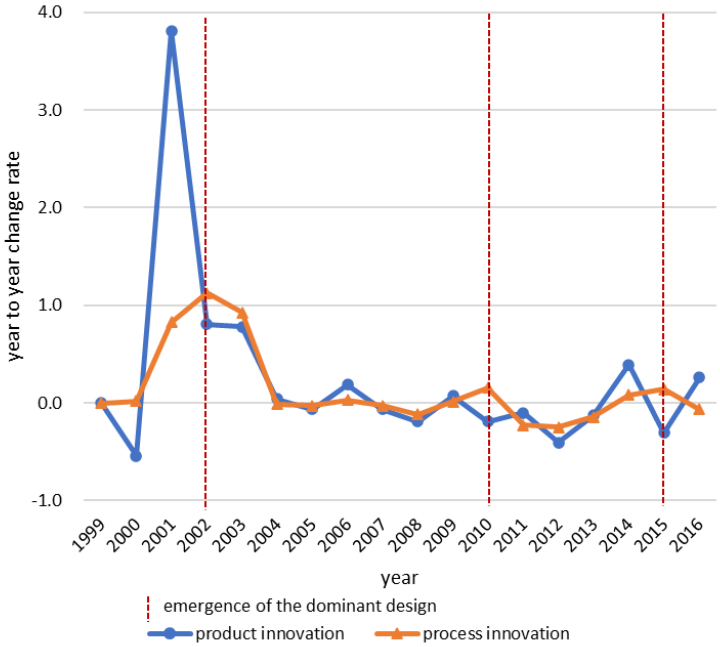

Fig. 6 - Year-on-year rates of change in product innovation, process innovation and timing of the emergence of dominant design

5. Considerations on The Content of Dominant Design

We have predicted the emergence of the dominant design in [Step 5], and we also discuss the content of this prediction. We predicted the content of the dominant design by comparing the characteristic products and ages of products released to the market by major product manufacturers, and identified the time of appearance of the dominant design. Although the time period from patent application to commercialisation varies according to the product and industrial field, previous studies [8][9] have shown that the average time from research and development to commercialisation and market release is 4.8 years. In addition, Fujimoto [10] determined the time to market from research and development of consumer electronics and appliances to be 2.75 years. Based on the results of these studies, we referred to the products that were released mainly in the period three to five years after the emergence of the dominant design, and assumed the characteristics of the dominant design [11]-[16].In the case of the projector, since the dominant design could have appeared in 2002, 2010, and 2015, in [Step 4], products that were released three to five years after each of these years were obtained from the product history [11]-[16].

(1)2002 dominant design: Three to five years after
2005, EPSON released a home-use projector.
(2)2010 dominant design: Three to five years after
2013, SONY released the world's first laser light source projector.
(3)2015 dominant design: Three to five years after
2018, LG launched a home laser projector with wireless connection to TV.
2018, LG launched a home projector that can work with Google ALEXA.

We evaluated the projectors using the method proposed above and observed that the dominant design appeared in 2002, 2010 and 2015. If we look at the products that were released three to five years after the emergence of the dominant design, the dominant design in 2002 was a home projector, the dominant design in 2010 was a laser light source projector, and the dominant design in 2015 was a smart projector with the ability to connect to devices and services such as phones, TVs, and AI assistants. In addition, three dominant designs emerged between 1999 and 2016, with intervals of eight and five years.

6. Conclusion

To study the method of obtaining the technical trend by using FI, theme codes and F-term, which are the original Japanese patent classification codes, there has not been sufficient research conducted on the method of obtaining patent applications and selecting FI and theme code. In this study, in order to investigate a flow of analysis methods for the target item, including selection of FI, theme codes and F-term, obtaining patent applications, visualization of the

innovation state, and prediction of the emergence of the dominant design, we developed a procedure for obtaining patent applications for the target item. We show a specific procedure for selecting the theme code and visualization of the innovation state using F-term, and we then predict the emergence of the dominant design by using the projector as an example. Looking at the products released in the market three to five years after the emergence of the dominant design, products with distinctive characteristics appeared in the market. Thus, in this study, our procedure allowed us to visualise the state of innovation and predict the emergence of the dominant design for the projector.

Acknowledgement

This research was supported by JSPS KAKENHI Grant Number JP19K01888.

References

[1] Utterback, J. M., & Abernathy, W. J. (1975). A dynamic model of process and product innovation, Omega 3, 6, 639-656
[2] Kim, G. and Bae. J. (2017). A novel approach to forecast promising technology through patent analysis Technological Forecasting and Social Change ,117, 228-237
[3] Jun, S. et. al. (2012). Technology Forecasting Using Matrix Map and Patent Clustering Industrial Management & Data Systems, 112, 5, 786-807
[4] Jun, S. and Park, S.S.. (2013). Examining technological innovation of Apple using patent analysis Industrial Management & Data Systems, 113, 6, 890-907
[5] P. L Chan, et.al. (2010). Using patent analyses to monitor the technology trend in an emerging field of technology: a case of carbon nanotube field emission display Scientometrics, 82, 1, 5-19
[6] Ken Kaminishi, et.al. (2014). A Study of Technology Trends Analysis Using Patent Search System Journal on Innovation and Sustainability, 5, 2
[7] Y.Ishii et.al.:(2019). A Study on Technology Trend of Camera by Using FI Code in Japanese Patent, Journal on Innovation and Management – RISUS, 10, 3
[8] Jun Suzuki. (2011). Analysis of lag structure from R&D activities to commercialization of Japanese companies RIETI Discussion Paper Series 11-J-002
[9] Economic and Social Research Institute 1986 Economic analysis of R&D and technological progress Economic analysis 103(Japanese)
[10] Takahiro Fujimoto. (2009). Product development performance Tokyo Diamond, Inc. (Japanese)
[11] EPSON https://global.epson.com/company/corporate_history/timeline/ 2020/07/04
[12] SONY https://www.sony.co.jp/SonyInfo/CorporateInfo/History/sonyhistory-n.html 2020/07/04
[13] RICOH https://jp.ricoh.com/company/history/2010_/ 2020/07/04
[14] CANON https://cweb.canon.jp/corporate/50th/history/ 2020/07/04
[15] CASIO https://www.casio.co.jp/company/history/chapter05/ 2020/07/04
[16] LG https://www.lg.com/us/projectors/cinebeam-story 2020/07/30