SELECTED PROBLEMS ARISING WITHIN CLUSTER ANALYSIS USAGE FOR MARKET SEGMENTATION

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Abstract

The present-day highly competitive environment on the product and service markets makes businesses change their standard strategies and seek new ways of serving the markets and creating a differentiated value for the customers through cooperation of the value network entities. An important role in these processes is played by market segmentation in accordance with the customers' requirements and shopping behavior on all markets, including the metals, metallurgic and metalworking products manufacturers' market. Such market segmentation supports increased profitability not only of the enterprise itself, but also of the entire value network. Modern market segmentation methods are based on combinations of various segmentation criteria. These combinations can be identified by a detailed analysis of the customers' behavior, particularly of the fact what the customers buy and why. Subsequently, it is necessary to compile a profile of the defined market segments to be able, within the cooperation of the value network entities, to apply a differentiated market strategy towards these markets. The paper deals with the cluster analysis as the most widely used method for customer segmentation and the problems arising within standardization of the ordinal scales used for measurement of the customers' preferences. It is because the commonly used standardization by conversion to the normal standardized distribution might lead to confusing outcomes. The paper analyses such outcomes and also specifies how to face these problems.

Keywords: cluster analysis, market segmentation, value network

1. INTRODUCTION

In the present highly competitive market environment, businesses are searching for new ways of servicing the markets and creating a differentiated value for customers [1]. At the same time, it is no longer enough if they pay their attention to the direct customers only, but it is essential to establish effective cooperation among all the value network entities**,** when this cooperation can take various forms [2], [3]. The performance of the value network**,** as well as individual entities depends on whether the value network is created in a systematic way and activities performed in it are coordinated [4]. An important role in these change processes is played by market segmentation on the basis of the customers' requirements and purchasing behavior and environmental and social expectations [5]. Such segmentation of a market contributes to increased profitability not only of the business itself, but of the entire value network [6]. Market segmentation methods are based on combination of various segmentation criteria, which we can identify by means of e.g. analysis if the customer behavior and the customer requirement preferences. Subsequently, it is necessary to compile a profile of the defined market segments to be able to apply, within cooperation of the value network entities, a differentiated marketing strategy towards these markets. The most widely used market segmentation methods include the cluster analysis. It is a number of different procedures having a common target to find objects that are as similar as possible in accordance with the given points of view. The resulting clusters then represent, for example, market segments. Application of the cluster analysis for market segmentation is accompanied by the two following strategic decisions: what criteria to use for input into the cluster analysis and how many clusters to discover. From the technical point of view, it is a choice between the methods of hierarchical and non-hierarchical clustering. The decision on the used criteria is connected with the question of the need for standardization of

the variable, where analysts show various opinions on this topic [7]. The thing is that the commonly used standardization by conversion to normal standardized distribution may result in misleading outcomes.

Therefore, the paper first aims to identify the present trends in the process of segmentation taking account of the possibilities of using the cluster analysis, to point out the problems relating to the use of attitude scales for measuring the level of the attitude segmentation variables, and to analyze these problems and specify how to face these problems on a model example. This should then result in a more sensitively performed segmentation affecting the effectiveness of the behavior of the entire value network on all markets, including the metals, metallurgic and metalworking products manufacturers' market. Target literature search in scientific literature, the experience with the cluster analysis in SPSS and the statistical analysis of model data were used as research methods and sources.

2. RECENT TRENDS IN THE PROCESS OF MARKET SEGMENTATION

The main points of segmentation are identification of important segmentation criteria and uncovering of the found segments. The market segmentation is defined as a process dividing the customers into homogenous groups with identical needs, wishes, and comparable responses to marketing and communication impulses [8]. McDonald and Dunbar extend the definition to the process of clustering the customers, or potential customers on the market, into such segments where the members share a similar level of interests in the same or comparable sets of needs, which they satisfy in a similar way [9]. It is the process of dividing the market into internally homogenous, but mutually heterogeneous groups having the tendency to respond differently to the marketing mix variables and various marketing strategies [10]. By using segmentation to create a suitable marketing mix, it is possible to get a competitive advantage [11]. It is also a way how to solve the problem that it is practically impossible to satisfy each customer's single need individually [9].

The first essential questions that must be solved in connection with segmentation are the conditions of homogeneity and heterogeneity [6], [12]. In practice, this refers to finding such a combination of factors whose mutual effects produce as different behavior of the segments as possible, where the members of a particular segment respond as similarly as possible. The first of the factors is the basis of segmentation variables, on the basis of which we create clusters. The second set of variables is then related to a particular product, service, marketing strategy, and we require that it produces the biggest possible difference between the segments [6]. Each segment must be characterized by its identity and adequate size [13]. The uncovered segments are often unstable and variable in time [14]. Therefore, it is necessary to repeat the process of segmentation periodically. The other requirements include availability, measurability, sufficient size, readiness for action, objectiveness and involvedness of these segments [6], [15]. The basic requirements concerning the data describing segments have been dealt with by a number of other authors, e.g. [16].

The segmentation process itself has been clearly described by e.g. authors, who divide it into four stages: definition of the given market, identification of the important criteria, uncovering of the segments, and development of the segment profiles [6], [12]. In the first stage, the basic questions of the following type should be answered: What should be segmented and why? Who is our potential customer? Where, in what market environment or on what level should the status of the segmented market be captured? [17].The grounds for definition of the given market have been dealt with by e.g. [6], [12]. Drummond et al, describe these grounds using the approach of so-called customer behavior, according to which understanding of the customer's purchasing behavior is the central theory to the successfully discovered and usable segmentation criteria [18]. Primarily, the customer behavior characteristics should be the basis, and then the market should be defined on the basis of the product type and geographic characteristics. Selection of the most convenient criteria for market segmentation belongs to the most important stage of this process [9]. The aim is to choose such market behavior characteristics that successfully help express the homogeneity of segments on the one hand, and on the other hand the heterogeneity from any other segments. There are a lot of ways how it is possible to arrange individual segmentation variables and categorize them in the literature and practice. In the case of

the B2C market, they can be categorized into groups: geographic, demographic and psychographic categories [19] or also into the category of behavioral variables [14], [15], [20]. Drummond and Jobber introduce profile variables, which represent the category arisen by combination of behavioral and psychographic categories [18], [21]. Segmentation variables can also be classified as defining and explaining [6], [12]. The third way of categorization is use of 2x2matrix, where the variables are evaluated and arranged from the points of view of: basic/specific (behavioral) and objective/deriver (psychographic) [8]. In a very similar way they are divided by Baker, who proceeds from two groups of questions: Who is our customer? and What and why do they buy? [22]. Segmentation criteria for the B2B market have to be defined in a slightly different way on the basis of the macro-segmentation variable concerning the customer's business as a whole and the micro-segmentation variable characterizing differences in the requirements, preferences and circumstances of the purchase and use of the product directly in the customer's operations [23], [24]. The choice of a suitable categorization model may be very important for clear arrangement and easy orientation while using more kinds of segmentation variables. However, it is the choice of the right segmentation variables what is important for the market segmentation. Stage 3 aims to find such combinations of the selected criteria that can best uncover segments from the point of view of their homogeneity and heterogeneity. These criteria are marked from the point of view of the cluster analysis as "clustering variables". They should bring a clear idea of which market segment a particular customer belongs to. At the same time, each segmentation analysis should include at least one customer behavior criterion [12]. New, innovative combinations of segmentation variables could also uncover new segments on the traditional, mapped markets [18]. The last stage of segmentation brings more detailed characteristics of individual groups using more development segmentation variables that were not used in the previous two stages and potentially a more detailed analysis of the basic variables [12]. The aim is to obtain sufficient amount of relevant information to get effective marketing orientation on a particular uncovered segment, not only from the point of view of the sellers' offer, represented by the 4P model, but primarily from the point of view of the perception of the offer by the customer, represented by the 4C model. The optimal marketing mix results from application of the 4P model to the initial 4C model [15].

3. CLUSTER ANALYSIS - SELECTED PROBLEMS

Cluster analysis can be very well applied within market segmentation according to different purchasing behavior of customers, etc. Generally, it is possible to identify 3 basic factors on which the results of the cluster analysis are dependent: suitable segmentation variables, the rate of distances among clusters, and the calculation algorithm [25]. Hierarchical methods are based on the principle of gradual clustering or dividing on the basis of the rate of similarity or distance. To measure the distance, it is possible to use, for the cardinal data, the Euclidean, Hamming, or Malanobis distance, or Čebyšev's method. For dichotomous data, it is first necessary to create a four-pole chart and subsequently to apply e.g. the method of the Matching coefficient or Jaccard coefficient. Ordinal scales have to be standardized before processing, i.e. convert them to the normal standardized distribution [26]. The identified distances among all the objects are then recorded into a square symmetric matrix with zeros in the main diagonal, which is then used as an input for various hierarchical clustering methods (agglomerative and division methods), see more in [26], [27]. The hierarchical model outcomes can be clearly illustrated in e.g. a dendrogram or a bidimensional graph. The advantage of these methods is the fact that they are simple, and that they do not require sophisticated software applications. The disadvantage is the fact that the volume of input data is limited, and also the fact that they cannot, unlike non-hierarchical models, work with a preselected final number of clusters.

Non-hierarchical models are based on the principle of division of individual objects into a predefined number of clusters according to a predefined criterion (the number can be constant or it can vary during the analysis). These clusters are not further divided, but they are optimized by rearrangement of their elements in the way to achieve the optimal even distribution of objects inside the cluster while maximizing their mutual distances and dissimilarity of the clusters. The distribution quality criteria differ in accordance with the targets that the

process of clustering should achieve and on the basis of the structure of the analysed data. The best-known non-hierarchical methods include the iteration methods of K-means clustering and Two Step clustering. The latest methods include a non-supervised algorithm based on the principle of neural networks, so-called Kohonen maps [25].

In the process of segmentation, it is possible to take of the attitude scales making it possible to measure not only the contents of an attitude, but also its approximate strength (e.g. a Likert scale). As an example, it is possible to mention market segmentation according to the needs on the basis of the perceived importance or preference of the selected product parameters or services connected with the products. Use of the cluster analysis in such segmentation requires careful data preparation before its statistical processing. To avoid misinterpretation of the outcomes, it is necessary to be careful, while processing a set of data, about selection of a suitable combination of segmentation variables, about identification of the missing values in segmentation variables and about transformation of (or standardization) of segmentation variables.

The suitability of variables for segmentation depends on material requirements imposed on the obtained market segments (particularly the high rate of the segment heterogeneity), and so it makes sense to consider only such factors to which the customers adopt different attitudes. However, suitability of the selection of variables also has to be judged from the statistical point of view [28]. The cluster analysis methods require that only statistically independent variables stay in the set. Strict compliance with this condition decreases the number of considered variables. Therefore, it is only a group of variables among which there is not a strong dependence what is usually considered. Another possibility is decreasing the number of mutually correlated variables using specialized statistical methods, e.g. factor analysis.

A frequent problem of actual data sets from marketing surveys is the existence of missing values. A typical cause is the respondents' unwillingness to adopt a stance or wrong ticking of answers in the questionnaire (e.g. ticking of more answers in the attitude scale). Certain reduction in the unwillingness in answering can be achieved by choosing a suitable range of the scale containing a midpoint (the respondent is then not forced to adopt either a positive or a negative stance). Wrong answers can be reduced by choosing a suitable way of data collection, e.g. electronic completion of the questionnaires, assistance of questioners with completion of the questionnaires. As for work with the missing values, we can practically distinguish two basic approaches. The first of them requires replacement of the missing values on the basis of the obtained respondent's answers to some other questions, e.g. by replacement of the value with a selected rate of position, or by estimation of the value on the basis of regression analysis of the relationship between the segmentation variable and the other variables in the data set, where the needed data is available. The second possible approach is exclusion of the respondents with missing data. However, this may lead to a significant decrease in the scope of the analyzed set.

The main objectives of segmentation variable transformation include elimination of the influence of the range of the scale (e.g. standardization to a non-dimensional scale from 0 to 1), standardization of the found values using z-scores, etc., but also the efforts to satisfy the presumptions of the used methods (e.g. with the reduced possibility of choosing proximities in the available statistical software). A typical example is transformation of categorized data to a group of binary variables, with which it is possible to work in the same way as with numeric variables. In the case of using attitude scales, which from the point of view of the type belong to ordinal scales, there is a possibility of using proximities for quantitative variables without prior standardization (the variable is then seen as a numeric one with a low number of the sign modifications). However, in these specific cases it is desired that the ordinal scale contains a sufficient number of sign modifications (a seven-point scale from -3 to +3 or from 1 to 7, an eleven-point scale from 0 to 10, etc.) and, at the same time, the distance between all the neighboring points of the scale could be considered as approximately the same. Differently perceived distances between the neighboring degrees in the scale are usually caused by the choice of the wording of the strength of the stance. That is why it is convenient, when collecting data, to replace verbal evaluation of the scale with numbers and name the outside limits of the scale only. Scale standardization then

only has its importance in the cases where the segmentation variables are based on measurement of attitudes in scales of different extents.

However, during the segmentation on the basis of scales we faced another problem, which cannot be eliminated by the ordinary standardization of segmentation variables described in the literature. It is the situation where different respondents adopt similar attitudes, but they use a different area of an ordinal scale for their evaluation. This can be illustrated on the following example. We have answers from 9 respondents evaluating, using an eleven-point scale from 0 to 10, the importance of 3 parameters of a certain product (3 segmentation variables v_1, v_2 and v_3). The respondents consider all the product parameters important, but they prefer one of the parameters to the others (PREF1, PREF2 a PREF3). When evaluating the importance, they also use a different area of the scale (UP - points 9, 10, MIDDLE - points 8, 9; DOWN - points 7, 8). The obtained answers are shown in **Table 1**.

Table 1 Model data for analysis

ID	*Respondent*	v_1	v_2	v_3	$z_1^{(1)}$	$z_2^{(1)}$	$z_3^{(1)}$	$z_1^{(2)}$	$z_2^{(2)}$	$z_3^{(2)}$
1	UP_PREF1	10	9	9	1.67	0.67	0.67	1.15	-0.58	-0.58
2	UP_PREF2	9	10	9	0.67	1.67	0.67	-0.58	1.15	-0.58
3	UP_PREF3	9	9	10	0.67	0.67	1.67	-0.58	-0.58	1.15
4	MIDDLE_PREF1	9	8	8	0.67	-0.33	-0.33	1.15	-0.58	-0.58
5	MIDDLE_PREF2	8	9	8	-0.33	0.67	-0.33	-0.58	1.15	-0.58
6	MIDDLE_PREF3	8	8	9	-0.33	-0.33	0.67	-0.58	-0.58	1.15
7	DOWN_PREF1	8	7	7	-0.33	-1.33	-1.33	1.15	-0.58	-0.58
8	DOWN_PREF2	7	8	7	-1.33	-0.33	-1.33	-0.58	1.15	-0.58
9	DOWN_PREF3	7	7	8	-1.33	-1.33	-0.33	-0.58	-0.58	1.15

To achieve better illustration of the way of creation of clusters, we have drawn up a dendrogram of the method of hierarchical clustering in the statistical software of SPSS (the method of measuring a distance between two clusters; between groups linkage; proximity: Euclidian distance). The acquired dendrograms of cluster analysis using both non-standardized and standardized segmentation variables are a part of **Fig. 1**.

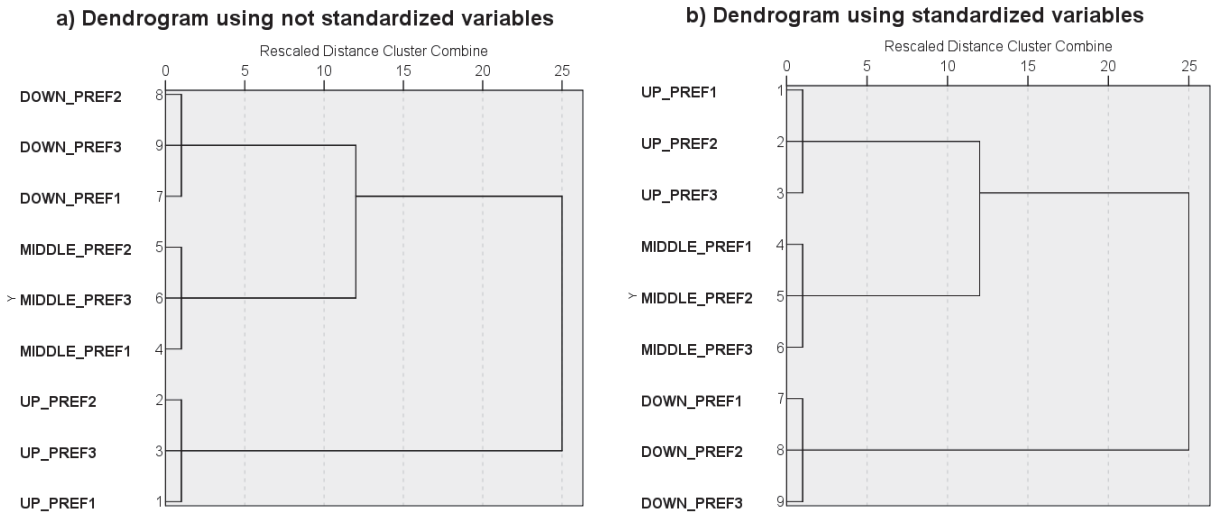

Fig. 1 Comparison of dendrograms using non-standardized and standardized variables

Segmentation variables have been standardized to z-scores in accordance with the formula (1):

$$z_{iv}^{(1)} = \frac{x_{iv} - \sum_i \frac{x_{iv}}{n}}{\sqrt{\frac{\sum_i \left(x_{iv} - \sum_i \frac{x_{iv}}{n}\right)^2}{n-1}}} \quad (1)$$

where x_{iv} is the value of variable v for respondent i and n is the number of respondents.

The performed analysis implies that the respondents will primarily cluster depending on the fact what area of the attitude scale they use (i.e. groups of UP, MIDDLE a DOWN respondents). As the respondents' answers are between 7 and 10 points in all the segmentation variables (i.e. the same range of the attitude scale was used in all the parameters), the classic procedures of variable standardization only affect the order in which three basic clusters connect. However, the difference in preferences of individual parameters (the strength of the attitude) is not sufficiently considered in cluster analysis.

This problem might be solved through a completely different approach to data standardization considering only the part of the attitude scale that is used by the survey respondents. Instead of standardization of segmentation variables, it would be possible to standardize answers of individual respondents. Even in such a case it is possible to use z-scores, which are however calculated for each respondent separately over all the segmentation variables according to the formula (2):

$$z_{iv}^{(2)} = \frac{x_{iv} - \sum_v \frac{x_{iv}}{m}}{\sqrt{\frac{\sum_v \left(x_{iv} - \sum_v \frac{x_{iv}}{m}\right)^2}{m-1}}} \quad (2)$$

where x_{iv} is the value of the variable v for respondent i and m is the number of variables.

The obtained dendrogram of hierarchical clustering after standardization of the respondents' answers is a part of **Fig. 2**.

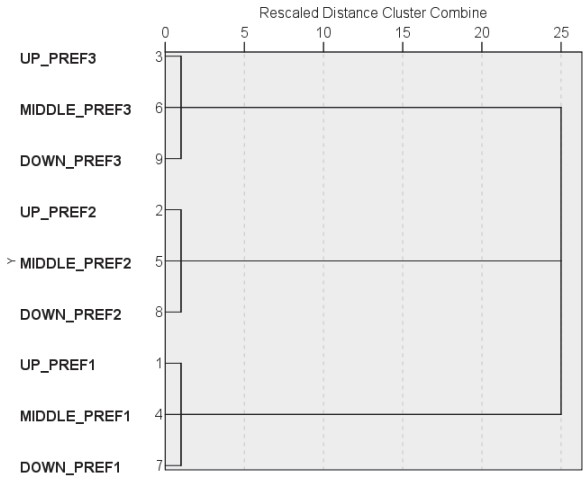

Fig. 2 Dendrogram using standardized responses

After elimination of the influence of using a different area and extent of the attitude scale, clusters are primarily created in accordance with the held preferences (i.e. a group of respondents PREF1, PREF2 and PREF3). Moreover, the order of connecting of clusters depends on the size of the detected differences in the attitude scale. As the illustrative sample of respondents evaluated the preferred parameter one point higher in all the cases, three basic clusters connect at the same time. Although by means of the mentioned standardization proposal the respondents are clustered according to different preferences of the product parameters, the

material importance of the positive and negative parts of the attitude scale is completely. In an extreme case, such a procedure may definitely connect two respondents who prefer the same parameter, but one of the respondents considers all the parameters in question as rather important while the second respondent considers them as rather unimportant. These consequences of such use of answer standardization have to be considered, particularly in interpretation of the created segments.

CONCLUSION

Segmentation criteria for the B2B market have to be defined a little differently from the B2C market using a macro-segmentation variable concerning the customer's business as a whole and a micro-segmentation variable characterizing the differences in requirements, preferences, and circumstances of purchase and use of the product directly in the customer's operations. Creation of new combinations of the selected criteria should bring a clear idea about the fact what market segment a particular customer belongs to, or also uncover new segments on the traditional and already mapped markets. The process of market segmentation can take advantage of scales, which measure not only the contents of an attitude, but also its approximate strength. Utilization of cluster analysis then requires careful preparation of the data before its statistical processing. To avoid misinterpretation of the outcomes, it is necessary, when processing the data, to pay attention just to the choice of a suitable combination of segmentation variables, and also to identification of the missing values and transformation of the segmentation variables.

However, the practical performance of market segmentation on the basis of scales brings another problem, which cannot be eliminated by common standardization of segmentation variables described in the literature. It is the situation where different respondents adopt similar attitudes, but in their evaluation they use a different area of the ordinal scale. Apparently, this problem can be solved through a completely different approach to standardization of the data consisting in considering only such an area of the scale which the respondents use in the survey. Instead of standardization of segmentation variables (the analysis implies that the respondents primarily cluster depending on the used area of the scale), we proposed standardization of answers of individual respondents. Such elimination of the effects of the use of a different area and extent of the scale resulted in clusters primarily created in accordance with the adopted preferences of individual parameters, i.e. in accordance with the strength of an attitude.

The impacts of utilization of the proposed different ways of standardization discussed in the paper should then lead to more accurate definitions of the market segments. And as a final consequence, this should result, within cooperation of the value network entities, in employment of a better-aimed differentiated marketing strategy towards these markets including market of metals, metallurgic and metalworking products manufacturers'.

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