International Journal of Engineering & Technology, 8 (1.4) (2019) 27-35

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

A Decision-making Support System Providing Data-based Analysis of Current Competition in the Industry

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Abstract

Small and medium enterprises need a wide range of information regarding technologies, industries, market conditions, other companies, and products to help them identify new growth opportunities and to respond quickly to changes in the business environment. Collecting such information, however, requires the input of resources (human resources, cost, and time), and the lack of marketability resulting from the shortage of such resources is often cited as the reason small and medium often fail in their attempts to commercialize their technology. The main purpose of this study is to analyze environmental factors such as market concentration and the current level of competition to help companies make the necessary decisions when considering market entry following R&D planning and technology commercialization or after the development of a new product. Our goal is to provide more objective and reliable data by conducting data-based analyses of the current level of competition and other economic and technological factors within an industry. The industry or market data used in this study were analyzed based on the annual sales of the companies within the entire industry, and this industry or market data was classified using the Korea Standard Industry Code Korea Standard Industry Code (KSIC). The study's outcomes were applied to develop an analysis module for KMAPS, an intelligence system for industry and market analysis. The outcome of this study is a growth opportunity index that makes it possible to see the competitive structure of an industry at a single glance, which we believe will help prevent failures in commercialization. Furthermore, an expert-based 5FORCE analysis can be performed using KMAPS, an industry and market intelligence system: this makes it possible to automatically produce analyses based on corporate finance and transaction data. The key contribution of the study is that it makes it possible to conveniently and quickly analyze 5 Forces, which had been a difficult task in environmental analysis, and that the outcomes of this study help companies in the decision-making process.

Keywords: *Market concentration, industry market, environmental analysis, current competition level.*

1. Introduction

To enable the actors pursuing technology commercialization through industry-academy-research cooperation to identify new commercial opportunities and to help these actors improve their rate of successful commercialization, it is crucial to provide accurate and trustworthy analytic data regarding the industry and market. According to research released by the Korea Federation of SMEs (KBIZ), "lack of marketability" is the highest-ranking cause of commercialization failure; this underscores that marketability analysis has a great impact on the outcome of technology commercialization [1]. It is the thus clear that market analysis is critically important not only for marketing but in every stage in the cycle of R&D technology commercialization, and therefore the actors and companies pursuing technology commercialization through industry-academy-research cooperation all invest effort in market analysis, even though the form or level of sophistication their market analysis may vary.

The method of market industry analysis must be rational and the data used for such analysis must themselves be reliable, accurate, up-to-date and continually and easily accessible to ensure that the analytic results can be used as a reliable basis for making decisions throughout the entire cycle of technology commercialization [2]. However, the majority of the actors and companies involved in technology commercialization through industry-academy-research cooperation are currently forced to rely on industry or market data that are available free of charge. Small and medium businesses most often lack the professional knowledge and resources that would enable them to conduct their own analysis of industry market data and experienced a lot of difficulty in acquiring the information essential to their needs. There is an urgent need to develop an industry and market intelligence system that supports small and medium enterprises by providing a variety of industry market information and enabling these enterprises to perform their own systematic information analyses that can be utilized for making decisions.

This study aims to help the actors seeking technology commercialization to make rational decisions pertinent to planning new business projects and entry into other industry markets by providing a growth opportunity index based on data regarding market growth rates and current levels of market competition. Furthermore, the system developed in this study makes it easier and more efficient to analyze the

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competition intensity within an industry and analyze the industry market conditions: we developed a 5 Forces analysis assistant based on the Korea Standard Industry Code, which we implemented as an analysis module in the Business Intelligence system. Specifically, in this study we subdivided the market according to the Korea Standard Industry Code (KSIC) and used the annual sales data of these companies as the basis for analyzing the market concentration, the market growth rate, and the upstream and downstream industry structure, and we offer users a KMAPS (KISTI Market Analysis and Prediction System) designed to enable them to analyze current competition levels comprehensively, across the entire industry [1]. Members of small and medium companies, even those without expertise in market analysis, can easily use KMAPS, and this accessibility will likely result in significant savings for small and medium enterprises in terms of the human resources, time and cost that they need to invest in collecting industry and market information.

2. Theoretical Background

2.1. Industry Structure Analysis Methodology

When a company is able to offer originality that differentiates it from its rivals, it can secure competitive superiority in the market and generate a profit rate above the industry's average [3]. The most important process for a company aiming to achieve and sustain this competitive superiority is strategic planning, which will direct the company to implement strategic management. The two most important factors for strategic planning are the analytic results regarding the company's internal resources on the one hand, and the external environment, on the other. Many studies have introduced various methods of external environmental analysis that companies can use as the basis for planning their strategy, but this study focused on one among the leading available methods, namely industry structure analysis. The purpose of industry structure analysis is to utilize general information about the industry's structure and the characteristics of players within the industry to diagnose the revenue potential of the industry and identify the various forces that can affect this potential, with the ultimate goal of helping companies establish a strategy that will maximize their profit rate [3].

Industry structure analysis emerged as a way to overcome the limits of the prevailing industrial organization theory, which had been premised on an industry's homogeneity, based on the claim that that aside from the firm size, firms are similar in their economic characteristics. Bain (1956) argued that the industry structure is not determined simply based on firm size, but rather determined by the entry barrier, and further argued that when the entry barrier blocks potential entrants from new markets, resulting in imperfect competition, the concentrated companies are then guaranteed higher revenue [4]. Later, Hunt (1972) introduced the concept of a strategic group, defined as a group of firms that follow the same strategy, and argued that the strategic group influences competition or differentiates the entry barriers and thereby has an impact on the industry's profit rate [5]. Building on these theories, Michael Porter developed a new analytic approach that explains profitability by analyzing the industry structure, competing firms, and industry evolution. This approach is now widely known as Porter's 5 Forces model [6-8].



Fig. 1: Porter's 5 Forces model

The 5 Forces model is an analytic framework that adapts industry structure analysis to render it more easily applicable in business management. This model is used to analyze the key forces that influence the potential profitability of an industry which ought to determine a firm's strategies in response to the external environment. Since the business performance achieved by a firm is determined by the industry structure and the firm's position within the industry, the firm must establish a strategy for obtaining the desired position within the industry to maximize its own profitability. As shown in the figure below, Porter identified the five forces in the industry to be the established rivals in the industry, suppliers, buyers, new entrants, and substitute products or services.

Among the five forces, the competition with established rivals in the industry is considered the most important factor influencing the profitability of the entire industry. Some of the factors that determine the competition intensity in the industry include market concentration, market growth rate, homogeneity among firms, the degree of differentiation among brands and products, cost structure, excess capacity and exit barriers. The supplier's bargaining power will vary depending on the market concentration in the industry to which the supplier belongs, supply capacity, the importance of the supplied goods, the existence of substitute products or services, the replacement cost, the supplier's upstream integration capability, and the level of influence exercised by the supplier group. The buyer's bargaining power will be influenced by factors including the concentration of buyers, the degree of differentiation among products, price sensitivity, the downstream integration capability of the buyer, the importance of the product, the knowledge level of the buyer, and replacement cost. The threat of new entrants will differ depending on how high an entry barrier is pitted against companies seeking to enter the industry. The entry barrier is determined by the size of capital required for entry, cost superiority, product differentiation, and channel of distribution, governmental policies, entry deterring prices and retaliation by incumbent firms. The presence of substitute goods and services has a direct impact on the product pricing and ultimately on the industries profit rate. Lastly, the threat posed by substitutes will be affected by the relative price and quality of the substitutes, replacement cost, and the buyer's preferences.

2.2. Competition Analysis Methodology

The structure of an industry and its current competition level affect the behavior of the firms in the market and thereby has an impact on the firm's performance and furthermore has a strong impact on the performance of the entire market. As explained above, the characteristics of an industry's structure is determined by factors including market share, concentration, entry barrier, and product differentiation; therefore, it is important to diagnose the competition in terms of each factor. There have been many studies regarding the impact that current competition levels, measured by market concentration, has on performance in an industry. J. S. Bain [9] and others compared the average net income after taxes of industries with high market concentration and those with low market concentration and found that when the market concentration increases, there is a corresponding increase in activities such as collusion among major firms which lead to increased profitability for a such firms. N. R. Collins [10] and others also conducted research that classified industries according to their level of market concentration and compared their price-cost margins and reported that there is a positive correlation with concentration. In addition, many researchers such as Chidambaran [11] have concluded that the market concentration level has a positive impact on the profitability of dominant firms, providing empirical support for Bain's paradigm [11-14]. In other words, in monopolistic conditions where there is high market concentration, the monopolistic firms invest in innovation to continually sustain their super-profit and this drives high performance [15]. It should be noted that some relatively recent studies have also found contradicting results, varying depending on the conditions of analysis and the targeted time period [16-17].

Although the attempt to use quantitative measures to analyze the market competition and structure has some limitations, it is possible to indirectly analyze the intensity of market competition by using a diverse range of analytic indices for market concentration. Among the indicators used to measure market concentration, one of the most widely used ones are the CR (Concentration Ratio) index and the Herfindahl-Hirschman Index. The concentration ratio (CR) of the top k number of firms is the sum of the values of the market share (S_i) of the k number of firms that are highest ranking in terms of market share, and this can be expressed as the following formula (1).

$$CR_k = \sum_{i=1}^{k} S_i \tag{1}$$

When CRk approaches 1(100%), this means that the conditions are closer to a monopolistic market, whereas a lower index indicates a more competitive market. In general, a CR3 of 80% or greater indicates a monopolistic market and a CR3 of 60% or greater indicates an oligopolistic market, whereas a market with CR3 of 60% or lower is classified as a competitive market [18]. The CR indicator is widely used because it is intuitive and makes it easy to measure the concentration of the top k number of firms. However, since the value of CRk represents the cumulative value of the market share of the top-ranking firms, the results of market concentration analysis will vary depending on the k value. For this reason, determining the value of k is critically important and must be performed with utmost care [19].

In the study, we directly used the Herfindahl-Hirschman Index (HHI): as in the case of CR, the market shares of the firms that participate in the market are identified by percentage and the HHI is the sum of all the squared values of these market shares (S_i), which is expressed below as formula (2). In the formula, n is the number of all firms and S_i is the market share of the i-th firm. HHI is one of the indices used to measure market concentration: a higher the number indicates higher market concentration and a lower number indicates that competition is more intense. Our study used HHI because this index not only reflects the market share of all the firms in a given industry, but also indicates the squared value of a firm's market share in a specific market and is therefore widely used in advanced countries.

$$HHI = \sum_{i=1}^{n} S_i^2 \tag{2}$$

When the HHI is at the maximum of 1 (10,000%), this indicates a monopolistic market, but when the market is characterized by even competition, the distribution of the market shares will decrease, and when all the firms have the same market share, HHI will reach the minimum value of 1/n. Generally, when the HHI is 1,000 or below, this indicates a market with low concentration, whereas HHI values between 1,000 and 1,800 indicate a competitive market, values between 1,800 and 4,000 indicate an oligopoly or duopoly, and values of 4,000 or higher are classified as a monopolistic market. However, since the HHI will vary depending on the total number of firms, there is a limitation to how accurately this index can reflect equality among markets and will have only limited use in identifying the market shares of all firms [12]. Other indicators that are used for analyzing market concentration include the Gini coefficient (G), Entropy Index and Rosenbluth Index.

3. Research Method

3.1. Collecting and Refining Data

To analyze the intensity of competition in an industry, we used corporate transaction data and analyzed the proportion of transactions between upstream and downstream industries, sales values, and the number of firms. Also, to analyze the market share structure within an industry, we referenced the amount of shipments, exports, and imports by industry and by item and used corporate sales data. Our source for the data regarding the value of shipments by domestic companies was the data from the survey of mining and manufacturing industries conducted by Statistics Korea (KOSTAT) and the source of our data regarding the value of imports and exports was the trade data provided by the Korea International Trade Association. The survey of mining and manufacturing industries conducted by Statistics Korea (KOSTAT) was organized by the Korea Standard Industry Code (KSIC) and the trade data was classified according to the Harmo-

nized Commodity Description and Coding System (HS, or the Harmonized System). Therefore, to simultaneously analyze the values of shipments by item and import and exports, it was essential to create a linkage between KSIC and HS. To achieve this linkage between KSIC and HS, we utilized the method presented in our previous research [20]. Data on the company's financial performance were obtained from Korean Enterprise Data. The information of more than 40 million companies was classified by KSIC and analyzed the competition situation in the industry. The results were compared with average data for similar industries.

3.2. Implementation of the Inference Engine and the System Development Environment

The system development environment is basically similar to that presented in our previous research [2]. When the user selects the Korea Standard Industry Code, the algorithm for the support system for performing the data-based intelligent industry structure analysis(5 Forces) presented in this study will automatically perform the analyses of the competition intensity within an industry, the market concentration levels by industry, and the upstream and downstream industry structure based on various sources of statistical data and will automatically generate qualitative analytic statements. The algorithm is also capable of researching and analyzing the market share of a specific product within an industry or an item category or analyzing the current level of competition among firms. The purpose of obtaining these results is to develop a single analytic module for the KMAPS system. As for the system development environment, the web server O/S was Linux and the authoring language consisted of Java, Jsp, and Javascript. For DBMS, we used Oracle 10g. The KMAPS system consisted of menu items including market analysis, industry structure analysis, feasibility analysis, environmental analysis, and a knowledge warehouse. The KMAPS system makes it possible for firms to easily acquire information about the market structure and competition based on data with enhanced reliability and objectivity, and helps these firms make decision regarding technology commercialization.

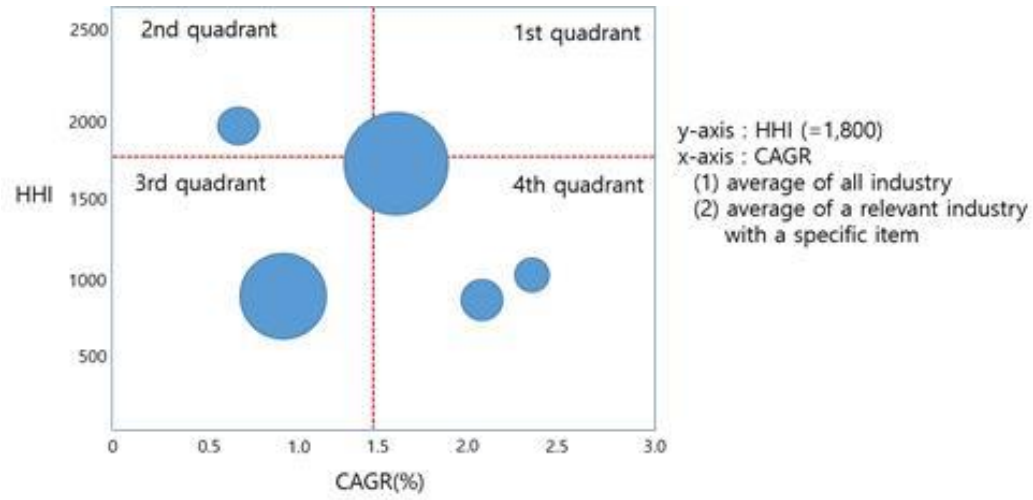


Fig. 2: KISTI market opportunity index

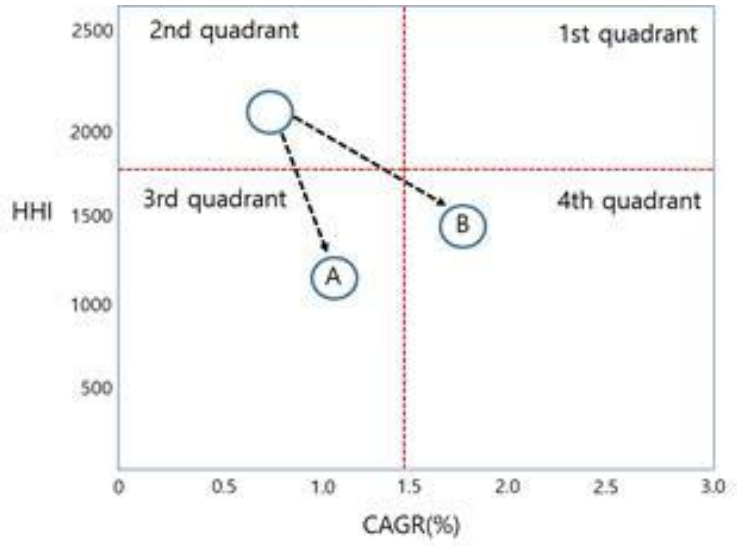


Fig. 3: Use case of KISTI growth opportunity index

4. Research Results

When actors or firms pursue technology commercialization through industry-academy-research cooperation and seek to enter a new market, they must first conduct an analysis of the market targeted for entry by a product, service, or brand and also perform an industry structure analysis to determine the current competition in the industry. When a company implements commercialization, it needs to know the competition structure of the industry to determine the industry's attractiveness and profitability it must also know information regarding

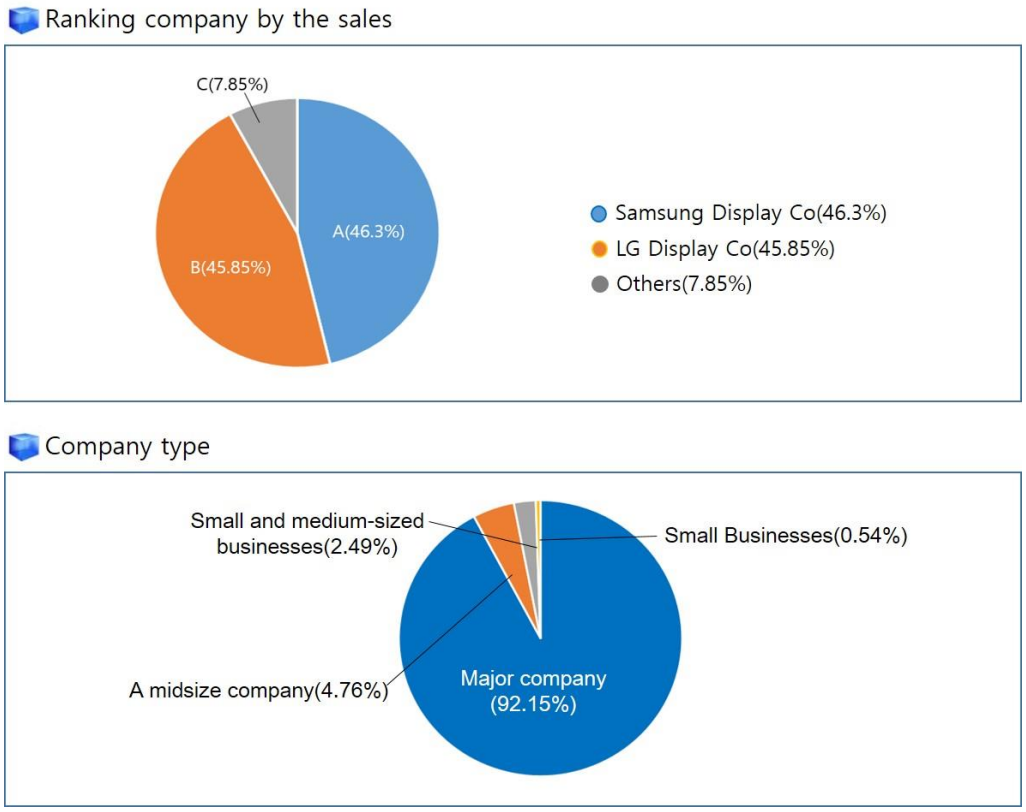
rival such as other potential entrants to minimize the risk of business failure. The market opportunity indicator developed in this study takes account of both the current market competition and the market growth rate and allows us to grasp at once both the competition and market growth potential of the industry or an item that we wish to analyze. Furthermore, these results also allow us to analyze the competition levels of other surrounding industries or other items within a given industry. In this study, to simultaneously consider both the market competition level and the market growth rate, we used HHI and the Compound Annual Growth Rate (CAGR) for each item for the most recent three years within the domestic market as our two axes.

[Figure 2] presents the market concentration HHI that enables us to analyze the market competition and the growth rate for the most recent three years tracked by industry and item as the X and Y axes. Applying HHI 1,800 as the threshold for an oligopolistic market and applying the average value for the all industries as well as the average value of the market growth rate in a specific industry, we divided the matrix into four quadrants. For example, in Figure 2, 1.5% represents the average three-year average growth rate of the items analyzed. We were thus able to analyze the market growth rate and competition intensity of each item. Furthermore, to make it possible to easily identify whether the analyzed market consists mainly of large companies or of small and medium-sized companies, we made the size of the circles correspond to the percentage of small or medium-sized companies out of the total number of firms, and this made it easy to judge whether the entry of a small or medium-sized company would be possible.

Let's examine the growth opportunity indicator in more detail. Quadrant 1 shows a high market growth rate, but because the market has a high concentration, new entry will be difficult but attempts at new market entry may be worthwhile in the case of innovative products that are clearly differentiated from existing products. Quadrant 2 has a lower market growth rate compared to quadrant 1, and therefore attempts at business diversification should be undertaken only after careful consideration. Quadrant 3 exhibits a relatively low market growth rate and includes the participation of a large number of firms, and therefore the market attractiveness is low but offers greater ease for new market entry. Quadrant 4 has low market concentration but the market growth rate is high and therefore this quadrant presents the highest level of growth opportunity for new entrants.

Also, by using the growth opportunity indicator, it is possible to analyze the market growth rate and Market concentration of other similar industries and this can help firms make decisions assessing the possibility of entering other Industries using the technology or products they have. Figure 3 shows a specific use case of the growth opportunity index. For example, suppose a company belongs to industry A in Figure 3. In Figure 3, industry A is in the second quadrant, which is relatively slower than similar industries. It also has a characteristic of oligopolistic markets. From Figure 3, it can be seen that the B industry is relatively low in market concentration and the growth potential of the market is relatively higher than that of A industry. In other words, the B industry can expect the entry barrier to be low due to the uncertainty of the leading company, while the rapid growth can be expected. Therefore, if the company is considering entering into a new industry among the industries similar to the A industry in which it has already participated, the B industry can be considered as a priority. The C industry can also be considered as another candidate for similar reasons. In other words, in the growth opportunity index picture, it is possible to select a new entry industry in the downward direction. In this way, we can help firms make decisions regarding technology commercialization by simultaneously providing information about the levels of market concentration and growth rates in other similar industries.

To facilitate the performance of 5 Forces analysis, which is a form of industry structure analysis, we provide analytic information regarding the market concentration of each industry, level of competition, and the upstream and downstream industry structure, utilizing corporate finance and transaction data. One notable distinction between Porter's 5FORCE analysis and the 5FORCE analysis developed in our study is that when a user makes selections based on the Korean Standard Industrial Classification, our system automatically uses various sources of statistical data to perform analyses regarding the intensity of competition within the respective industries, market concentration, downstream and upstream industry structure, etc. This system can only perform analysis regarding the competition intensity within an industry and the bargaining power of suppliers and buyers.



There are 142 firms included in the category of liquid crystal flat panel display, and the most active participation is by large sized companies.

Samsung Display Co., Ltd. and LG Display Co., Ltd. comprise 93% of the total market share. The difference in market share between the companies respectively ranked 1st and 3rd in market share is 38.44%.

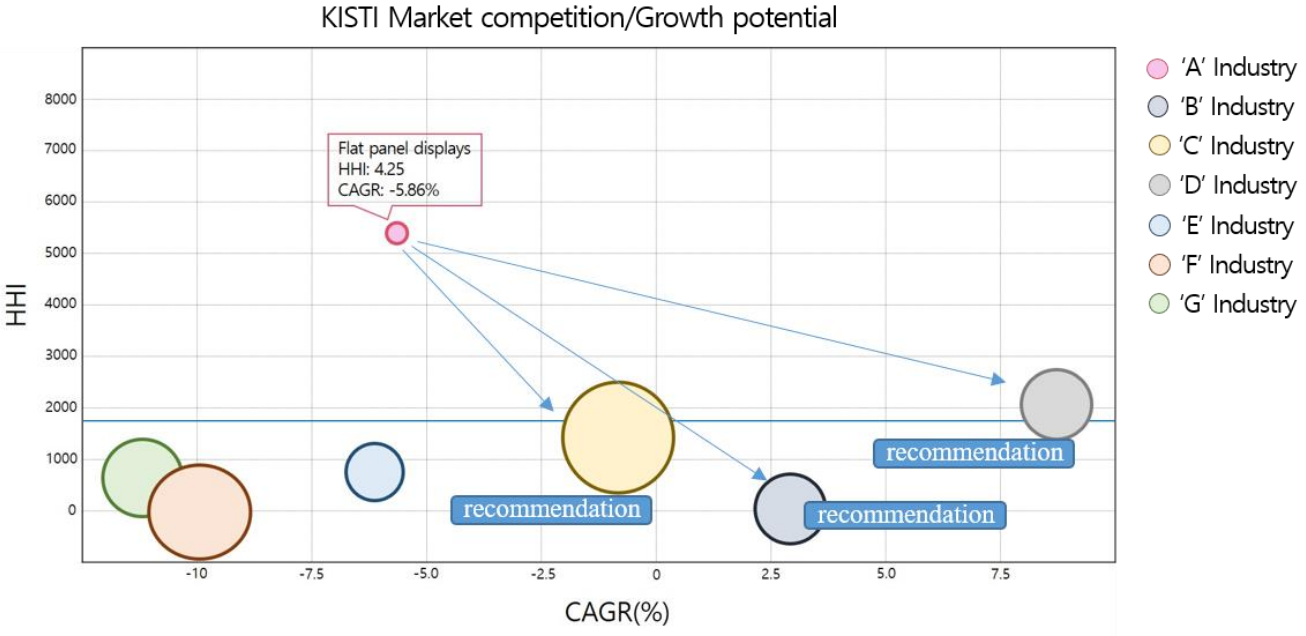
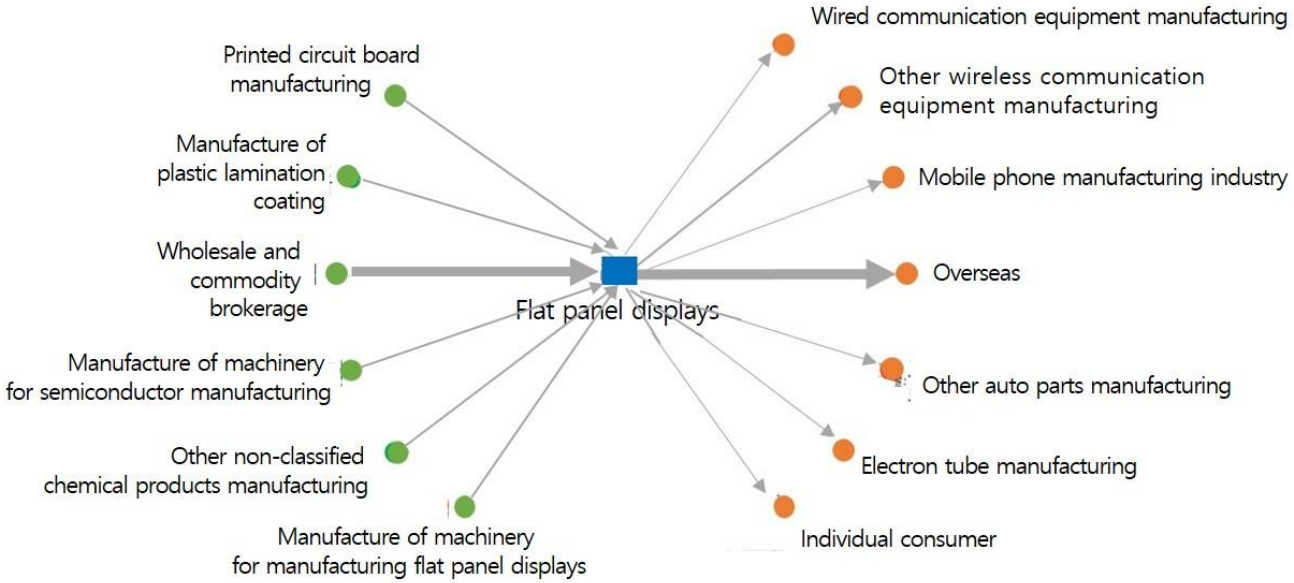


Fig. 4: Analysis of competition status in a market

As shown in [Figure 5], when the user selects the analysis target item, the user will not only learn information about the competition structure of firms included in the industry or market but also be able to obtain analysis of whether the market consists mainly of large companies or of small and medium companies. For example, when the user selects the industry of "liquid crystal flat panel display," the results will show the market share of each company in the top rankings in terms of sales and indicate that the market competition structure is dominated by large companies. Specifically, it can be seen that Samsung Display Co., Ltd. and LG Display Co., Ltd. almost divide

the liquid crystal flat display market in Korea. In addition, since they are large corporations, the sales portion of large companies in the overall market is very high, while the sales portion of SMEs is very low, indicating that SMEs are not suitable for new participation. The system also provides automatic rule based analysis sentence generation. It finds the most basic and characteristic issues of the market and generates analysis sentences according to the set rules.



The percentage of supplier transactions for the selected item (industry) (out of 100%)

The total sales value of the supplier companies for the selected item (industry) (unit: trillion Korean won)

The number of supplier companies for the selected item (industry)

Selected Item (industry)	The Percentage of Transactions(%)	The total sales value(unit: trillion Korean won)	The number of companies
Wholesale and commodity brokerage	38.44	430	48,000
Manufacture of machinery for semiconductor manufacturing	14.22	10	1,000
Other electronic components manufacturing	12.51	30	2,000
Other non-classified chemical products manufacturing	10.7	10	800
Manufacture of plastic lamination, coating and other surface treatment products	8.47	4	400
Manufacture of machinery for manufacturing flat panel displays	8.39	4	100
Printed circuit board manufacturing	6.88	9	700

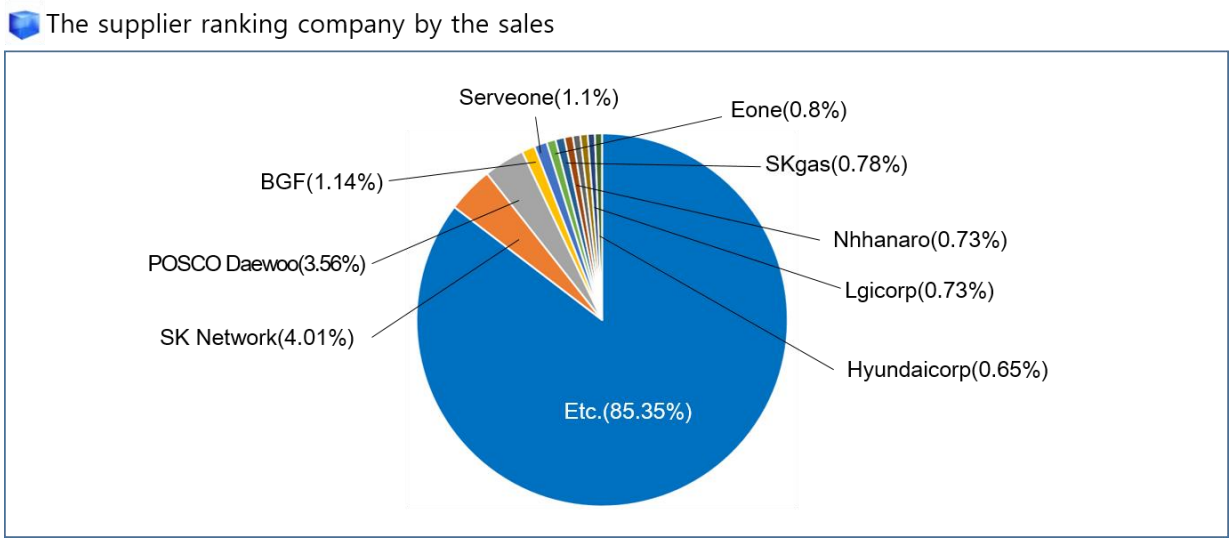
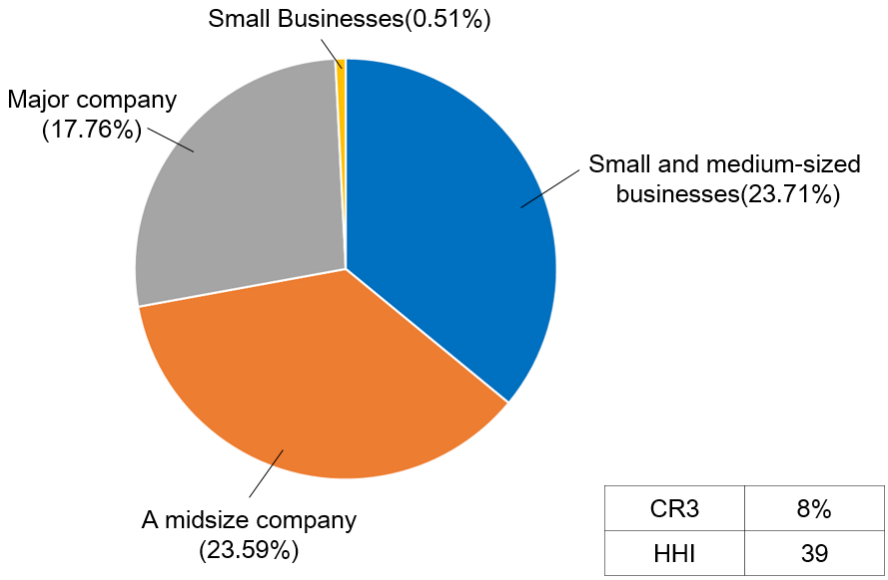


Fig. 5: The upstream and downstream industry structure

Based on the analytic results, the system will automatically generate a statement that "there are 142 firms included in the category of liquid crystal flat panel display, and the most active participation is by large sized companies" and that "Samsung Display Co., Ltd., LG Display Co., Ltd., and other companies comprise 93% of the total market share." In addition, we can compare growth potential and market concentration with neighboring industries by using the aforementioned growth opportunity indexes.

In order to assist in analyzing supplier and buyer bargaining power in performing 5 forces analysis, we provide upstream and downstream industrial structure analysis module. The analyses of upstream and downstream industry structures based on corporate financial and transaction data are presented as shown in [Figure 5]. In this industrial structure network, the target industries are located in the center. On the left is the upstream industry, ie, the supply industry, and on the right is the downstream industry, ie, the demand industry. The direction of the arrow indicates the direction of movement of goods and services. The thickness of the arrow indicates the relative size of the transaction. The larger the thickness of the arrow, the more tradable the industry is. If you select an important industry among various forward and backward industries, you can see the competition status of that industry. At this time, the thickness of the arrow may be a good selection criterion. To enable a more detailed analysis, the name of the item (industry), percentage of transactions (%), total sales and the number of companies are presented in a table format. When the item (industry) name is selected in terms of supplier and buyer, the system will provide a list of the top sales ranking companies in related items (industries) and their respective market share, information about company structure and CR3, and the HHI values. Based on the data, the system will generate statements that identify which industry is the leading supplier industry and inform the user of the number of related companies and the analysis of the state of market concentration and competition.



CR3	8%
HHI	39

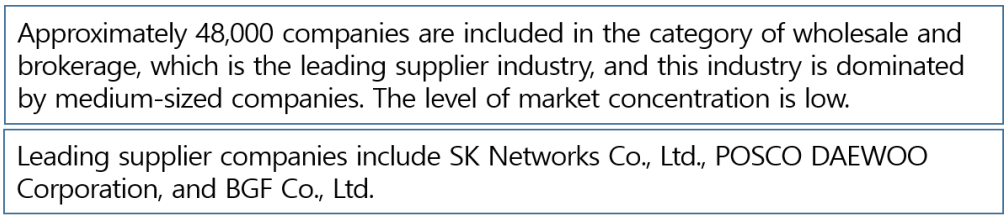


Fig. 6: Competition in the downstream industry

For example, if the user selects "wholesale and brokerage" as the supplier for "liquid crystal flat panel displays," the system will automatically generate statements regarding the analytic results, such as "approximately 48,000 companies are included in the category of wholesale and brokerage, which is the leading supplier industry, and this industry is dominated by medium-sized companies. The level of market concentration is low" and "Leading supplier companies include SK Networks Co., Ltd., POSCO DAEWOO Corporation, BGF Co., Ltd., SERVEONE Co., Ltd., and EWEON Co., Ltd." In [Figure 5] shows the percentage of buyer and supplier transactions, value of transactions, and the number of involved firms within the actual "liquid crystal flat panel display" industry. This data on transaction between industries was generated exclusively by KMAPS by distilling around 1.8 million items of data regarding transactions performed by actual firms. This system was developed to thus provide the status of competition and economic and technological factors within the industry based on data to equip users with more objective and reliable information.

5. Conclusion

The corporate environment is changing rapidly, and with fluctuations in business conditions such as the state of the global economy, customer demand, surplus supplies, and new technologies, rational decision making becomes all the more important to strengthen a company's competitiveness. As companies respond to these changes in the external environment, it is critical for them to understand the industry's market structure and competition level to succeed in developing new products, improve the success rate of technology commercialization, and secure the engine of continued growth. KMAPS succeeds in performing a crucial industry market information service, providing key data that small and medium enterprises need to plan their technologies, including information on market size, future demand, and conditions of competition by using data generated by KISTI and public sources of Big Data. In other words, KMAPS is an artificial intelligence system that offers essential industry and market information that small and medium enterprise need for technology planning, based on highly objective and reliable public data. This study presented a way to analyze the growth opportunity in a market and the industry structure with greater ease by searching results by industry or by item category. The contribution of the study is that it presents a way to use corporate transaction data to automatically analyze industry structure and industry competition indicators with results arranged according to the Korea Standard Industry Code (KSIC); these results in power companies to more effectively and efficiently utilize information required when they make decisions regarding technology commercialization. Hereafter, we will need to further subdivide the items to enhance the reliability and objectivity of our analysis of market concentration and competition. The significance of the study is that it provides a system for analyzing market concentration and competition that company managers directing technology commercialization can easily use free of charge, even in cases where they had found it difficult to collect industry market data, and that it provides a method of automatically performing the industry structure analysis of 5 Forces.

Acknowledgement

This research was supported by Korea Institute of Science and Technology Information (KISTI).

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