Application of Multidimensional Scaling (MDS) Structural Analysis: A Case Study on Dog Food Products

Byoung-Guk Jeong1 and Hong-Kyu Kwon2*

1Department of Visual Information Design, Namseoul University, 91 Daehakro, Seonghwan-eup, Seobuk-gu, Cheonan-si, Chungcheongnam-do, 31020, South Korea; kukido@nsu.ac.kr
2Department of Industrial & Management Engineering, Namseoul University, 91 Daehakro, Seonghwan-eup, Seobuk-gu, Cheonan-si, Chungcheongnam-do, 31020, South Korea; hongkyuk@nsu.ac.kr

Abstract

Objectives: In the modern marketing strategy, MDS (Multidimensional Scaling) can be an important core technique carving a company’s product or brand in the differentiated position in comparison with competitors. In order to extract efficient information from the data and to summarize these relationships among objects from the dissimilarity or similarity data, MDS is the typical method. MDS is one of the multivariate analysis methods in terms of statistical analysis method.

Methods/Statistical Analysis: On this study, seven functional properties of dog foods are selected to apply MDS. The dog foods highly ranked in sales in Korean domestic dog food market are classified into five classes such as organic, holistic, super-premium, premium, and grocery. Five products per each class except of the premium class (four products on the premium class) are extracted. In order to visualize a two-dimensional positioning map, the statistical software (SPSS 22+) and 24 products are used. By using the Euclidean distance matrix, the analysis of 24 products is mapped on the two-dimensional positioning map. According to a similarity result, the similarity at low values less than 1.0 turned up on the rational distance matrix. The products of the high similarity were a group of the organic class and the holistic class. And the grocery class also showed that domestic products mostly consisted of its class. Findings: The outcome of this research can be that the Korean brands’ super premium class with slightly high main nutrients can be viewed as having the highest competitiveness from the efficient preemption of market gap. Improvements/Applications: The results are applied to build a competitive brand positioning strategy to cope with the market changes in the domestic dog food market.

Keywords: Dog Food, Market Strategy, Multidimensional Scaling, Multivariate Analysis, Relationship Analysis

1. Introduction

Blind choice and parameterization of data mining tools often produce ambiguous or completely misleading results. Interactive visualization can do, not only extensive exploration of data but also better matching of classification schemes to the data type being analyzed. MDS, which uses particle dynamics to the error function minimization, is a good candidate to be a computational engine for interactive data mining1,2. And also MDS is one of the multivariate analysis methods in terms of statistical analysis method. In the modern marketing strategy, MDS can be an important core technique carving a company’s product or brand in the differentiated position in comparison with competitors. MDS is a technique visualizing and projecting multidimensional

*Author for correspondence
and complex relations such as the products’ attributes, or consumers’ ideal point or preference, as well as brand or product into two-dimensional or three-dimensional perception space. This can be revealed though the positioning map. Such a series of processes correspond to the positioning strategy of a company, are one of the effective methods that can predict market, when a new product is introduced or a new product is launched, or an existing product is repositioned.

Many scholars have defined positioning. Positioning is generally defined as an activity carving a company’s product, and brand or service into the valuable and differentiated position in the perception of consumers (target customers). Holmes (1973) defines positioning as consumer’s perceived image on competitor’s similar products and innovative company’s similar product. In positioning is a concept that does not exist alone, but has common scale, and that has the meaning of selection or market segmentation on which characteristics of a product or brand should be emphasized to consumers. Therefore, a company needs to precisely identify where its products should be positioned in the consumer’s perceived image map. A company also needs to analyze which competitors are close to the positioning of its own products, and how many competitors exist around those products. Based on such identification and analysis, the most ideal point in marketing strategy is to carve company’s products in the consumers’ perceived map through the emphasized characteristics of its products.

There are about 270 dog food products distributed and sold in Korea, and individual products exceed 2,000 types. This study targeted domestically and internationally distributed products, and selected dog foods for all ages of dogs with the highest sales among them. In view of the dog foods classified into five classes such as organic, holistic, super-premium, premium, and grocery, 24 products (five products per each class, only four products on the premium class were selected since the products for all ages of dogs with the highest sales were limited) were analyzed not to be inclined to specific classes. The evaluation factors of the dog foods are the functional attributes that consist of dog foods, namely, the following seven functional attributes: size of dog food grain, dog food grade, main component, the rate of crude protein, rate of crude fat, rate of calcium, and price. These are connected with rational benefit among three benefits classified in the benefit segmentation concept by. In brand image, those seven functional attributes are connected with functional brand image made to solve the consumption desire manifested externally, such as a concept devised to meet the consumption desire created from the external environment, psychological desire, and safety desire to escape from anxiety. Based on such functional attributes, statistical software (SPSS 22+) was used to visualize the results in the two-dimensional positioning map. This study also carried out an analysis by presenting the product position using similarities among the products. The purpose of this study is to present the basic data of marketing research through which Korean dog food products can strategically respond to market change by identifying the positioning strategies, and have competitiveness in the rapidly growing Korean dog food market amid the foreign products-leading fierce competition.

2. Theoretical Review on Multidimensional Scaling Model

Based on mathematical data on objective or subjective relations between the subjects of analysis, MDS refers to a series of statistical techniques revealing the subjects of analysis in terms of the position in a multidimensional space. Through MDS, overall relation structure that cannot be understood with only numerical value data can be easily identified through figures on the space. MDS is also said to be a statistical tool that can measure and prove relations of the subjects, when understanding on the dimensional relations of the subjects is not enough. Metric MDS developed by was the beginning of MDS used in the modern times. After that developed the nonmetric MDS based on an ordinal scale. The INDSCAL and SLSCAL used in marketing recently a lot are to analyze respondents’ preferences and similarities among individuals in a nonmetric fostered them.

MDS is a method spatially describing the data on the two-dimensional plane, and making a decision, which is companies, brands, products, concepts, ideas and services which are research subjects perceived by respondents, or things that can be commonly perceived. MDS has an exploratory purpose to clearly examine innate and subjective dimension affecting customers’ behaviors. MDS is also used to acquire evaluation criteria to compare the evaluation subjects when no clear data through which the subjects can be compared is revealed, or the data cannot be defined.
For example, MDS reveals the dimensions used to shape overall similarity perception or preference of respondents, and indicates the evaluation subjects in the evaluation dimensional space with coordinates. The suitability of the multidimensional model on respondents' one-dimensional data appeared in the process is measured. This can be measured with stress values, and can determine the usefulness of the model drawn by applying MDS. Perception differences among respondents can be analyzed by deciding and interpreting the drawn evaluation dimensions. There is no need to require the attributes comparing the evaluation subjects clearly in MDS, but it is important to make the evaluation subjects precise, and to be assured of the common basis used for the respondents to compare the evaluation subjects. The reason is that the evaluation dimensions of the evaluation subjects are too much comprehensive or may include intangible emotional factors. Due to such a reason, MDS is known to be an appropriate evaluation method for the research in an area difficult to be used as universal comparative criteria, and for marketing positioning research.

3. Field Survey on Dog Food Products

Interest in companion animals and the companion animal industry have continuously evolved with the persistent economic growth, the national income increase, and the advent of DINKs (double income, no kids). As the DINKs recently evolve into Dink-pets who raise pets as the subjects of love, due to loneliness without a child, the pet dog industry continuously grows 15–20% annually. This can be an odd phenomenon in the view of the recent global continuous low growth economic environment including Korea. Therefore, the pet dog industry is evaluated as an industry irrelevant of economic recession. Although the U.S. showed −2.4% in economic growth rate in 2009, and recorded the worst economic downturn in 63 years since World War II, the pet dog industry posted a high growth from USD 43.2 billion in 2008 to USD 45.4 billion in 2009. Upon looking at the Korean pet dog industry, 19% of Korean households (10 million people) raise pets, and the number of pets are estimated about 3 million. Korean pet dog industry size is expected to reach from KRW 1.8 trillion in 2012 to KRW 2 trillion in 2015 and to KRW 6 trillion in 2020 which shows 15–20% of rapid average annual growth rate. According to the sales tally of E-Mart in 2015, the sales ratio of pet dog products grew 86.7% compared to the previous year. Annual 24% of sales growth trend was revealed in the case of Open Market Auction for the recent three years.

Especially, the pet food market in the pet dog industry predicts a growth to KRW 600 billion by 2020. Cheil-Jedang (CJ), a leading company in the Korean pet food industry, targeted KRW 10 billion in sales in 2013. CJ remarked that the company will grow its products into KRW 30 billion in the Korean market which is dominated by foreign products like Nestle and Royal Canin. The foreign companies are also intensively investing in marketing and resources so that its pet food brand (OFRESH) to grow furthermore. KGC (Korea Ginseng Corporation) sets a goal to preempt the Korean market by launching its organic farming high quality pet food (GINIPET) added with red ginseng and aronia. In addition, other Korean leading food companies such as Dongwon F&B and Sajo Industries are actively marketing in the Korean pet dog industry.

Dog foods can be divided on the basis of dog foods' intended role, moisture content, preservation method, and nutrient content. A representative classification method is to classify dog foods into dry feed (9–12% of moisture content), semi-moist feed (20–30% of moisture content), and moist feed (70–80% of moisture content) according to the ratio of moisture content. According to the material quality, the dog foods are recently classified much in reality into organic farming class, holistic class, super premium class, premium class, and grocery class as described below.

- **Organic Class**: Pesticides, chemical fertilizer, synthetic preservative, coloring, or GMO are not used in the process of manufacture and the products. The Organic ingredients certified by United States Department of Agriculture (USDA) and European Union (EU) are mostly used.
- **Holistic Class**: It is the best feed made of the human-edible ingredient certified by USDA. It is high in meat and has unrefined whole grains, herbs, vegetables, and fruit. The crops such as corns, beans, and wheat which may cause allergy are not used.
- **Super Premium Class**: It is higher in meat than grains. It is a fine quality feed free from by-products, meat powder, and bone powder. It is preserved by natural vitamins C and E and rosemary extract instead of synthetic preservative and oxidizer. Shredded grains and
the crops such as corns, beans, and wheat which may cause allergy are used.

- **Premium Class**: It is a generic class feed mainly with by-products. Meat powder and bone powder are added. Synthetic preservatives are used. It is cooked in high temperature to sterilize and preserve. It is filled with little nutritious contents and artificial addictive are used for better taste.
- **Grocery Class**: It is a low-price feed mainly with grains and by-product, meat powder, and bone powder. Synthetic preservative, oxidizer, coloring, and artificial addictive are used. Low quality oil and grain draft and even unknown ingredient are used.

4. Experimental Research of Dog Food Products

The subjects used for the experiment in this research were focused on the dog foods distributed and sold in the Korean market. As a result of a survey, the dog foods for all ages of dogs were extracted except for those for the special purpose use among some 270 products. In view of the dog foods characteristics classified into five categories according to the content quality, 24 products shown on Figure 1 were selected as the ultimate experiment subjects not to be inclined to specific classes. Five products per class were selected, but only four products were selected from the premium class due to the limitation of the product for all ages.

As mentioned in the research method and scope, this research extracted, analyzed, and evaluated the representative variables in terms of dog foods’ physical attributes corresponding to rational benefit among three benefits that are classified in the benefit segmentation concept. Seven representative variables (size of dog food grain, dog food grade, main component, rate of crude protein, rate of crude fat, rate of calcium, and price) were extracted. Based on these variables, a distance measuring procedure was used by calculating the dissimilarity distance matrix shown on Figure 2 among the products. To identify the position of the products on a two-dimensional coordinate, a nonmetric statistical method (SPSS 22+'s ALSCAL) was used. To interpret the direction of an axis, a factor analysis was also conducted. Finally, 24 products’ positioning was interpreted by projecting the coordinates of Euclidean dissimilarity distance matrix into the two-dimensional coordinate space.

As for the dissimilarity distance matrix result shown on Figure 2, similarity was calculated using the concept of Euclidean distance between two points on the coordinates. A subject with similarity is indicated as lower value than 1.0 in the dissimilarity distance matrix, which means that it is the product of which attributes are similar. As the numeric value is lower, it can be interpreted as in the primary competition relation.

Upon looking at the products with the highest similarity, Natura Pet Natural Core Organic Eco1 Lamb had the highest similarity with Cargill Agri Purina Nutrena Gungang Baekseo Organic Barley & Salmon (.67), Now Grain Free Adult DF (.76), and ANF Organic 6 Free Lamb (1.18). Now Grain Free Adult DF had the highest
similarity with CargillAgri Purina Nutrena Gungang Baekseo Organic Barley & Salmon (.76), and had quite a high similarity with ANF Organic 6 Free Lamb (1.49) and PPN Go Natural Salmon Oatmeal Formula (1.54). NF Holistic Lamb & Rice showed the highest similarity with ANF Premium Lamb 28 (1.20).

The Korean product, CJ Pet Food O Fresh Prime Meat &Oatmeal, showed high similarity with Diamond Pet Food Taste of The Wild Roast Duck & Sweet Potato (1.00) and ANF Premium Lamb 28 (1.14). KIRKLAND Signature Natures Domain Salmon Meal & Sweet Potato Dog was in competitive relation with CJ JERONY Any Pet All-Stage (1.19) having high similarity. Due to the farthest in dissimilarity distance shown on Figure 2, reversely, DongaoneDogchung Smart and WoosungFeed New Verygood showed the low similarity in most organic farming products, super premium class products, and some premium class products including Natura Pet Natural Core Organic Eco1 Lamb (7.25), CargillAgri Purina Nutrena Gungang Baekseo Organic Barley and Salmon (7.06), and Now Grain Free Adult DF (6.91).

The reason for the above classification can be estimated because the major components like crude protein, crude fat, crude fiber and calcium, and product’s price factor consist of the products. The classification criteria classified according to the material quality were just partially applied as the criteria classifying similarity in the dissimilarity distance matrix. Upon looking at the products with high similarity in the actually analyzed dissimilarity distance matrix, the products with high similarity were shown among the organic farming class, holistic class, and super premium class products.

Coordinates were extracted by the ALSCAL of SPSS 22+. The ratio measurement in the analysis option was standardized with Z score to calculate the similarity distance, and Euclidean distance for section measurement was used to calculate the distance matrix from the data. The conversion criterion of stress was set as 0.001, minimum stress value was set as 0.005, maximum iteration number was set as 30, and the distance processed as missing value was set as 0. According to the analysis result, four times of iteration occurred, and the improvement of a stress value was 0.00026 which ended up smaller than 0.001. The current stress value was 0.20083, and RSQ (R-squ)

The products positioned in the closest position in the positioning map have the similarity of physical attributes used in the analysis, and they are positioned in the most competitive position. The groups with the most fierce competition are 1 (Natura Pet Natural Core Organic Eco1 Lamb), 5 (ANF Organic 6 Free Lamb), 7 (Pet n H Achime Hand Made Feed), 8 (OSP Natural O Organic Chicken &Mussel), and 9 (CargillAgri Purina NutrenaGungangBaekseo Organic Barley & Salmon), and most of these belong to organic farming dog foods. In another group, there are 11 (ANF Premium Lamb 28), 12 (Natural Balance Allergy Formula), 13 (Diamond PetFood Taste of The Wild Roast Duck & Sweet Potato), and 14 (CJ PetFood O Fresh Prime Meat &Oatmeal), and they are super premium class dog foods. In the last group, there are 22 (InterPet Korea Dobyjin), 23 (DongaoneDogchung Smart), and 24 (WoosungFeed New Verygood), and they are all Korean brandsand also grocery class dog foods.

The factor analysis shown on Figure 4 was conducted for the dimension interpretation of coordinate axis. To reduce variables, factor rotation was carried out by varimax using the principal component analysis in terms of the factor extraction method, and the dimensions were limited to two dimensions. As a result of the factor analysis, KMO (Kaiser-Meyer-Olkin) value was .679 which exceeded the suitable minimum criterion (0.5) of the analysis, and thus, the result was suitable. In the rotated component matrix, the rotation result acquired from the iterated calculation was presented in the rotated component matrix. The variables used for the factor analysis were seven at first, however, re-analysis was conducted after the two variables not bundled well after the first rotation were removed. As a result shown on Figure 5, this research set up dimension 1 (y-axis) as the class of the dog foods, and dimension 2 (x-axis) as the main nutrients.
Application of Multidimensional Scaling (MDS) Structural Analysis: A Case Study on Dog Food Products

Upon looking at the factor map of rotation space shown on Figure 5, the + direction (right) from the center of the y-axis shows the space with the high class of the dog food, and the – direction (left) can be the space with the lower class of the dog food and slightly lower price. The + direction (upward) from the center of the x-axis is the space with the high rates of calcium, crude fat, and crude protein, which are the main nutrients. The – direction (downward) can be interpreted as the space with the slightly low contents of the main nutrients.

Upon looking at the projection results of the positioning map on Figure 6, there were the products in the following order in terms of the highest dog food class in the space: 1 (Natura Pet Natural Core Organic Eco1 Lamb), 9 (Cargill Agri Purina Nutrena Gungang Baekseo Organic Barley & Salmon), 5 (ANF Organic 6 Free Lamb), 2 (Now Grain Free Adult DF) and 8 (OSP Natural O Organic Chicken & Mussel), and most of these products belonged to the organic class. They were followed by 14 (CJ PetFood O fresh Prime Meat & Oatmeal), 11 (ANF Premium Lamb 28) and 4 (NF Holistic Lamb & Rice), and the holistic class and the super-premium class were positioned together. Among the highclass of the dog foods in the space, the following products were mainly positioned in the + direction (upward), centered on x-axis, in the order of the highest value: 7 (Pet n H Achime Hand Made Feed), 24 (InterPet Korea DobyJin) and 21 (CJ PetFood JERONY Wolf King). Among these products, five products were the organic class (7, 9, 1, 8 and 5), and the remaining three products were the holistic class (10, 2 and 6).
5. Conclusion and Discussion

This research extracted the functional attributes that constitute dog food products using the multidimensional scaling method, and identified the dimensions and structure through positioning map. A positioning map is a very important analysis technique and strategy in the modern marketing enabling effective marketing activity. There are several reasons: First, market's competition structure can be identified. Since consumers perceive that the brands close to a company's own brand are similar and substitutable, such a relation is regarded as competitive relation. Second, the characteristics of the products that consumers want can be understood by identifying the position of an ideal product or brand, through which consumer needs can be grasped, and market can be segmented. Third, market opportunities can be identified by analyzing consumers' ideal point and competitor brand's relative position together, based on which competitive marketing strategies can be established. Fourth, information on where one's own company's brand should be positioned is offered by examining the gap of the market.

From the results of this research, Korean brands took up high ratio in the low priced products, and mostly foreign brands took up high priced and high class products. Not to be inclined to one group by awarding fairness to the fullest by each level of dog food in the process of selecting 24 products used in this research, the products were extracted based on the sales volume of Korea's largest price comparison search site, “enuri.com,” and all Korean brands were not low priced products. In the Korea's major producers, holistic class and super premium class, as well as organic farming class, were developed to quite degree, and they make efforts a lot to dominate the Korean pet dog market, where foreign brands are positioned. However, Korean producers have shorter history than foreign brands, and brand exposure is smaller than the foreign brands. Therefore, Korean brands' sales are conjectured to be slightly lower than the foreign brands. Because pet dog culture and industry developed more abroad than in Korea, and they were introduced from abroad, consumers' reliability on foreign brands is considered higher.

Also, animal hospitals and pet shops, which can be major distribution network in terms of distribution process and channel, mainly sell high quality dog foods. And therefore, the Korean brands’ distribution channels are insufficient. Lastly, the reason of low sales of many Korean brands can also be that the unit packing is higher than foreign brands. Many Korean brands' packing unit is mostly large packing of 15-30kg, and the foreign brands' main packing unit is 1-5kg. Because unit price per gram becomes lower as packing unit increases in view of product feature, therefore, Korean brands' prices had no other choice but to be lower.

The outcome of this research can be that the Korean brands’ super premium class with slightly high main nutrients and middle and middle-low prices can be viewed as having the highest competitiveness from the efficient preemption of market gap, avoiding fierce competition structure. There is a need to carve brand image through aggressive brand marketing, because the Korean brands' exposure and recognition are lower than those of the foreign brands. What should not be ignored in this process is that brand naming structure of pet dog foods mostly consisted of company name, brand name and product name (i.e. OSP Natural O Organic Chicken & Mussel). Because the dog food products have quite longer names, it is very difficult to be carved into consumer's brain. In this regard, Korean large companies need to establish differentiated brand strategies on whether to stress company name or brand name. Also, researches should be continuously carried out in order to inculcate functional benefits in consumers, as well as brand's symbolic benefits.

6. Acknowledgement

Funding for this paper was provided by Namseoul University.

7. References

1. Piotr P, Witold D. Interactive data mining by using multidimensional scaling. Procedia Computer Science. 2013; 18:40–9.
2. Thulasi BN, Sambasiva R, AnandaRao A. Hadoop based Feature Selection and Decision Making Models on Big Data. Indian Journal of Science and Technology. 2016Mar; 9 (10):1–6.
3. Mika S. Multidimensional Joint Scale and Cluster Analysis. Procedia Computer Science. 2015; 61:11–7
4. Periasamy C, Rama N. Bi-Analysis Recommendation for Utilization of ICT in E-Governance Service for BSNL using
Data Analysis. Indian Journal of Science and Technology. 2016 Jan; 9 (4):1–7.
5. John HH. Profitable Product Positioning. MSU Business Topics. 1973;27–32.
6. David AA, Gray JS. Positioning Your Products. Business Horizons. 1982; 25(3):56–62.
7. Russell IH. Benefit Segmentation: A Decision-Oriented Research Tool. Journal of Marketing. 1968 Jul; 32(3):30–5.
8. Whan PC, Bernard JJ, Deborah JM. Strategic Brand Concept Image Management. Journal of Marketing. 1986 Oct; 50(4):135–45.
9. Torgerson WS. Theory and methods of multidimensional scaling. New York: John Wiley and Sons; 1958:91.
10. Kruskal JB. Analysis of factorial experiments by estimating monotone transformation of data. Journal of the Royal Statistical Society. 1965; 27:251–63.
11. Roger NS. The Analysis of proximities: Multidimensional scaling with an unknown distance function. Psychometrika. 1962 Jun; 27(2):125–40.
12. Douglas CJ, Jih-Jie C. Analysis of individual differences in multidimensional scaling via ann-way generalization of Eckart-Young decomposition. Psychometrika. 1970 Sep; 35(3): 283–319.
13. Yoshio T. Multidimensional successive categories scaling: A maximum likelihood method. Psychometrika. 1981 March; 46 (1):9–28.