SEGMENTATION OF THE ELECTRIC SCOOTER MARKET IN POLAND

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Abstract: The growing popularity of electric scooters has resulted in the dynamic development of this market on a global scale. Each potential customer has different preferences and therefore should be able to choose a scooter that meets their expectations. The study used a dataset comprising 42 scooters available on Polish market with their specifications. The aim of the study was to present the structure of the electric scooter market in Poland and carry out a market segmentation. On the basis of an arbitrary decision, under the terms of the quotients of the coefficients in successive stages of combining into clusters, two and four classes of scooters were distinguished. The comparison of clusters with the adopted price ranges proved that, with the increase in the performance of the electric scooter, the price rises. Such a combination can help customers choose the cheapest scooter from a given market segment, according to their budget constraints and personal preferences.

Keywords: market segmentation, electric scooters in Poland, classification, factor analysis.

1. Introduction

The market for two-wheeled electric vehicles, including, of course, scooters, is currently booming (Jamerson and Benjamin, 2012). It is estimated that by 2024 the global electric scooter market will increase with a cumulative annual growth rate

(CAGR) of up to 6% (Technavio, 2020), thus the electric scooter market in Poland is nowadays highly developed. This has been particularly emphasized in the context of the current coronavirus pandemic. It has been noted that the electric scooter, a small platform with two wheels propelled by an electric motor, plays an important role in the development of cities, becoming an attractive form of urban mobility, alongside public transport (Clewlow, 2018; Hornea and Dobre, 2018; Kostrzewska and Macikowski, 2017). The market of shared electric scooters (operating as part of the rental for minutes system) has expanded significantly due to the growing potential of the sharing economy (Janczewski, 2019; Jędrzejewski and Koralewski, 2019; Li, Lee, Yang, and Chang, 2020). Many countries have even decided to invest in purchasing electric scooters for their local communities in order to extend their urban development (Moreau et al., 2020). Despite the fact that the shared scooter market is huge, it has been observed that it is also full of uncertainty (Schellong, Sadek, Schaetzberger, and Barrack, 2019). Nevertheless, it is worth paying attention to the fact that in the face of the pandemic, private property plays a greater role than shared property, mainly due to hygienic and sanitary aspects. Detailed information on the impact of the rapid spread of SARS-CoV-2 virus on the electric scooter market is presented in the Research Report World (2020) paper.

Electric scooters, as examples of low-weight vehicles, have many undoubted advantages (Fenton and Hodkinson, 2001). They are cheap, easy to use, mobile, and their use is associated with significant amenities, often regulated by local and central governments. The market for shared minute rental scooters has convinced city societies to want to have them, although the coronavirus pandemic has also intensified the desire to own them. At the end of October 2020, all 12 electric scooter rental companies in Poland made available a total of 18.8 thousand of these vehicles in 39 cities (Smartride.pl, 2020). In Poland there are two main options for purchasing an electric scooter: through a local distributor or, by importing it directly from the manufacturer, most often from China. The first variant is associated with paying a much higher unit price for the scooter but it is the purchase of a finished product, covered by a 2-year warranty. Distributors operating in Poland usually also run service points, so in the event of technical faults they are able to provide support and repair under the warranty. Importing an electric scooter directly from a Chinese manufacturer is, indeed, associated with a lower total price (even after adding the transport fee and customs duties), but it also brings far-reaching concessions. Shipping from China does not include the shipment of the assembled product, the shipped product comes in parts; their assembly is directly related to e-scooter expertise. In addition, there are other warranty laws that apply in China and these are often less restrictive. Typically, Chinese companies offer a 1-year limited warranty on scooter--related parts. However, the warranty often does not cover improper installation, as in this case the responsibility is usually assigned to the consumer. It is worth noting that Chinese corporations, to be able to trade in the European Union, must have the appropriate permits and certificates of compliance with European law applied to

each e-scooter sold within the EU. Moreover, scooters are often imported directly from Chinese manufacturers and do not differ much (or not at all) from those sold at local distributors.

Despite the growing demand for scooters and thus their increasing popularity, as far as the authors are concerned, there is still no research on the segmentation of this market, and this results in a significant research gap that can be filled in various scientific fields. Such segmentation can, for example be used in logistics where the impact of using scooters as the medium of daily commuting can be verified. Moreover, in logistics such a research may allow to examine how the average distance traveled per day affects the decision to buy a scooter from a given segment and whether such a scooter has to be faster to cover longer distances. In economics such grouping can be further processed and used in price estimates or research on other market segments, while in management this segmentation of electric scooters can be used to create new, more streamlined business models.

The objective of the article is to present the structure of the electric scooter market in Poland and to conduct the market's segmentation. The following research questions were posed: to what extent are the technical properties of a scooter connected to its performance? What is the relationship between the price and the performance of a scooter? What are the similarities among the available electric scooters in Poland? What kind of scooter groups can be distinguished?

2. Research methodology

The aim of the research was to segment the electric scooter market. Based on the conducted study the following research hypothesis was verified: the better the properties and thus the performance of the scooter, the more expensive it is on average. The study used the dataset of the most popular models of electric scooters in Poland. The first stage was to examine the popularity of scooters on the Polish market by checking the number and types of opinions on online forums and groups of social networks (such as Facebook). Then, on the basis of the collected information, 42 models of e-scooters were arbitrarily selected, which was the starting point for creating the dataset consisting of them. Their properties and features were obtained from the websites of five online scooter stores in Poland on 25 November 2020 (Table 1). If the information was not available, it was supplemented directly from the websites of Chinese manufacturers, mainly via the Alibaba marketplace.

An electric scooter, like any product, has many features (properties) that should be taken into account and which have a significant impact on the price of the device or its quality. For instance, a scooter's price is positively correlated with the immeasurable prestige of the brand and the quality of the used components, as noted by Kizielewicz and Dobryakowa (2020). The weight of the scooter turns out to be an important criterion that determines the purpose of a scooter, and this can be used in the segmentation process (Kizielewicz and Dobryakowa, 2020; Yang, 2010).

Table 1. Variables used in market segmentation

Property (attribute)		Unit
Price (gross)		Polish zloty [PLN]
Number of engines		pieces [pcs]
Total nominal power*		watts [W]
Electric voltage		volts [V]
Battery capacity		ampere-hours [Ah]
Range		kilometers [km]
Length	Dimensions	centimeters [cm]
Width		
Height		
Number of brakes		pieces [pcs]
Type of brake		*ordinal variable*
Type of amortization		*ordinal variable*
Tyre size		inches [in]
Maximum speed (Vmax)		kilometers-per-hour [kph]
Weight		kilograms [kg]

* It should be noted that in the case of two models of scooters (Boyueda and Janobike T85), the manufacturers do not specify whether the engine power is nominal or maximum. It was assumed that these powers were nominal and they were used in the study.

Source: own elaboration

With the intent of conducting the research (segmentation), classification methods such as hierarchical cluster analysis, were used. In order to measure the distance between the variables, the Euclidean distance (squared) was applied (Danielsson, 1980; Dokmanic, Parhizkar, Ranieri, and Vetterli, 2015), which is widely described and used in scientific research (dos Santos, 2013; Kashwan and Velu, 2013; Kauko, Hooimeijer, and Hakfoort, 2002; Shin and Sohn, 2004). It was decided to choose a square measure, as it allows for obtaining larger differences with more diverse objects. The Euclidean distance (squared) is expressed by the following formula:

$$d(x,y) = \sum_{i=1}^{p} (x_i - y_i)^2,$$

where: $d(x, y)$ – distance, i – next iteration, and p – number of all variables in the cluster.

In order to be able to use the Euclidean distance metric, the different variables must be comparable. Therefore it is advisable to pre-standardize the variables (Walesiak, 2016). This was performed using the following formula:

$$z_i = \frac{x_i - \bar{x}}{s_x},$$

where $\bar{x}$ – mean and s_x is the standard deviation.

The factor analysis was performed on the basis of the correlation coefficients. In this case Varimax rotation, and a heuristic criterion that describes which variables match a certain factor. These methods were widely described and used in the scientific works of Kim and Mueller (1978a, 1978b) and Gatnar and Walesiak (2004). The number of factors was determined based on the explained variance.

Due to the application nature of the article, the basic formulas for transforming variables and measures of similarity were provided. A more detailed description of the methods can be found in the literature (Rozmus and Trzęsiok, 2017; Trzęsiok, 2016).

The Ward hierarchic method was adopted as the classification method for this study (Walesiak, 2009; Ward, 1963). The measure of the diversity of the cluster in relation to the mean values is ESS (Error Sum of Squares), which is defined by the formula:

$$ESS = \sum_{i=1}^{k} (x_i - \bar{x})^2,$$

where: x_i – value of the variable which is the segmentation criterion for the i-th object; k – number of objects in a cluster.

The Ward method uses the ANOVA approach to estimate the distances between clusters. This method, in simple terms, aims to to minimize the sum of the squared deviations of any two clusters that may be formed at any stage. This is considered very effective, although it aims to create clusters of a small size. As a result of applying hierarchical methods, one obtains a dendrogram which is seen as a convenient way to visualize (Roman, 2016). It illustrates the hierarchical structure of a set of objects due to the decreasing similarity between them (Roman, 2016). Ward's method, in terms of the accuracy of reproducing the actual data structure, is commonly regarded as the most effective among agglomeration methods (Basiura and Sokołowski, 2005; Hiederer, 2009). It is widely used in scientific research, mainly for classification purposes (Brzezińska, 2020; Trzęsiok, 2016).

When it comes to the extraction process, first, four groups were distinguished as a result of the criterion of determining the number of clusters and then the set of prices was divided analogously into the same number of subsets (albeit equal). As detailed above, two division methods were used: one for prices, and one for scooter types that contain the same number of subgroups. The division of the groups results from the increase in the coefficient of quotients.

2.1. The course of the study

The first step of the analysis was to examine the basic characteristics of the distribution of variables. Descriptive statistics were calculated for metric variables, and the frequency distribution was presented for non-metric variables. The correlation coefficients were calculated for the dimensions of the scooters, and then, using the factor analysis, the DIMENSIONS variable combining the length, height and width of the scooter was created. The same was carried out to create the newly created variables: PERFORMANCE (consisting of the following obtained variables: nominal engine power, voltage, maximum speed) and BATTERY (consisting of the acquired variables: capacity, scooter's weight, range).

The second stage of research was the segmentation. The electric scooters were divided into two and four subsets (depending on the price and type, respectively; arbitrarily based on the coefficient quotient criterion) using hierarchical cluster analysis based on Euclidean distance (squared) and Ward's method. In addition, using the classification tree (dendrogram), the following price ranges for electric scooters were proposed: up to PLN 2,000 ("cheap"), up to PLN 4,000 ("moderately expensive"), up to PLN 8,000 ("expensive"), over PLN 8,000 ("extremely expensive"). Taking this division into account, descriptive statistics for the separated price segments were presented.

3. Results

The average price of an electric scooter measured as a mean value is PLN 5,569, and the values on average deviate from the mean value by as much as PLN 4,832. The coefficient of variance is 87.33%, which proves a high price differentiation. The cheapest scooter is PLN 1059, while the most expensive is PLN 24,999. The characteristics of the remaining variables are presented in Table 2 and Figure 1.

The greatest variation occurs in the total power, while the smallest occurs in the maximum speed. All the variables are characterized by right-hand asymmetry (the largest asymmetry occurs in the case of price, and the smallest in maximum speed). The maximum speed has a platokurtic distribution which indicates a low concentration of observations around the mean value. In turn, the price has a leptokurtic distribution, which results in a high concentration of observations around the average. Based on the calculated quartiles for the price, it was decided to create four price ranges (relatively equal) – up to PLN 2,000, up to PLN 4,000, up to PLN 8,000, above PLN 8,000. These price groups are called "cheap", "moderately expensive", "expensive" and "extremely expensive", respectively.

As many as 55% of the scooters observed have one motor, while the remaining 45% have two motors. Additionally 55% of the analyzed scooters have two brakes, of which disc brakes are most often used (48%; 24% have hydraulic brakes). Only one in ten scooters has only a regenerative brake (electric) and merely 2%

Table 2. Descriptive statistics of the characteristics of electric scooters

|		Price (gross) [PLN]	Total nominal power [W]	Battery capacity [Ah]	Range [km]	Maximum speed [kph]	Weight [kg]
Mean		5569.24	1723.10	18.07	62.90	51.00	26.24
Median		4094.00	900.00	15.45	52.50	50.00	22.50
Mode		4499	350	13.00	30	25	12.50
Standard deviation		4863.51	1758.43	10.01	33.07	22.54	13.94
Coefficient of variation		87.33%	102.05%	55.40%	52.58%	44.20%	53.13%
Skewness		2.02	1.32	0.869	1.01	0.441	1.14
Kurtosis		5.25	0.92	0.623	0.597	−0.752	0.984
Minimum		1059	250	5.2	20	20	11.00
Maximum		24999	6720	49.0	150	100	70.00
Percentiles	25	1986.50	350	10.40	34.25	28.75	15.25
	50	4094.00	900	15.45	52.50	50.00	22.50
	75	7999.00	2400	24.63	80.00	66.25	35.50

Source: own elaboration.
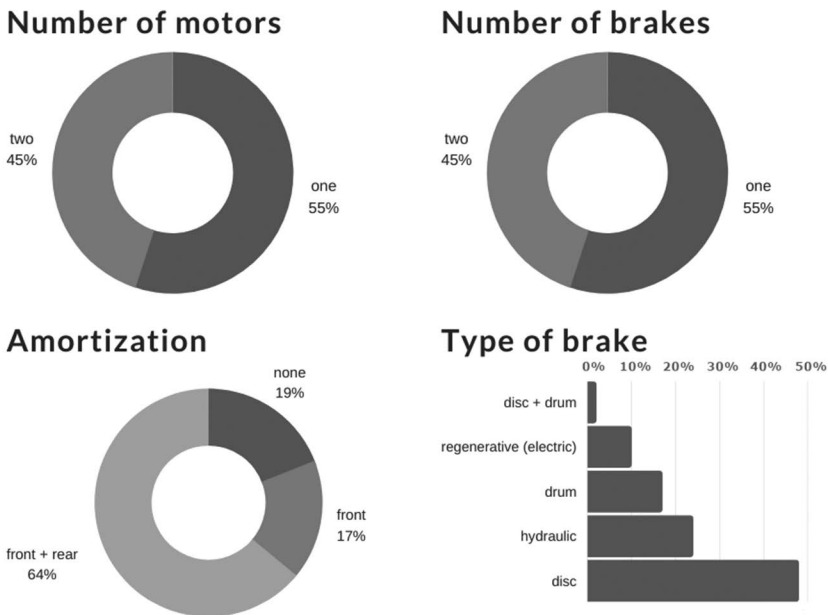
Fig. 1. The structure of the data set in terms of scooters' number of motors, number of brakes, type of amortization and type of brake

Source: own elaboration.

a combination of two types of brakes (disc and drum). Almost two-thirds of the scooters have double-shock absorption (front and rear), and 19% do not have it at all.

In the further part of the analysis, it was assumed that the larger the scooter, the larger its dimensions. This assumption is confirmed by the Pearson correlation coefficients between the individual dimensions calculated in pairs. The results are presented in Table 3.

Table 3. Correlations of the dimensions of the scooters

	Length [cm]	Width [cm]	Height [cm]
Length [cm]	1	0.566	0.703
Width [cm]	0.566	1	0.512
Height [cm]	0.703	0.512	1

*All correlations are significant at the 0.01 level.

Source: own elaboration.

On the basis of the data presented in Table 3, it can be concluded that there is a moderate strength of dependence and that it is positive (which means that an increase in one dimension on average leads to an increase in the other). Therefore, with the use of factor analysis (principal components method, Varimax rotation), the SIZE factor was distinguished. It explains 71.44% of the variability of these variables, and is composed of dimensions with the following values: length – 0.893, width – 0.798, height – 0.870.

An analysis of the dependencies of the variables that directly results in the performance of the scooter was carried out in a similar way. The results are presented in Table 4.

Table 4. Pearson correlation matrix – scooter performance

	Voltage [V]	Total power [W]	Battery capacity [Ah]	Range [km]	Maximum speed [kph]	Weight [kg]
Voltage [V]	1	0.808	0.823	0.830	0.928	0.816
Total power [W]	0.808	1	0.888	0.860	0.888	0.872
Battery capacity [Ah]	0.823	0.888	1	0.940	0.917	0.930
Range [km]	0.830	0.860	0.940	1	0.921	0.916
Maximum speed [kph]	0.928	0.888	0.917	0.921	1	0.926
Weight [kg]	0.816	0.872	0.930	0.916	0.926	1

*All the correlations are significant at the 0.01 level.

Source: own elaboration.

The conclusion here is that all the variables are strongly related to each other, based on the results from Table 4. From an econometric point of view, including them together in one model may cause the variables to be repeated, which would distort the essence of the results. Despite the high correlation coefficients, two factors should be distinguished: PERFORMANCE (affecting the power of the scooter and its effects), and BATTERY (which consists in battery capacity, range and weight). This division is the result of the following relationship: the maximum speed depends on the engine power and voltage. A more powerful motor must have a higher voltage. Manufacturers use larger capacity batteries for stronger scooters to improve their performance and thus the weight of a scooter increases. The relationship between the weight of the scooter and the battery size is shown in Figure 2.
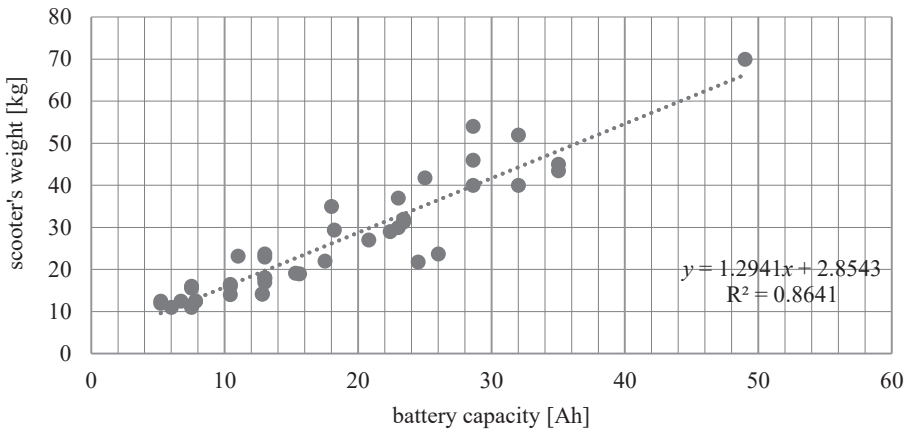

Fig. 2. Relationship between the weight of the scooter and battery capacity

Source: own elaboration.

Estimated regression function proves that the relationship is approximately linear ($R^2 = 86.41\%$). As the capacity increases by 1 Ah, the weight of the scooter on average increases by 1.3 kg. However, this is a far-reaching simplification because the weight of the battery increases on average by about 1–1.4 kg per 5 Ah (see Table 5). This is because larger batteries are used in more powerful scooters (see correlation in Table 3).

Table 5. Battery weight, capacity and voltage – manufacturer: Liitokala

V\Ah	10	12	15	20	25	30
36	1.5	2	2.5	3	4	4.5
48	2	2.6	3.3	4	5.2	5.9
60	–	–	3.6	4.5	5.8	5.2

Source: own elaboration.

The factors PERFORMANCE and BATTERY were distinguished with the use of factor analysis (i.e. principal components method, Varimax rotation). The first one explains 91.67% of the variability of the following values: total power – 0.938, voltage – 0.953, maximum speed – 0.981. The second one explains 95.26% of the variability of the following values: battery capacity – 0.980, range – 0.976 and weight – 0.972.

The market segmentation was performed using hierarchical cluster analysis (i.e. Ward's method, Euclidean distance [squared]; standardization) based on the separated factors (DIMENSIONS, PERFORMANCE, BATTERY). The number of specified groups results from an arbitrary decision, supported by the analysis of coefficients quotients (Figure 3). The process of merging into clusters is presented in Figure 4.
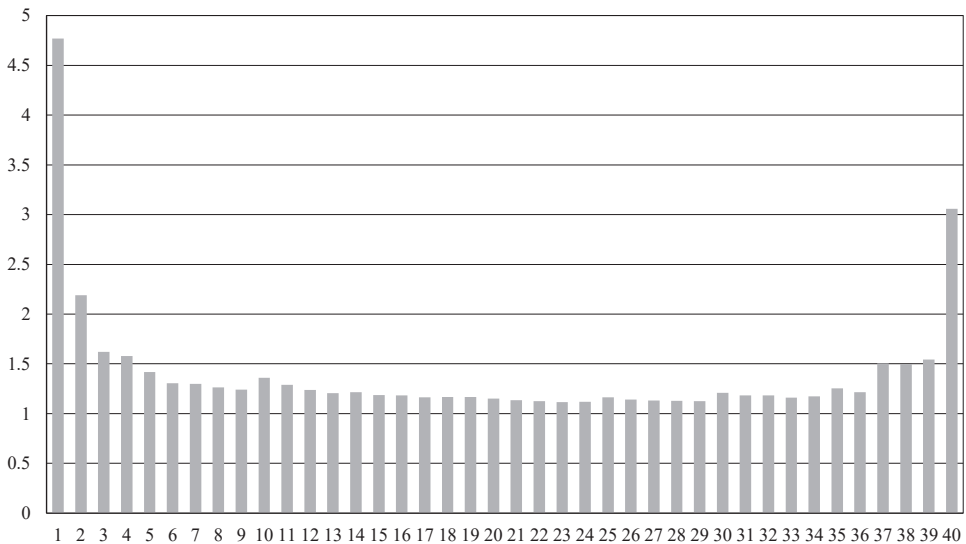

Fig. 3. The ratio of the coefficients of joining into successive clusters

Source: own elaboration.

The segmentation was distinguished in two variants: the first one assumes the creation of two groups, while the second one – four groups. Bearing in mind the first variant: group 1 includes 17 scooters and group 2 includes 25 scooters. Based on the parameters, it can be concluded that the first group is better in terms of performance and it is similar in size. According to this division, it is intuitive to say that since scooters have better performance, they should be more expensive on average. They were also classified into two equal groups with a division of 21 scooters based on the price (up to PLN 4,000 and over PLN 4,000). The groups were called "cheap"
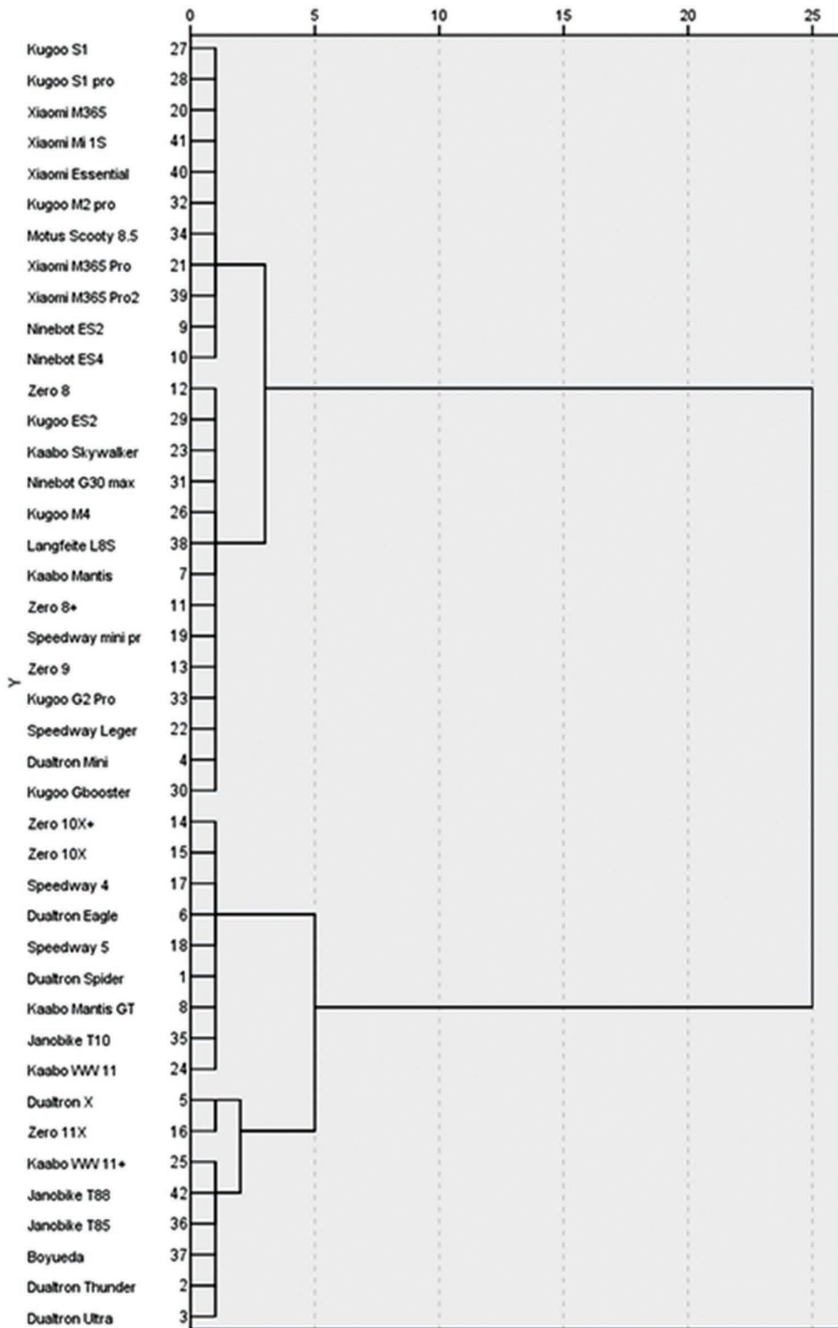
Fig. 4. The process of merging into clusters

Source: own elaboration.

and "expensive", respectively. The summary of the price and groups based on performance is presented in Table 6.

Table 6. The price group in segments of the scooter market (I variant)

		Price group		
		up to PLN 4000 "cheap"	above PLN 4000 "expensive"	Total
Type (performance) of scooter group	1	1	16	**17**
	2	20	5	**25**
	Total	**21**	**21**	**42**

Pearson chi-square with continuity correction = 19.37 (*p*-value < 0.001), Exact Fisher test (*p*-value < 0.001), V-Kramer test = 0.728

Source: own elaboration.

There is a noticeable dependance (correlation) that the more expensive the scooter, the better its performance (Table 6), so in this case the scooter should be assigned to group 2. An ideal division in terms of performance would be that the algorithm qualified 21 scooters to each of the groups. However, the results of the calculated statistics results prove that the variables "price group" and "type of scooter group" are dependent. The correlation is positive, therefore it can be said that a scooter with better performance is in fact more expensive on average. It is worth noting that the Janobike T10 scooter with its considerably better performance is one of the cheaper electric scooters. The opposite situation is observed for the following five e-scooters: Dualtron Mini, Kaabo Mantis, Zero 9, Speedway Leger, and Kugoo G-Booster. In the second variant of the classification, individual "type of scooter" groups characterized by the following numbers as well as the working names of these segments, are presented in the Table 7.

Table 7. Indication of clustered "type of scooter" groups

Group number	Group size	Group working name
Group 1	9	"high-performance" / "stunt"
Group 2	8	"professional"
Group 3	14	"advanced"
Group 4	11	"urban"

Source: own elaboration.

The scooters were classified into four groups according to the price (up to PLN 2,000, PLN 2001-4,000, PLN 4,000-8,000, above PLN 8,000). The groups were called "cheap", "moderately expensive", "expensive" and "extremely expensive", respectively. The summary of the price and the groups made in terms of performance is presented in Table 8.

Table 8. The price group in segments of the scooter market (II variant)

		Price group				
		up to PLN 2000 "cheap"	PLN 2001-4000 "moderately expensive"	PLN 4000-8000 "expensive"	over PLN 8000 "extremely expensive"	Total
Type of scooter group	1 "stunt"	0	1	4	4	**9**
	2 "professional"	0	0	3	5	**8**
	3 "advanced"	1	8	5	0	**14**
	4 "urban"	10	1	0	0	**11**
	Total	**11**	**10**	**12**	**9**	**42**

Pearson Chi-square = 52.32 (p-value < 0.001), Likelihood ratio = 56.79 (p-value < 0.001), V-Kramer correlation coefficient 0.644.

Source: own elaboration.

A similar division suggests the identical conclusion: the better the scooter's performance, the more expensive it is on average. The expected values of the individual cells in Table 8 are less than 5, therefore the assumption of the Chi-square test is not met. Therefore a likelihood-ratio test was used to check the presence of a relationship. Based on the results of this test, it should be concluded that there is a strict relationship between the price group and the scooter group in terms of performance. It should be noted that the number 0 appears in each group row, which means there are no extreme variations. This can be interpreted as an underestimation of value or its overestimation in relation to market value.

4. Discussion and conclusions

Electric scooters prove to be an effective means of navigating in urban environment, making it easier to negotiate crowded streets. However, it should be noted that the legal powers of electric scooters are insufficient. Currently, in Poland they not permitted to drive in car lanes, only on pavements. By achieving higher speeds than pedestrians, electric scooters pose a potential risk to them. Appropriate legal regulations regarding personal transport devices (such as e-scooters) can bring real benefits to other road users, while not limiting the potential of scooters too much.

The electric scooter market is expanding as a response to increasing demand. There are several dozen different models of electric scooters in Poland, and their number is constantly growing. These models differ from each other in terms of power, maximum speed, range, weight and, above all, price.

According to these characteristics, the similarity between the individual models can be determined and thus their segmentation is possible. On the basis of an arbitrary

decision determined by the quotients of the coefficients of the successive stages, combining into clusters, two and four classes of scooters were distinguished.

The comparison of clusters with the adopted price ranges proved that the better performance of the scooter is related to its price. The better the scooter performs, the higher its price. Through such a statement, it is possible to determine whether a given scooter is too cheap or too expensive. The conducted segmentation allows for a scooter price comparison, along with the assignment to specific performance groups. For potential buyers, this can be a benchmark as to which scooters are within the buyer's budget and which performance is close to their expectations.

Further research will focus on the use of other classification methods, as well as other distance measures such as the Chebyshev distance and the city block distance (Manhattan). In addition, an econometric model that explains the price impact of the scooter performance will be created.

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SEGMENTACJA RYNKU HULAJNÓG ELEKTRYCZNYCH W POLSCE

Streszczenie: Wzrost popularności hulajnóg elektrycznych spowodował dynamiczny rozwój tego rynku w skali globalnej. Każdy potencjalny klient posiada odmienne preferencje, powinien zatem móc wybrać hulajnogę dopasowaną do swoich oczekiwań. W opracowaniu wykorzystano zbiór danych 42 hulajnóg dostępnych na polskim rynku wraz z ich specyfikacjami. Celem opracowania było przedstawienie struktury rynku hulajnóg elektrycznych w Polsce oraz przeprowadzenie segmentacji rynku. Na podstawie arbitralnej decyzji, bazującej na ilorazach współczynników kolejnych etapów łączenia w skupienia, wyodrębniono 2 i 4 klasy hulajnóg. Zestawienie skupień z przyjętymi przedziałami cenowymi dowiodły, że wraz ze wzrostem osiągów hulajnogi elektrycznej wzrasta jej cena. Takie zestawienie może również pomóc klientom wybrać hulajnogę najtańszą z danego segmentu rynku, zgodnie z ich ograniczeniami budżetowymi oraz preferencjami.

Słowa kluczowe: segmentacja rynku, hulajnogi elektryczne w Polsce, klasyfikacja, analiza czynnikowa.