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CLUSTER ANALYSIS OF AUTOMOTIVE INDUSTRY COMPANIES [*]

The aim of this paper is to determine the financial health of companies of the automotive industry by performing cluster analysis for the time period 2007−2011. Factor analysis will be used as input to perform cluster analysis. Cluster analysis classified companies of the automotive industry, which are in different financial situation into subsets with similar characteristics.
Keywords: financial health; bankruptcy; factor analysis; cluster analysis; automotive industry.
JEL classification: G32; G33.

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КЛАСТЕРНИЙ АНАЛІЗ ПІДПРИЄМСТВ АВТОМОБІЛЕБУДУВАННЯ

У статті зроблено спробу визначити фінансовий стан підприємств автомобілебудування шляхом кластерного аналізу за даними 2007−2011 років. Попереднім етапом кластерного аналізу став факторний аналіз. Корпорації автомобілебудування згруповано у 4 кластери за параметрами схожості фінансової ситуації.
Ключові слова: фінансовий стан; банкрутство; факторний аналіз; кластерний аналіз; автомобілебудування.
Табл. 6. Літ. 10.

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КЛАСТЕРНЫЙ АНАЛИЗ ПРЕДПРИЯТИЙ АВТОМОБИЛЕСТРОЕНИЯ

В статье сделана попытка определить финансовое положение предприятий автомобилестроения путём кластерного анализа по данным за 2007−2011 годы. Предварительным этапом кластерного анализа стал факторный анализ. Автомобилестроительные корпорации сгруппированы в 4 кластера по параметрам схожести финансовой ситуации.
Ключевые слова: финансовое состояние; банкротство; факторный анализ; кластерный анализ; автомобилестроение.

Introduction. The concept of financial health refers to the ability of a company to maintain balance under changing environmental conditions and also in relation to all involved in business. We are talking about financial health of a company if it maintains its own existence and is able to assess the invested capital to the extent required by its shareholders. The results of financial analysis differ in companies of different industries, because companies have different assets and financial structure, and also different structure of their profit. Financial health is required to achieve sufficient profit, as well as long-term liquidity. For bankruptcy, we will consider the situation when organization is not able to reverse their poor financial health and this condition is in accordance with valid legislation in the country. These technical terms are also used as "business failure" (or corporate failure).

In assessing financial health of a company and predicting financial difficulties of enterprises various financial indicators are used as input for expert estimations or for

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creating various models with the use of multivariate statistical methods. The main disadvantage of the approach that is based on selected statistical methods, is its limited temporal validity, and also complexity of model modifications, when conditions on the availability of quality input data are changed. Another frequent problem is inappropriate structure of the input file. We must be extremely careful in choosing the appropriate method, the model design and especially in the interpretation itself, as this may result in significant overestimation of its predictive power. The advantage is very good quality of prediction in the existence of high-quality data file (Altman, 2006). Performance was measured and assessed in the past on the basis of financial ratios and powerful organization was the one that appreciated the invested capital and provided adequate profits (Ivanickova, 2014).

In the expert approach which is based on calculating the total score of company on the basis of its values of financial indicators, the advantages include the ease of implementation and its simple interpretation. The disadvantage is setting strict boundaries in interpretation. This may lead to determining companies with nearly identical values of financial indicators belonging to different groups. Greater disadvantage of this approach is that it usually does not take into account possible relationships between indicators and each of them is perceived in isolation.

Due to opening borders between markets, competition is growing. Enterprises are engaged in fierce competition to maintain their position and thus they need to have information enabling them quickly respond to changes not only at their domestic but also at foreign markets. Based on the quality of the processed information an enterprise makes decisions on future investments and in a timely manner predict possible risks. This information is delivered to enterprise through financial analysis, which is an integral part of business management (Staskova and Niznikova, 2015).

In analysing financial health and in prediction of financial problems of companies various financial indicators are used which are the entry point for expert estimation or for creation of various models with the use of, for example, dimensional statistic methods (Lee et al., 2009). Prediction models have been applied in many studies unsuccessfully. Companies of the automotive industry in the application of prediction models cannot keep the recommended values from the forecasting methods, because of completely different economic environment and different timing. Altman model, Springate model, Tafflers model, index IN, as well as other models for predicting bankruptcy are often obsolete and outdated.

Data and methods. The object of our research is 30 concerns of the automotive industry (Table 1). These companies are members of the International Organization of Motor Vehicle Manufacturers (OICA), consists of 37 national unions around the world. 20 of these associations represent the leading automobile manufacturers in Europe, America and Asia. Input data are financial statements, namely balance sheets and profit and loss accounts. Selected companies produce cars, and also trucks and buses. M.A.N. AG has been producing trucks and buses (not cars).

Using the statistical software "SPSS" we obtain the first correlation matrix and subsequently carry out the factor analysis, cluster analysis and discriminant analysis. The question is how to reduce the number of the selected financial ratio indicators (in our case — 27) so that we do not lose much information.

Table 1. **The selected enterprises of the automotive industry,** *authors'*

Toyota Motor Corporation	Nissan Motor Co.	Fiat Group	Chana Co.	Dongfeng Motor	Mahindra Group
General Motors Corporation	Honda Motor Company	Daimler AG	Tata Motors	Isuzu Motors Ltd.	AB Volvo
Volkswagen Group	PSA Peugeot Citroen	B.M.W. AG	Geely Group	Brilliance Auto	Jiangxi Jiangling Group
Hyundai	Suzuki Motor Co.	Mazda Motor Co	BYD Auto	Great Wall Motors	Proton
Ford Motor Company	Renault S.A.	Mitsubishi Group	Fuji Heavy Industries	M.A.N. AG	Porsche

The options are:

- based on our experience, we will reduce the number of financial ratio indicators, so that they are independent of each other;

- to use factor analysis, which reveals the hidden factors, the so-called "latent variables".

Factor analysis deals with the analysis of interdependence of variables based on the assumption that these dependencies are the result from the effect of a certain small number of measurable latent variables. The aim of factor analysis is to find and interpret such common factors that clearly illustrate the dependence between variables. Also the number of factors should be minimized. Factors should best explain the variability in observed variables. Factor analysis is used as input for further cluster analysis.

The main role of cluster analysis we can formulate mathematically: it is grouping of objects X_i ($i = 1, 2, ..., n$) to clusters C_1, C_2, ..., C_q ($2 \leq q \leq n$) so that objects belonging to the same cluster are similar, close and objects belonging to different clusters are distant, different. Cluster analysis we can generally define as general logical process, formulated as a procedure by which objects are merging into groups — clusters, based on their similarities and differences.

Results. The aim of factor analysis is to reduce the dimension of space (27 indicators) of the area of far lower number of dimensions. Latent variables (financial ratio indicators) are replaced with a lower number of hidden factors, so that we do not lose much information. Factor analysis by the method PCA without rotation we conducted in "SPSS". After the factor analysis 7 main components remained. According to the dependence, we can divide the components as:

- *Factor of rentability* — the highest representation in this factor have the indicators of profitability. These indicators are used for analyzing the effectiveness of company activities. The highest representation has the indicator ROE — return on equity (88.6%) as it expresses the ratio of net income to equity ratio and ROA indicator (88.1%).

- *Factor of debt* — the highest proportion have financial ratio indicators: debt ratio to equity ratio (88.5%) Tangible fixed assets financed from debt (88.3%), capital cover (88.2%) and the share of current assets in total assets (87.6). These indicators reflect the payment discipline of companies.

- *Liquidity factor* – the indicator of the highest proportions of liquidity ratios. These indicators tell us about the financial situation of the company, the ability to speed the transformation from stocks to cash.

- *Factor of indebtedness* – the highest representation in this factor has the indicator of long-term indebtedness (59.5%) and self-financing (47.5%).

- *The operating factor* – the highest representation has the proportion of trade receivables to trade payables (70.9%) and an increase in net sales revenues (32.4%).

- *Factor of financing* – financing of tangible fixed assets is represented here (25.2%) and also total indebtedness.

- *Profitability factor* – in this factor the largest representation have the increase in net profit (63.4%) and increase in operating profit (41.7%).

Factor analysis we have carried out for the time period of 2008–2011. In the years 2008–2010 remained the same 7 principal components after performing the factor analysis in comparison with 2007. The last monitored year was 2011, for which we also used the factor analysis PCA without rotation. In comparison with the monitoring time period 2002–2010 we got different results, particularly in the number of principal components.

For 2011, after the factor analysis 6 components remained, according to the dependence we could divide them into components (factors):

- *Liquidity factor* – the highest proportion of liquidity indicators.

- *Factor of indebtedness* – the highest representation in this factor has the indicator of long-term indebtedness (68.3%), total indebtedness (69.4%) and the ratio of debt to equity (82%).

- *Profitability factor* – in this factor has the largest representation has the increase in net profit (53.3%) and also increase in operating profit (60%).

- *Factor of rentability* – the highest representation in this factor have the indicators of profitability. The highest representation has ROE (55.5%), the ratio of net income to equity indicator and ROA (55.9%).

- *Cash factor* – the highest representation has the ratio of cash flow to net proceeds from sales represented by 63.9%.

- *The operating factor* – the indicator of operating profit (52.5%).

Factor analysis is an important method in the evaluation of industry, which allows reducing the number of factors to minimum, so that the industry is sufficiently described. Using our factor analysis we perform cluster analysis with k-means for the time period 2008–2011 for the same companies. This method detects 4 clusters, each of them will have at least one company and the Euclidean distance between the centers of individual clusters is the largest. Cluster analysis with k-means we also perform in "SPSS", on the basis of heuristic approach (subjective opinion). We use Euclidean square distance and choose the condition that the center of clusters is calculated to include all objects in different clusters.

Year 2007. The initial centers of clusters are presented in Table 2. They are vectors with values determined by 7 variables related to 4 clusters.

Table 3 presents the final centers of the clusters. If we compare the initial and the final centers of the clusters, the third and fourth clusters are not changed.

Cluster 1 has significant high values of individual factors, the highest value (though not high) get the operating factor, profitability factor and the financing fac-

tor. Liquidity factor has the highest value in cluster 2, which means that these companies are able to pay their debts. Factor of rentability with the highest value belongs to cluster 3. Factor of indebtedness gets the total highest final value of the centers of clusters, namely 2.74 and belongs to cluster 4.

Table 4 shows to which cluster each object belongs to and new centers of clusters.

Table 2. **The initial centers of clusters in 2007,** *authors'*

Factor of	Cluster			
	1	2	3	4
rentability	-1.11892	.21169	1.63007	2.73674
debt	-.37664	.78433	-3.67281	1.56117
liquidity	.65179	1.28645	.60546	-.21945
indebtedness	.54341	-1.22692	.15264	2.41655
operating factor	1.85587	-.37285	-.38358	.43336
financing	1.86251	-2.30637	-.39903	.04760
profitability	-.65085	-1.32356	-.10251	-.74309

Table 3. **Final centers of clusters in 2007,** *authors'*

Factor of	Cluster			
	1	2	3	4
rentability	-.20846	-.48277	1.63007	2.73674
debt	.04238	.50609	-3.67281	1.56117
liquidity	-.29482	1.24714	.60546	-.21945
indebtedness	-.17910	-.02062	.15264	2.41655
operating factor	.27053	-1.27904	-.38358	.43336
financing	.14657	-.56684	-.39903	.04760
profitability	.19351	-.62117	-.10251	-.74309

Table 4. **Affiliation to clusters in 2007,** *authors'*

Company	Cluster	Distance
Fiat	1	1.656
Fuji	1	2.100
Isuzu	1	2.261
Hyundai	1	1.465
Chana	1	2.931
Man	1	1.409
Mitsubishi	1	1.876
Nissan	1	.756
PSA	1	.906
Renault	1	1.882
Suzuki	1	1.675
Toyota	1	3.063
Volkswagen	1	1.348
Volvo	1	1.401
Brilliance	2	3.250
Daimler	2	2.521
BMW	2	2.991
Geely	3	.000
Ford	4	.000

The first cluster consists of Fiat, Fuji, Isuzu, Hyundai, Chana, Man, Mitsubishi, Nissan, PSA, Renault, Suzuki, Toyota, Volkswagen and Volvo. All these companies have manufacturing facilities in Slovakia. In the second cluster are Brilliance, Daimler and BMW, the third cluster is represented by Geely and the fourth − by Ford.

Table 5 contains the distance between the final centers of clusters, where the distance between the first and the fourth clusters is 4.32 and the distance between the third and the fourth clusters is 6.

Table 5. **Distance of final centers in the clusters in 2007,** *authors'*

Cluster	1	2	3	4
1		2.503	4.349	4.317
2	2.503		4.844	4.785
3	4.349	4.844		5.975
4	4.317	4.785	5.975	

Differences between F-means allow making general conclusions about the significance of different mean value in the formation of clusters. Table 6 shows ANOVA results, and it is obvious that the debt factor has the greatest influence on the formation of clusters and financing factor has the least effect.

Table 6. **ANOVA in 2007,** *authors'*

Factor of	Cluster		Error		**F**	Sig.
	Mean square	df	Mean square	df		
rentability	3.818	3	.436	15	**8.750**	.001
debt	5.573	3	.085	15	**65.331**	.000
liquidity	2.099	3	.780	15	**2.691**	.084
indebtedness	2.104	3	.779	15	**2.701**	.083
operating factor	2.089	3	.782	15	**2.671**	.085
financing	.475	3	1.105	15	**.430**	.734
profitability	.748	3	1.050	15	**.712**	.560

Year 2008. From the total number of 30 companies in 2008, the second cluster get 24. The first cluster consists of Ford only and the third cluster has Mahindra. Dongfeng, Porsche and Greatwall are included in the last, fourth cluster.

Year 2009. The difference in the number of companies between one cluster and all the other is also observer for 2009. The fourth cluster in this year is represented by 25 companies. Brilliance, Fiat and Renault make up the first cluster. Mahindra is the only one included in the second cluster and Ford is the third cluster.

Year 2010. 2010 shows less differences in the numbers of companies by clusters. The first cluster consists Mahindra only. The second cluster is the most numerous one, it consists of 18 companies. Ford represents the third cluster. The fourth cluster has 10 companies.

Year 2011. After using factor analysis of the financial ratio indicators, the number of factors decreased in 2011 to 6. If we compare the starting year of in the time period (2007) and the remaining 2008−2010 after the factor analysis there were 7 factors.

As with the previous years, for 2011 we have performed cluster analysis with k-means, where we choose 4 clusters and we use the Euclidean square distance with the condition that the center of clusters is calculated after the inclusion of all the objects into different clusters.

If we compare the results of the initial and the final centers of clusters in 2011, the centers of third and the fourth clusters do not change. Values in different clusters are not very significant, the highest value is reached by the third cluster, at liquidity factor. Mahindra, which is the only one in the third cluster has the highest liquidity value.

In the first cluster are Daimler, Ford, General Motors, Isuzu, Mazda, Mitsubishi, Nissan, PSA, Toyota, Volkswagen, Volvo and BMW. As in 2007 also in 2011 the first cluster is the most numerous one. The second cluster consists of Brilliance, Byd, Dongfeng, Fiat, Fuji, Honda, Geely, Man, Renault, Suzuki and Tata. The third cluster is represented by Mahindra and the fourth cluster – by Porsche.

The first factor called liquidity factor has the greatest influence on the formation of clusters and the least important, sixth factor, is the operating factor.

Conclusion. Evaluating the financial health of a company determines its value. If company maintains its own existence and is able to assess the invested capital to the extent required by shareholders we are talking about financial health. Financial health is required to achieve sufficient profit, as well as long-term liquidity.

We have focused mainly on the years 2007–2010, when like most others industries, the automotive sector felt the effects of the global financial crisis. Ford in 2006–2008 had serious financial problems and reported its biggest loss ever, it had to lay off 10,000 employees and sell two brands from its portfolio. Toyota was the leader during the entire period of the car market and the impact of the financial crisis reached Toyota last of the big car companies. Toyota is situated in a cluster with other companies which were not significantly damaged by the financial crisis.

By means of cluster analysis we have classified companies of the automotive industry, which are in different financial situation into subsets with similar characteristics, thus creating groups of companies with similar financial situation. Cluster analysis provides us with a methodology to determine the financial health of companies in the automotive industry.

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