www.ees.uni.opole.pl
ISSN paper version 1642-2597
ISSN electronic version 2081-8319
Economic and Environmental Studies
Vol. 19, No. 1 (49/2019), 31-54, March 2019

Using TMAI to determine the competitive position of companies in Poland's chemical industry

Barbara FURA

University of Rzeszów, Poland

Abstract: Currently, the fastest growth of the chemical industry is, besides the Asian markets, expected in the countries of Central and Eastern Europe, including Poland. However, the Polish chemical industry is facing several challenges, such as high prices of raw materials, tougher environmental standards and growing competition from the rapidly growing Asian markets. It is, therefore, appropriate to define the competitive position of companies in the chemical industry in Poland. This goal was achieved through the use of the Taxonomic Measure of Attractiveness of Investment (TMAI), which belongs to a group of multidimensional comparative analysis. The assessment was made of 23 chemical companies listed on the Warsaw Stock Exchange (WSE) in Poland in terms of liquidity, debt, turnover, profitability and market efficiency. Companies were ranked in terms of their competitive position in two-time points, 2012 and 2016. Rankings were presented in two variants namely, with weighted and unweighted indicators. The research confirmed a compliance of companies' rankings calculated in both variants of the applied method. Repeatedly high ranking positions were achieved by the majority of companies engaged in the production of mineral fertilizers. Although cosmetics companies were, in 2012, classified low, most of them recorded improvements in 2016. The opposite was observed in respect of manufacturers of pharmaceutical and medical products. The results obtained are useful in assessing the market value of companies in the chemical industry and in developing strategies for the development of the chemical industry in the light of sustainable development.

Keywords: TMAI, competitive position, company, performance, chemical industry, sustainable development

JEL codes: L25, O14, C38

DOI: https://doi.org/10.25167/ees.2019.49.2

Correspondence Address: Barbara Fura, Department of Quantitative Methods and Economic Informatics, Faculty of Economics, University of Rzeszów, Ćwiklińskiej 2, 35-601 Rzeszów, Poland. Tel.: +48 17 872 1617 Fax: +48 17 872 1609 E-mail: bfura@ur.edu.pl

1. Introduction

Addressing future energy needs, reducing a demand for raw materials and energy, reducing environmental pollution, and reducing water consumption, are great economic, environmental and social challenges facing our contemporary world. Various models, concepts or strategies for growth and economic development are being developed to meet these objectives. Among them are concepts of sustainable development, smart development, the idea of green growth, or the model of a circular economy that denies the validity of a linear economic model. Common elements of the abovementioned concepts are, amongst others, saving renewable and non-renewable resources, reduction of impurities, e.g. through re-use of waste, exploration, and use of alternative energy sources or energy efficiency practices. Furthermore, new technologies are gradually being developed to identify and use wastes as valuable secondary raw materials (de Menezes et al., 2013: 269). Essentially, the chemical industry was also one of the first to adopt principles of sustainable development, explaining the need to integrate its ecological, economic and social areas (Díaz López and Montalvo, 2015: 32).

The implementation of the above tasks is not possible without the involvement of hi-tech industries supporting the development and use of innovative solutions. Innovation processes, transforming ideas into new, useful processes, methods, products or services, are crucial for any expansion of economies, regions and individual companies (den Butter and Möhlmann, 2008: 2010; Chorób, 2012: 374-375). One of the industrial sectors in which innovation plays a key role is the chemical sector, which is one of the major industries in the world. Future developments in chemical companies are highly dependent on innovation. Although this sector is energy intensive, it provides products that are available everywhere, starting with products that accompany us on a daily basis (pharmaceuticals, detergents, paints, etc.) to products that are processed by other industries, such as food processing, automotive industry, electronics, cosmetics, construction or agriculture (Terterov and Reuvid, 2005: 185). Thus, the importance of chemical industry is immense, both for the improvement of life comfort, as well as from the point of view of safety and climate protection (Gietka and Lubiewa-Wieleżyński, 2010: 2).

The chemical sector is developing steadily in the world, with an average sectoral annual growth rate of 7% from the mid-1980s to 2010, when the chemical sector reached 2.4 billion euros. The overwhelming share of this increase was in Asian countries, which now account for almost half of the global sales of chemical products, and by 2030 it may account for 2/3 of the global

market (Mierzecki, 1998: 83). Forecasts show global chemical markets will grow in the next 20 years at an average annual rate of 3%, driven mainly by the activity of China and the Middle East, and the European market at a slightly slower pace (*Chemical Industry…*). In 2004, the European Union (EU) industry, which has been the leader in chemical production, lost the leading position in favour of Asian countries (Pietrzak, 2013: 36). The dynamic development of the chemical industry in this region has been driven by increased local and global investment, cheaper raw materials and less restrictive environmental regulations (especially in China and the Middle East) (Majchrzak, 2013: 176). Currently, only 24% of the world's sales of chemicals fall on the European chemical industry. Two-thirds of the EU's production is provided by Germany, France, Italy and the United Kingdom. Among the new EU members, Poland is the largest producer of chemicals (2.1% share of the total sales) (Gietka and Lubiewa-Wieleżyński, 2010: 2). The fastest growth of the chemical industry in Europe is expected in Central and Eastern European countries (*Chemical Sector*…). The chemical industry in Poland is now a highly developed sector of the Polish economy. Relying on modern technology, it is largely a determinant of modernity and progress. On the other hand, the chemical sector is one of the industries with a high environmental impact, therefore, an important goal is to use environmentally friendly solutions in the production (Kajanova, 2009: 803). The post-1989 development of the chemical industry in Poland resulted in the creation of companies competing freely in the international arena, which in consequence has positively stimulated the country's economic growth. The total share of sold production, in the total value of industrial output, amounted to 11.7% in 2015. This represented an increase by 1.04% compared to 2014 and by 3.59% compared to 2005 (GUS 2016). Leaders of the chemical industry in the market are, among others, Grupa Azoty, Grupa Chemiczna Ciech, Synthos or Polpharma. The results of chemical companies have confirmed the role that the sector plays in the Polish economy. The share of chemicals and chemical products sold in the total industrial output in 2004 amounted to 4.64%, the production of pharmaceutical products was 1.01%, and the share of rubber and plastic products was 6.05% (GUS 2016).

Poland is a major producer of mineral fertilizers, especially nitrogen fertilizers. The domestic industry produces about 1.6–1.7 million tons of nitrogen fertilizers yearly from pure ingredients, representing 1.5% of the world production. Poland is the biggest producer of nitrogen fertilizers in the EU, producing about 20% of their total volume. The production capacities of the largest remaining producers, i.e. France, the Netherlands, and Germany are much smaller and do

not reach 1 mln tonnes. Nitrogen fertilizers produced in Poland are, first of all, to meet national agricultural demand, but a significant part of the production is also exported (Zalewski, 2014: 142). Poland is not only one of the largest fertilizer markets, but also the sixth market for cosmetics in Europe, which entails the development of, e.g. a packaging industry and cooperation with plastics manufacturers (Korkosz-Gębska, 2016: 225). However, the development of the chemical industry is heavily dependent on sources of raw materials. The basic raw material in the chemical industry is high methane natural gas. Chemical companies are its largest recipients in Poland. Gas consumption in this sector accounts for about one-third of the industrial use, which translates to about one-fifth of the total gas consumption in the country (*Strategia…*).

In the situation in which the structure of energy resources at the disposal of Poland can, similarly to China, be characterized by the words "rich coal, less gas, lack of oil" (Li and Hu, 2017: 13), there are many challenges facing the chemical industry. The chemical sector is the most energy intensive of all producing sectors, accounting for 20% of the EU's industrial energy use, well above its 7% share of production output (Gladkykh, 2015: 65). Thus, it is necessary to develop more and more efficient, more economical techniques and technologies for their gradual solution. Another problem is the tightening of environmental standards in the EU, which the Polish chemical industry is also facing. It is, from this point of view, important to determine the level of competitiveness of Poland's chemical companies.

To the best of our knowledge, similar studies have, so far, not been conducted. The aim of this paper is to determine the competitive position of chemical companies listed on the Warsaw Stock Exchange (WSE) in Poland in 2012 and 2016 and to identify the change in the competitiveness of the companies in the examined period. The choice of the time range of the study was due to the desire to compare the situation of Polish chemical industry after the economic crisis of 2008–2009, with the present situation. In the paper, an indicator of competitive position is the companies' financial situation that determines their survival and development capacities in a dynamic and competitive environment. As the research method, the Taxonomic Measure of Attractiveness of Investment (TMAI) was applied.

2. Literature review

Empirical studies on the assessment of the financial position and market value of companies listed on the WSE, using TMAI, are quite numerous in the literature. Such studies have been undertaken, among others by Dmitruk (2012), whose empirical analysis covered 2007–2011. There were, among the examined companies, 33 companies representing various sectors of the economy, including 4 companies from the chemical sector namely, Ciech, Synthos, Zakłady Azotowe Police and Zakłady Azotowe Puławy. This research showed that during the period under study the financial position of the above-mentioned companies was stable. The average value of TMAI was highest in Zakłady Azotowe Puławy (0.36), followed by Synthos (0.35), and Ciech (0.25) while the lowest was in Zakłady Azotowe Police (0.24). In 2010, both the highest and the lowest return rates of all the examined companies were represented by Synthos and Ciech, 1st and 33rd positions respectively. Synthos also repeated its success in 2011. The same research method was used by Chrzanowska and Zielińska-Sitkiewicz (2014) to compare the financial situation of 30 large construction companies listed on the WSE. The authors analysed the situation of the companies in 2008–2012 and noted that the most difficult period for the construction industry in Poland was 2012, in which the majority of companies recorded losses. The financial condition of property development companies using TMAI was analysed by Gostkowska-Drzewicka (2015) who showed that in the period 2007–2013 the group of entities with a stable competitive and financial situation was relatively small. Most of the examined companies underwent quite frequent changes in their ranking positions. However, the research sample was dominated by the entities with worsening financial conditions.

The relatively longest time span for a study was taken by Flotyński (2016). The author covered with his analysis the stock quotes of about 80 companies listed in the sWIG80 index in the years 2009–2014. The surveyed companies represented different areas of economic activity, including the chemical industry. Among them were: Śnieżka, Ciech, Zakłady Azotowe Police. Foltyński (2016) demonstrated that companies with the lowest TMAI value had, in general, the worse financial situation and tended to be managed in a less efficient way which in their opinion led to the downturns in companies' stock prices. In the above-mentioned studies, the Euclidean distance was used to determine the distance of the examined object from the pattern. Its generalization is, however, the Mahalanobis distance (Nielsen et al., 2016). Comparative studies on the attractiveness of 10 of the 20 largest joint stock companies listed in the prestigious WIG20 index using both distance measures were carried out by Rutkowska-Ziarko (2013). According to

their research, the ranking of companies based on the Euclidean distance was similar to that based on the Mahalanobis distance except one firm, where there was a difference of 3 positions between rankings. The TMAI values, as well as ranking positions of companies obtained in both variants of the method, were strongly correlated (Person's correlation = 0.92, Spearman's correlation = 0.90 respectively), thus confirming the high compatibility of both rankings. The most attractive investment company was KGHM Polska Miedź S.A., while the least was Polski Koncern Naftowy Orlen S.A.

A multidimensional comparative analysis of the financial condition of 116 industrial companies, including 18 chemical and petrochemical entities in Opole Province, was undertaken by Zygmunt (2013). The research covered the period between 2005 and 2010. The average value of TMAI in chemical and fuel companies was 0.91, with only 1.25% variability showing a stable situation of the surveyed companies in the region.

Stock market investors, interested in successively increasing the market value of their company, look for opportunities to invest their capital in stocks of those companies that consistently develop and strengthen their market positions. Such companies are the most competitive companies that have an advantage over rivals not only through high-quality products, competitive prices or customer service activities, but also by creating the image of socially and/or environmentally responsible companies. Pieloch-Babiarz's study (2015), located in the above stream, showed that the inclusion of companies in the Respect index, i.e. the index of socially responsible companies, created an added value, manifesting itself in the high investment attractiveness, especially that of new companies in the index. Despite the slightly higher level of risk connected with investing in stocks of companies included in the Respect index, investors could expect slightly higher returns on such investments.

The literature review presented above shows a lot of studies on the application of TMAI in assessing the status of companies listed in the WSE at different time points. Individual analyses, however, concerned entities representing different areas of the economic spectrum (different sectors), which significantly hindered comparisons among companies. However, the use of TMAI is justified in the case of an analysis both from the sectoral or industrial point of view. This article fills in the identified research gap by providing research results on the assessment of the situation of Polish chemical companies in two time periods of 2012 and 2016. This assessment also provided a basis for determining the competitive position of companies in the examined industry.

3. Companies' competitive position – a chemical industry perspective

The term 'competitiveness' derives from a phenomenon of competition, which forms the basis for the market economic system functioning. It is a phenomenon with very specific consequences, but – at the same time – difficult to quantify and even identify (Owczarzak, 2004: 166). Competition is defined as a process by which market participants, striving to achieve their goals, try to present better offers than others in terms of price, quality or other characteristics affecting the decision to strike a deal (Kamerschen et al., 1992). Thus, competitiveness relies on the ability of firms to consistently and profitably offer products that meet the requirements of an open market in terms of price, quality, delivery, etc. (Sipa, 2015: 446).

The literature review on an enterprise competitiveness leads to the conclusion that it can be defined as an aggregate system. This system consists of three cause-effect related factors namely, competitive potential, competitive position and competitive strategy (Buckley et al., 1990). Processes and resources at the company's disposal create its competitive potential. It consists, amongst others, of innovation, quality, manufacturing technology, knowledge or managerial competence. The competitive potential determines the achievement of a competitive position in the market (Dzikowska et al,. 2017; Horta and Camanho, 2014; Piatkowski, 2012), whose determinants can be the company's market share or financial position. These characteristics can be considered both in static and dynamic terms. Subsequently, the competitive position, resources and skills that companies possess determine, to a large extent the company's strategy. Its implementation contributes to changing the potential of the company, which in turn can change the competitive position.

The ambiguity of the concept of competitiveness makes the authors propose to measure it with indicators of different construction and different meaning. Some of the indicators relate to the assessment of potential, and thus provide an estimation of the ability to compete, while others present the status achieved, thus evaluating the market position. Porter (1980), in his breakthrough work entitled *Competitive Strategy*, focused on the competitive position of a company within the industry and the competitive advantage as key elements in the process of formulating the company's strategy. The company's competitive advantage creates resources and skills that are referred to key success factors (Prahalad and Hamel, 1990). Key resources and competencies are the source of the company's competitiveness, which relate to universal, functional areas of companies' activities,

such as production, including manufacturing technology, distribution, marketing, or management (Matthyssens and Vandenbempt 1998; Srivastava et. al 2013).

In the case of manufacturing companies, including the chemical sector, the most frequently used sources of competitiveness are production sources, such as cost advantage, production advantage or manufacturing technology that enable new product innovations. The utilization of these sources of competitiveness requires intensive R&D, unconventional skills, high capital expenditure (Kawachi, 2003: 7) or knowlegde sharing (Lin and Chen, 2017: 1663). Nevertheless, innovation is currently one of the leading sources of companies competitiveness, guaranteeing their survival and development over a long period of time. It provides the uniqueness of the product and, in time, the manufacturer's identity.

One of the most important challenges facing the Polish chemical industry is the development of innovation and knowledge-based economy. The more the economy is saturated with knowledge-intensive economic processes, the greater is its profitability and productivity (Majchrzak, 2013: 176). The chemical industry was one of the first that undertook to introduce modern environmental management programs, which means adoption of the sustainable development principles, ecological certificates, implementation of cleaner and safer technologies, and a broad information system for the community regarding their activities (Barthelemy and Agyeman-Budu, 2016: 30). Sustainability is essential for the chemical industry due to high entry barriers of the sector, the cyclical nature of the sector development and the existing competitive environment (Hyršlová et al., 2017: 283).

This industry has in an effective and dynamic way minimized its negative impacts on the environment, thus breaking the psychological barriers to creating the image of an environmentally friendly industry in the society. In turn, a responsible approach to the environment, health and safety, and technology development has further strengthened competitiveness, deepened technological development in specific disciplines, including technology synthesis within different disciplines. If companies hope to enhance their competitive advantages through green innovation, they must check their green innovation performance in advance (Chen and Chang, 2013: 271).

Since competitiveness is a complex concept determined by a multiplicity of factors, it seems that the most appropriate way to estimate its level is by using multidimensional or composite indicators (indexes) of competitiveness. The construction of indicators could, however, be associated with the dilemma of selecting appropriate variables (individual indicators) and weights

representing their relative importance (priority) as well as of choosing an aggregation method (Siudek and Zawojska, 2014: 92). Based on these arguments, the following hypothesis was proposed. **H:** The multidimensional assessment of the company's financial standing is the basis for a credible determination of its competitive position in the sector. Verification of the hypothesis allows for confirmation or rejection of the credibility of the presented research results, thus being a potentially useful source of knowledge concerning the competitive state of companies in Poland's chemical industry.

4. Data and Method

The study covered companies whose main business area was located in the Chemical manufacturing sector (325), according to the North American Industry Classification System (NAICS), listed on the WSE. Data on companies were obtained from Emerging Markets Information Service (EMIS). There were, as of 1.08.2017, 26 of such joint stock companies on the EMIS list. The largest group contained representatives of Pharmaceutical and Medicine Manufacturing (3254 NAICS code). These were: Biogened, Biomax, BioMaxima, Bioton, Celon, Mabion, Master Pharm, Med-Galicja and Pharmena. The next group was formed by companies representing Soap, Cleaning Chemicals, and Toilet Preparation Manufacturing (3254 NAICS code), such as Global Cosmed, Harper Hygienics, Miraculum and PCC Exol. Four more companies included were Grupa Azoty, Grupa Azoty Zakłady Azotowe Puławy, Grupa Azoty Zakłady Chemiczne Police and Comeco representing Pesticide, Fertilizer, and Agricultural-Allied Chemical Manufacturing (3253 NAICS code). The next six companies, i.e. Boryszew, Ciech, Fluid, Selena FM, PCC Rokita and Prymus belonged to Chemical-Allied Product and Preparation Manufacturing (3259 NAICS code). However, the main business activity of Ciech and Prymus also included subsectors from 3251 to 3256. In addition, the representative of Basic Chemical Manufacturing (3251 NAICS code) was Boruta Zachem company, Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing (3252 NAICS code) was Synthos, while the representative of Paint, Coating, and Adhesive Manufacturing (3255 NAICS code) was Fabryka Farb i Lakierów Śnieżka.

The empirical data in the form of financial indicators were collected or calculated on the basis of companies financial statements for both 2011, 2012 and 2015, 2016. Financial statements

were obtained through the EMIS database. These data were supplemented with market efficiency indicators downloaded from https://www.money.pl/. Due to a lack of market data for 2012 for PCC Rokita this company was excluded from further research.

In order to determine the competitive position of companies, a method of multidimensional comparative analysis was used, which allowed the creation of a taxonomic (aggregate) measure of the attractiveness of investment. TMAI allows for a comprehensive assessment of a company business situation based on the most important financial indicators, presenting them in a synthetic way. It also allows the comparison of companies within a sector and the creation of rankings from a point of view of the attractiveness of investments in a given company. In this research, the analysis of basic indicators (X_1–X_{11}) was applied, which represented the following areas of financial analysis: liquidity (X_1, X_2), debt (X_3), turnover (X_4–X_7), profitability (X_8, X_9) and market efficiency (X_{10}, X_{11}). The names of individual indicators, their formulas, the type of indicators (stimulant, destimulant, nominant)[1] and the reference values for the nominants are shown in Table 1.

Table 1. Ratios and their influence on a company's competitive position

No.	Ratio	Area	Formula	Indicator type	Reference value
X_1	current ratio (CR)	liquidity	$\frac{current\ assets}{short\ term\ \ liabilities}$	nominant	[1.2–2.0]
X_2	quick ratio (QR)		$\frac{current\ assets - inventory}{short\ term\ liabilities}$	nominant	[1.0–1.2]
X_3	debt ratio (DR)	debt	$\frac{total\ debt}{total\ assets}$	destimulant	minimum
X_4	receivables turnover ratio (days)	turnover	$\frac{total\ short\ term\ recivables}{revenues\ from\ sales} \cdot 365$	destimulant	minimum
X_5	liabilities turnover ratio (in days)		$\frac{short\ term\ liabilities}{revenues\ from\ sales} \cdot 365$	destimulant	minimum
X_6	inventory turnover ratio (in days)		$\frac{inventory}{revenues\ from\ sales} \cdot 365$	destimulant	minimum
X_7	total assets turnover (TAT)		$\frac{net\ revenues\ from\ sales}{total\ assets}$	stimulant	maximum
X_8	return on assets (ROA)	profitability	$\frac{net\ profit}{total\ assets}$	stimulant	maximum

[1] Stimulants are variables, whose growing values have a positive effect on the studied phenomenon. Destimulants are variables, whose growing values have a negative effect. Nominants are variables whose desired value is within a certain range, and each deviation (on +, on -) has a negative effect on the studied phenomenon (Pociecha and Zając, 1989: 72).

X_9	return on equity (ROE)		$\frac{net\ profit}{equity}$	stimulant	maximum
X_{10}	price earnings ratio (PE)	market efficiency	$\frac{market\ value\ per\ share}{earnings\ per\ share}$	stimulant	maximum
X_{11}	price to book value (P/BV)		$\frac{market\ value\ per\ share}{book\ value\ per\ share}$	stimulant	maximum

Source: Gostkowska-Drzewicka, 2015: 55.

Maintaining liquidity is a prerequisite for a continued functioning of the company. Financial liquidity is a guarantee that a company can incur new liabilities in the future, and as a result, receive new assets used in its business activity. The most commonly used measure of liquidity is a current ratio (X_1), which informs to what extent current assets cover short term-liabilities. It is assumed that in industrial enterprises, the value of this indicator should be within the range from 1.2 to 2.0. The quick ratio (X_2) is a complement to the current liquidity ratio and measures a company's ability to meet its short-term liabilities with its most liquid assets. Values of the quick ratio (X_2) ranging from 1.0 to 1.2 are considered as a reference. A complement of financial liquidity analysis is the debt analysis, which is presented in the study by the debt ratio (X_3). This indicator presents the most general picture of company's asset finance structures and shows the proportion of a company's assets that are financed by debt. The higher the value of the indicator, the higher the indebtedness of the company, hence X_3 indicator is a destimulant.

The success of a company is largely determined by the way it manages its assets. This area of business activity used to be analysed by the turnover evaluation. It covered, in the current study, the following assets: receivables, liabilities, inventories (in days) and total assets. From the point of view of the company's financial condition, the most favourable situation is when receivables are quickly collected, liabilities are settled on time, inventories are often renewed, which helps to increase sales revenues. Since the lowest values of turnover ratios are expected (Gostkowska-Drzewiecka, 2015: 56), the X_4, X_5, X_6 indicators are therefore considered destimulants.

A stimulant is, however, the total assets turnover (TAT) (X_7), and it measures how well a company is utilizing its assets in order *to* generate sales revenues. Typically, companies with low sales profitability have a relatively high assets turnover rate and vice versa. Profitability is a category that reflects the efficiency of equity and efficiency of asset management. Both returns on assets (X_8) and return on equity (X_9) are stimulants. Another area of analysis of the company's situation was market efficiency, which is related to the assessment of the business situation via the capital market. Thus, the X_{10} indicator presents investors' expectations concerning the company's

future. The higher the value, the better the market assesses the company's development perspectives. In turn, a low value of the indicator shows the low popularity of a given company among investors. The last indicator (X_{11}) shows how many times the share price is higher or lower than the book value of a share. The index value higher than unity means that a company generates profits for shareholders.

The presented set of variables (financial and market indicators), according to Tarczyński and Łuniewska (2005), makes it possible to compare all listed companies regardless of the sector they represent. This assumption was the starting point for further considerations, and indicators presented in Table 1 were further applied to create TMAI.

The method of TMAI is widely described in the literature of the subject (e.g. Mastalerz-Kodzis, 2012; Nermend, 2009), hence its detailed presentation has, in this study, been abandoned for a brief description of the method. The TMAI procedure includes the following steps (Tarczyński, 2014: 56): 1) creating an observation matrix X, 2) transforming variables to comparables, 3) standardizing variables, 4) creating a weighing system for diagnostic variables, 5) calculating distances of each object from the pattern, and 6) normalizing a synthetic measure. In order to ensure comparability of variables, both destimulants and nominants were transformed into stimulants. For this purpose the following transformations were applied (Tarczyński and Łuniewska, 2005: 525):

for destimulants: $$x_{ij}' = \frac{1}{x_{ij}}, \tag{1}$$

where x_{ij} – initial value of a destimulant, x_{ij}' – value of a destimulant transformed into a stimulant,

for nominants: $$x_{ij}' = \frac{\min\{x_{ij}, n_D\}}{\max\{x_{ij}, n_G\}}, \tag{2}$$

where n_D – lower limit of an optimal range for a nominant, n_G – upper limit of an optimal range for a nominant, x_{ij} – initial value of a nominant, x_{ij}' – value of a nominant transformed into a stimulant. Weights for diagnostic variables were determined based on variability criterion of individual variables (Mastalerz-Kodzis, 2012: 547). The following formula was used for weights estimation:

$$\omega_j = \frac{V_j}{\sum_{j=1}^{m} V_j} \qquad (j = 1,2,\dots,m) \tag{3}$$

$$V_j = \frac{S_j}{\overline{x_j}} \tag{4}$$

where: ω_j – weight of the jth variable, V_j – coefficient of variation of the jth variable before standardization. The application of the above formulas (3–4) led to the assignment of the highest weights to variables with the highest variability. This can be justified by the fact that features with the highest level of variability differentiate the examined phenomenon with respect to the criterion tested most distinctively. This approach is, unfortunately, not devoid of defects, since taking the statistical criterion alone into account means an ignorance of the substantive significance of individual indicators. Having this in mind, rankings of companies for 2012 and 2016 were calculated in two variants: without taking account of weights that differentiate the effects of individual variables, and with the weights being considered. The conformity of companies rankings in both variants (for 2012, 2016) was measured using rank Spearman's correlation coefficient.

4. Results and Discussion

4.1. Descriptive statistics of variables

The description of variables was based on standard descriptive statistics, i.e. mean, standard deviation, and a coefficient of variation. Values of descriptive statistics in 2012, 2016 are shown in Table. 2.

Table 2. Descriptive statistics, 2012, 2016 (25 entities)

DS	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
2012											
Max	7.95	5.55	0.88	2652.46	1677.35	262.33	5.57	32.48	50.07	31.42	127.91
Min	0.50	0.29	0.02	27.48	26.84	3.07	0.02	-35.38	-49.73	-8.17	0.11
Mean	2.25	1.56	0.42	200.17	211.06	56.12	1.28	3.08	5.54	1.33	11.18
SD	1.69	1.20	0.21	512.62	376.53	52.73	1.09	13.10	21.61	6.49	26.04
CV [%]	75.1	76.6	50.7	256.1	178.4	94.0	85.0	425.3	390.2	487.1	233.0
Weight	0.03	0.03	0.02	0.11	0.08	0.04	0.04	0.18	0.17	0.21	0.10
2016											
Max	18.97	17.57	0.99	3547.55	35055.89	2345.12	2.44	15.95	33.69	14.24	162.22
Min	0.47	0.32	0.07	21.75	27.96	0.99	0.01	-50.61	-3113.00	-4.73	0.00
Mean	2.86	2.21	0.48	229.82	1766.76	162.41	0.90	1.18	126.64	1.24	14.56
SD	3.77	3.44	0.20	681.51	6855.44	449.14	0.60	13.88	610.09	3.73	33.41
CV [%]	132.0	155.6	42.5	296.5	388.0	276.6	66.8	1178.2	481.8	302.2	229.4
Weight	0.04	0.04	0.01	0.08	0.11	0.08	0.02	0.33	0.14	0.09	0.06

Notes: DS – descriptive statistics, Max – maximum, Min – minimum, SD – standard deviation, CV – coefficient of variation.
Source: author's own study.

As the maximum values of variables X_4 and X_5, in both time periods (2012, 2016) far exceeded the minimum value or average value, companies for which such values were observed were thus considered as outsiders. These were Biomax and Mabion companies, which were eliminated from further analysis. The exclusion of Biomax also solved the problem of extremely low values of X_9 indicator observed in 2016 for this company. The descriptive statistics, having reduced the number of examined companies, is presented in Table 3.

Table 3. Descriptive statistics, 2012, 2016 (23 entities)

DS	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
2012											
Max	7.95	5.55	0.88	159.57	370.35	145.64	5.57	32.48	50.07	31.42	127.91
Min	0.50	0.29	0.02	27.48	26.84	3.07	0.11	-35.38	-49.73	-8.17	0.11
Mean	2.22	1.49	0.43	75.73	104.37	47.84	1.39	3.60	6.55	1.46	12.02
SD	1.74	1.19	0.21	37.11	82.65	33.07	1.07	13.51	22.19	6.75	26.98
CV [%]	78.1	80.2	49.7	49.0	79.2	69.1	76.9	375.5	338.9	461.1	224.4
Weight	0.0415	0.0426	0.0264	0.0260	0.0421	0.0367	0.0408	0.1995	0.1800	0.2450	0.1193
2016											
Max	18.97	17.57	0.74	232.92	3835.71	284.60	2.44	15.95	33.69	14.24	162.22
Min	0.59	0.32	0.07	21.75	27.96	0.99	0.02	-12.32	-47.67	-1.34	0.09
Mean	3.05	2.36	0.46	79.64	265.91	67.77	0.98	2.33	1.76	1.55	15.81
SD	3.87	3.55	0.18	53.94	764.36	56.32	0.57	6.97	17.06	3.66	34.55
CV [%]	126.7	150.7	39.9	67.7	287.4	83.1	58.0	299.1	966.5	236.2	218.5
Weight	0.0500	0.0595	0.0157	0.0267	0.1134	0.0328	0.0229	0.1180	0.3814	0.0932	0.0862

Notes: see Table 2.
Source: author's own study.

The average value of both liquidity ratios (X_1 and X_2) was, both in 2012 and 2016, above the permissible reference values, with the higher value being observed in 2016. It was, relying on this information, considered that, on average, the surveyed companies did not have any problems with repaying the most demanding (short-term) liabilities, as they even had an excess of funds in relation to their obligations. The similarity of values of coefficients of variation of both variables X_1 and X_2 (78.1%, 80.2% in 2012 and 126.7%, 150.7% in 2016, respectively) have resulted in their similarity of weights, i.e. 0.0415 and 0.0426, respectively in 2012, as well as 0.0500 and 0.0595, respectively in 2016. The X_3 variable, characterizing financing structure of an enterprise's assets, had one of the lowest level of variability in 2012 (49.7%) and in 2016 (39.9%). Relatively low

average levels of X_3 (0.43 in 2012 and 0.46 in 2016), on the one hand, proved the financial independence of companies, but on the other hand, that the companies, on average, did not fully use the financial leverage effect. Variables X_4, X_5, and X_6 that measured (in days) the turnover of receivables, liabilities, and inventory, respectively, were characterized by a relatively high level of variation coefficient. In 2012, the longest time duration between the occurrence receivables to the moment of their repayment (X_4) was observed in Global Cosmed, while the shortest was in the Zakłady Chemiczne Police S.A. The worst and the best companies, in this regard in 2016, were Biogened and Med-Galicia, respectively.

The companies surveyed in both 2012 and 2016 were the most diversified in terms of liabilities turnover (X_5). In 2012, liabilities turnover (X_5) was observed in the worst company (Bioton), almost 14 times higher than in the best company (Boruta Zachem). In 2016, this ratio was over 137:1 (Fluid:Boruta Zachem). The highest inventory efficiency was, in 2012, observed in Fluid, while the lowest was in Med-Galicja. In 2016, Prymus and Fluid were, in this regard, the best and worst companies, respectively. The average level of turnover of assets of companies was higher in 2012 than in 2016. The leader in 2012 was Med-Galicja, which received a revenue of PLN 5.57 from each PLN 1 engaged in the business activity. In 2016, Prymus was the leader, achieving PLN 2.44 from each PLN 1 invested. The weakest asset turnover in both time periods was in Fluid company.

Very high levels of variation of 375.5% (in 2012) and 299.1% (in 2016) were observed in terms of ROA. This variable (X_8) was assigned relatively high weight values of 0.20 (2012) and 0.12 (2016). Four companies namely, Pharmena, Miraculum, Ciech and Fluid achieved a negative ROA in 2012. There were seven of such companies in 2016, including Med-Galicja, Pharmena, Fluid, Miraculum, Bioton, Hyper Hygienics and Global Cosmed. The listed companies also received negative values for ROE – X_9. The variables, X_8 and X_9, were positively correlated and Pearson's correlation coefficient was 0.88, both in 2012 and 2016 (Table 4).

Table 4. Correlation matrix, 2012, 2016

2012	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
X_1	1.00	0.84	-0.53	-0.11	-0.47	0.40	0.27	0.09	0.03	0.06	-0.05
X_2		1.00	-0.51	0.11	-0.41	-0.05	-0.04	0.18	0.12	0.09	-0.02
X_3			1.00	0.08	0.37	-0.13	0.05	-0.23	-0.10	-0.31	-0.17
X_4				1.00	0.57	-0.04	-0.21	-0.06	0.00	-0.18	-0.20
X_5					1.00	0.20	-0.35	-0.35	-0.24	-0.19	-0.16

X_6						1.00	0.38	-0.28	-0.27	-0.07	-0.09
X_7							1.00	0.19	0.26	0.01	-0.06
X_8								1.00	0.88	0.36	0.23
X_9									1.00	0.35	0.12
X_{10}										1.00	0.91
X_{11}											1.00
2016	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
X_1	1.00	0.68	0.00	0.20	-0.40	0.12	-0.12	0.28	0.25	0.05	0.13
X_2		1.00	0.17	0.16	-0.28	0.20	0.23	0.13	0.13	-0.05	0.01
X_3			1.00	0.17	0.22	0.92	-0.25	-0.06	-0.07	-0.02	-0.07
X_4				1.00	0.47	0.03	0.19	0.11	0.05	0.20	0.23
X_5					1.00	0.16	0.19	0.29	0.20	0.20	0.12
X_6						1.00	-0.19	0.14	0.15	-0.06	-0.12
X_7							1.00	0.19	0.26	0.01	-0.06
X_8								1.00	0.88	0.36	0.23
X_9									1.00	0.35	0.12
X_{10}										1.00	0.91
X_{11}											1.00

Source: author's own study.

In 2012, the most profitable company, in terms of ROA and ROE, was Master Pharm. However, the leader in 2016, in terms of ROA, was Fabryka Farb i Lakierów Śnieżka, while in terms of ROE, was Ciech. The highest market efficiency measured by X_{10} and X_{11} indexes, in both time periods, was obtained by Azoty Group Zakłady Azotowe Puławy. This means that market investors were expecting steady earnings from investments in this company shares. The very high variability of X_{10} index resulted in assigning it the highest weight of 0.2450 in 2012. The return on equity (X_9) was the highest in 2016 and consequently, the highest weight was assigned to it in that year.

Weights based on the criterion of variability (Table 3) were compared to weights established by experts that are available in the subject literature. Suggested values in the literature for individual groups of indicators, i.e. profitability, turnover, liquidity, and indebtedness are 0.2; 0.05; 0.1 and 0.1, respectively (Chrzanowska and Zielińska-Sitkiewicz, 2014).

In this study, profitability was expressed by X_8 and X_9 ratios, whose averages were 0.19 (2012) and 0.25 (2016). In 2016, the weight of X_9 indicator was overestimated, compared to the weight established by experts. The average weight of turnover ratios (X_4, X_5, X_6) was 0.03 (2012) and 0.06 (2016). A significantly higher weight than the reference value was, from amongst all turnover ratios in 2016, obtained for the X_5 index. The other weights for this group of indicators

were at the levels close to 0.05. Adopting the criterion of variability to determine weights impacted on the underestimation of liquidity ratios (X_1, X_2), for which the average weight in 2012 was 0.04 and 0.05 in 2016. A similar situation occurred regarding the debt ratio (X_3). The lack of experts weights for the market efficiency criterion made similar comparisons in this area impossible. The observed discrepancies between the obtained weights and the experts weights influenced the decision to present research results in two variants, i.e. taking into account the designated weights and without them being considered.

4.2. Financial situation as a determinant of the company's competitive position in the sector

On the basis of the values of TMAI in 2012 and 2016, a ranking of the examined listed companies was made (Table 6).

Table 6. Companies' competitive position in the sector (2012, 2016)

Company	Ranking with weights			Ranking without weights		
	Rank position 2012	Rank position 2016	Change of position	Rank position 2012	Rank position 2016	Change of position
Biogened S.A.	11	21	-10	17	18	-1
BioMaxima S.A.	10	9	1	14	10	4
Bioton S.A.	19	20	-1	21	17	4
Boruta Zachem S.A.	20	18	2	19	15	4
Boryszew S.A.	16	8	8	13	8	5
Celon S.A.	14	22	-8	15	19	-4
Ciech S.A.	22	6	16	20	4	16
Comeco S.A.	5	11	-6	7	11	-4
Fabryka Farb i Lakierów Śnieżka S.A.	3	2	1	5	3	2
Fluid S.A.	9	23	-14	2	23	-21
Global Cosmed S.A.	12	12	0	16	12	4
Grupa Azoty S.A.	2	3	-1	3	1	2
Grupa Azoty Zakłady Azotowe Puławy S.A.	1	7	-6	1	2	-1
Grupa Azoty Zakłady Chemiczne Police S.A.	6	4	2	4	6	-2
Harper Hygienics S.A.	8	17	-9	11	16	-5
Master Pharm S.A.	4	16	-12	6	14	-8
Med-Galicja S.A.	18	13	5	12	22	-10
Miraculum S.A.	21	19	2	23	20	3

PCC Exol S.A.	17	5	12	10	7	3
Pharmena S.A.	23	15	8	22	21	1
Prymus S.A.	15	1	14	18	5	13
Selena FM S.A.	13	10	3	9	9	0
Synthos S.A.	7	14	-7	8	13	-5

Source: author's own study.

In 2012, in both rankings, the leading position was taken by Grupa Azoty Zakłady Azotowe Puławy. In the variant, without weights, the lowest position was attained by Miraculum, while in the variant with weights it was Pharmena. In 2016, the weakest position (in both rankings) fell to Fluid company.

While comparing the ranking positions of companies in 2012 and 2016, it was observed that the greatest progress was made by Ciech company. For both variants of the ranking, the company moved up 16 positions improving significantly its competitive position in the chemical industry. These results demonstrate the success of the company's restructuring plan introduced in 2012, which was based on three priorities: reversal of the negative trend in its financial results, cost restructuring, organizational restructuring, and new production capacities, which togeather pulled the company out of a deep collapse (http://ciechgroup.com). Positive changes were also observed in Prymus which, in a similar way as Ciech, is a manufacturer of pharmaceuticals, chemicals, and other chemical products. Prymus company moved in the rankings (without weights) from the 18th position to the 5th and from the 15th position to the 1st position (with weights). Advances in 5 and 8 positions, respectively, in both rankings were observed in the competing company Boryszew, which in addition to the production of other chemical products, also manufactures plastic products. A deterioration of the financial situation and – in consequence – the competitive position was observed in Synthos, which is one of the largest producers of chemical raw materials in Poland. At the same time, the highest decreases were observed for Fluid which, similarly as Boryszew or Selena FM, also produces other chemical products. Declines were observed in companies whose main activity is the manufacturing of pharmaceuticals and medicines, i.e. Biogened, Celon or Master Pharm, whose position significantly worsened. The exception in this respect was BioMaxima which significantly improved its competitive position in the sector.

Overall improvements were observed in respect of cosmetics producing companies namely, Miraculum, Pharmena, as well as PCC Exol that also produces detergents, washing and cleaning agents. Global Cosmed retained, in 2016, a relatively unchanged position in comparison with 2012.

The exception was Harper Hygienics, a manufacturer of cosmetic and hygienic products, whose ranking position deteriorated compared to 2012.

The production of artificial fertilizers plays an important role in the Polish chemical industry. Leaders in this field are Zakłady Azotowe Puławy and Zakłady Chemiczne Police that belong to the Azoty Group. Zakłady Azotowe Puławy was the leader in the rankings both in 2012 and 2016. The use of weights in the ranking did not change the position of Zakłady Azotowe Puławy in 2012, in contrast to 2016, when it was ranked the 7th. This situation was probably influenced by the relatively lower turnover of assets experienced in the company in 2016. Grupa Azoty Zakłady Chemiczne Police kept its position from 2012 in the sector. A larger decrease was observed for Comeco which is, amongst others, also a manufacturer of fertilizers. Improvements in the situation of one of the major producers of paints and varnishes in Poland, Fabryka Farb i Lakierów Śnieżka S.A, is worthy of note. Improvements were also in 2016 noted for Boruta Zachem, a producer of dyes and pigments.

The greatest differences between results achieved in both variants were observed with respect to Fluid (the 2nd and the 9th position, respectively), Biogened (the 17th and the 11th position, respectively) and Med-Galicja (the 12th and the 18th, respectively). Identical positions of companies in both rankings were observed with respect to the leader, namely Zakłady Azotowe Puławy in 2012 (the 1st position), and in 2016 regarding Boryszew (the 8th position), Comeco (the 11th position), Fluid (the 23rd position) as well as Global Cosmed (the 12th position).

The compliance of results in both variants (with or without weights) was examined with the use of Spearman's correlation, amounting to 0.8626 (2012) and 0.8913 (2016). The results obtained attested to the high level of conformance of both rankings.

4.3. Verification of the research hypothesis and further research

In the presented research, annual financial statements were adopted as the primary source of information about the performance of the companies at selected times, including observable changes in their financial situations. They were both a source of data for a one-dimensional analysis based on the value of individual indicators, measuring one area of business activity, but first and foremost, they served as the basis of multidimensional analysis taking into account the different areas of entities' functioning.

Due to the fact that business units are complex objects, their financial situation was, in this research, described with a large number of financial indicators (Nowak, 1997; Węgrzyn, 2015). The conducted empirical analysis enabled the assessment of the competitive position of chemical companies listed on the WSE at two-time points 2012 and 2016. Using TMAI, the following areas of financial analysis were taken into consideration, i.e. liquidity, debt, turnover, profitability, as well as information from the market in the form of its two performance indicators (Koralun-Bereźnicka, 2013).

Relying on the TMAI values, it was possible, not only, to identify the companies with the best and worst positions in the sector, but also point out the largest changes in their rankings in 2016, compared to 2012. The high degree of comparability of the ratings obtained in the two variants of the method confirmed the companies' rankings reliability. These facts allowed concluding that the multidimensional assessment of the company's financial standing is a basis for credible determination of its competitive position in the sector. Therefore the hypothesis stated was positively verified.

However, it is worth pointing out that the value and competitive position of the company is not only influenced by specific balance sheet inputs, but also intangible factors such as good reputation, consumer product popularity, brand value, logo, company image, environmental attitudes, local environmental issues, and other difficult-to-measure factors. Unfortunately, the TMAI method does not take into account the impact of hardly quantifiable off-balance items, which undoubtedly have an impact on the competitive position of a company. Their inclusion is especially important for companies operating in the chemical sector, which is generally seen as a sector that is harmful to the natural environment.

The results presented should, therefore, be considered as a contribution to further research aimed at developing more and more accurate methods for assessing the competitive position of a company. In addition, the procedure of defining weights also requires improvements. It was, in the presented analysis, based solely on the statistical criterion. The choice of weights would, however, be further deepened by considering the substantive significance of the measures taken into account.

5. Conclusions

It is generally assumed that the basic measure of a company's performance, and therefore its success, is to gain a competitive advantage in the sector and a relatively high market share, thus ensuring a steady income and opportunities for further growth and development.

Information concerning a company's position within the sector is valuable both to managers, employees, customers, suppliers, shareholders, investors, competitors, or other stakeholders. The importance of this information gives high ranks to procedures, methods, and techniques that allow for a comprehensive assessment of its financial situation and in consequence the competitive position of the firm. One of such methods is the TMAI, whose advantages are widely recognized in the literature of the subject. In this study, TMAI was used to assess the competitive position of companies in the chemical industry. It consists of entities producing chemicals and chemical products, pharmaceutical, cosmetic and hygienic products, rubber and plastic products, thus indicating the strong diversification of the chemical sector. In such circumstances, comparison of entities' positions cannot be based on the values of individual indicators.

The proposed approach to identifying the situation of companies in Poland's chemical industry, based on TMAI, thus seems to be a good choice. Its main advantage is the ability to express the position of a company with one TMAI value, which makes it easier not only to interpret results obtained, but also to make comparisons within a sector. Despite its simplicity, this measure carries a high information load, which consists of values of individual indicators contained in the index that characterizes the various areas of an entity's business.

Acknowledgements

This paper was prepared as a part of the research grant financed by the National Science Centre, Poland [grant no. 2016/23/D/HS4/03007].

Literature:

Barthelemy, P.; Agyeman-Budu, E. (2016). European chemical industry's contribution to sustainable development. *Current Opinion in Green and Sustainable Chemistry* 1: 28-32

Buckley, P.J.; Pass, C.L.; Prescott, K. (1990). The Implementation of an International Market Servicing Strategy in UK Manufacturing Firms. *British Journal of Management* 1: 127-136.

Central Statistical Office (GUS), Statistical Yearbook of Industry – Poland (2016) Warsaw. Available at: http://stat.gov.pl/obszary-tematyczne/roczniki-statystyczne/roczniki-statystyczne/rocznik-statystyczny-przemyslu-2016,5,10.html (accessed 20 July 2017).

Chemical Industry Vision 2030: A European Perspective (2016). Available at: https://www.accenture.com/us-en/insight-chemical-industry-vision-2016 (accessed 25 July 2017).

Chemical Sector in Poland. Polish Information and Foreign Investment Agency Warsaw. Available at: http://www.msp.gov.pl/en/polish-economy/economic-news/5067,Chemical-industry-in-Poland.html (2013) (accessed 20 July 2017).

Chen, Y.-S.; Chang, K.-C. (2013). The nonlinear effect of green innovation on the corporate competitive advantage. *Quality and Quantity* 47: 271-286.

Chorób, R. (2012). The significance of innovative integration relations in regional development compared to globalization processes. *Nierówności Społeczne a Wzrost Gospodarczy* 28: 370-377.

Chrzanowska, M.; Zielińska-Sitkiewicz, M. (2014). An Application of Taxonomic Measure Attractiveness of Investment for Classification of Major Construction Companies Listed on the Warsaw Stock Exchange. *Acta Universitatis Lodziensis. Folia Oeconomica* 2(301): 39-50.

de Menezes, U.; Dias, V.; Gomes, C.; Scherer, F.; Kruglianskas, I. (2013). Management of Sustainable Innovation in an Internationalized Company. *Journal of Technology Management & Innovation* 8: 264-273.

den Butter, F.A.; Möhlmann, J.L.; Wit, P. (2008). Trade and product innovations as sources for productivity increases: an empirical analysis. *Journal of Productivity Analysis* 30(3): 201-211.

Díaz López, F.J.; Montalvo, C. (2015). A comprehensive review of the evolving and cumulative nature of eco-innovation in the chemical industry. *Journal of Cleaner Production* 102: 30-43.

Dmitruk, J. (2012). Taksonomiczna miara atrakcyjności inwestowania (TMAI) na przykładzie spółek giełdowych (Taxonomic Measure of Investment Attractiveness on the example of Listed Companies). *Zeszyty Naukowe SGGW w Warszawie. Ekonomika i Organizacja Gospodarki Żywnościowej* 99: 161-173.

Dzikowska, M.; Gorynia, M; Jankowska, B. (2017). The theoretical, empirical and methodological aspects of company competitiveness. In: Dzikowska, M.; Gorynia, M.; Jankowska, B. (eds). *International competitiveness of Polish Companies: during and after the global economic crisis*: 93-122. Warsaw: Difin.

Emerging Markets Information Service (EMIS) Polska. Avaiable at: https://www.emis.com/pl (accessed 25 June 2017).

Flotyński, M. (2016). The application of a multidimensional comparative analysis for the short selling of stocks. In: Urbanek, P. (ed.). *Economy Today. An Interdisciplinary Approach to Contemporary Economic Challenges*: 147-168. Łódź: University of Łódź Publishing.

Gietka, A.; Lubiewa-Wieleżyński, W. (2010). Sustainable development of the Polish chemical industry – challenges and barriers. *Chemik* 64(6): 1-2.

Gladkykh, D. (2015). European chemical industry competitiveness: historical trends and development prospects. *Baltic Journal of Economic Studies* 1: 62-66.

Gostkowska-Drzewicka, M. (2015). Kondycja finansowa jako wyznacznik pozycji konkurencyjnej przedsiębiorstw deweloperskich (Financial standing as a determinant of competitive position of real estate development companies). *Financial Sciences* 1(22): 49-68.

Horta, I.M.; Camanho, A.S. (2014). Competitive positioning and performance assessment in the construction industry. *Expert Systems with Applications* 41, 974-983.

http://ciechgroup.com (accessed 25 June 2018).

https://www.money.pl (accessed 25 June 2018).

Hyršlová, J.; Tomšík, P.; Vnoučková, L. (2017). Relation between sustainability-related communication and competitiveness in the chemical industry. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis* 65(1): 283-292.

Kajanowa, J. (2009). Competitiveness and chemical industry in the Slovak republic. *Economics & Management* 14: 802-808.

Kamerschen, D.R.; McKenzie, R.B.; Nardinelli, C. (1992). Ekonomia [Economics]. Gdańsk: Fundacja Gospodarcza Solidarność.

Kawachi, S. (2003). Technological competitiveness in the chemical industry. *Computer Aided Chemical Engineering* 15: 7-11.

Koralun-Bereźnicka, J. (2013). Corporate Performance: A Ratio-Based Approach to Country and Industry Analyses. Heidelberg: Springer.

Korkosz-Gębska, J. (2016). Wykorzystanie koncepcji CSR w działalności przedsiębiorstw sektora chemicznego (The implementation of CSR concept in activity of companies of chemical industry). *Scientific Papers of Silesian University of Technology. Organization and Management Series* 93: 221-230.

Li, J.; Hu, S. (2017). History and future of the coal and coal chemical industry in China. *Resources, Conservation and Recycling 124*: 13-24.

Lin, Y.-H.; Chen, Y.S. (2017). Determinants of green competitive advantage: the roles of green knowledge sharing, green dynamic capabilities, and green service innovation. *Quality and Quantity* 51: 1663-1685

Majchrzak, J. (2013). Reindustrialisation of the European Union as an opportunity for the chemical industry in Poland. *Chemik* 67(3): 175-176.

Mastalerz-Kodzis, A. (2012). Application of Fundamental Analysis Methods to Compare Efficiency of Complex Portfolios consisting of Values Listed on Stock Exchange. Proceedings of the 30th International Conference Mathematical Methods in Economics, Karvina: Silesian University, School of Business Administration.

Matthyssens, P.; Vandenbempt, K. (1998). Creating competitive advantage in industrial services. *Journal of Business & Industrial Marketing* 13: 339-355.

Mierzecki, R. (1998). The Polish Chemical Industry. In: Homburg, E.; Travis, A.S.; Schröter, H.G. (eds) *The Chemical Industry in Europe, 1850–1914: Industrial Growth, Pollution, and Professionalization*: 59-71. Dordrecht-Boston-London: Springer Netherlands.

Nermend, K. (2009). Vector Calculus in Regional Development Analysis. Comparative Regional Analysis Using the Example of Poland, Heidelberg: Physica-Verlag.

Nielsen, F.; Muzellec, B.; Nock, R. (2016). Classification with mixtures of curved Mahalanobis metrics. *2016 IEEE International Conference on Image Processing (ICIP)*. p. 241-245. Phenix. Available at: https://doi.org/10.1109/ICIP.2016.7532355 (accessed 20 July 2018).

Nowak, E. (1997). A Multi-Dimensional Comparative Analysis in the Modelling of the Financial Condition of Enterprises. *Annales Universitatis Mariae Curie-Skłodowska Lublin-Polonia* Vol. XXXI, Sectio H: 111-123.

Owczarzak, R. (2004). Globalizacja a potencjał i pozycja konkurencyjna przedsiębiorstwa (Globalization in the face of a company's potential and competitive position). *Ruch Prawniczy, Ekonomiczny i Socjologiczny* 2: 163-182.

Piatkowski, M. (2012). Factors Strengthening the Competitive Position of SME Sector Enterprises. An Example for Poland. *Procedia Social and Behavioural Science* 58: 269-278.

Pieloch-Babiarz, A. (2015). Ocena atrakcyjności inwestycyjnej spółek giełdowych odpowiedzialnych społecznie (Assessment of investment attractiveness of socially responsible listed companies). *Journal of Management and Finance* 13(1): 21-37.

Pietrzak, M. (2013). Competitiveness of Europe in manufacture of chemicals in the conditions of globalization. *Economic and Regional Studies* 3: 41-48.

Pociecha, J.; Zając, K. (1989). Cluster analysis methods and regression modeling. *Control Cybernetics* 18(1): 69-80.

Porter, M.E. (1980). Competitive Strategy: Techniques for Analyzing Industries and Competitors. New York: Free Press

Prahalad, C.K.; Hamel, G. (1990). The Core Competence of the Core Corporation. *Harvard Business Review* 68(3): 79-91.

Rutkowska-Ziarko, A. (2013). Fundamental Portfolio Construction Based on Mahalanobis Distance. In: Lausen, B.; van den Poel, D.; Ultsch, A. (eds). *Algorithms from and for Nature and Life. Classification and Data Analysis*: 417-426. Cham-Heidelberg-New York-Dordrecht-London: Springer.

Sipa, M. (2015). Determinants of Competitiveness of Small Enterprises: Polish Perspective. Procedia Economics and Finance 27: 445-453.

Siudek, T., Zawojska, A. (2014). Competitiveness in the economic concepts, theories and empirical research. *Acta Scientiarum Polonorum Oeconomia* 13(1): 91-108.

Srivastava, M.; Franklin, A.; Martinette, L. (2013). Building a Sustainable Competitive Advantage. *Journal of Technolody Management and Innovation* 8(2): 47-60.

Strategia dla przemysłu chemicznego w Polsce do 2010 roku. Available at: https://www.msp.gov.pl/download/2/11630/Strategiadlaprzemysluchemicznegodo2010roku.pdf (2002) (accessed 20 July 2017).

Tarczyński, W. (2014). Different variants of fundamental portfolio. *Folia Oeconomica Stetinensia* 14(1): 47-62.

Tarczyński, W.; Łuniewska, M. (2005). Stability of Selected Linear Ranking methods – An Attempt of Evaluation for Polish Stock Market. In: Baier, D.; Wernecke, K.-D. (eds). *Innovations in Classification, Data Science, and Information Systems*: 523-534. Berlin-Heidelberg-New York: Springer Verlag.

Terterov, M.; Reuvid, J. (eds). (2005). Doing Business with Poland, 4th edition, London: GMB Publishing company Ltd.

Węgrzyn, T. (2015). The TMAI Model – Performance of portfolios constructed on the base of correlated and uncorrelated financial ratios. *Folia Oeconomica Stetinensia* 14(2): 125-139.

Zalewski, A. (2014). Analiza konkurencyjności polskiego eksportu nawozów azotowych (Analysis of the competitiveness of Polish export of nitrogen fertilizers). *Zeszyty Naukowe Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie. Problemy Rolnictwa Światowego* 14(1): 141-147.

Zygmunt, A. (2013). Wielowymiarowa analiza porównawcza kondycji finansowej przedsiębiorstw przetwórstwa przemysłowego w województwie opolskim (A comparative multivariate analysis of financial situation of manufacturing enterprises from the region of Opole). *The Wroclaw School of Banking Research Journal* 2(34): 477-488.

Zastosowanie TMAI do określenia pozycji konkurencyjnej przedsiębiorstw sektora chemicznego w Polsce

Streszczenie

Sektor chemiczny jest jednym z kluczowych sektorów gospodarki europejskiej. Obecnie najszybszego wzrostu przemysłu chemicznego oprócz rynków azjatyckich, oczekuje się w krajach Europy Środkowej i Wschodniej, w tym w Polsce. Polski przemysł chemiczny stoi jednak w obliczu wielu wyzwań, takich jak wysokie ceny surowców, ostrzejsze normy środowiskowe i rosnąca konkurencja. W związku z tym właściwe jest określenie pozycji konkurencyjnej przedsiębiorstw w sektorze chemicznym w Polsce. Cel ten został osiągnięty poprzez zastosowanie taksonomicznej miary atrakcyjności inwestycyjnej (TMAI), która należy do grupy wielowymiarowych analiz porównawczych. Ocenę przeprowadzono na przykładzie 23 spółek chemicznych notowanych na Giełdzie Papierów Wartościowych w Warszawie (GPW) pod kątem płynności, zadłużenia, obrotowości rentowności i efektywności rynkowej. Badane podmioty zostały uszeregowane pod względem zajmowanej pozycji konkurencyjnej w dwóch momentach czasowych, 2012 i 2016. Rankingi przedsiębiorstw zostały przedstawione w dwóch wariantach, a mianowicie z uwzględnieniem współczynników wagowych oraz bez ich uwzględnienia. Badania potwierdziły zgodność rankingów wyznaczonych w obu wariantach zastosowanej metody. Wysokie pozycje w rankingu utrzymywała większość przedsiębiorstw zajmujących się produkcją nawozów mineralnych. Chociaż przedsiębiorstwa kosmetyczne zostały w 2012 r. sklasyfikowane na niskim poziomie, większość z nich odnotowała poprawę w 2016 r. Odwrotnie było w przypadku producentów produktów farmaceutycznych i medycznych. Uzyskane wyniki są przydatne w ocenie wartości rynkowej podmiotów z sektora chemicznego oraz w opracowywaniu strategii rozwoju tego sektora w świetle idei rozwoju zrównoważonego.

Słowa kluczowe: TMAI, pozycja konkurencyjna, przedsiębiorstwo, wynik, przemysł chemiczny, rozwój zrównoważony

Kody JEL: L25, O14, C38