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Original Paper

The use of correspondence analysis in exploring consumer purchasing behavior

Eva Matejková*, Vladimír Matušek

Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Institute of Statistics, Operations Research and Mathematics, Nitra, Slovak Republic

ABSTRACT

The aim of this paper is to present the use of multivariate statistical methods in the evaluation of questionnaire surveys. In particular, it is a presentation of correspondence analysis, a technique for graphically visualising the connections between the categorical variables being studied. Using the aforementioned method, we examine consumer purchasing behavior during the COVID-19 pandemic. The calculations were performed in the SAS EG statistical software. A contingency table that uses a correspondence map to graphically represent the relevant correlations between the study's variables is the end result of the correspondence analysis. The use of the method was presented in a questionnaire survey to ascertain consumer preferences for food shopping during the Covid 19 pandemic. According to the study's findings, self-service tills were used for shopping by 50% of respondents in the age groups of 25–29 and 19–24. During Covid 19, older respondents preferred not to purchase via self-service tills.

KEYWORDS: correspondence analysis, consumer, contingency table, COVID 19

JEL CLASSIFICATION: C10, C12, M30

INTRODUCTION

Consumer behaviour can be considered as a new economic discipline, so there is no definition of consumer behaviour that is precise. Different authors have devoted to definitions of consumer behaviour. L.G. Shiffman and L.L. Kanuk (2004) define the terms as a behavior where consumers exhibit in purchasing and evaluating products and services that they expect to satisfy their needs, it is focused on the decision making of individuals in spending their own financial resources related to consumption. Consumer behaviour became part of marketing strategy in the late 1950s, when companies came to see the importance of

* Corresponding author: Ing. Eva Matejková, PhD., Institute of Statistics, Operations Research and Mathematics, Faculty of Economics and Management, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, e-mail: eva.matejkova@uniag.sk

examining the psychological and social needs of customers in addition to the actual sale. Therefore, in order to design the production of new products and determine marketing strategies to satisfy consumers, it was important to examine in detail the consumer behaviour of consumers themselves (Vojková, 2010).

Rombach (2022) et al. compared consumer behaviour on a sample of 3091 consumers. This study was based on a sample from different countries and continents including China, the USA, the UK, France, Spain, the Netherlands, New Zealand, Brazil and the Dominican Republic, and they used structural equation modelling using the least squares method. They found that consumers are willing to pay a higher price for meat from healthy farms. When comparing samples of men and women, it was found that women in particular preferred good quality meat from healthy farming. Yilmaz and Kahveci (2020) addressed food waste, they reported that more than one-third of the food produced globally is wasted. To address this problem and reduce food loss and waste, several attempts have been made to use food waste as an ingredient in new food products, called upcycled food. The pandemic has affected economies around the world and, as a result, consumer behaviour has changed. Consumer trends have been disrupted.

Timpanaro and Cascone (2022) addressed the issueof consumption in the aftermath of the Covid-19 virus pandemic, sampled consumers, and used statistical analysis to highlight aspects of health and that the advice of experts also has a correlative effect on food purchasing, health and the environment, as well as production methods and packaging in line with the ecological transformation. Kogan and Konstantin (2022) report that panic buying emerged as one of the main headlines in the media at the beginning of the COVID-19 pandemic. This type of consumer behaviour was clearly triggered by fears that supermarkets would run out of food and other basic goods. Haider (2022) says that panic buying is critical because it leads to stocks reaching minimum levels, which in turn could lead to major instability in the market.

The press release "Impact of the covid-19 pandemic on changes in consumer purchasing behaviour in Slovakia" (2021) states that the COVID-19 pandemic has changed consumer purchasing behaviour in Slovakia. However, this is not true for all consumers and there are several specificities in Slovakia. A statistically significant difference was observed between age categories and changed purchasing behaviour during the COVID-19 pandemic. Čuláková et al. say that the consequences of the COVID-19 pandemic may have a long-term effect on the everyday life of the population, including their purchasing behaviour. The results of studies focusing on the impact of the pandemic suggest that health concerns as well as concerns about changed financial conditions have an impact on changes in purchasing behaviour. Because of these concerns, consumers are changing their shopping behaviour by considering different ways of shopping that allow them to deal with or avoid the indicated risks (Truong and Truong 2022). Analysis of the perception of the coronavirus pandemic and its impact on people's daily lives was also the focus of Šipoldová's (2021) paper, in which she compared the differences in the perception of the situation during the Covid 19 pandemic between different generations) using the method of correspondence analysis.

MATERIAL AND METHODS

Correspondence analysis is a method of data analysis developed by Herman Otto Hartley and advanced by Jean-Paul Benzécri (Dodge, 2003). According to research highlighted in the report published by Kráľ et al. (2009), it has been applied to marketing analytics, where it may be used to analyze buyers' propensities, preferences, and brand fidelity. This procedure comes under multivariate analysis - as we are looking at no less than two purported indicators ending each subject matter. In this paper we present a simple correspondence analysis, i.e., we consider the investigation of the relationships between only two variables, where the variables are expressed qualitatively.

The requirement needed to use this technique is that there must be a highly reliable connection between the elements being studied, which can be confirmed through tests such as the
Chi-Square Test of Independence.

The input to the correspondence analysis is data from a bivariate contingency table with absolute frequencies n_{ij}. From the table, it is possible to calculate the marginal row (column) abundances from which the correspondence matrix (p_{ij}) elements are calculated, i.e., the relative abundances calculated as % of the whole. These relative forms are respectively known as Row/Column Masses, as well as row/column profiles.

The correspondence matrix can then be calculated using the formula:

$$\begin{bmatrix} P & r \\ c^T & 1 \end{bmatrix} = \begin{bmatrix} p_{11} & p_{12} & \dots & p_{1s} & r_1 \\ p_{21} & p_{22} & \dots & p_{2s} & r_2 \\ \vdots & \vdots & \dots & \vdots & \vdots \\ p_{r1} & p_{r2} & \dots & p_{rs} & r_r \\ c_1 & c_2 & \dots & c_s & 1 \end{bmatrix}$$

Each row (column) of the correspondence matrix can be thought of as a point in s-dimensional (r-dimensional) space with coordinates corresponding to the values of the corresponding profiles. We can then calculate the mutual distances between the points, the most commonly used being the chi-squared distance (Vojtková and Labudová, 2010).

The aim of the method is to reduce the multidimensional space of row and column profile vectors while still preserving the information contained in the original data. The interpretation assumes that the individual points are closer to each other in case of higher similarity between the corresponding categories.

Another indicator is the contributions of the row points to the inertia in the corresponding dimension. They express the relative degree of influence of a given category on the resulting orientation of each axis. From them, we obtain information about which row (or column) categories contribute most to the orientation of the first axis and which categories have the highest influence on the orientation of the second axis. The last group of indicators are the contributions of the axes to the reproduction of the row (column) categories. They tell us the contribution of each axis to the explanation of the respective row (column) category. They can be interpreted as the correlation of row (column) profiles with individual axes (Shipold, 2021).

The main output of the correspondence analysis is a symmetric correspondence map in which the different categories of primes are graphically displayed. In it, the individual distances represent the chi-squared distances that have been identified between objects (Farkasovsky,

2015). Using it, we can visually assess the categories of a given variable, their similarity or dissimilarity between them, or associations with categories of other variables. This method is particularly useful when analyzing contingency tables with a large number of columns and rows, where graphical displays can be much clearer than spreadsheet outputs (Coss, 2017).

The drawback of correspondence analysis is that it merely analyzes and explains relationships between variables as an exploratory tool. Testing hypotheses and determining whether a solution is appropriate are not verification methods (Coss, 2017).

RESULTS AND DISCUSSION

The data presented in the paper are obtained from a questionnaire survey conducted between February 2022 and March 2022, involving 510 respondents (3 questionnaires were subsequently excluded from further analysis due to incomplete completion). Respondents answered 24 questions, of which 7 dealt with the socioeconomic characteristics of the respondents. In terms of content, the survey was aimed at investigating consumer preferences for food purchasing during the Covid 19 epidemic. In this paper, our primary objective is not to analyse consumer preferences in food purchasing, but to use the data from the survey to present a multivariate graphical method - correspondence analysis - that can be used to visualise the relationships between the variables under investigation. Correspondence analysis from a theoretical point of view has been reported by several authors in their works. In the presented paper, we have drawn on the works of the following authors: Hirschfeld (1935), Benzécri (1973), Coss (2017) and Dodbe (2003).

The method is presented on question 14: "After the outbreak of the pandemic, did you start to prefer the following payment methods and services in stores MORE?". In the question, respondents expressed their opinion on payment cash, payment card, payment with a Phone or Smartwatch, using self-service tills, and shopping with a handheld scanner. Opinions were expressed using a four-point scale (Strongly Agree, Agree, Disagree, Strongly Disagree). The results of this question are presented in Figure 1.

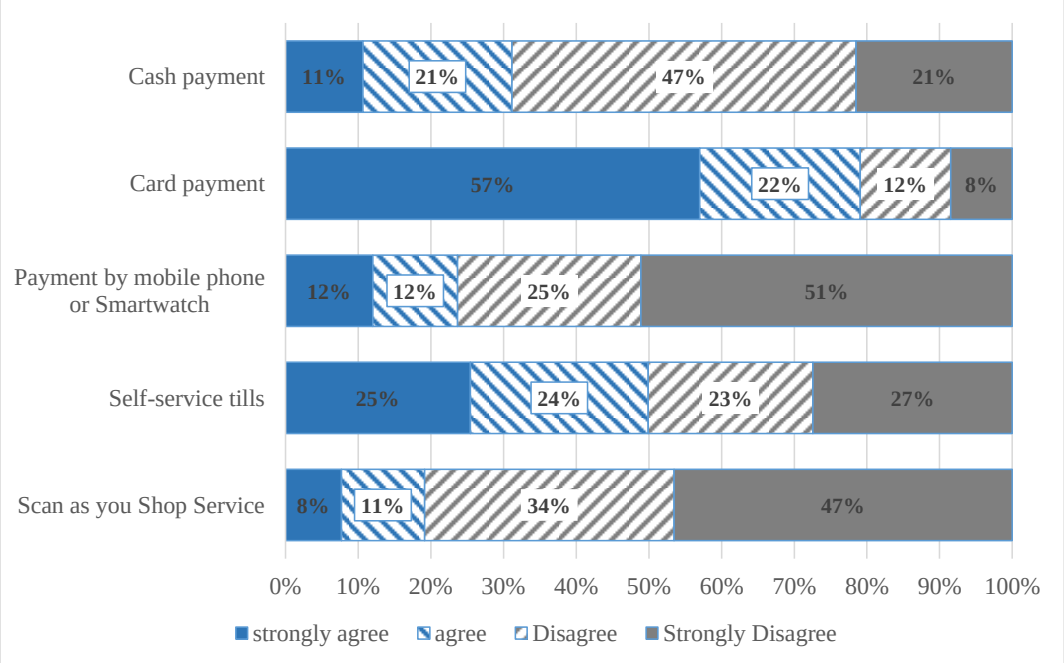

Figure 1 "Did you start to prefer the following payment methods and services in stores MORE?"
Source: Own processing in MS Excel

Correspondence analysis is presented in this paper to investigate the existence of a relationship between the age of respondents and the use of self-service checkouts for shopping during the Covid 19 pandemic. We were interested in whether the use of self-service checkouts during the Covid 19 pandemic depended on the age structure of the respondents. Two categorical variables were included in the analysis, so we used simple correspondence analysis. We have chosen the age variable as a line variable, which takes 5 age categories. The self-service tills served as a column variable via which we specified how much we agreed with using a certain service while making a purchase. They expressed their preference according to a four-point scale (Strongly Agree, Agree, Disagree, Strongly Disagree). The results of the analysis can be found in the following outputs (Tables 1 to 7 and Figures 2 and 3) implemented in the SAS EG statistical software.

Observed values of absolute frequencies are displayed in a contingency table (Table 1). In Table 1, in addition to the pooled absolute frequencies, there are also Active Margin frequencies of 1st degree, which inform about the distribution of frequencies in terms of age (Sum of Rows) or in terms of the opinion on the use of self-service tills (Sum of Columns).

Table 1 Contingency Table (use of self-service tills by age)

Contingency Table – self-service tills					
Age	Strongly agree	Agree	Disagree	Strongly disagree	Sum
19 - 24 years	20	12	8	2	42
25 - 29 years	19	8	9	4	40
30 - 44 years	44	33	50	22	149
45 - 64 years	38	55	36	41	170
more than 65 years	8	16	12	70	106
Sum	129	124	115	139	507

Source: Own processed in SAS EG

The condition for using correspondence analysis is the existence of a statistically significant relationship between the variables under study. This condition can be verified by the Chi-Square Test of Independence (Chi-Square Test of Independence). The calculation of this test is related to Tables 2,3 and 4. This indicates the existence of a significant difference between these values, i.e., we can assume that the H0 hypothesis of no relationship will be rejected.

Table 2 Expected Frequencies

Chi-Square Statistic Expected Values				
Age	Strongly agree	Agree	Disagree	Strongly disagree
19 - 24 years	10.686	10.272	9.527	11.515
25 - 29 years	10.178	9.783	9.073	10.967
30 - 44 years	37.911	36.442	33.797	40.850
45 - 64 years	43.254	41.578	38.560	46.608
more than 65 years	26.970	25.925	24.043	29.061

Source: Own processed in SAS EG

In Table 3, the value of 40.99 is highlighted. This represents the largest difference between the observed and expected frequencies.

Table 3 Residuals

Observed Minus Expected Values				
Age	Strongly agree	Agree	Disagree	Strongly disagree
19 - 24 years	9.314	1.728	-1.527	-9.515
25 - 29 years	8.823	-1.783	-0.073	-6.967
30 - 44 years	6.089	-3.442	16.203	-18.850
45 - 64 years	-5.254	13.422	-2.560	-5.608
more than 65 years	-18.970	-9.925	-12.043	40.939

Source: Own processed in SAS EG

Table 4 illustrates the calculation of the chi-square test statistic, whose resulting value represents the sum in the lower right corner of 133.346 (highlighted value).

Table 4 Contributions to the Total Chi-Square Statistic

Contributions to the Total Chi-Square Statistic					
Age	Strongly agree	Agree	Disagree	Strongly disagree	Sum
19 - 24 years	8.117	0.291	0.245	7.862	16.515
25 - 29 years	7.648	0.325	0.001	4.425	12.399
30 - 44 years	0.978	0.325	7.768	8.698	17.769
45 - 64 years	0.638	4.333	0.17	0.675	5.816
more than 65 years	13.343	3.8	6.033	57.671	80.847
Sum	30.725	9.073	14.216	79.332	133.346

Source: Own processed in SAS EG

Tables 5 and 6 show the row and column profiles.

Table 5 Row Profiles

Row Profiles				
Age	Strongly agree	Agree	Disagree	Strongly disagree
19 - 24 years	0.476	0.286	0.190	0.048
25 - 29 years	0.475	0.200	0.225	0.100
30 - 44 years	0.295	0.221	0.336	0.148
45 - 64 years	0.224	0.324	0.212	0.241
more than 65 years	0.075	0.151	0.113	0.660

Source: Own processed in SAS EG

The highlighted value in Table 5 (Row Profiles) expresses how many of the total number of youths aged 19 to 24 years are the proportion of respondents who said they definitely preferred to purchase through self-service checkouts during the Covid-19 pandemic (47.6%).

Table 6 Column Profiles

Column Profiles				
Age	Strongly agree	Agree	Disagree	Strongly disagree
19 - 24 years	0.155	0.097	0.070	0.014
25 - 29 years	0.147	0.065	0.078	0.029
30 - 44 years	0.341	0.266	0.435	0.158
45 - 64 years	0.295	0.444	0.313	0.295
more than 65 years	0.062	0.129	0.104	0.504

Source: Own processed in SAS EG

Profiles are used to ensure the comparability of row and column categories. The row profile represents conditional relative abundances that describe the structure of the column variable for the i-th category of the row variable. In the case of the j-th category of a column variable, column profiles represent conditional relative abundances that illustrate the structure of the row variable. The profiles show the relative abundance of a row or column. The value at the same position in the Column Profiles table (Table 6) reflects the proportion of the total number of respondents who said that they definitely preferred self-service checkouts for purchases, i.e., 15.5% of respondents aged 19-24 years of the total number of respondents who definitely preferred self-service checkouts for purchases.

The output (Figure 2), which assesses the effectiveness of the transformation of points into space, is the following section of the output.

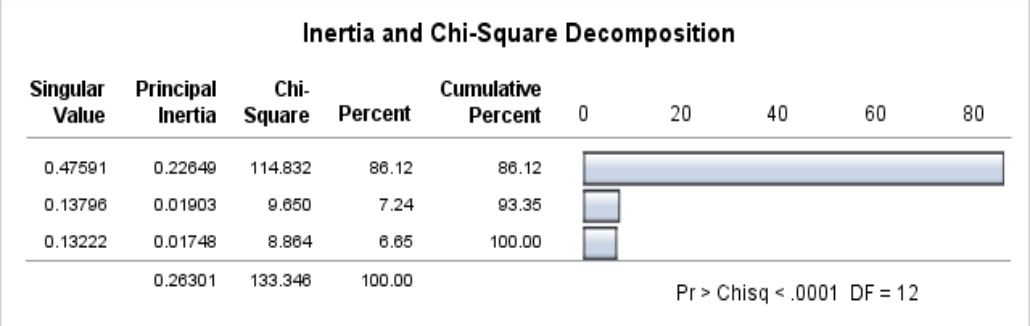

Figure 2 Inertia and Chi-Square Decompositon
Source: Own processed in SAS EG

The first column contains the Singular Value, which is calculated from the matrix of standardized residuals. This is a total of three values, i.e., the original data from the contingency table can be represented using three dimensions, the number of which is determined from the lower value of the number of row or column categories minus one. In our example, we have 5 age categories and 4 consent categories, i.e., the lower value is 4, the number of dimensions is therefore determined as $4 - 1 = 3$. Based on the Singular Value, the Principal Inertia is then calculated. By summing these values, we get the total inertia (0.263), which is a measure telling the quality of the transformation of the points of the multidimensional space into the correspondence map. The values in the Chi-Square column represent the distances of the individual points. Their sum gives the value of the chi-square test statistic. Per cent columns show the percentages of the inertia of each dimension, where each inertia represents a fraction of the total inertia. The relative shares are then cumulated (Cumulative Percent). This column is used to decide how many dimensions are sufficient to present the data from the contingency table. The first dimension explains 86.12% of the variability of the relationships in the contingency table, while the second dimension only explains 7.24% of the variability, i.e., we capture 93.35% of the variability of the original points in the two-dimensional space in total, which is sufficient. The histogram of the individual inertias in relative terms is shown on the right below. Below the plot is the result of the chi-square test statistic for statistical significance. In our example, the p-value is <0.0001, i.e., there is a statistically significant relationship between the age categories of the respondents and their preferences for using self-service checkouts.

The presented method seeks to search for new factors that represent the axes (dimensions) of the root correspondence map, in which the results of the analysis are displayed by marking the relationships between categories in space in the newly defined dimensions.

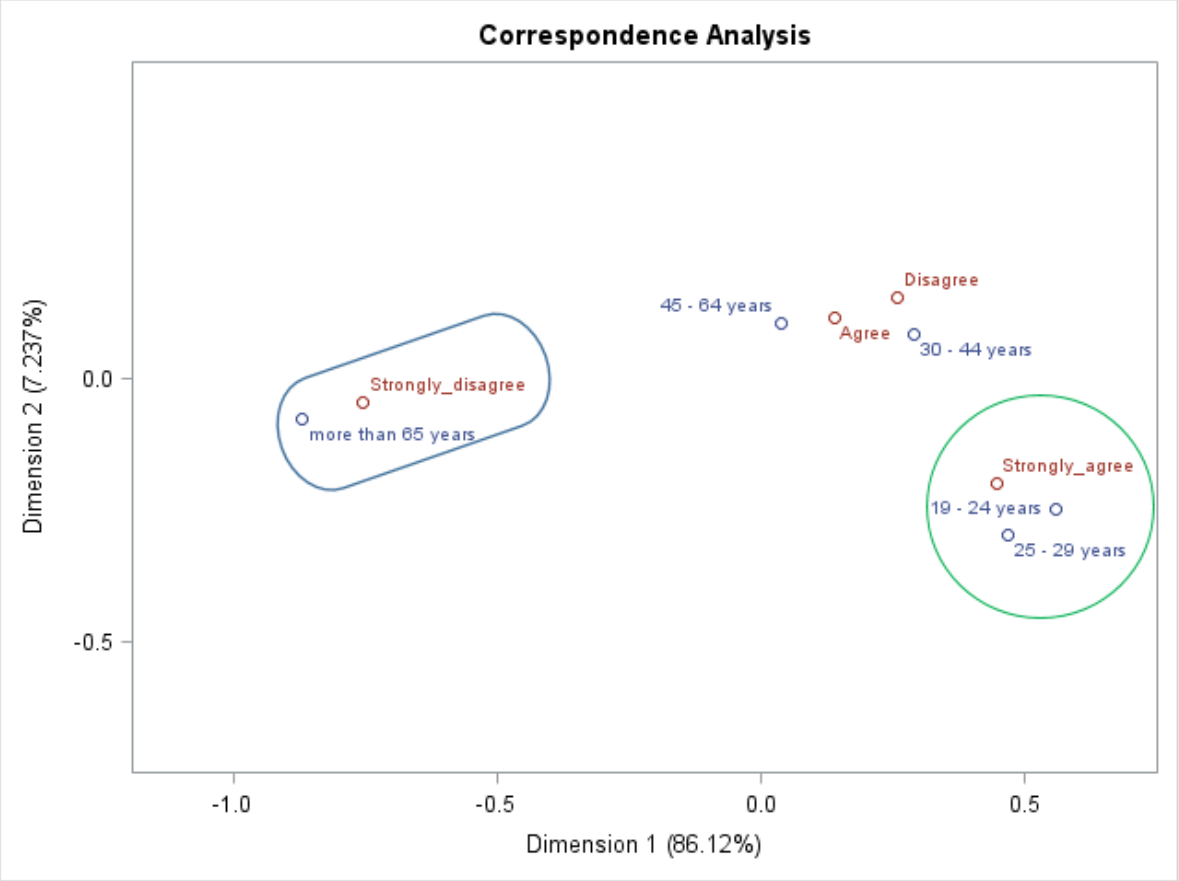

Figure 3 Correspondence Map
Source: Own processed in SAS EG

In the resulting correspondence map, the position of the row and column profiles indicates which categories are related, i.e., correspond to each other. Respondents aged 19-24 and 25-29, i.e., the younger generation, are very similar in terms of their use of self-service checkouts for shopping. Due to the pandemic, respondents have started using self-service checkouts more when shopping. Almost 50% of them were positive about using this service (strongly agree with the response). Respondents aged 65+ are closest to the Strongly Disagree response option shown on the map, i.e., the oldest consumers made minimal use of this service in their purchases even though there was a pandemic. Despite the advantages of this method of shopping (saving time on smaller purchases, reducing the possibility of infection), the older generation is more comfortable with the traditional way of shopping. The views of respondents in the 30-44 and 45-64 age groups (middle generation) are similar, with respondents in the 30-44 age group more likely to indicate the Disagree option and respondents in the 45-64 age group more likely to indicate the Agree option. The existence of a correlation is also evident in this graphic.

Table 7 Summary Statistics for the Row and Column Points

Obs	TYPE	Age	Quality	Mass	Inertia	Dim1	Dim2
1	INERTIA				0.263		

2	OBS	19 - 24 years	**0.952**	0.083	0.124	0.559	-0.249
3	OBS	25 - 29 years	**0.992**	0.079	0.093	0.469	-0.297
4	OBS	30 - 44 years	0.772	0.294	0.133	0.291	0.086
5	OBS	45 - 64 years	0.357	**0.335**	0.044	0.038	0.104
6	OBS	more than 65 years	**0.998**	0.209	**0.606**	-0.869	-0.076
7	VAR	Strongly_agree	**1.000**	0.254	0.230	0.446	-0.197
8	VAR	Agree	0.446	0.245	0.068	0.140	0.114
9	VAR	Disagree	0.735	0.227	0.107	0.259	0.154
10	VAR	Strongly_disagree	**0.999**	0.274	**0.595**	-0.754	-0.046

Source: Own processed in SAS EG

In Table 7, the Summary Statistics are presented in terms of individual row or column categories, with rows 2-6 containing the outputs for the row variable (Age) and rows 7-10 providing information on the column variable (Degree of agreement with self-service checkout purchases). Row 1 contains data on total inertia (0.263) as well as individual inertia for dimension 1 (0.226) and dimension 2 (0.019), which are also included in Figure 2.

The values in the Quality column tell us about the "quality" of the points presented, i.e. the values in that column should be close to 1. In our example, the row categories (19-24 years, 25-29 years and more than 65 years) and column categories (Strongly agree and Strongly disagree) are equal to 1 or very close to 1, i.e. the quality of the representation of the individual categories of the Row and Column variable using these 2 axes is very effective.

The Mass column presents marginal relative abundances, e.g., the highest value (0.335) says that 33.5% of the respondents were aged 45-64 years of the total respondents.

In the Inertia column, in addition to the total inertia, there are row (column) Inertia for each category of variables, which conveys information about the variability, i.e., the degree of dispersion, of each row (column) category. The highest degree of inertia is for the category of respondents aged 65 and over for the first variable and respondents who did not use self-service checkouts at all, i.e., the two categories in the correspondence map were closest to each other.

Dim1 and Dim2 represent the coordinates of the axes for each row and column category of the variables, respectively. The correspondence map is constructed based on these points.

The Contr1 and Contr2 in Table 8 columns present the contributions of row (column) points to the inertia of the respective dimensions (Contribution of Point to Inertia of Dimension) - they express the relative degree of influence of a given category on the resulting orientation of the individual axes. This gives us information about which row (column) categories contribute most to the orientation of the axes. The category of respondents aged 65 and over who did not use self-service checkouts at all when paying had the greatest influence on the orientation of the first axis. In the case of the orientation of the second axis, the greatest influence was among respondents aged 25-29 who, on the contrary, preferred self-service checkouts for their purchases.

Table 8 Contributions of row (column) points to the inertia of the respective dimensions

Obs	Contr1	Contr2	SqCos1	SqCos2	Best1	Best2	Best

1	0.226	0.019					
2	0.114	0.269	0.795	0.157	2	2	2
3	0.076	**0.365**	0.708	0.284	0	2	2
4	0.110	0.113	0.711	0.061	0	0	2
5	0.002	0.190	0.043	0.315	0	2	2
6	**0.697**	0.064	**0.990**	0.008	**1**	0	1
7	0.224	**0.521**	0.836	0.164	2	2	2
8	0.021	0.167	0.268	0.178	0	0	2
9	0.067	0.281	0.544	0.191	0	2	2
10	**0.688**	0.030	**0.995**	0.004	**1**	0	1

Note: Dim1, Dim2: Partial Contributions to Inertia for the Row or Column Points
Contr1, Contr2: Indices of the Coordinates That Contribute Most to Inertia for the Row or Column Points
SqCos1, SqCos2: Squared Cosines for the Row or Column Points
Source: Own processed in SAS EG

SqCos1, SqCos2 are Squared Cosines for Row/Column Points, which are used to measure the importance (quality) of each point in that dimension. The sum of the Squared Cosines is equal to the Quality value for that category, i.e., the interpretation of the values is similar to that of the Quality column. If the value is close to 1, it means that the category is well represented by the corresponding dimension. In our example, this is especially true for dimension 1, where again the close relationship between the categories of respondents over 65 years old who do not prefer self-service checkouts is confirmed.

The Best1, Best2 and Best columns present the information from the Contr1 and Contr2 columns in a clearer way. There is a minimum criterion (MININERTIA=0.8) that is required for a category to be identified as having a significant impact on a given dimension. Again, the categories of respondents aged 65+ who do not prefer to purchase through self-service checkouts are dominant in dimension 1. The categories of young respondents aged 24+ who strongly prefer to purchase through self-service checkouts also have an influence in dimension 1, but their influence is more dominant in dimension 2, hence the value of 2 in the Best1 column for these categories. Similarly, we could interpret the values in the Best2 column. The last column, Best, shows the number of dimensions in which the respective category takes on a higher value than in the Contr1 and Contr2 columns. There are more values of 2 in this column, indicating that more categories are presented in dimension 2. However, we only captured 7.24% of the variability of the original scores with the second dimension. More significant is the first dimension, which speaks to a strong relationship among the oldest respondents, who did not prefer shopping via self-service checkouts at all in the COVID 19 period and are highly unlikely to prefer it now that the current epidemiological situation no longer requires special measures in stores.

CONCLUSIONS

The verification of associations is a fundamental statistical procedure used in the evaluation of numerous survey questionnaires. The correspondence analysis described in this study is one of the more recent helpful methods for identifying links between categorical variables. The significance of using the above method or procedures falls into this category since they supplement the normal methodological instrument employed in questionnaire surveys. It

provides a different viewpoint on the data under study and enables better visualising of the results that are presented in order to interpret them.

In terms of how the approach was presented, it looked into consumer preferences for food purchases made throughout the Covid 19 period. We can say with confidence that there is a statistically significant correlation between customer age and the use of self-service checkouts to pay for food purchases. The data revealed that younger age groups had a tendency to use checkouts more frequently. Despite the heightened risk of contamination from standing in line at checkouts, older customers continued to prefer the conventional manner of paying for their groceries.

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