MULTIDIMENSIONAL COMPETITIVE POSITION ANALYSIS OF MOST INNOVATIVE PHARMACEUTICAL & BIOTECHNOLOGY COMPANIES – 2012 PERSPECTIVE

KAROL ŚLEDZIK

Abstract: *In Knowledge Based Bio-Economy over the past two decades, biotechnology has provided a motor for environmentally sustainable production and for the development of a diverse range of innovative products. The paper presents the possibility of using euclidean distance from the Positive Development Pattern (PDP) to identify those biotech companies which are characterized by the highest levels of innovation. As a result there was created synthetic ratio with range from 0 to 1 for each of 173 objects (Enterprises). Sorted from highest to lowest value of SMD (Systematic Measure of Development) ratio became a ranking of competitive position of most innovative companies in pharmaceutical and biotechnology industry. The role biotechnology could play in addressing what are considered the most serious challenges to world economies and societies over the next decades. These challenges include agriculture, healthcare, industry and other resources and services to a world that will see its population increase by a third in the face of mounting environmental stresses over the next 20 years. The purpose of the article is to present possibility of usage of multidimensional analysis to evaluate the competitive position of enterprise. Author presents SMD ratio for pharmaceutical and biotechnology companies. Presented tool solves the problem of low level of utility of one-dimensional analysis.*

Keywords: *competitive, position, taxonomy, innovation, biotechnology, multidimensional analysis*

JEL Classification: *G32, O3, O16*

1. INTRODUCTION

After only three decades of scientific and entrepreneurial resolve, the biotechnology industry holds great promise for addressing a wide range of critical challenges in developed and developing countries including: healthcare, alternative energy, environmental remediation, and agricultural productivity [1],[2],[3],[4]. In the conditions of Knowledge Based Economy the biological sciences generates value added in a significant part of products and services. This leads to conclusion that nowadays we may have to deal with Knowledge Based "Bio-Economy". The knowledge foundations to the concept of Knowledge Based Bio-Economy is advances in life sciences and biotechnologies in convergence with other technologies such as medicine, nanotechnologies, physics, chemistry, information technologies. This is one of the fastest growing areas of the economy. For example the European Bio-Economy has an approximate market size of over 1.5 trillion euro, employing more than 22 million people. It has become possible thanks to globalization and European strengths such as: excellent life sciences and biotechnology, research base, strong chemical and enzyme industries, strong vaccine industry, strong food and feed industry, high-tech textile industry. The drivers of Knowledge Based Bio-Economy are global challenges such as [5]:

- Growing and aging populations;
- Increased demand for high quality food and sustainable food production;
- Increased incidence of food-related disorders (cardiovascular, obesity, etc);
- Increased demand for feed;
- Increase in infectious animal diseases and zoonoses;
- Danger of plant diseases, new pathogens and pesticides;
- Limited resources of raw materials and energy;
- Threat of global warming and other global changes (biodiversity loss, etc.).

In Knowledge-Based Bio-Economy over the past two decades, biotechnology has provided a motor for environmentally sustainable production and for the development of a diverse range of innovative products. The continued commercial application of biotechnology could lead to the development of a Bio-Economy, where a substantial share of economic output is partly dependent on the development and use of biological materials. Advances in biotechnology-related fields such as genomics, genetic engineering, chemical engineering and cell technology are transforming the industrial and environmental process and management landscapes. Microorganisms, enzymes or their products are replacing processes that depended heavily on chemicals, many of which are implicated in environmental damage. The role biotechnology could play in addressing what are considered the most serious challenges to world economies and societies over the next decades. These challenges include: agriculture, healthcare, industry and other resources and services to a world that will see its population increase by a third in the face of mounting environmental stresses over the next 20 years [6]. One can therefore conclude that the evaluation of the competitive position of companies operating in the Pharmaceutical & Biotechnology sector is an important research problem.

Development of civilization and Knowledge-Based Economies leads to increase of complexity of competitiveness evaluation process. There is no doubt that in practice almost every evaluation must be multidimensional.

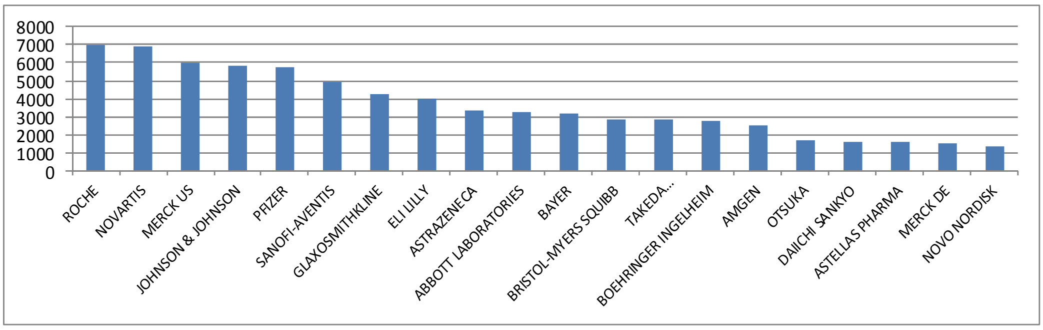

Figure 1 R&D expenses of Pharmaceutical & Biotechnology Companies in 2012 (million EUR)
Source: Own calculation

This is due to the mutual interaction of many phenomena being evaluated. This also applies the assessment of the competitive position. Innovation is traditionally understood as a firm-based activity, in sectors where firms strive to integrate R&D into new products and processes [7]. Traditionally, nations develop strategies to improve their competitiveness [8]. But increasingly, innovation has become studied as something that happens within a field of social and economic activities, in services, in clusters and networks as well as sectors and regions in global scale. The life sciences are an example which allow the investigation of such approaches to innovation. They include global biotechnology & pharmaceutical companies with high R&D investments, new biotech firms and innovative financing systems [9],[10]. Basic assumption of the research is that most innovative company has the best competitive position on the market. It is possible because most innovative company must commercialize innovations which results in the high level of sales, profit, cash flow etc. Most popular indicator related to innovation level of the companies is Research and Development (R&D) expenses. 20 biggest (according to R&D expenses) Pharmaceutical & Biotechnology enterprises in 2012 spent on R&D over 73.2 billion EUR.

In this one-dimensional ranking unquestioned leader from the perspective of R&D expenditure is Swiss Roche and Novartis (about 7 billion of EUR). Then Merck from US (about 6 billion EUR) and Johnson & Johnson with Pfizer (5,8 billion of EUR) (see Figure 1). However evaluation of competitive position of Pharmaceutical & Biotechnology companies based only on R&D expenses is insufficient. The purpose of this article is to present possibility of usage of multidimensional analysis to evaluate the competitive position of enterprise. Author presents SMD (Systematic Measure of Development) ratio for Pharmaceutical & Biotechnology companies. Presented tool solves the problem of low level of utility of one-dimensional analysis.

2. METHODOLOGY

The research was based on UE database of 2000 most innovative companies in 2012 [11]. From 2000 companies there were selected 215 enterprises form a Pharmaceutical & Biotechnology industry. In the next step of the research was performed the analysis of data completeness. From the 18 indicators available for 2000 enterprises, because of the gaps in the values of indicators, there were chosen 5 (all for the year 2012): R&D expenses, sales, Capex, profits and number of employees. In the effect 42 companies were deleted from the set of entities. As a result, In the study there were 173 objects.

The paper presents the possibility of using euclidean distance from the Positive Development Pattern (PDP) to identify those companies from Pharmaceutical & Biotechnology industry, which are characterized by the highest levels of innovation. The procedure consisted of the following stages of the calculation:

1. Creating a matrix of Enterprises and Indicators

	I_1	I_2	I_3	…	I_m
E_1	X_{11}	X_{12}	X_{13}	…	X_{1m}
E_2	X_{21}	X_{22}	X_{23}	…	X_{2m}
E_3	X_{31}	X_{32}	X_{33}	…	X_{3m}
…	…	…	…	…	…
E_n	X_{n1}	X_{n2}	X_{n3}	…	X_{nm}

where: (1)

$E_{1 \ldots n}$ – Enterprise
$I_{1 \ldots m}$ – Indicator
X_{nm} – the value of m-th features (I - Indicator) of the n-th object (E – Enterprise)

2. Due to the fact that the features can be stimulants, destimulants or nominants before next step there should be (if necessary) used procedure to bring uniformity of characteristics (features). In the study assumed that number of employees is destimulant. The lower the number of employees at a given level of profit, sales and spending on R&D, the better.

The second step of the calculation is to bring the different variables comparable titers with standardization. As a result of diagnostic standardization of each variable will have a mean value of 0 and standard deviation equal to 1. Standardization is made according to the following formula:

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{S_j} \quad (i = 1,\ldots,n,\ j = 1,\ldots,m) \qquad (2)$$

where:
z_{ij} – standardized value of j-th features of the i-th object
x_{ij} – the value of j-th features of the i-th object
$\bar{x}_j$ – the arithmetic mean of the j-th features
S_j – standard deviation of the j-th features

As a result there will be matrix: (3)

	sI_1	sI_2	sI_3	…	sI_m
E_1	Z_{11}	Z_{12}	Z_{13}	…	Z_{1m}
E_2	Z_{21}	Z_{22}	Z_{23}	…	Z_{2m}
E_3	Z_{31}	Z_{32}	Z_{33}	…	Z_{3m}
…	…	…	…	…	…
E_n	Z_{n1}	Z_{n2}	Z_{n3}	…	Z_{nm}

3. The third step was to estimate the Zpj – Positive Development Pattern (PDP) by setting the maximum value in each column of standardized features.

Z_{pj} = = *Max { Z_{ij} }* – Positive Development Pattern (PDP) (4)

4. The next step was to estimate the weights for different features. The criterion to estimate the importance of the individual assumes that preference is given to the characteristics of the most volatile because they differentiate the best studied phenomenon. To estimate the various scales used the following formula:

$$w_j = \frac{V_j}{\sum_{j=1}^{m} V_j} \qquad (5)$$

where:

w_j – weight of diagnostic

V_j – coefficient of variation of the variable j before standardization

5. Calculating the distance of each object from the PDP, taking into account the impact of various strength characteristics of the study examined the phenomenon. Used Euclidean distance and the weight determined by the formula:

$$d_i = \sqrt{\left[\sum_{j=1}^{m} w_j \left(z_{ij} - z_{pj}\right)^2\right]} \quad (i = 1,...,n) \qquad (6)$$

where:

d_i – weighted Euclidean distance from PDP

Z_{pj} = *Max { Z_{ij} }* - Positive Development Pattern (PDP)

The advantage of the synthetic ratio which is the weighted Euclidean distance from PDP is that the result is a one (synthetic) variable indicating the direction and magnitude of changes in the assessment process allowing objectify the phenomenon of innovation.

6. Due to the fact that synthetic variable defined by equation (6) is not normalized, di ratio must be change in normativity process. This will lead to changes in preferences of variable, were a larger value will stand to the higher level of the studied phenomenon (innovation level). That synthetic variable will take values in the range from 0 to 1. Formula is as follows:

$$SMD = 1 - \frac{d_i}{d_0} \quad (i=1,...,n) \qquad (7)$$

where:

SMD – Synthetic Measure of Development for i-th object

d_i – weighted Euclidean distance from PDP

d_0 – ratio which provides acceptance by *zi* values in the range from 0 to 1 (transforming *zi* into stimulant)

where:

$$d_0 = \bar{d} + 2 S_d \qquad (8)$$

where:

$\bar{d}$ – the arithmetic mean of the variable *di*

S_d – standard deviation of the variable *di*.

As a result there were created Synthetic Measure of Development - SMD ratio with range from 0 to 1 for each of 173 objects (Enterprise). Sorted from highest to lowest value of SMD ratio became a ranking of competitive position of most innovative companies in Pharmaceutical & Biotechnology industry in 2012.

3. FINDINGS

In the research (from geographic point of view) there were: 1 company (in each country) from Australia, Belgium, Cayman Islands, Finland, Hong Kong, Hungary, Israel, Slovenia and The Netherlands; 3 companies form India, Ireland, Italy and Spain; 4 companies form China, France and Sweden; 6 companies from Switzerland; 7 companies form Germany and UK, 8 companies from Denmark; 27 companies from Japan and 85 companies form USA. It gives a picture of the distribution of forces in Pharmaceutical & Biotechnology sector in the global economy.

The advantages of multidimensional analysis is the fact that in evaluating the competitive position at the same time are taken into account the expenditure on R&D but also the level of sales, profit, capital expenditure and number of employees of the companies. The results from the SMD ratio point of view differ from all the one-dimensional ranking (based only on the R&D expenditure). In one-dimensional ranking first three companies were: Roche, Novartis, Merck US. In multidimensional ranking first three companies are: Johnson &Johnson, Roche and Novartis.

As a result of research there were created a ranking of pharmaceutical and biotechnology companies. Most of the companies (148 enterprises from 173) has SMD ratio between 0,10 and 0,20. SMD between 0,20 and 0,30 were observed for 13 objects. 4 Companies were in the range 0,30 - 0,40 of SMD value. Also 4 enterprises were in the range 0,40 - 0,50 of SMD. And Also 4 companies were located in highest range 0,50 - 0,60 of SMD ratio. 10 best and 10 worst ratings of Pharmaceutical & Biotechnology companies were presented in Table 1 below:

Table 1 10 best and 10 worst ratings of pharmaceutical and biotechnology companies – 2012 perspective

No	10 BEST COMPANIES	COUNTRY	SMD	No	10 WORST COMPANIES	COUNTRY	SMD
1	JOHNSON & JOHNSON	USA	0,553709272	164	STALLERGENES	France	0,124400412
2	ROCHE	Switzerland	0,540318205	165	ZERIA PHARMACEUTICAL	Japan	0,124347690
3	NOVARTIS	Switzerland	0,525801715	166	NIPPON SHINYAKU	Japan	0,124338069
4	PFIZER	USA	0,511354479	167	DIASORIN	Italy	0,124299349
5	MERCK US	USA	0,486968170	168	TECAN	Switzerland	0,123952476
6	GLAXOSMITHKLINE	UK	0,469587185	169	ALK ABELLO	Denmark	0,123034504
7	SANOFI-AVENTIS	France	0,467368532	170	AFFYMETRIX	USA	0,122827492
8	BAYER	Germany	0,411970079	171	GENUS	UK	0,122506551
9	ABBOTT LABORATORIES	USA	0,357264513	172	DENDREON	USA	0,120457184
10	ASTRAZENECA	UK	0,356704530	173	SIMCERE PHARMACEUTICAL	Cayman Islands	0,119781580

Source: Own calculation

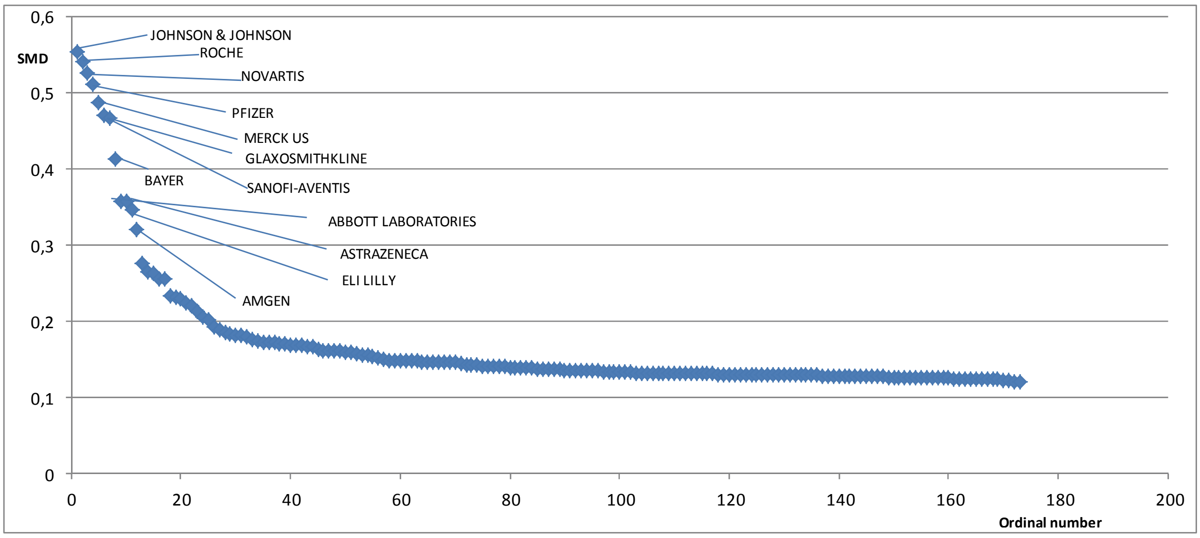

Figure 2 SMD – Systematic Measure of Development of Pharmaceutical & Biotechnology Companies in 2012
Source: Own calculation

The values of SMD – Systematic Measure of Development ratio of Pharmaceutical & Biotechnology Companies in 2012 were presented in chart (see Figure 2) where in OY axis were marked values of SMD ratio and on OX axis were marked ordinal numbers of the objects (companies). Additionally best companies position in the rating were marked on the Figure 2 below. From a graphical point of view can therefore be emerge three clusters of objects in the range of 0.3 - 0.6. First cluster consists 7 companies (Johnson & Johnson, Roche, Novartis, Pfizer, Merck US, Glaxosmithkline and Sanofi-Aventis). Those are enterprises with relatively highest sales, profits, capital expenditures, R&D expenses with given number of employees. Second is one-object cluster consists german Bayer. Third and last cluster consists 4 companies: Abbot Laboratories, Astrazeneca, Eli Lilly and Amgen.

Significant impact on the final results of the ranking were the maximum values of the various indicators of the surveyed companies. The more the maximum values of 5 indicators the higher position in multidimensional ranking. Moreover, this is the main reason why the one-dimensional rank differs from multidimensional ranking. For example, in the study in 2012 Roche has the highest R&D expenses (7 billion EUR), Johnson&Johnson has the highest sales (over 5 billion EUR) and capex ratio (2,2 billion EUR), Pfizer has highest profits (13.8 billion EUR) while Furiex Pharmaceutical form US has the lowest number of employees (only 24). Those (best) values of ratios after standardization are Positive Development Pattern coordinates. If there would be one company with best ratio values in 2012 highest R&D expenses, highest sales and capex ratio, highest profits and lowest number of employees it would be probably most innovative Pharmaceutical & Biotechnology company in 2012 with the best competitive position.

4. DISCUSSIONS

A main interest in the creative destruction concept [12],[13] is to account for the differences in R&D performance on the market between when a radical change in technological regimes occurs, what can generate a "discontinuity" [14]. In fact, systematic underperformance in R&D against competitors is widely considered one of the main explanations for their market failure [15]. Differences in R&D performance in the new technology is one of three broad determinants of differences in the market performance, the other two being differences in investment and differences in the ownership of complementary assets [16],[17]. Next important area of company innovation issue is profitability of knowledge assets. In Pharmaceutical & Biotechnology industry knowledge assets are main value driver of the companies. That is why in the research besides R&D expenses was included sales and profit. Investment strength was evaluated by amount of capital expenditure. Last ratio in multidimensional analysis was number of employees. In this issue the lowest number of employees, with high financial performance, the bigger innovative potential resulting from intellectual capital of the firm. In other words the highest level of innovation of the company must be reflected in the financial results.

The author is aware of the fact that research can be enhanced with another indicators. This is an additional challenge for the continuation of research in the future. However on this stage of the research conclusions resulting from the application of the chosen method seems to be interesting.

5. CONCLUSION

The short and long term strategies of Pharmaceutical & Biotechnology companies play a crucial role in their competitive position. Short term strategies focus on patenting and licensing issues and long term strategies focus on R&D. Pharmaceutical & Biotechnology companies are distinctly positioning themselves from the innovation point of view on the basis of their R&D strength. In the research multidimensional competitive position evaluation of Pharmaceutical & Biotechnology companies in 2012 leads to the conclusion that innovation level depends on many factors (not only on R&D). Results of the research established the rule that "big can more" and that behind innovation must stand capital and profit. Without commercialization of innovation, visualized in the financial results, the concept becomes just an "empty shell".

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Karol ŚLEDZIK, PhD
University of Gdańsk, Faculty of Management, Department of Banking
ul. Armii Krajowej 101, 81-824 Sopot, Poland
e-mail: ksledzik@wzr.ug.edu.pl