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A STUDY ON IDENTIFICATION OF PRODUCT VALUE BASED ON PATENT ANALYSIS: THE CASE OF THE PROJECTORS

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Abstract Companies are required to understand the external environment, develop growth strategies, and implement them. One aspect of the external environment is the market itself. To understand customer needs, we use patent information as the approach from the product, rather than the approach of listening to the voice of the customer, based on the three levels of product. We proposed a method to show the value of a product based on the concept of commonality and uniqueness by comparing multiple samples. In the case of projectors, Japanese patents were analyzed. We conclude that the common content represents the core benefits of the product, and that the characteristic content represents the product attributes.

Keywords: product value, patent analysis, text mining, product inventions, projector

1. Introduction

Companies are expected to continue innovating. They are required to understand the characteristics of the external environment, draw growth strategies for new market and product development [1], and implement these strategies. One aspect of the external environment is the technology required to develop products and services. To forecast technological trends, analysis methods using patent information have been proposed [2], [3]. Another aspect is the market, which is the set of actual and potential buyers of a product or service [4]. To capture market trends, an understanding of the customer needs of these buyers is required.

Interviews, focus groups, and ethnography are well-known approaches to listening to the voices of customers (VoC) [4, 5, 6, 7]. However, these approaches also have drawbacks. Timoshenko and Hauser [5] pointed out that approaches that rely on human interactions, such as experiential interviews and focus groups, are expensive and time-consuming. Livotov [6] indicated that the main difficulty of VoC approaches is that customers' requirements are often imprecise. Ulwick [7] argued that the traditional approach of asking customers for solutions is wrong because most customers have a very limited frame of reference.

Kotler and Armstrong [4] defined a product as anything that can be offered to a market for attention, acquisition, use, or consumption that might satisfy customer needs. They classified a product into three levels in terms of the benefits offered to customers. Figure 1 illustrates the three product levels. The first is the core customer value of a product. The second is the actual product, which consists of a combination of product attributes that offer core customer value. The third is the augmented product, which offers additional benefits such as product support. Customers perceive products as complex bundles of benefits that satisfy their needs. If the customer is satisfied with the value of the product, he will buy it.

Based on the above relationship between a product and customer needs, we believe that customer needs are understood by approaching them from the product side rather than the customer side. Therefore, in this study, we attempt to demonstrate the value of a product to understand customer needs. Since we think that at least one of the various product attributes that compose a product offered to a market is created by a differentiated technology or invention, we

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examine the use of patent information as the approach from the product side. The advantages of patent analysis over the VoC approach are that it does not require much time and money, and does not rely on customers.

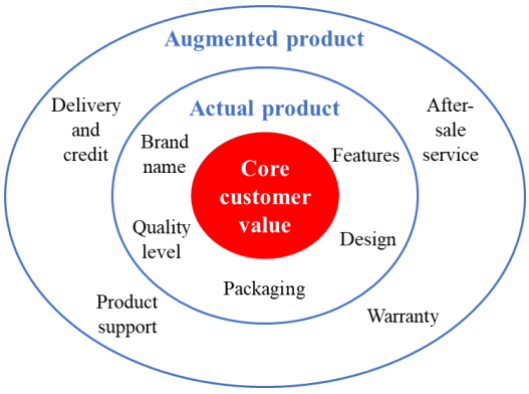
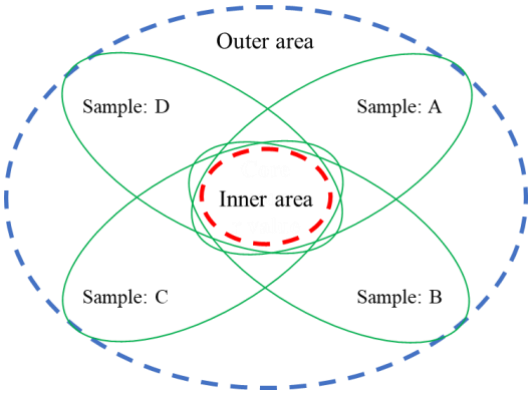


Fig 1. Three levels of product [4]

2. Methods

We propose a method to show the value of a product using patent analysis to understand customer needs. Figure 2 illustrates the concept of the proposed method. Patents related to a certain product are set as a population and samples are extracted from the population based on conditions related to the technology. Each sample is included in the population and thus contains content related to the product, while each sample is extracted based on technology-related conditions and thus contains content



related to the technology. By comparing each sample, the contents that all samples contain in common and the contents that only one or a few samples contain in a characteristic manner are selected.

Fig 2. Concept of the proposed method

Figure 2 shows a case in which the population was classified into four samples (A, B, C, and D). In contrast to Figure 1, the inner area in Figure 2 is the content related to the product that all the samples have in common, and thus, is regarded as the core customer value of the product. The outer area of Figure 2 shows the technological content that is characteristic of only one or a few samples, and thus is regarded as the differentiated product attributes created by the technology. An actual product comprises multiple product attributes. Based on this concept, by selecting the common contents (inner area) and the characteristic contents (outer area) from the patent information of the product, the benefits corresponding to the first and second levels of the three levels of the product, that is, the product values, can be shown.

Figure 3 illustrates the flow of this analysis. First, a population of patents related to the target product was generated. Multiple samples were extracted under technology-related conditions. In this analysis, Japanese patents were used and the samples were extracted in two phases. In the first phase, the population was separated into two sub-populations: product inventions and process inventions. Masuda and Haruyama [8] reported that this separation leads to the observation of different technological evolutions in the technology S-curve. This suggests that each sub-population may represent different product attributes created by technology. The following analysis was performed by replacing the population with two sub-populations. In the second phase, a general patent classification was used.

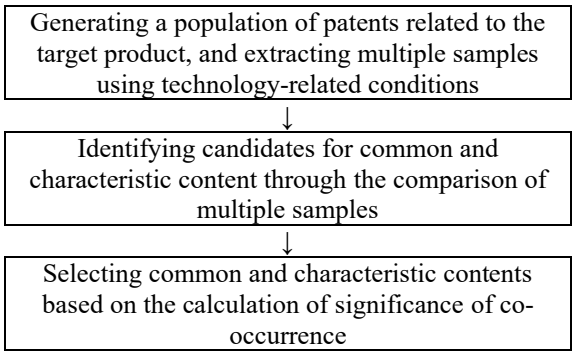


Fig 3. Analysis flow

Next, candidates for common and characteristic content were identified through a comparison of multiple samples. The patent abstract was used as the patent information. The Japan Patent Office (JPO) [9] states that an abstract should be a brief summary of the contents to quickly obtain information about the essential contents of the invention. The abstract

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was expected to have a higher keyword density than the description. To extract content from the abstracts, text mining was performed using MeCab [10], a morphological analysis software for Japanese. Each candidate content was set to a single morpheme. Because more than 80% of the morphemes occurring in the samples were nouns, the part of speech of the morpheme was limited to nouns. Using the frequency of occurrence of a word (a noun morpheme), a word with a high frequency in all samples was identified as a common word, and a word with a high frequency in only one or a few samples was identified as a characteristic word.

Finally, the common and characteristic contents were selected based on the calculation of the significance of co-occurrence. Each content was set as a noun bigram. By expanding the content from a word (a common or characteristic word) to two words (a bigram), the meaning of the content becomes clearer. As indices of significance, we focused on the typical t-score and MI-score [11],[12] and calculated them using the RMeCab package [13]. There were important differences between the two indices, and a t-score of 2 or higher and an MI-score of 3 or higher were considered significant [11].

3. Results and Discussions

3.1 Results

Projectors were chosen as the target products. Since sales and the number of patent applications for projectors in Japan have passed their peaks, we think that the benefits that the product offers to customers have already been shown both in the market and in patents.

A population of approximately 30,000 patent applications was generated using two search queries: the theme code (2K203), which is a patent classification unique to Japan, and the publication date (1981-2020), for the JPO's published patent applications. In the first phase, the populations were separated according to whether the title of the invention contained a noun phrase consisting of a combination of keywords related to process innovation, such as production or manufacturing, and the word "process." Two sub-populations were generated, the former being process inventions and the latter being product inventions. In the second phase, the File Index (FI) assigned to Japanese patents was applied as a patent classification, especially the leading FI, which was assigned only once per patent. Because the samples are compared in terms of commonality and uniqueness, it is necessary to avoid overlapping patents. Table 1 shows the results of sorting the leading FIs by the number of patents and extracting the top leading FIs so that they contain at least 25% of the patents in each sub-population. The numbers in parentheses indicate the percentage of patents. Four samples were extracted from each sub-population.

Table 1. Top leading FIs for each sub-population

Sub-populations	Leading FI			
Product inventions	G03B21/14, A (8.8%)	G03B21/00, D (8.3%)	G03B21/14, Z (5.3%)	G03B21/16 (5.2%)
Process inventions	G03B21/14, Z (7.7%)	G03B21/00, D (7.7%)	H04N5/74, D (7.2%)	H04N5/74, Z (6.1%)

Next, a document was composed of the abstracts of all patents in each sample, and the term frequency-inverse document frequency (tf-idf), a weighted frequency of occurrence, was calculated for each of the four documents in each sub-population. Table 2 shows the top seven words in the square root of the sum of squares (RSS) of tf-idf for each sample of product inventions. The characters in parentheses are romanized Japanese morphemes. The words "thing" and "offer" were excluded because they are frequently used words specific to patents and have no meaning in this analysis. Looking at the top words, "*equipment*," "*projector*," "*projection*," and "*display*" are higher than the threshold value in all samples, indicating that these words are common words. Looking at "*cooling*," which is next, one sample has a value of 0.445, but the other three samples have values less than the threshold value, so it is not a common word. The threshold value was set at 0.030. Common words were removed from the RSS ranking list. A characteristic word was designated as one with a tf-idf exceeding the threshold value in only one or two samples, which was less than half of the four samples.

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Figure 3 shows the top four characteristic words for each sample. The top four common words and the top three characteristic words for each sample were identified in the order of frequency of occurrence (bold letters in Tables 2 and 3).

Table 2. Words with high RSS in product inventions

	G03B21/00, D	G03B21/14, A	G03B21/14, Z	G03B21/16	RSS
Equipment (Souchi)	0.371	0.520	0.401	0.424	0.865
Thing (Koto)	0.446	0.350	0.433	0.385	0.811
Offer (Teikyou)	0.380	0.384	0.439	0.389	0.797
Projector (Purojiekuta)	0.271	0.159	0.222	0.257	0.463
Projection (Tosya)	0.312	0.120	0.288	0.130	0.460
Display (Hyoji)	0.301	0.136	0.258	0.165	0.450
Cooling (Reikyaku)	0.011	0.015	0.007	0.445	0.446

Table 3. Characteristic words with high tf-idf in each leading FI in product inventions

G03B21/00, D		G03B21/14, A		G03B21/14, Z		G03B21/16	
Screen (Sukurin)	0.080	**Fluorescence (Keiko)**	0.083	**Adjustment (Chosei)**	0.051	**Cooling (Reikyaku)**	0.445
Correction (Hosei)	0.062	**Emission (Hakko)**	0.078	**Position (Ichi)**	0.044	**Temparature (Ondo)**	0.095
Adjustment (Chosei)	0.060	**Use (Riyo)**	0.066	**Lens (Renzu)**	0.044	**Fan (Fuan)**	0.076
Position (Ichi)	0.053	Body (Tai)	0.062	Face (Men)	0.039	Exhaust (Haiki)	0.060

Finally, to derive the common content, the four documents of each sub-population were combined into a single document, and a bigram search for nouns was conducted. From the search results, several co-occurrence words that were linked to a common word regarded as a node were extracted, and the significance of co-occurrence for a node and each co-occurrence word was calculated. Table 4 lists the top four bigrams for each score. As two bigrams matched the t-score and MI-score, six bigrams were selected as the common content of product inventions. The common contents were divided into three categories: product category ("*display equipment*," "*liquid crystal projector*"), main structure category ("*light equipment*," "*illumination equipment*," "*projection lens*"), and function category ("*video display*"). All these categories represent the core structure and function of products related to projectors.

Table 4. Common contents with each high score in product inventions

t-score		MI-score	
Display equipment (Hyoji sochi)	38.7	Video display (Eizo hyoji)	4.3
Light equipment (Kogen sochi)	29.3	Projection lens (Tosya renzu)	3.9
Video display (Eizo hyoji)	24.0	Display equipment (Hyoji sochi)	3.6
Illumination equipment (Shomei sochi)	20.9	Liquid crystal projector (Ekisho purojiekuta)	3.5

To derive the characteristic content, the same process as above was applied to each of the four documents in each sub-population. Table 5 shows the top two bigrams for each score, satisfying a t-score of 2.0 or higher and an MI-score of 3.0 or higher. In G03B21/00, D showed the same bigrams between the t-score and MI-score, whereas the other samples showed different bigrams. This is because of the different significance of the two indices. This result supports the suggestion that one should not be content with one index [12].

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Table 5. Characteristic contents with each high score in each leading FI in product inventions

	t-score		MI-score	
G03B21/00, D	Distortion correction (Yugami hosei)	6.2	Distortion correction (Yugami hosei)	6.4
	Position adjustment (Ichi chosei)	4.0	Position adjustment (Ichi chosei)	3.9
G03B21/14, A	Use efficiency (Riyo koritsu)	15.0	Use efficiency (Riyo koritsu)	5.6
	Light use (Hikari riyo)	9.2	Emission device (Hakko soshi)	4.7
G03B21/14, Z	Projection lens (Tosya renzu)	5.2	Lens shift (Renzu shifuto)	6.1
	Lens shift (Renzu shifuto)	3.9	Position gap (Ichi zure)	6.1
G03B21/16	Cooling efficiency (Reikyaku koritsu)	9.1	Temperature increase (Ondo josho)	6.1
	Temperature increase (Ondo josho)	7.5	Cooling object (Reikyaku taisho)	4.1

Contents such as "*distortion correction*" in G03B21/00, D and "*lens shift*" in G03B21/14, Z were related to high image quality (quality). Contents such as "*use efficiency*" in G03B21/14, A were related to brightness (feature), and the contents such as "*cooling*" in G03B21/16 were related to lifetime (feature) and high reliability (quality). Each sample had different content, which represented the features or quality of the projector.

The same procedure was applied to process inventions. Table 6 lists the common contents. Since one bigram matched between two scores, seven bigrams were selected as the common contents of the process inventions. The common contents were categorized into three categories: product category ("*display equipment*," "*projection equipment*"), main structure category ("*optical equipment*," "*information processing equipment*"), and function category ("*projection image*," "*image data*"). As in Table 4, the basic structures and functions of the products were represented.

Table 6. Common contents with each high score in process inventions

t-score		MI-score	
Display equipment (Hyoji sochi)	11.0	Information processing equipment (Johoshori sochi)	4.1
Projection image (Tosya gazo)	9.3	Display equipment (Hyoji sochi)	3.6
Projection equipment (Toei sochi)	8.8	Image data (Gazo deta)	3.5
Projection image (Toei gazo)	7.5	Optical equipment (Kogaku sochi)	3.3

Table 7 lists the characteristics of the content. The contents of G03B21/00, D and H04N5/74, D were related to high image quality (quality). They were similar in terms of "*distortion correction*," however the former was also characterized by "*color*." The contents in G03B21/14, Z were related to brightness (feature), and the contents in H04N5/74, Z were related to interactivity (feature). Each sample had different content, which represented the features or quality of the projector.

Table 7. Characteristic contents with each high score in each leading FI in process inventions

	t-score		MI-score	
G03B21/00, D	Distortion correction (Yugami hosei)	5.2	Color irregularity (Iro mura)	6.4
	Trapezoid distortion (Daikei yugami)	3.9	Trapezoid distortion (Daikei Yugami)	6.1
G03B21/14, Z	Projection lens (Tosya renzu)	2.6	Fluorescence unit (Keiko yunitto)	6.7
			Lens unit (Renzu yunitto)	5.9
H04N5/74, D	Distortion correction (Yugami hosei)	6.6	Image quality degradation (Gashitsu rekka)	7.0
	Trapezoid distortion (Daikei yugami)	6.1	Auto trapezoid (Jido daikei)	6.5
H04N5/74, Z	-	-	Video information (Eizo joho)	4.3
			Indication position (Shiji ichi)	3.7

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3.2 Discussions

The common contents of the two sub-populations (Tables 4 and 6) were compared. Both sub-populations included three categories, which represented the core structure and function of the product, and their contents were nearly equivalent. We consider these common contents to be the core benefits of the product, the projector. By separating product inventions from process inventions, different leading FIs were extracted, and different characteristic contents were selected. The characteristic contents of the same leading FI (Tables 5 and 7) were also compared. In G03B21/00, D, the former was characterized in terms of "*position*" and the latter in terms of "*color*." In G03B21/14, Z, they were similar in terms of "*lens*," however the former was characterized differently by "*shift*" and "*gap*" and the latter by "*unit*." Thus, even for the same leading FIs of the two sub-populations, the characteristic contents were different, representing a feature or quality of the product. We consider the characteristic contents of each sample to be various product attributes of the projector.

4. Conclusion

In this study, based on the concept of commonality and uniqueness by comparing multiple samples in contrast to the three levels of products, we propose a method to show the value of a product using patent analysis. Projectors were chosen as the target products, and Japanese patents were used in the analysis. The population was separated into sub-populations of product inventions and process inventions, and multiple samples were extracted using the leading FI. Common and characteristic contents were selected using text mining of the patent abstracts.

We conclude that the common content represents the core benefits of the product, the projector, whereas the characteristic contents for each sample represent the different product attributes of the projector. The separation of product inventions from process inventions is useful in this analysis because it allows us to find product attributes from a different perspective.

We consider the following two points. First, we will apply our method to U.S. and European patents. Second, since this study focuses on a product in the maturity stage, that is, a projector, we will try to apply our method to a product in the growth or introduction stage. Furthermore, we attempt to estimate the value of a potential product rather than an existing product. This method may contribute to the development of new products by showing the core benefits of a product and various product attributes based on patent information.

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