Analysis of trading companies on the basis of Kohonen networks

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Abstract

The contribution deals with the analysis of trade companies using artificial neural networks, more specifically Kohonen networks, where the basis for the analysis is primarily the data from evaluating economic performance of a business entity, where each entity strives for increasing its market value. This contribution also estimates the development of trade companies. For the analysis, the data of 11,604 companies in the given sector in the Czech Republic were used. Cluster analysis is carried out using neural networks. From the clusters, those with the highest number of companies were chosen. Subsequently, the analysis of absolute values of selected financial statements items is carried out. From the owners´ point of view, the situation is not positive, as the rate of deposits appreciation is even lower than the risk-free appreciation of 10-year state bonds. In the conclusion, recommendations for trade companies are given.

Keywords: Kohonen networks, neural networks, economic performance of company, trade, cluster analysis.

Introduction

Evaluating economic performance of a given business entity in the best possible manner is the wish of every owner (or investor). From their perspective, it is particularly important to find out whether their enterprise is able to increase its value and hence to gain early return on investment (Kisel'akova et al., 2018). According to Onuferová and Čabinová (2018), there is a question, however, of how to measure such enterprise performance. They further add that monitoring financial performance of a particular organization is undoubtedly the most important measure. Narkuniene and Ulbinaite

(2018) state that there is practically a wide range of company evaluation approaches, and their use is based on the current market situation as development of markets brings about shifts in performance measures. Also, as Malichová, Ďurišová and Tokarčíková (2017) remark, there is a current shift in the area of indicators that are capable of measuring performance of business entities.

Vochozka et al. (2017) state that, for instance, to evaluate trading companies, which this contribution addresses, Czech entrepreneurs focus mainly on monitoring traditional indicators of financial analysis, i.e. indicators of indebtedness, activity, liquidity, profitability, etc. Due to over-criticism of some regular indicators, new approaches to evaluation of trading companies have gradually developed in business practice. Nowadays, the most common methods include Benchmarking, creditworthy and bankruptcy models, EVA, MVA, Balanced Scorecard, and the increasingly popular method of artificial neural networks.

As part of a specific analysis carried out in this contribution, importance of the trade sector within the Czech economy shall be briefly discussed. According to the MPO (2015), the above sector is the second largest employer as well as contributor to GDP (or GVA), with the sector itself representing more than 10% of the Czech economy's GDP. In 2014, for instance, trade accounted for 14% of total employment (and with the category of entrepreneurs – self-employed individuals included as well, the total even reached 18%, which means that the number of people working in the trade sector is estimated at around 700,000).

Equally significant in this respect is even the volume of investment in the business network development, which has reached over CZK 600 billion since the 1990s. Apart from that, the Czech Republic holds one of the largest ratios of sales area per capita (1.5 m^2).

Additionally, retail in the Czech Republic is one of the most advanced in Europe as it uses modern technologies and introduces many new trends. There is a great deal of competition among individual traders as well, which is mainly beneficial to consumers being ultimately able to choose the most reasonable price.

Another positive trend is that household consumption expenditures (as one of the main factors of economic growth) have risen slightly in recent years. The year-on-year increase in household consumption in terms of retail trade is almost 2%.

An average four-person household spends more than CZK 24,000 per month in the retail sector, which is more than CZK 120,000 per person on average annual spending.

Recently, there have also been notable changes in the manner of selling products, with a major increase being in Internet sales. In 2014, revenues of e-shops were 2.5 times higher than in 2008 and accounted for 7.1% of total revenues.

Artificial neural networks – Kohonen maps

An artificial neural network is currently a well-known term representing an algorithm inspired by knowledge of neurons and neural networks of living organisms and their abilities – to learn, generalize, solve complex nonlinear problems, etc. (Rowland and Vrbka, 2016). Vochozka and Machová (2018) claim that artificial neural networks are relatively easy to use and are mainly applied to predictions and complex problems. Owing to a number of advantages, artificial neural networks are used in various areas (Sánchéz and Melin, 2015). Weinlichová and Fejfar (2010) add that their use is being explored, for instance, in all areas of business (whether it's for business risk assessment, marketing, management or other financial aspects, etc.).

Ahmad and Yusof (2016) observe that SOMs – Self organizing maps – are increasingly being used for business studies. At present, they are the basic and most popular kind of neural networks widely known as Kohonen maps (Bodyanskiy, Deineko and Eze, 2018). Wehrens and Kruisselbrink (2018) view Kohonen maps as popular tools for grouping and visualizing of data in many areas of science.

According to Trafialek, Laskowski and Kolanowski (2015), this kind of networks is classified as the so-called non-teacher learning networks which do not need ideal patterns to set up. Juszczyk and Zima (2017) further add that they are single-layered networks with full unit-to-input linking between their inputs and competitive layer, i.e. each neuron has information about the value of each input.

Pasa, Costa and Medeiros (2017) state that thanks to their ability to self-organize and cluster objects with similar characteristics into groups, Kohonen maps are predestined for decision-making, identifying and classifying objects, signals, etc. There are a number of options regarding the use of Kohonen maps, and even some experts quite rightly say: “If you don't know which algorithm to use, use Kohonen maps” (Haimoudi et al., 2016).

In addition, Šuleř (2017) used Kohonen maps in his study on examining possibilities of their use to identify businesses likely to go bankrupt. On the basis of three conducted analyses of a sample of construction companies operating in the South Bohemian Region between 2006 and 2015, he found that Kohonen networks are not suitable to be used as a tool for predicting possible bankruptcy of companies. However, it is possible that, in combination with other tools, more significant results could be achieved.

The main objective of this contribution is to analyse trading companies operating in the Czech Republic through Kohonen networks and subsequently predict their development.

Methods and Data

For the purpose of the contribution, a data set will be created, which will include complete data of financial statements of 11,604 companies trading in the Czech Republic in 2016. They are the subjects, the prevailing business of which is classified in section G of CZ-NACE classification of economic activities. The set of companies will be generated from the Albertina database of Bisnode company.

The data will be recorded in a table in the format of Excel Application. Every row will contain a financial statement of a particular company, which will be identified by its name and identification number. The companies which did not perform their main business activities during the whole monitored period will be removed from the set. They are the companies which were closed (and did not significantly influence the direction of national economy) in this period, and the companies the business activities of which were commenced (and likewise did not significantly influence the direction of national economy in the Czech Republic). The case of the companies which commenced their activities on 1 January 2016 and those which terminated their activities on 31 December 2016 could be discussed. However, it does not have a significant impact on fulfilling the objective of this contribution. Furthermore, the columns which do not provide a dispersion will also be excluded.

The set will subsequently undergo a cluster analysis using Kohonen networks. Dell´s Statistica software, version 12 will be used for the cluster analysis. Data mining module will be applied as a specific tool of neural network. At this point we will select self-learning neural networks, i.e. Kohonen networks. We will specify the data for the analysis, i.e. we will select a table with the data set from the Excel application. They are continuous predictors in all of the cases. The set will be divided into three parts:

1. Training data set: it includes 70% of companies from the set. This data set will serve for the purpose of creation of Kohonen network.
2. Testing data set: this includes 15% of the companies of the original set. We will verify the parameters of the Kohonen network with the help of this data set.
3. Validation data set: this will include 15% of the companies of the original set as well. We will verify the obtained Kohonen network with the help of this data set in order to determine whether it is applicable or not.

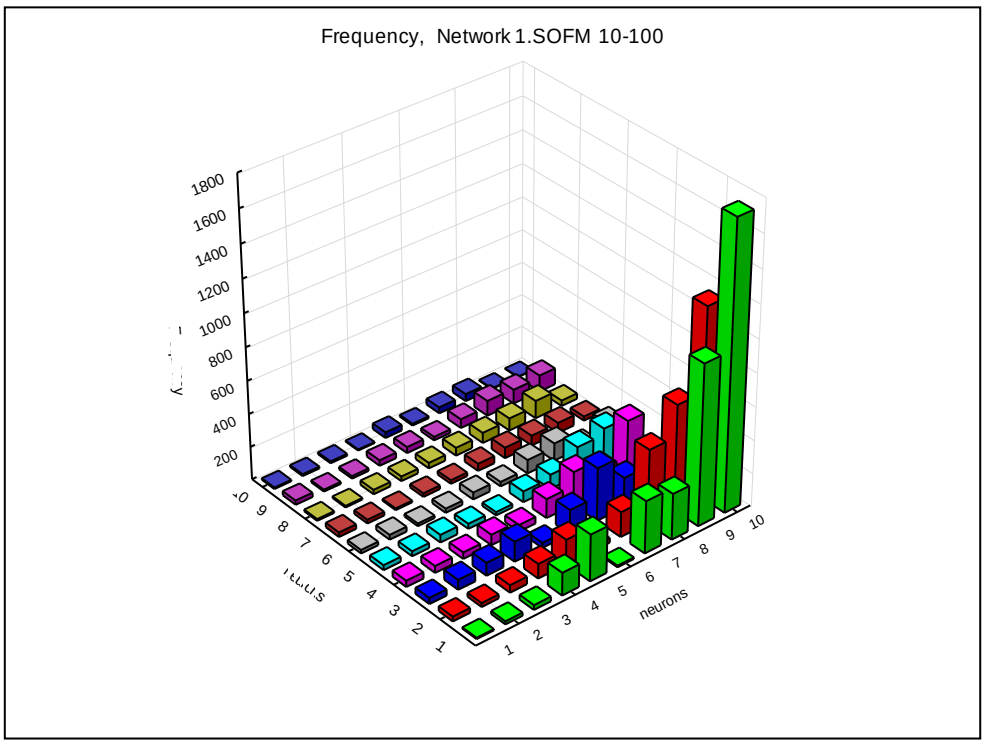
Both the topological length and the topological width will be defined as 10. The number of iteration will be defined as 100,000. Nevertheless, it is important to remind the reader of the fact, that the error level is crucial. If there is not an improvement of the parameters of Kohonen network when following iteration takes place, the training will be terminated before the 100,000th iteration occurs. In case that network parameters improve when 100,000th iteration takes place, the whole process must be repeated and a higher value of required parameters must be defined in order to be certain that the achieved result is the best possible one. The learning speed will initially be defined at 0.1 and subsequently at 0.02.

The results (the division of 100 individual companies into clusters) will be transported into a table in Excel application. Subsequently the individual clusters will undergo an analysis of absolute and selected ratio indicators, i.e. their mean values, arithmetic means, and the results will be interpreted.

Results

Clusters were created on the base of applied methodology. The division of quantities of companies in individual clusters is shown in picture No. 1.

Figure 1: Division of companies in individual clusters of Kohonen map



Source: Own processing.

Figure 1 shows a three dimensional Kohonen map of the quantity of companies in individual clusters. It is obvious that the biggest number of companies is in cluster (1, 10). The following cluster is (2, 10). The third position is cluster (1, 9). Furthermore, it is possible to observe a slightly bigger proportion of clusters (2, 9), (2, 8), (4, 9), (3, 7) and (1, 7). The other clusters contain a significantly lower proportion of companies.

Table 1 shows specific values presented for the purpose of making a detailed example of the proportion of companies in individual clusters.

Tab. 1: Proportion of companies in individual clusters of Kohonen map

	Network: 1.SOFM 10-100 Samples: Training, Testing, Validation									
	1	2	3	4	5	6	7	8	9	10
1	8	19	29	137	281	10	316	278	969	1726
2	29	24	45	88	150	26	151	446	636	1138
3	37	60	78	121	31	148	320	181	97	283
4	38	42	40	64	40	116	201	137	354	60
5	30	30	46	31	20	66	88	178	214	1
6	21	30	16	25	43	28	83	107	15	79
7	28	23	10	22	22	44	65	61	63	25
8	10	10	27	29	34	48	63	75	108	34
9	26	12	16	34	37	22	55	93	87	101
10	9	11	11	6	35	11	37	44	4	3

Source: Own processing.

The table clearly shows that only the clusters highlighted in red always include more than 100 companies. The clusters highlighted in yellow contain more than 500 companies. The other clusters always contain less than 100 companies. Further analysis only includes the following clusters (1, 10), (2, 10), (1, 9), (2, 9), (2, 8), (4, 9), (3, 7) a (1, 7). They consist of 5.905 companies and are represented by 8 clusters out of 100 existing clusters, i.e. 50% of companies in the set. Moreover, one particular cluster (1, 10) includes 1,726 companies, which is nearly 15% of the whole set. Therefore, it is appropriate to conclude that the analysis will be a valuable representation of the potential of entire Czech trade.

Mean values of the data set as a whole and selected cluster in assets are given in Table 2.

Tab. 1: Selected variables mean values of clusters

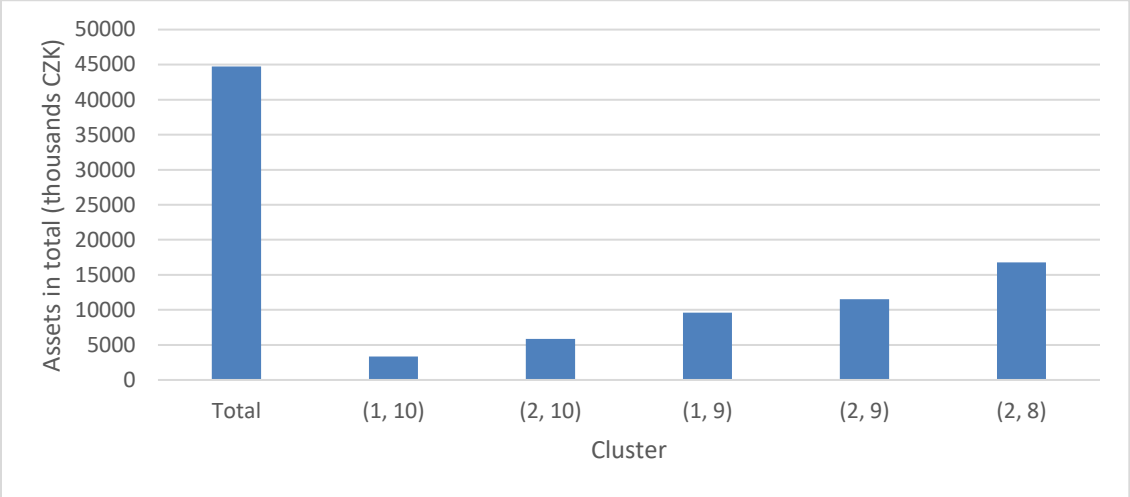
Captions	Total	(1, 10)	(1, 7)	(1, 9)	(2, 10)	(2, 8)	(2, 9)	(3, 7)	(4, 9)
Assets in total	44,717.82	3,325.669	1,6670.41	9,602.85	5,860.159	16,798.03	1,1509.6	18,589.83	20,900.69
Fixed assets	11,366.46	549.3592	1,0437.77	1,229.674	1,199.341	1,819.722	1,616.296	2,389.859	2,863.356
Current assets	32,848.42	2,726.213	6,094.823	8,214.43	4,579.923	14,691.88	9,779.395	16,073.06	17,789.22
Equity	20,126.67	680.7039	6,276.092	3,208.833	2,226.957	2,241.868	6,564.502	14,005.87	14,402.73
Liabilities	24,269.38	2,619.081	10,310.61	6,289.757	3,587.876	14,325.94	4,861.075	4,501.038	6301.085
Performances	3,108.327	119.4983	346.0823	106.2714	302.4745	401.1413	306.3695	45.32813	719.6695
Value added	10,266.52	642.6715	2,230.896	509.7152	3,222.928	2,086.081	4,344.454	19.05625	6,188.963
Operating earnings	3,315.922	101.5122	396.9462	117.3209	857.6204	456.213	1,556.689	148.325	2,695.297
Earnings before interest and tax	55.0904	1.325608	7.664557	2.412797	17.93673	8.069507	34.64623	-0.575	59.12429

Note: The amounts are given in thousands CZK.
Source: Own processing.

The table clearly shows the difference between the values in terms of the whole trade sector and the individual clusters. Mean values of the whole trade sector are significantly higher than mean values of the clusters with the highest number of companies. This can mean that the selected clusters significantly reflected the size of companies as one of

parameters (this necessarily did not have to be a primary parameter; it could have happened inadvertently). The most important assets values are given in the individual graphs below. Figure 1 shows a comparison of mean asset values for trade as a whole and for individual selected clusters.

Figure 1: Mean assets values for trade sector and for selected clusters

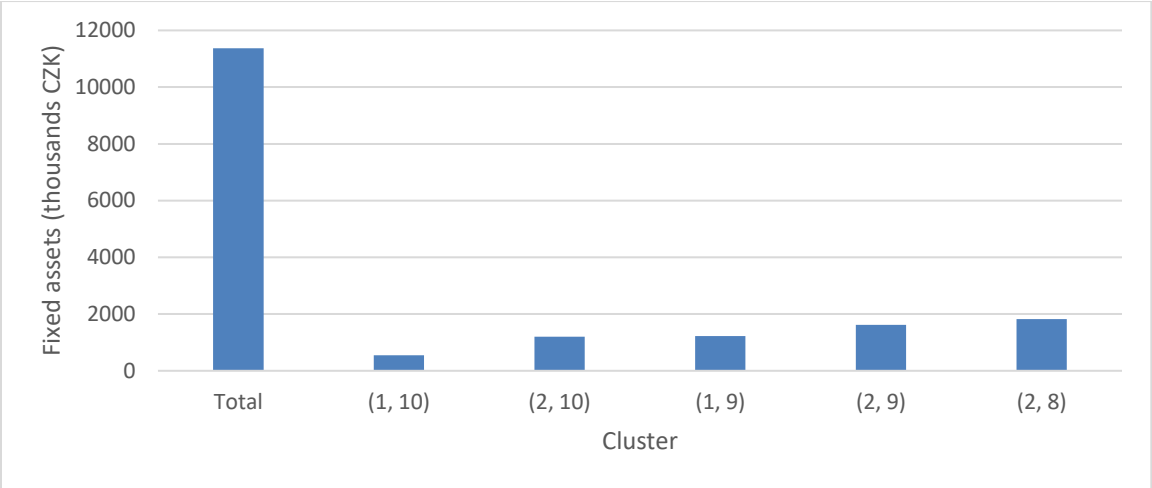


Source: Own processing.

The average balance sheet, that is, the value of assets for the trade sector is almost CZK 45 million per company. Cluster (1, 10) achieves the average assets value of CZK 3.3 million. Only two of the clusters from the graph achieve the average total assets value of more than CZK 10 million. The companies of the (2, 8) cluster have assets in the average value of nearly CZK 17 million. Another cluster exceeding CZK 10 million is the cluster (2, 9) with the average value of more than CZK 11,5 million. The cluster (1, 9) with the average value of CZK 9,6 million is also close to the limit.

An equally interesting indicator that distinguishes companies in individual clusters in the trade sector is the amount of fixed assets (for more details, see Figure 3).

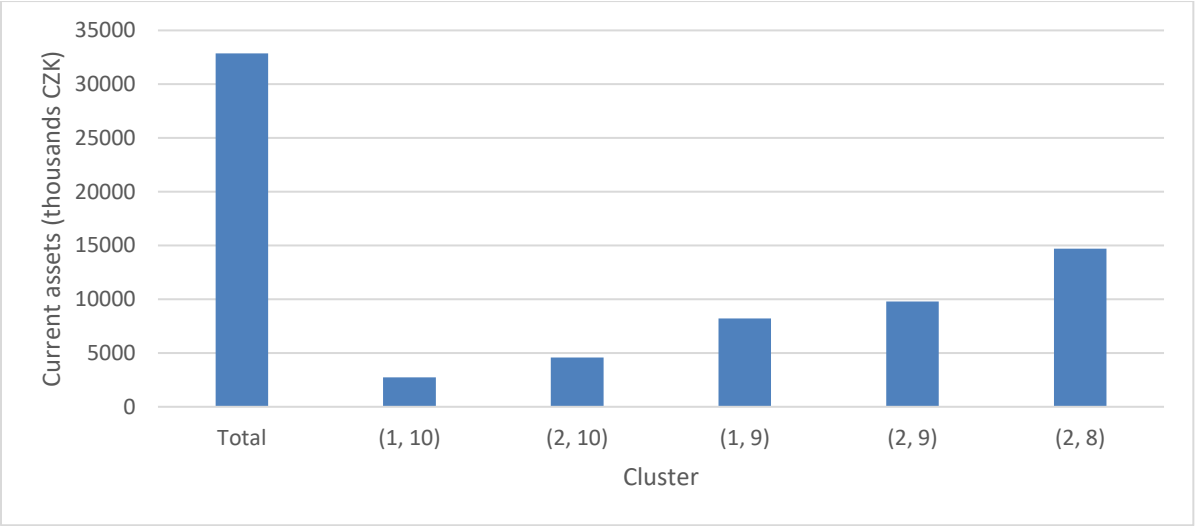
Figure 2: Mean values of fixed assets for trade sector and for selected clusters



Source: Own processing.

Trade is essentially a very specific sector of the national economy. It itself does not create a value. However, traders are able to mediate the exchange of tangible goods produced by manufacturing companies or service companies with customers producing a demand. Mediating trade itself carries the value added (either directly or through additional service – distribution, promotion, etc.). A lot of resources are concentrated in trade. Depending on the subject of trade, a large volume of current assets or receivables can be expected, as well as a large amount of liabilities. The marginal rate of capital substitution for labour force does not work well in trade (except for sales through vending machines). The level of automation is relatively low in trade. Trade as a whole is above the fixed assets value of CZK 11 million per one company. The companies in the examined clusters use the fixed assets significantly less. The best is the cluster (2, 8), reaching the value higher than CZK 1,8 million. The cluster with the highest number of companies (1, 10) reach the value of nearly CZK 0.55 million per company. The cluster with the second highest number of companies (2, 8) achieves CZK 1.2 million per company. The remaining two clusters reach the value of CZK 1.2 million, namely it is CZK 1.2 million for the cluster (1, 9) and CZK 1.6 million for the cluster (2, 9). Assuming that the rate of fixed assets involvement increases with the size of companies, it can be concluded that the examined clusters do not include large or extremely large companies operating in the trade sector of the Czech Republic. Other variable examined is current assets. For more details, see Figure 4.

Figure 3: Mean current assets values for trade sector and for selected clusters

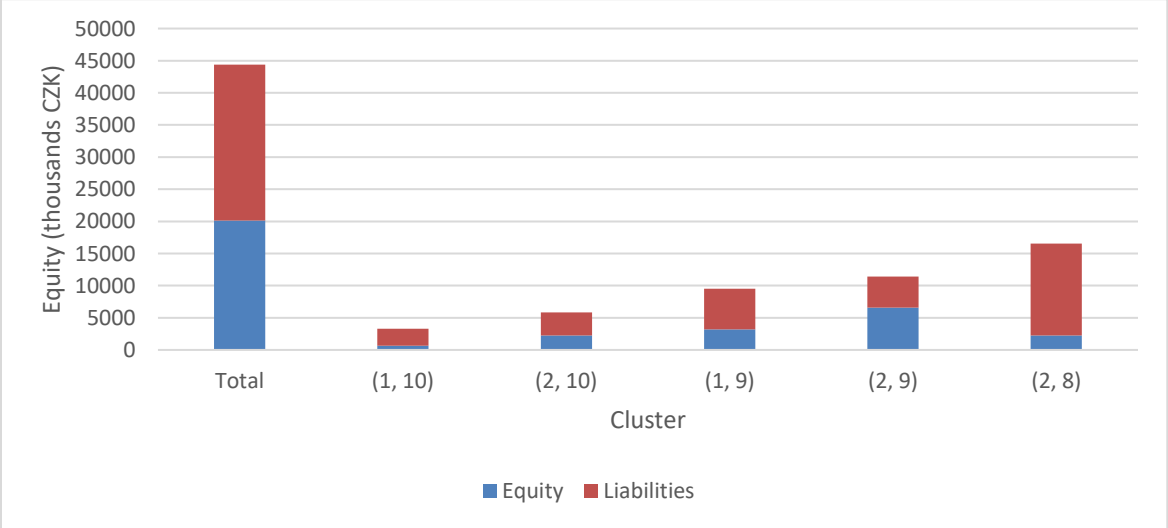


Source: Own processing.

Current asset (although it is not the same as working capital) is a very important of every company, especially a commercial company. It represents the basic purpose of its existence, that is, the volume of goods the company trades in. It thus includes inventory, mainly goods, receivables and financial assets. Mostly these are retail companies, where payments are in cash or online by credit cards; the receivables therefore are not high. The highest mean value of current assets shows trade as a whole, nearly CZK 33 million. The companies in the cluster (1, 10) have the average current assets value of CZK 2.7 million. In the case of the clusters (2, 10), (1, 9) and (2, 10), it is less than CZK 10 million. The companies in the remaining cluster (2, 8) own the current assets of the average value of nearly CZK 15 million.

Not surprisingly, equally interesting values are for the assets financing sources, capital. The structure of commercial companies financing is shown in Figure 6.

Figure 4: Mean values of equity and liabilities for trade sector and for selected clusters

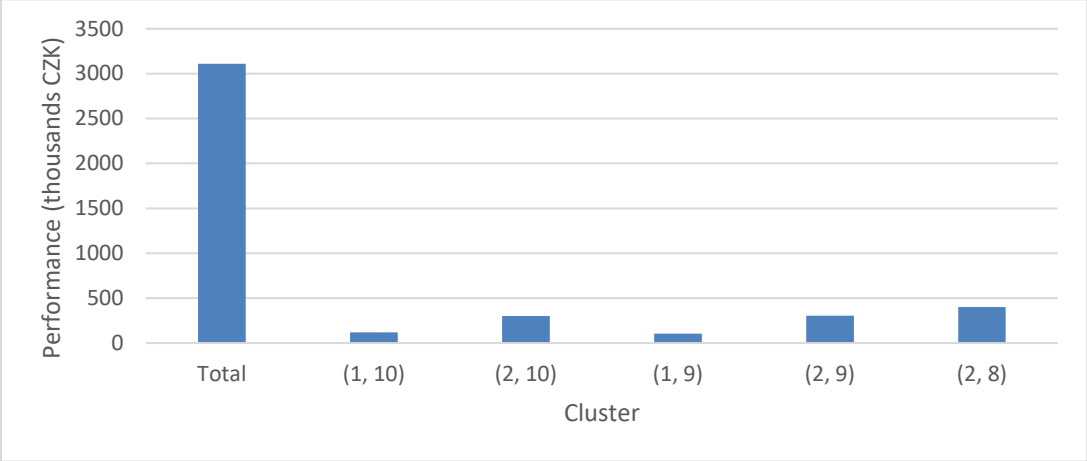


Source: Own processing.

Figure 6 shows the ratio of equity and liabilities for selected clusters and for the whole trade sector. The figure indicates that the share of liabilities in the trade sector is nearly 55% on average. In the case of the whole data set, the equity as well as the liabilities is at CZK 45 million. The highest capitalized cluster in the monitored data set is the cluster (2, 8). Its sources are CZK 16.5 million. However, in the case of this cluster, the liabilities prevail significantly. The average indebtedness of this cluster is nearly 86.5%, which exceeds significantly the values recommended. Even in the remaining clusters, the liabilities are predominant. The only exception is the cluster (2, 9).

Due to the extent of the contribution, it is only possible to focus on several selected items in the earnings and loss account, the comparison of average performance in the trade sector being the first of them (see Figure 7).

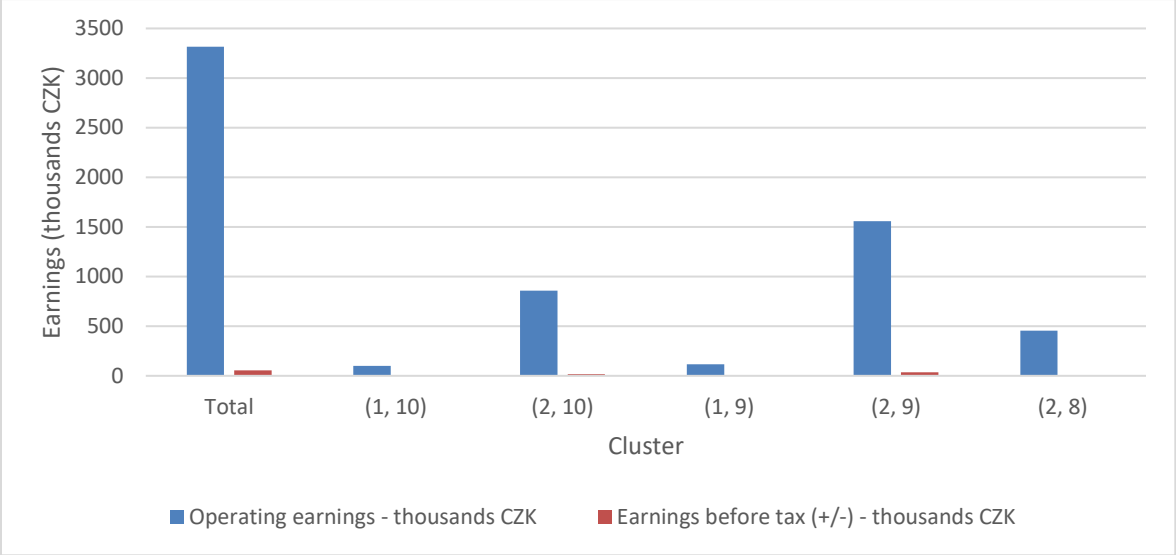
Figure 5: Average performance values for trade sector and selected clusters



Source: Own processing.

An average trading company´s performance is more than CZK 3,1 million. Just for comparison, an average trading company´s performance is over CZK 30 million. From the clusters examined, the highest value is for the cluster (2, 8). An average value of a company in this cluster is nearly CZK 0.46 million. The cluster with the highest number of companies (1, 10) generates an average performance of CZK 0.1 million. Figure 8 shows a comparison of the earnings achieved. In particular, it deals with the operating earnings and earnings before tax.

Figure 6: Average values of earnings for trade sector and for selected clusters

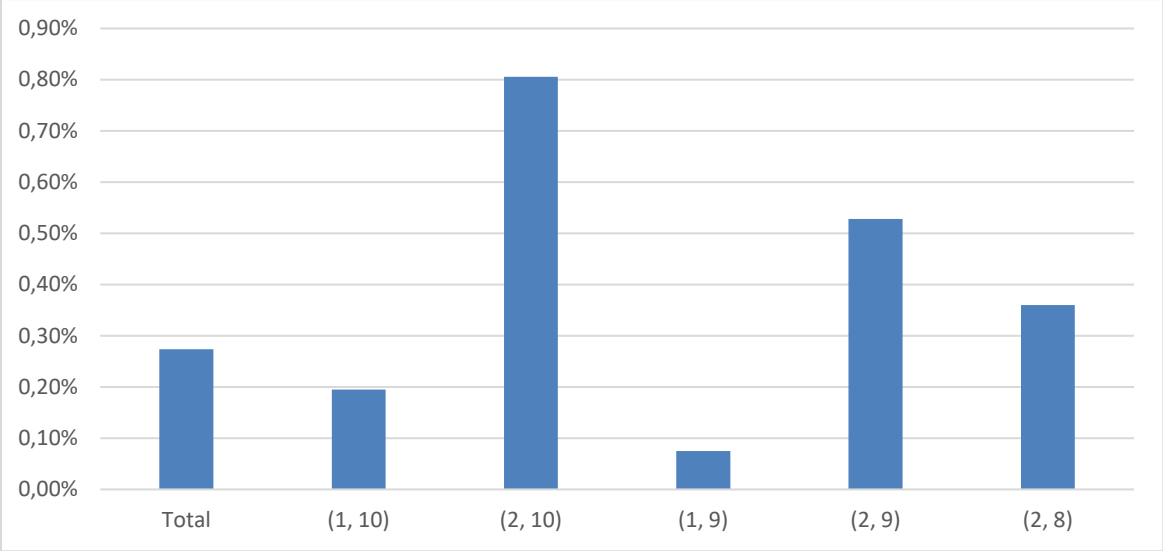


Source: Own processing.

The most important earnings for a company is the operating earnings, which represents the results of the company activities, or the activities for which the company was founded. The highest value of both operating earnings and earnings before tax are achieved by the trading companies as a whole. The mean value of the operating earnings is approx. CZK 3.3 million. However, the value of the earnings before tax is only CZK 55,000. Such a big difference between the value of the operating earnings and earnings before tax is evident in all examined clusters. This means that the financial and extraordinary result must be significantly negative in total. Similarly, the clusters (2, 10), (2, 9) and (2, 8) achieve a significant amount of operating earnings. However, even in this case, the earnings before tax is minimal.

So far we could assume that companies of different size were compared, which intensified their clustering. For better illustration, a relative indicator will be added, namely return on equity. This is an interesting indicator, since it is able to assess the fulfilment of the basic company objective, which is the appreciation of the owners´ investment. It is an indicator of ratio comparing earnings after tax to equity capital. Specific values for the trade sector and the selected clusters are shown in Figure 9.

Figure 7: ROE Indicator of mean values for trade sector and selected clusters



Source: Own processing.

It follows from the figure that neither the trade sector nor the individual clusters achieve high values. Taking into account the value of risk free investment (i.e. ten-year government bond interest) as of 31 December 2016, the results appear to be completely unsatisfactory. Risk free rate as of the aforementioned date was 0.53%. In 2016, this value was achieved by the companies in the cluster (2, 9) and exceeded by the companies in the cluster (2, 10). Other companies, including the average of the trade sector did not even reach this rate of owners´ investment. Moreover, when considering that the rate of investment appreciation is compared with risk free return, the resulting ROE of the cluster (2, 10) is also insufficient. If the situation persisted in the following years, the owners should consider investment in other sectors of the national economy.

Conclusion

The objective of the contribution was the analysis of companies operating in trade in the Czech Republic by means of Kohonen networks and prediction of their development.

The objective of the contribution was fulfilled. A cluster analysis was performed. From the clusters those with the highest number of companies were selected. Subsequently, the analysis of absolute values of the selected financial statements items was carried out. As a typical representative of a cluster, the mean in cluster examined was determined.

Overall, it can be stated that trading companies show relatively bad values – minimum assets, high debt and minimum earnings before tax. Perhaps the only positive value is the operating earnings which is in certain contrast with the earning before tax. This allows assuming long life of trading companies. However, from the owners´ point of view the situation is not good. The rate of their investment appreciation is even lower than the risk-free 10-year government bonds. The owners are thus faced with the decision whether to

keep investing in trading companies or whether to transfer their investment into companies operating in other sectors of the national economy.

As for the individual clusters results, it can be summarized as follows:

1. Five clusters with the highest number of companies represent more than 50% of companies operating in the trade sector.
2. The clusters examined showed lower, sometimes significantly lower values of the selected financial statements items (balance sheet, fixed assets, earnings, etc.).
3. It follows that the examined 50% of the companies generate 50% of the trade sector performance.
4. It follows that the remaining 50% of the companies play a more significant role in the trade sector performance than that one corresponding to 50%.

It can thus be concluded that the remaining 50% should be examined thoroughly in order to identify which companies (or clusters) positively influence the results of the entire trade sector. This would enable to predict the future development of the whole institutional sector of the national economy.

In conclusion trading companies are recommended to:

1. Consider whether they work only with the operationally necessary assets.
2. Reduce their indebtedness.
3. Try to increase the trading margin (even at the price of offering other services related to selling goods, know-how, etc.).
4. Focus on the optimization of the earnings.

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