

Monika Zielińska-Sitkiewicz<sup>1</sup>  
Szkoła Główna Gospodarstwa Wiejskiego w Warszawie

## THE IMPACT OF NORMALIZATION PROCEDURES ON THE CLASSIFICATION OF BUILDING MATERIALS COMPANIES LISTED ON THE WARSAW STOCK EXCHANGE

*One of the stages of the comparative analysis of multivariate objects is the data normalization. There are many procedures of the normalization of the variables described in the literature. The choice of the normalization method is one of the most crucial steps for the researchers as it has a profound effect on the results of the analysis. The main goal of the present study is to examine the sensitivity of the result of linear ordering of objects, using three selected normalization methods, in calculating a synthetic taxonomic measure TMAI to create ratings of 15 building materials companies, listed on the Warsaw Stock Exchange. The study was made for the years 2013 and 2014. The conducted study shows that the use of different normalization formulas of variables can cause the change of the results of the companies classification, which does not result neither from the data structure change nor the effectiveness modification of their operations.*  
**Key words:** the data normalization, taxonomic measure, TMAI, building materials companies

### Introduction

The construction sector in Poland is now a vastly developed branch of Polish economy. It is an indicator of modernity and progress. The very important role of the construction industry results from the implementation of investments present in the daily life of almost every human being and the ability to generate economic growth.

The analysis of the construction market and the industry of building materials is conducted on many levels. They are important from the point of view of the needs of the companies in the sector, which want to achieve a reasonable profit from the business, but also from the point of view of households, which are the customers as well as the investors.

Methods of linear ordering of objects are one of the groups of methods of the Multivariate Comparative Analysis. There are many algorithms for creating synthetic indicators, using the appropriately selected diagnostic variables. Z. Hellwig (1968) was the first one to propose the synthetic measure of development for the comparison of the level of economic development of the selected countries. The methodology of constructing taxonomic meters for various applications were developed in Poland by, among others, Cieślak (1974); Bartosiewicz (1976); Strahl (1978); Zeliaś, Malina (1997); Kukuła (1986, 2000); Walesiak (2003); Gatnar, Walesiak (2004), and Tarczyński and Łuniewska (2006).

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<sup>1</sup> Katedra Ekonometrii i Statystyki

Normalization of diagnostic features is the standardization of the characteristics values from the point of view of a particular criterion carried out in order to bring the characteristics of various titles to their comparability. Among others, Hellwig (1968), Bartosiewicz (1976), Nowak (1977), Strahl (1978), Borys (1978), Grabiński (1992), Kukuła (2000), Lira et al. (2002), Pawełek (2008), Panek (2009), Walesiak (2003, 2004, 2014) dealt with the issues of selecting the standardization formula.

In the algorithm of the synthetic index construction the researcher has to make decisions related to the selection of individual procedures at each stage. As the result of the comparative analysis depends on the set of methods and tools. Changing the way of normalization of diagnostic features may cause changes in the position of objects in the ranking, which are not necessarily caused by the growth or decrease of the assessment of their “quality” (Dębkowska, Jarocka, 2013).

The main goal of the presented article is to examine the sensitivity of the result of linear ordering of objects, in applying three different procedure of variable normalization in the construction of rankings of 15 companies in the industry of building materials. Calculation was made for the years 2013 and 2014. Moreover, it was examined how the use of different normalization methods of the same diagnostic variables impacts the results of classification and the obtained results were compared to the model ranking proposed by the expert using the Spearman’s rank correlation coefficient. The paper used the Taxonomic Measure of Investment Attractiveness (TMAI), which calculates the distance of each object from the pattern, taking into account the varied strength of impact of variables on the studied phenomenon. This meter allows the use of the comprehensive analysis of companies based on the most important financial indicators, presenting it in the form of a synthetic ranking.

### **The selected aspects of the financial analysis of the companies from the building materials industry – expert ranking**

Fifteen listed companies from the sector of the building material industry were selected for the study, listed on the main market of the Warsaw Stock Exchange, the activity of which is carried out primarily in Poland and which profit and loss account is prepared in the spreadsheet system.

From the point of view of the nature of the conducted activity by the analysed companies, they can be divided according to the following criteria:

- companies specialising in the production of materials for finishing the interior: Decora S.A., Ceramika NovaGala S.A., Investment Friends S.A.<sup>2</sup>, Paged S.A., Polcolorit S.A., Pozbud S.A., Rovese S.A., Śnieżka S.A.;
- companies, the production of which concentrates on precast and products for the construction industry: Izolacja-Jarocin S.A., Izostal S.A., KBDom S.A., Lena Lighting S.A., Ropczyce S.A., Selena FM S.A., Yawal S. A..

Analysing the financial statements of the studied companies from 2013 and 2014 one can state that revenues from the sale of companies of the interior finishing materials were almost two times higher that of the companies producing precast and materials for the construction industry. However, in 2014, the “interior design” companies noted only

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<sup>2</sup> To July 2014 the old name: Budvar Centrum S.A.

the 4% drop in revenues, and companies producing prefabricated materials a 1% increase in revenues in relation to the previous year.

When examining the financial net result achieved by the companies producing building materials it can be noticed that in contrast to the slight drop in revenues in 2014 by 3%, the net profit for the entire group dropped by 134%. Large losses were recorded by the companies: Rovese S.A. group (associating the Cersanit and Opoczno companies, manufacturers of ceramic and bathroom products), Investment Friends (as Budvar Centrum – production, assembly, sales of windows and window accessories, and currently the company experiencing great economic difficulties) and Decora S.A. (manufacturer of interior finishing materials). Compared to other companies, the following companies can be positively distinguished: Śnieżka S.A. (manufacturer of paints and putty), Paged S.A. (manufacturer of wooden materials and furniture), Pozbud S.A. (manufacturer of windows and doors), Lena S.A. (manufacturer of the professional lighting) and Yawal S.A. (manufacturer of architectural systems of aluminium profiles), which in 2014 improved their financial results.

When building *the expert ranking* of companies in the sector of building materials industry, the most stable positions of the financial statement were taken into account, i.e., the total assets and own equity from the balance and the net profit and revenues from sales from the profit and loss account. It was assumed that the relatively low information potential is in the indicators relating to the balance positions, which can result from one-time events, e.g., created on December 31. When creating the classification of companies the ability of companies for the effective management of the assets and to cover the current liabilities of the current assets, effectiveness of own equity and return on sales were taken into account.

The following companies: Śnieżka S.A., Paged S.A. and Pozbud S.A. were qualified as the best companies, while the weakest ones were represented by KBDom S.A., Polcolorit S.A. and Investment Friends S.A.. The company Śnieżka S.A. is the undisputed leader among all analysed companies. Of all the companies of the studied sector, the companies: Śnieżka S.A., Paged S.A. and Pozbud S.A. have used their assets best, have not involved excessive foreign capitals into the financing of the activity, and in the turnover they have reached the optimal receivables, almost textbook values. It should be noted that the Rovese S.A. group oriented to the export of its products, the former market leader, started bearing losses with the start of the political crisis. Polcolorit S.A. is a company, which had troubles paying off its obligations, which could be a consequence of excessive lending of own clients and freezing the assets in the supplies. The KBDom S.A. company until 2012 has focused its significant part of the economic activity on the housing, which activity led to its exceptionally large losses. In 2013, the company changed its business profile towards the production of precast, which did not, unfortunately, improve the effectiveness of property management and liquidity. The company Investment Friends S.A. with low profitability on sales suffered losses in the years 2013-2014, which resulted in the negative results of indicators based on the financial result.

Tables 4 and 5 include the layout of companies in the expert ranking for the years 2013 and 2014.

## Synthetic TMAI measure – description and results of the study

The group of nine most important financial indicators recommended by the literature was used for the construction of the synthetic taxonomic TMAI indicator in the study of companies of the building materials. They characterise the most important aspects of the company: profitability (*ROE*, *ROA*, *ROS*), liquidity (*CR*), efficiency (*ITR*, *LR*, *ATR*, *RTR*) and debt (*DR*). The eight applied indicators, recommended in the works by Tarczyński and Łuniewska, were described in Table 1:

**Table 1.** The selection of variables and their impact on the general criterion

Ratio	Formula	The impact on the general criterion
<i>Return on Equity (ROE)</i>	<i>Net Income / Shareholder Equity</i>	stimulant
<i>Return on Assets (ROA)</i>	<i>Net Income / Average Total Assets</i>	stimulant
<i>Inventory Turnover Ratio (ITR)</i>	<i>Net Sales / Average Inventory</i>	stimulant
<i>Liabilities Ratio (LR)</i>	<i>(Average Liabilities / Net Income)* 365</i>	stimulant
<i>Asset Turnover Ratio (ATR)</i>	<i>Net Sales Revenue / Average Total Assets</i>	stimulant
<i>Receivable Turnover Ratio (RTR)</i>	<i>Sales Revenue / Average Receivables</i>	nominant (7 – 10)
<i>Current Ratio (CR)</i>	<i>Current Assets / Current Liabilities</i>	nominant (1,0 – 1,2)
<i>Debt Ratio (DR)</i>	<i>Total Liabilities / Total Assets</i>	nominant (57%-67%)

Source: Based on papers by Tarczyński and Łuniewska (2004, 2006).

In addition, *Return on Sales (ROS)* was introduced to the analysis, calculated as:  $(Net\ profit / Sales\ revenue) * 100$ . This indicator is a stimulant, as its growing value talks about the improving profitability of sales, which in turn may indicate the reduction of operating costs or increasing the sales margin. Moreover, it can be an additional indication for investors, when making investment decisions.

In the first stage of the study the distributions of the financial indicators were analysed, as not only the scale of variable measurement should be taken into account when selecting the normalization formula, but also such characteristics of the variable distribution, like the arithmetic mean, standard deviation and the range designated for the normalized values of the variables (Walesiak, 2004). The tables 2 and 3 contain the results of the basic descriptive statistics calculated for all financial indicators for the years 2013 and 2014.

In 2013 extreme values were observed for the indicators *Liabilities Ratio (LR)* and *Current Ratio (CR)*, what generated a very strong asymmetry of distributions. The remaining indicators assumed values that did not exceed the non-outlier range.

**Table 2.** Descriptive statistics of variables for 2013 year

Ratio	mean	median	min	max	Q <sub>1</sub>	Q <sub>3</sub>	range	standard deviation	coefficient of variation	skewness	kurtosis
<i>ROE</i>	0,052	0,053	-0,061	0,220	-0,014	0,085	0,282	0,078	148,998	0,768	0,423
<i>ROA</i>	0,032	0,029	-0,044	0,131	-0,007	0,053	0,175	0,049	149,768	0,565	-0,137
<i>ROS</i>	0,046	0,045	-0,075	0,127	0,008	0,098	0,202	0,054	115,451	-0,520	0,353
<i>RTR</i>	6,284	5,692	3,124	12,496	4,282	8,866	9,372	2,657	42,287	1,037	0,380
<i>ITR</i>	5,933	6,006	1,937	9,983	3,958	7,695	8,046	2,683	45,219	0,110	-1,157
<i>LR</i>	50,292	46,038	17,958	144,274	32,759	52,305	126,316	30,136	59,922	2,359	6,953
<i>ATR</i>	0,959	1,015	0,214	1,873	0,633	1,235	1,659	0,478	49,821	0,371	-0,522
<i>CR</i>	2,118	1,697	1,028	6,868	1,340	1,920	5,840	1,524	71,941	2,676	7,203
<i>DR</i>	0,350	0,393	0,089	0,469	0,293	0,430	0,380	0,112	32,008	-1,140	0,746

Source: own studies

**Table 3.** Descriptive statistics of variables for 2014 year

Ratio	mean	median	min	max	Q <sub>1</sub>	Q <sub>3</sub>	range	standard deviation	coefficient of variation	skewness	kurtosis
<i>ROE</i>	-0,023	0,047	-1,001	0,194	0,001	0,081	1,196	0,282	-1238,152	-3,377	12,306
<i>ROA</i>	-0,021	0,026	-0,743	0,119	0,000	0,051	0,863	0,205	-977,990	-3,519	13,087
<i>ROS</i>	0,056	0,044	0,012	0,135	0,025	0,081	0,123	0,038	67,579	0,713	-0,463
<i>RTR</i>	6,002	5,018	3,232	9,479	4,398	8,383	6,247	2,154	35,887	0,507	-1,341
<i>ITR</i>	6,355	5,357	0,000	21,444	3,140	8,753	21,444	5,128	80,684	1,861	4,945
<i>LR</i>	51,223	47,416	19,586	101,442	32,153	58,853	81,857	24,618	48,060	0,940	0,084
<i>ATR</i>	0,920	0,809	0,353	2,092	0,582	1,111	1,739	0,488	53,064	1,144	0,969
<i>CR</i>	3,173	1,640	0,733	17,230	1,310	4,248	16,497	4,156	130,961	3,132	10,674
<i>DR</i>	0,375	0,395	0,116	0,49	0,305	0,45	0,374	0,099	26,25	-1,29	2,131

Source: own studies

In 2014 the indicators *Return on Equity (ROE)*, *Return on Assets (ROA)* and *Current Ratio (CR)* had the extreme values, what resulted in the coefficients of skewness exceeding the value |3| and proved the excessive skewness. Furthermore, the outliers were observed for the indicators: *Inventory Turnover Ratio (ITR)*, *Liabilities Ratio (LR)* and *Asset Turnover Ratio (ATR)*.

In the second stage, due to the nature of variables *Current Ratio (CR)*, *Debt Ratio (DR)* and *Receivable Turnover Ratio (RTR)* were individually transformed from nominants into stimulants, taking into account the specificity of this indicator. The detailed description of the financial indicators and transformations of variables

being nominants into stimulants used in the study was included in the author's work (Chrzanowska, Zielińska-Sitkiewicz, 2014).

In the next step three normalization formulas were selected<sup>3</sup>:

- standardization 
$$z_{ij} = (x_{ij} - \bar{x}_j) / s_j \quad (1)$$

- Weber standardization 
$$z_{ij} = (x_{ij} - Me_j) / 1,4826MAD_j \quad (2)$$

- unitization with zero minimum 
$$z_{ij} = [x_{ij} - \min_i \{x_{ij}\}] / r_j \quad (3)$$

in order to unify the magnitudes selected for the analysis of financial indicators. The following demands were included in their selection:

- deprivation of titres, which express the features,
- bringing the order of variable magnitudes to the state of comparability,
- possibility of normalization of the characteristics adopting the positive and negative values or only the negative ones,
- possibility of normalization of the characteristics adopting the zero value (Kukuła, 2000).

The classic and Weber standardization cause the unification of the values of all variables in terms of variation measured with the standard deviation or the median absolute deviation. This means the elimination of variation as the basis for differentiation of objects. It is recommended to use the Weber standardization, when the distribution of the studied empirical variables is highly asymmetric. Normalization formula – the unitization with zero minimum has the advantage, as it ensures the diverse variability to the normalized values of variables (measured with the standard deviation) and at the same time the constant range for all variables (Walesiak, 2004).

The last stage of the study has determined the Taxonomic Measure of Investment Attractiveness for each of the studied periods. The calculations did not include any weighs for the applied financial indicators (Łuniewska, Tarczyński, 2006). The research results for 2013 and 2014 with the expert ranking are presented in tables 4 and 5:

**Table 4.** Results of the TMAI measure and the ranking of the studied companies for 2013

Normalization formulas:	standardization		Weber standardization		unitization with zero minimum		EXPERT ranking
	TMAI	nr	TMAI	nr	TMAI	nr	
DECORA	0,3360	6	0,7659	7	0,3464	6	<b>5</b>
INVESTMENT FRIENDS	0,1902	11	0,7159	11	0,2341	10	<b>12</b>
IZOLACJA	0,2253	9	0,2126	14	0,2605	8	<b>13</b>
IZOSTAL	0,4256	5	0,7757	5	0,4649	5	<b>8</b>
KBDOM	0,3151	7	0,8101	1	0,3163	7	<b>9</b>
LENA	0,1430	14	0,0000	15	0,1322	14	<b>6</b>
NOWAGALA	0,1448	13	0,7250	10	0,1436	13	<b>10</b>
PAGED	0,4854	2	0,7803	4	0,5385	2	<b>2</b>
POLCOLORIT	0,0000	15	0,7073	12	0,0000	15	<b>14</b>
POZBUD	0,4355	3	0,7925	2	0,4713	4	<b>3</b>
ROPCZYCE	0,2425	8	0,7472	8	0,2373	9	<b>4</b>

<sup>3</sup>  $\bar{x}_j, s_j, r_j$  - arithmetic mean, standard deviation, range for  $j$  variable,

$Me, MAD$  - median and absolute median deviation

ROVESE	0,1805	12	0,7470	9	0,1830	12	<b>11</b>
SELENAFM	0,4263	4	0,7817	3	0,4736	3	<b>7</b>
SNIEZKA	0,5123	1	0,7738	6	0,5794	1	<b>1</b>
YAWAL	0,2004	10	0,6750	13	0,2212	11	<b>15</b>

Source: own studies

**Table 5.** Results of the TMAI measure and the ranking of the studied companies for 2014

Name	Normalization formulas: standardization		Weber standardization		unitization with zero minimum		EXPERT ranking
	TMAI	nr	TMAI	nr	TMAI	nr	
DECORA	0,3967	7	0,7225	9	0,3747	7	<b>10</b>
INVESTMENT FRIENDS	0,0000	15	0,0000	15	0,0000	15	<b>15</b>
IZOLACJA	0,3885	8	0,6855	11	0,3527	9	<b>7</b>
IZOSTAL	0,3356	11	0,7380	7	0,2874	12	<b>9</b>
KBDOM	0,4617	6	0,7365	8	0,4204	6	<b>14</b>
LENA	0,2722	13	0,6642	13	0,2441	13	<b>3</b>
NOWAGALA	0,2636	14	0,6565	14	0,2291	14	<b>12</b>
PAGED	0,5377	3	0,8174	2	0,5326	3	<b>2</b>
POLCOLORIT	0,3211	12	0,7129	10	0,3161	11	<b>11</b>
POZBUD	0,5565	1	0,8138	3	0,5470	1	<b>4</b>
ROPCZYCE	0,3662	9	0,7534	6	0,3232	10	<b>5</b>
ROVESE	0,3624	10	0,6840	12	0,3544	8	<b>13</b>
SELENAFM	0,5544	2	0,8071	4	0,5347	2	<b>8</b>
SNIEZKA	0,5348	4	0,8198	1	0,5269	4	<b>1</b>
YAWAL	0,4670	5	0,7795	5	0,4414	5	<b>6</b>

Source: own studies

Based on the analysis of results of the individual rankings it can be concluded that the selection of the normalization procedure in the process of their construction affects the result of the acquired classification. In order to perform a detailed analysis of changes in the position of the surveyed companies, depending on the adopted formula of transformation of the criteria characteristics, the Spearman rank correlation coefficients were calculated between the assessments of companies designated with the TMAI measure and the expert method. The obtained values are presented in tables 6 and 7.

**Table 6.** Values of the Spearman rank correlation coefficients between the ranking results for 2013

Normalization formulas	standardization	Weber standardization	unitization with zero minimum	expert ranking
standardization	1	0,767	0,989	<b>0,72</b>
Weber standardization		1	0,749	<b>0,58</b>
unitization with zero minimum			1	<b>0,684</b>
<b>expert ranking</b>				<b>1</b>

Source: own studies

**Table 7.** Values of the Spearman rank correlation coefficients between the ranking results for 2014

<b>Normalization procedure</b>	standardization	Weber standardization	unitization with zero minimum	<b>expert ranking</b>
standardization	1	0,878	0,985	<b>0,613</b>
Weber standardization		1	0,842	<b>0,735</b>
unitization with zero minimum			1	<b>0,569</b>
<b>expert ranking</b>				<b>1</b>

Source: own studies

For 2013 and 2014 a very high convergence was obtained for the ranking, in the construction of which the normalization formulas were used: standardization and unitization with zero minimum. Moreover, in 2013, these two rankings indicated a quite high compliance with the expert ranking and identified three first companies in the classification in an almost identical manner with the expert. In the same year, the lowest coincidence with the expert list was obtained for the ordering using the Weber standardization.

In 2014, the state of compliance with the expert ranking was reversed. The classification obtained using the formula of the Weber standardization indicated the layout of companies closest to the expert ordering, distinguishing the three best companies in an almost identical manner. This can be explained by the occurrence of the profitability indicators and liquidity of the extreme values in the distributions, and the extreme asymmetry, in which case it is recommended to use the Weber formula.

Financial indicators are a group of specific variables, because they can be distorted by some one-time events, which are reflected in the financial statement, e.g., in the balance sheet drawn up for a specific day. Some indicators may take even astronomical values for a pretty good company, which after the balance day will be able to regulate its situation. Thus, if the comparative studies of the companies are conducted periodically, the in-depth analysis of the balance sheet items and the adjustment of the methodology of normalization for financial indicators should be recommended in the case of stating outliers, or extreme values.

## Summary

It results from the conducted study that the use of different formulas of variable standardization can cause the modification of the results of multivariate object classification, which does not result from the change of the data structure. Modification of the methodology of the company ranking within the stage of bringing the financial indicators to their mutual comparability has contributed to the changes in ordering companies in the given year, which has not been related to the change in “quality” of their operations. Moreover, conducting analyses based on financial indicators, particular attention should be paid to the distribution of their values in the studied group and the occurrence of outliers and extreme values. If they have been stated, one should check whether the change of the standardization procedure from the classic standardization

(commonly used in the literature with the TMAI calculation) into the Weber standardization does not provide a more accurate classification.

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## Streszczenie

Jednym z etapów wielowymiarowej analizy porównawczej obiektów jest wybór procedury normalizacji zmiennych. W literaturze prezentowanych jest wiele metod transformacji normalizacyjnej. Wybór jednej z nich jest jednym z najważniejszych etapów badania, bowiem może mieć znaczny wpływ na wynik analizy.

W artykule wykorzystano i porównano trzy procedury normalizacji zmiennych przy budowie rankingów w oparciu o TMAI dla 15 spółek przemysłu materiałów budowlanych notowanych na

Warszawskiej Giełdzie Papierów Wartościowych dla lat 2013 i 2014. Przeprowadzone badania wskazują, że stosowanie różnych wzorców normalizacji zmiennych może powodować zmianę wyników klasyfikacji firm, która nie wynika ani ze zmiany struktury danych finansowych, ani z poprawy efektywności ich działania.

**Słowa kluczowe:** normalizacja zmiennych, taksonomiczne mierniki, TMAI, przemysł materiałów budowlanych

Informacja o autorze:

***Dr Monika Zielińska-Sitkiewicz***

Katedra Ekonometrii i Statystyki

Wydział Zastosowań Informatyki i Matematyki

Szkoła Główna Gospodarstwa Wiejskiego w Warszawie

e-mail: monika\_zielinska\_sitkiewicz@sggw.pl