VISUALIZING THE EFFECTIVENESS OF PRODUCT PORTFOLIO WITH RESPECT TO PRODUCT SPECIFICATIONS

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Abstract

Most companies consistently analyze product portfolio to gain insights for establishing future strategies. The effectiveness of portfolio a kind of analysis index referring to market share of portfolio with respect to the number of models in portfolio. Since there are too many products in the market, companies need to divide market into comprehensible size for analysis. Traditionally, market segmentation is used for categorization. However, it has limitations on implementation especially in fast-changing markets consisting of an excessive number of products. To overcome this issue, we propose a new method to divide a market with respect to product specifications in the perspective of engineering design. Since it is conducted on market data, practitioners are able to analyze market objectively by reflecting up-to-date market situation. We adopt self-organizing map as a clustering method to visualize the effectiveness of portfolio. Engineering designers are able to gain clues on candidate models for elimination and the direction of specifications for new models from visualized analysis results. We develop a Matlab-based software to enhance usability for practitioners.

Keywords: Portfolio management, Portfolio effectiveness, Market implications, Visualisation, Market group

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1 INTRODUCTION

Most companies compose product portfolio to meet various needs in the market. Product portfolio refers to various products released in the market as a result of strategic decision. Enterprises develop various products with different specifications to cover more customers with different preference on products. As more components are modularized and interfaces are standardized, it is easier to develop various products (Gershenson et al., 2003). In this reason, product variation is especially prevalent in electronic consumer markets. For example, an electronic company has a portfolio of microwave consisting of 250 (Salvador et al., 2002).

However, too broad portfolio often results in cannibalization and exacerbates the complexity of operation. Similar products are not able to differentiate themselves. And they reduce potential sales from each other. In reality, consumers have difficulties in distinguishing the characteristics of various products in a store (Huffman an Kahn, 1998). Also, increasing variety of products leads companies to higher complexity in operation. To produce and deliver various products, business process and related organizations become complex as well (Child et al., 1991). Since complexity induces non-valuable cost in exponential manner with the variety of products, product variety burdens manufacturing companies (Wilson and Perumal, 2009). Therefore, managers attempt to manage product portfolio within a reasonable variety.

It is important to understand the effectiveness of current product portfolio for managing an existing product line and develop new product models. The effectiveness of product portfolio refers to the market share of product portfolio with respect to the portion of models of the company in the market. Since each product is released for targeted customers, sales of portfolio is supposed to increase as more products are introduced (Cooper et al., 2002). By comparing the portion of models in the market and market share of portfolio, companies are able to acknowledge the soundness of current product mix. Based on this understanding, products with poor sales are candidate for elimination. Also products with high-sales volume provides product developers clues about how to determine product specification for new models.

Traditionally, marketing departments segment market with geographic or demographic criteria for analysing the effectiveness of product portfolio and establishing a portfolio strategy (Armstrong and Kotler, 2000). Since there are too many products and their producers in the market, companies have difficulties in comprehend the market as a whole. They assume that people with similar cultural and geographical backgrounds have similar preference. By segmentation, they aim to cluster consumers with similar preference on product specifications (Wedel and Kamakura, 2000). On the top of segmentation, they set target customers and develop new products in order to meet the need of targeted users. However, this approach contains some limitations such as subjectiveness of segmentation criteria, difficulty of earning required information, and difficulty of sustaining up-to-date information.

To overcome these limitations, we provide an alternative view on market purely based on product specifications. We cluster the whole market into small-size market groups with similar product specifications. We assume that each product generates a granule market containing consumers who buy it. Therefore, a market group consisting of granule markets with similar product specifications possesses customers with similar preference on product specifications. In our approach, a market group is a basic unit of analysis for product portfolio instead of a market segment.

We develop an application program based on Matlab software to represent the effectiveness of portfolio. This program presents overall market landscape by clustering products into market groups. For visualizing clustered results, we adopt self-organizing map as a clustering method. Managers are able to comprehend the effectiveness of its portfolio for each market group at a glance. Also it provides detailed specification information for each market group. Based on it, product developers are able to gain insights on the direction of specification for new models.

2 CONSTRUCTING MARKET GROUP

Since there are too many products in the market, market analysers often divide market into a reasonable size to comprehend it. Especially, a myriad number of models exist in the market of electronic consumer products. For example, there are 772 models in Korea notebook market in January 2011. In a view point of customers, they do not consider all products in the market. Instead, they compare products within competitive relationships when they purchase a product. That is, a potential notebook customer in January 2011, Korea might consider not all 772 models but several models best suited for his/her preference. Therefore, it is important to cluster products in the market into the group of products in competitive relations.

Market segment is widely used for analysing market and establishing a portfolio strategy. The basic principle of segmentation is to cluster consumers who have similar preference on product specifications (Wedel and Kamakura, 2000). The segmentation method assumes that people with similar segmentation variables such as demographic, geographic, psychographic, or behavioral characteristics share similar preference on product specifications (Kotler, 1991). Based on segmentation, enterprises design products for a targeted segmentation and position them.

Market segment, traditionally used for dividing the market, has some limitations in implementation. At first, the establishment of segmentation might be subjective. In practice, segment criteria are selected in a heuristic manner. However, many practitioners adopting segmentation are not confident in selecting proper segmentation variables for analysing their industries (Dibb and Simkin, 2001). Secondly, it takes too long time to analyse the market with segmentation frame (Dibb, 1998). Although a focal company acknowledges each product model belongs to which market segment, it takes time and efforts to analyse products position of competitors. Since product life cycle is getting shorter and the number of models is growing, market situation has changed while practitioners gather data and analyse them.

We propose *market group*, a different unit to divide market purely based on product specifications, to understand the effectiveness of product portfolio in terms of engineering design. Following utility theory (Fishburn, 1968), we assume that a consumer buys a product providing the greatest utility to him/her. Therefore, a set of consumers who buy the same product can be considered as ones who possess similar preference structure on product specifications. We consider each product has a granule market consisting of such buyers. By clustering products with similar product specifications, granule markets possessing consumers with similar preference are clustered. We refer clustered granule markets as a market group. The market group is a basis of analysing the effectiveness of product portfolio instead of market segmentation.

Analysis on market group has following advantages. Since product specifications are objective values, clustering criteria is objective. It is able to resolve difficulties such as selecting segmentation criteria and threshold values of categories. Also, this approach enables practitioners to analyse the market based on up-to-date data. It is quite easy to gather product specification data in the market. Therefore, product engineers can make a decision based on the analysis results of current market. Lastly, product engineers do not need to interpret the preference of the market segment to proper product specification. Since clustered results show product specification itself, product engineers recognize the effectiveness of portfolio intuitively.

3 THE EFFECTIVENESS OF PRODUCT PORTFOLIO

For each market group, the effectiveness of portfolio can be analysed. When the company composes product portfolio, it expects each product to generate proper sales volume. Therefore, the effectiveness of product portfolio can be evaluated as the market share of portfolio compared to the portion of products in portfolio as Equation (1).

$$Effectiveness\ portfolio = \frac{market\ share\ of\ portfolio}{portion\ of\ \mathrm{mod}\,els\ in\ portfolio} \tag{1}$$

Effectiveness is evaluated in either whole market or an each market group. Although market share is relatively reasonable, its portfolio might not be effective if it consists of excessive number of products. Composition of product portfolio has impact on the effectiveness. Products of similar specifications compete on customers with similar preference. As the number of products of similar specifications increases, market share of each product decreases as a result of competition. Cannibalization refers to the competition between products of the same company (Kim and Chhajed, 2000). Improper composition of portfolio exacerbates cannibalization and lowers effectiveness. Figure 1 represents the difference between differentiated and non-differentiated portfolio. If products of the company have similar specifications, potential customers, represented as market coverage, are overlapped as Figure 1(a). Whereas, cannibalization is less likely to occur when portfolio is well differentiated as Figure 1(b). The results of effectiveness analysis are able to indicate clues to reconfigure portfolio in consideration of product differentiation.

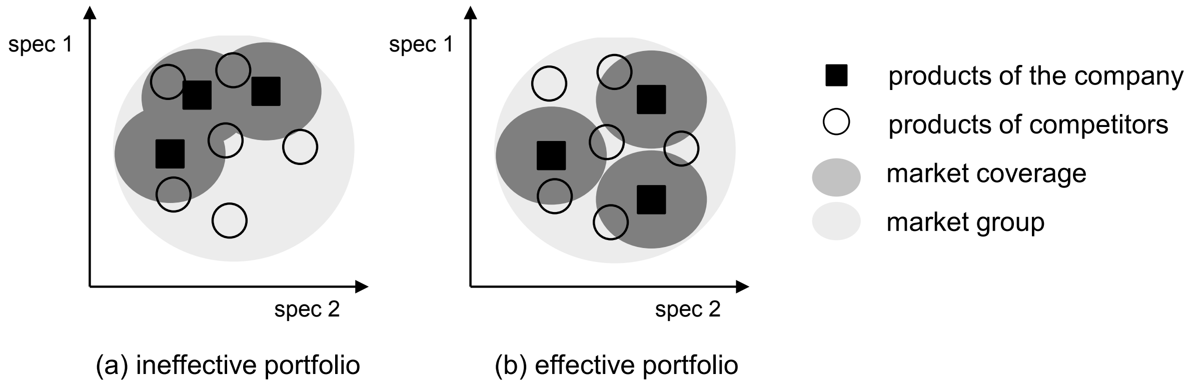


Figure 1. The comparison of different portfolio composition

4 GROUPING METHOD: SELF-ORGANIZING MAP

A top priority of selecting clustering technique is the visualization of results in two dimensions. We attempt to project clustering results on two-dimension screen since practitioners require the visualized effectiveness of their portfolio to understand market situation as a whole. Since a product has many specifications, the clustering results are often multi dimensions. If the number of specifications exceeds four, it is unable to represent market group as Figure 1 where the product has only two specifications. There are some data mining techniques for dimension reduction. By conducting correlation analysis, redundant variables can be eliminated. For uncorrelated variables, principal components analysis is widely used for reducing dimensions (Shmueli et al., 2007). It finds a few principal components, weighted sum of existing variables, to reduce dimension. However, it has limitations that a user needs to interpret the meaning of principal components.

Self-organizing map is the most suitable clustering method for constructing market group in the consideration of visualization. Self-organizing map is developed by Kohonen (1990). Once a user sets lattice of cells to be clustered, the algorithm of artificial neural network clusters data to each cell through many iterations. Clustering algorithm for constructing market groups is explained in Appendix. In a cell, products with similar specifications exist as Figure 2. Each cell, a hexagon, represents market group. Since the seed of each cell is updated by reflecting the average of seeds of neighbourhood cells, spatially adjacent cells represent similar characteristics. As a result, distance between cells indicates the dissimilarity between market groups. For example, market group K and L are more similar than market group B and L in Figure 2. Therefore, users comprehend the market as a whole with the recognition of similarity between market groups.

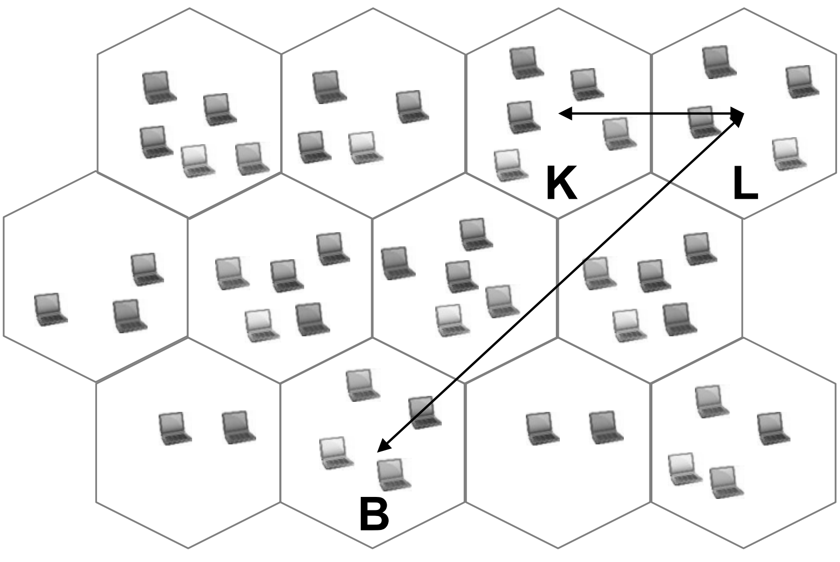


Figure 2. Grouping market with self-organizing map

5 CASE DESCRIPTION: NOTEBOOK MARKET IN KOREA

We implement our developed methodologies on notebook market in Korea. Notebook industry is one of best candidates for applying our methodology in following reasons. At first, numerous enterprises and their products exist in notebook market. In January 2011, there are 772 notebook models provided by 19 brands. Also, product life cycle of notebook is short that market changes rapidly. In fact, about one third of models were released within three months. Therefore, quick analysis for excessive number of products is required. In this perspective, analysing product portfolio based on market group is suited on this industry.

We use monthly market data provided by GfK (www.GfK.com) for analysing the market. The dataset contains the lists of notebook models in January 2011, Korea. In details, the data contains the information of model number, brand, 31 kinds of specifications, price, and sales volume for each model. On the top of GfK market data, we supplement weight information of each model.

6 PREPARING CONSTRUCTION OF MARKET GROUP

Although self-organizing map represents clustered results in two dimensions, it is required to reduce the dimensions, the number of specifications, before clustering. The first criteria of reducing dimensionality is usefulness of categorical variable for clustering. If most models contains the same categorical value for a single specification, the specification is useless for clustering. In notebook market data, more than 95% of models has the same specification value for 16 categorical specifications such as adoption of wireless lan, remote control, process brand and so on. The second option is using correlation analysis between numerical specifications. If one specification is strongly correlated with other one, one of two can be a representative of them. In the case, resolution of screen is highly correlated with the size. Therefore, we set the size of screen as the representative of resolution.

Remaining categorical variables might be converted into numerical variables. Categorical variables increase the number of dimensions with respect to the number of categories. If a specification has *n* categorical values, *n-1* dimensions are required to represent it with dummy variables. However, numerical specification possesses only one dimension. In the case, we adopt benchmark score provided by Passmark software (www.cpubenchmark.net) to represent the performance of CPU numerically. The categorical values related to CPU processor such as process number, the number of cores, processor brand is substituted with benchmark score. Other categorical specification conceived as not important to customers are eliminated from list after consulting with domain experts. As a result, specifications for clustering market are weight (KG), size of screen (inch), CPU benchmark score, size of hard disk (GB) and size of RAM (MB).

To calculate the distance between the seed of cluster and each product, specifications are normalized between zero to one. Since units of specifications are not compatible, they have to be normalized in the same scale. We adopt minmax normalization method for clustering (Xu and Wunsch, 2008). Each specification variable is normalized as Equation (2).

$$Norm\_A_{spec\_x} = \frac{A_{spec\_x} - Min_{spec\_x}}{Max_{spec\_x} - Min_{spec\_x}} \tag{2}$$

Normalized value of specification *x* of model A is relative value compared to maximum and minimum value of specification *x* for all models in the market. The distance between two notebook models, A and B, is the sum of difference between normalized values for all specifications as Equation (3).

$$Dist_{(A,B)} = \sum_{spec\_i} \left| Norm\_A_{spec\_i} - Norm\_B_{spec\_i} \right| \tag{3}$$

This distance is used for clustering. For example, distance between two notebook models, X and Y, is calculated as Table 1.

Table 1. Example of calculating distance between two product models

	Model X		Model Y		Difference
	Original value	Normalized value	Original value	Normalized value	
Weight (KG)	2.4	.387	1.2	.168	.219
Size of screen (inch)	15.6	.761	10.1	.373	.387
CPU benchmark score	1251	.158	286	.008	.150
Hard disk (GB)	320	.309	160	.146	.163
RAM (MB)	2048	.200	1024	.067	.133
Distance					1.053

7 MARKET ANALYSIS: PORTFOLIO COVERAGE ANALYSER SOFTWARE

In following paragraphs, the analysis is executed in the perspective the company L. L is one of major notebook manufacturing companies in Korea. In January 2011, there were 772 models in the market. The number of notebooks sold in the period was 138,800. L's market share was 23.6% whereas the portion of L's models was 33.8%. It means that the portfolio of L was ineffective. Compared to the number of models released in the market, L sold relatively the low number of products. Reason of low effectiveness in the perspective of product specifications is able to be found through market analysis.

We develop Matlab-based software called *portfolio coverage analyser* to enhance usability for practitioners. This software is operated with input of market data pre-processed as an excel file. Since Matlab provides a package to generate a self-organizing map, we choose Matlab as an analysis program. Basically, Matlab software is operated on command window by entering codes. We utilize graphic user interface provided by Matlab. This tool enables practitioners to use portfolio coverage analyser by point-and-click control as Figure 3.

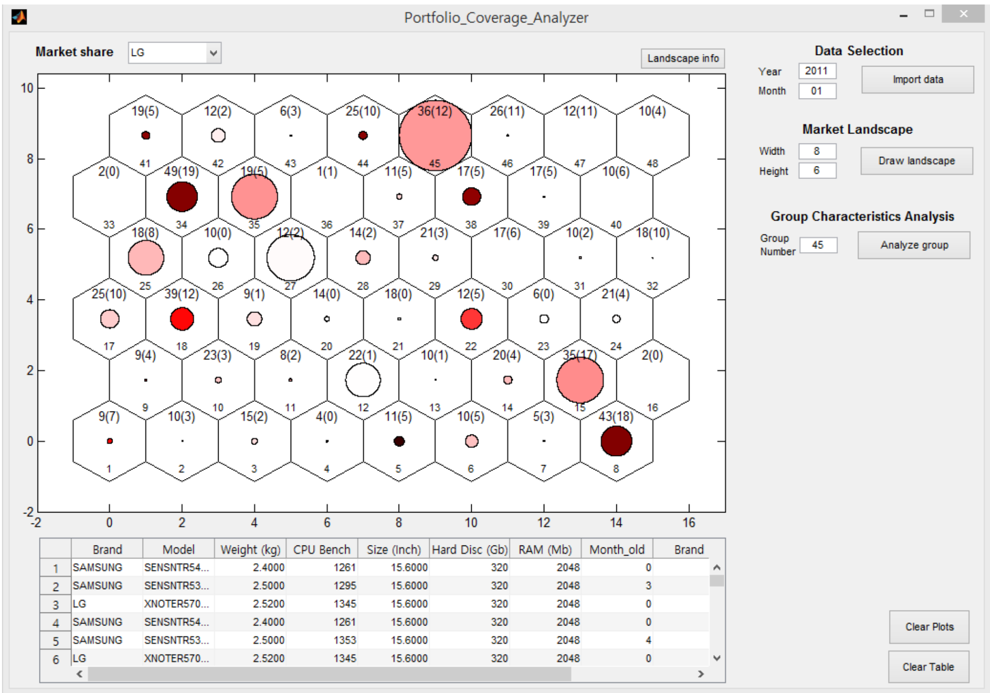
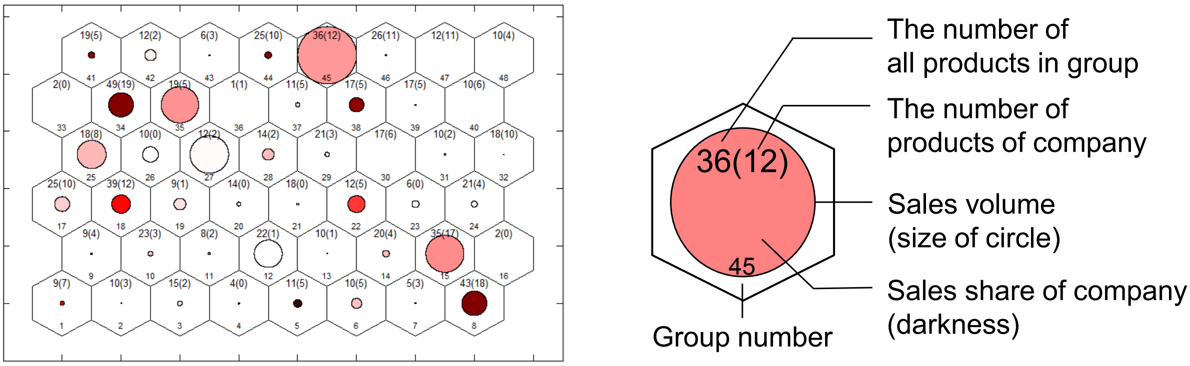


Figure 3. Portfolio coverage analyser

7.1 Market landscape

By using self-organizing map, overall market is analysed as in Figure 4. We refer to the graphical results of grouping as *market landscape*. With market landscape, practitioner is able to comprehend overall market situation. Since we set the lattice of market landscape as 8 x 6, there are 48 market groups in landscape.



(a) Market landscape **(b) Market group**

Figure 4. Illustration of market landscape and market group

Market landscape provides basic information of each market group as in Figure 4(b). In each group, the lower number indicates market group number. The size of circle presents the total sales volume of the market group. In this case, group 45 is the largest one. The color of circle represents the share of company's share. The higher share the company possesses, the darker the color is. Among many market groups, L has high market share in group 5, 8, 34, and 38, which are relatively small-size market. The upward number in circle indicates the number of total products in the group and L's products respectively. In group 45, there are 12 products of L among 36 products. The portfolio of L is not effective in this group. Whereas about one third of models are released by L, the sales share of L is only 20.2%.

In the window of market landscape, the characteristics of each market group are not represented. Two axes does not give any information about the characteristics of group in terms of specifications. When clustered by self-organizing map, products are allocated to the group of which the seed is the closest. Therefore, the seed information represents the characteristics of each market group. Since a seed is a multi-dimension variable, we represent the value of seed for each dimension as Figure 5. The darker market group represents high value of the specification. For example, products in left upper groups are larger with respect to size and heavier with weight.

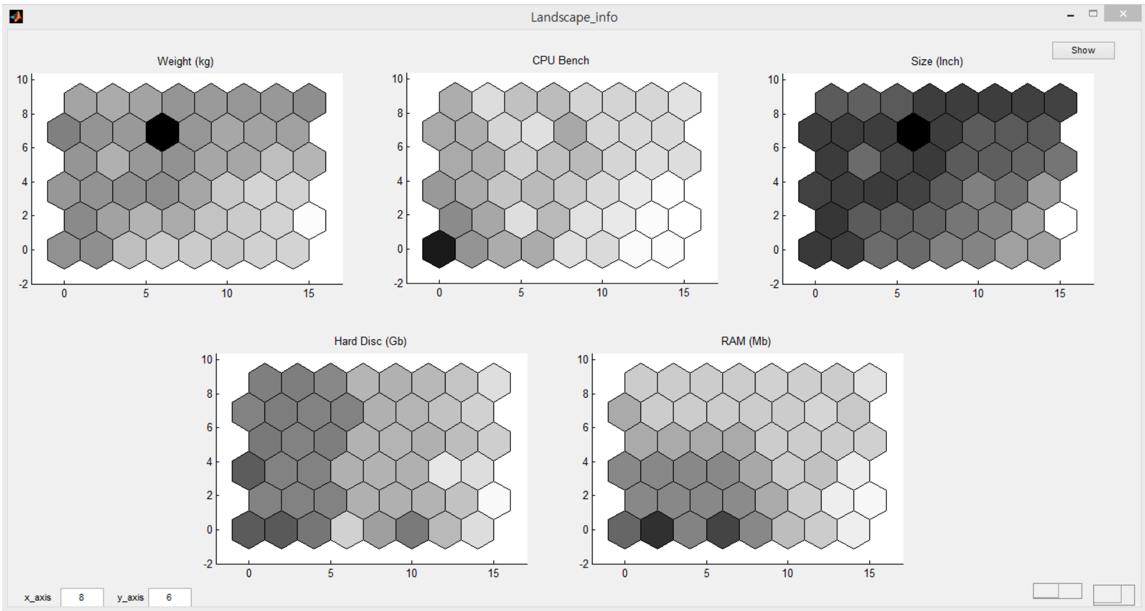


Figure 5. The window for the information of market landscape

7.2 Market group

For each interesting market group, the software provides detailed information as a pop-up window for managers to gain insights. At first, a pop-up window represents the distribution of model frequency for each specification and price as Figure 6. In this market group, weight, CPU performance and price are distributed. However, the capacity of hard disk, that of ram and screen size are almost the same for all products. Therefore, these specifications might not be differential points within the market group at current situation. The left lower table contains the information of products in the market group. Practitioner is able to check each product in the group. The right lower table represents the mean specification of products in the group.

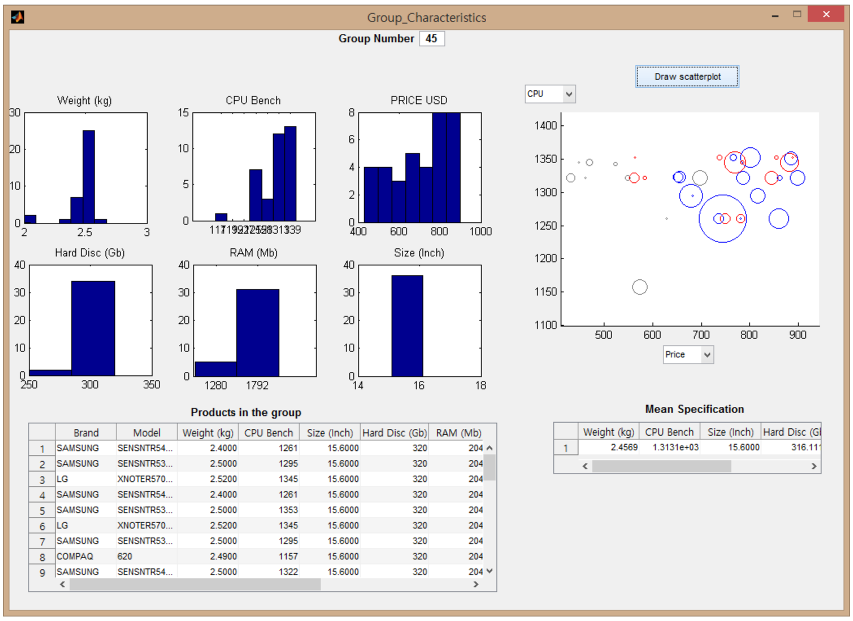


Figure 6. Window for analysing the characteristics of the group

The dispersion map represents the dispersion of products in the market group. Size of circle stands for the sales volume of each model. The products of L is highlighted with red color and its rival, S, is done with blue. Figure 7 represents dispersion map with different specifications, weight, CPU bench score and price, as axes. Practitioner is able to gain insights that notebooks with lower weight and cheaper price are sold well. Models with high CPU performance were sold less than models with less performance and lower price and weights. Most products of L is heavier and more expensive than average whereas they have good performance. This is why the effectiveness of L in this market group is low in this market group in the perspective of specifications. An engineering designer of L might design new models with lighter with less performance to enhance effectiveness in this group.

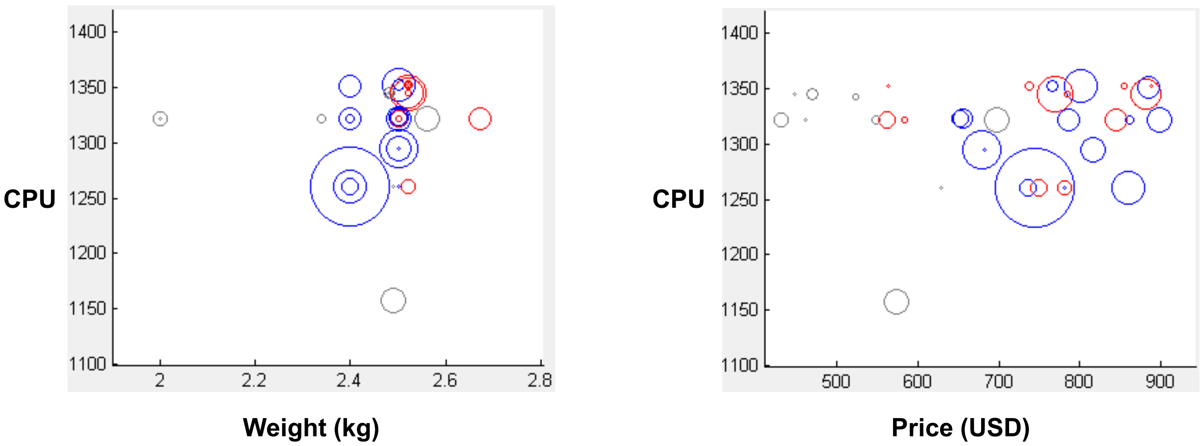


Figure 7. Dispersion map

8 CONCLUSION AND FUTURE WORK

Managing product portfolio is important for companies aiming to maximize profit within limited resources. Effective portfolio helps achieve this goal by possessing sufficient sales volume per model in average. Market analysis is a basic step for establishing effective portfolio. However, the excessive number of product models and fast-changing market make practitioners difficult implement market segmentation. It requires long time and large efforts. Also, engineering designers need to interpret the results of analysis into the view point of specification. We propose a new methodology to divide market based on specifications. Since it is conducted on the top of market data, it requires less efforts and is able to reflect fast-changing market situation. To enhance usability of practitioners, we develop a software and conduct case study on notebook market in Korea.

In the future, we plan to expand this study for following directions. At first, we attempt to consider the change of market landscape in time series. This study analyses market at a time point, a certain month. If trend of change in market group is able to be recognized in analysis, it can provide engineering designers clues to plan future product models. Secondly, we plan to apply this methodology to other industries. Through implementation of software on various industries, software and methodology can be upgraded with feedbacks.

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APPENDIX

The appendix explains the mechanism of self-organizing map used as a clustering technique in this study. Following contents summarizes the research of Kohonen (1990). Before using self-organizing map, a user needs to designate the lattice of map. If user set the number of rows, x, and columns, y, $x \times y$ groups are created. At first, self-organizing map initialize the seed of each group. The seed consists of the same dimension as products. The SOM package in Matlab software initializes seeds by reflecting data characteristics. After the initialization of seeds, each product is allocated to each group of which seed is closest to it. Then, all seeds are updated to be close to its neighborhood seeds with randomness. Update of seeds and allocation of products are iterated within the designated number. Followings are the algorithm of self-organizing map.

Algorithm

0) Initialize the seed of each group
1) Allocate products to group of which seed is the closest one
2) Update the seed and repeat from 1) until the iteration number is lower than the designated number