INTELLECTUAL CAPITAL AND FINANCIAL PERFORMANCE OF BIOTECH COMPANIES IN THE PHARMACEUTICAL INDUSTRY

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Abstract
The paper's aim is to analyse the interdependency between the intellectual capital and the financial performance of biotechnological (biotech) companies in the pharmaceutical industry. The analysis was performed for 24 biotech companies in this branch considered during 2002-2014, based on several indicators available on the Thomson Reuters database. The financial performance was measured through the return on assets (ROA), return on equity (ROE) and the debt-to-equity ratio (DE). In order to capture the intellectual capital, the focus was on a designing a new indicator, proposed by the authors, respectively the efficiency of research and development expenditures (ECD), along with another proxy, previously attested by the literature and reflected through the market to-book ratio (MTB). The research methodology resides on applying the correlation method, robust regression, and structural equations modelling (SEM). The results reveal a significant negative relationship between ROA, ROE and MTB, which contradicts the literature and suggests that, for this particular type of companies, MTB isn't relevant to express the intellectual capital. MTB was positively correlated with DE. When we used the ECD, the results attested a strongly positive and significant relation with ROA and ROE, and a negative one with DE. Therefore, the applied tests confirm ECD as the most suitable indicator to appreciate the intellectual capital for the biotech companies in the pharmaceutical industry.

Keywords: intellectual capital, bioeconomy, biotech companies, company's value, financial performance, correlation analysis, structural equation models (SEM).

JEL Classification: O34, Q57, G32, C58.

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Introduction

In the last decades, the high global pressure on the sustainable development, without compromising the chances of future generations, has caused many changes of the economic principles, culminating with bioeconomy formation, as a fundamental part of the knowledge-based economy. This action is mainly supported by the contribution of science to the development of new techniques and technologies, capable of sustaining the industry growth, while reducing its negative impact on the environment.

There is no commonly accepted definition of the bioeconomy concept, however, at the first Global Summit on this topic, it is recommended to understand the bioeconomy as a "knowledge-based production and utilization of biological resources, innovative biological processes and principles to sustainably provide goods and services across all economic sectors" (Communiqué Global Bioeconomy Summit, 2015, p. 4). Therefore, bioeconomy represents a developing sector, supported by the conjunction of intellectual capital and technology, through science, into human/Earth relationship. The equivalent term for this combination is the one of industrial biotechnology. Biotechnology is the one that ensures the continuous flow of innovation and the tools needed to produce new products based on renewable technologies.

At the same time, biotechnology fulfils a role that "goes beyond industrial growth, since it provides opportunities for progress towards many of the UN sustainable development goals (SDGs)" (Lokko et al., 2018, p. 5). This is already revolutionizing, mainly, the manufacturing industry, the chemical industry, agriculture, medical and health services, offering year by year an increase in the quantity and quality of bio-based products (obtained by replacing the traditional resources with renewable biological ones). Specific to technological development, the human resource plays a key role in the development and dispersion of knowledge underlying biotechnology (Zucker and Darby, 1997). In fact, in the chase of sustainable growth, the role played by the intellectual capital has increased in all fields of the world economy, reaching the rank of vital component in the biotechnologies industries (known as "biotech" abbreviation). Knowledge, approached as intangible assets, is considered to be the most important resource in obtaining the competitive companies advantages and the raw material of their financial results (Pereira-Rodrigues and Santos-Rodrigues, 2017). For biotech companies, the implication of intellectual capital to research, development and innovation is indubitable the conclusive factor of their financial performance.

The biotechnology progress and of the biotech companies' emergence is related to the discovery and development of medicines. This scientific finding represented a discontinuity for the existing pharmaceutical firms, while providing a unique opportunity for the biotech companies start-up (Hess and Rothaermel, 2012). Nowadays, the pharmaceutical industry (medical and healthcare) holds a leading position in the global biotech market, biopharmaceuticals generated by modern molecular biology leading to significant increases of this industry (Sabourin, 2016; Lokko et al., 2018).

Considering these aspects, the present paper has as research aim the analysis of the causal relationship between the intellectual capital and the financial performance of biotech companies from the pharmaceutical industry. The paper is structured in order as follows. After a brief introduction in the field of bioeconomy and emphasizing the biotechnologies (biotech) importance, particularly in the pharmaceutical industry, as well as the

implications of human resources (through intellectual capital formation and the knowledge development) on the firms' performance, a literature review is performed. This is deployed on three major directions in interdependence with the general research objective, namely: the significance and assessment of intellectual capital; the role of intellectual capital in biotech companies from the pharmaceutical industry; and the relationship between intellectual capital and financial performance. The data (the statistical population and the dynamics of its intellectual capital), the scientific hypotheses and the research methodology are grounded on the studies' results in the field, but also on our own findings. We have proposed and tested a new instrument for intellectual capital evaluation in the context of the activity of biotech pharmaceutical companies', namely "the research and development efficiency (EDC)", along with other well-known indicators of intellectual capital assessment (such as Market to-book value, MTB). These are the subject of the second section of our paper. The results and discussion are presented in the last part of the paper, accomplished by concluding remarks.

1. Review of the scientific literature

On the transition framework to an economy based on renewable biological resources, the Intellectual Capital (IC) has the leading role in the process of generating value, maintaining competitiveness and increasing companies' performance. A number of studies highlighted the raising of intellectual capital and intangible assets significance at 87% of market value for companies from developed markets (Bhasin, 2016), respectively around 47% for listed companies in development economies (Anghel, 2008). Intellectual capital was already acknowledged as groundwork for success in the knowledge-based economy, its importance surpassing that of company's physical capital. However, in the literature, there is still no unanimously accepted definition of the intellectual capital concept. Almost every researcher offers a new definition.

In their endeavour of unifying the common approach of the concept, some authors define the intellectual capital in terms of its intangible asset nature (Dženopoljac, Janoševic and Bonti, 2016; Forte et al., 2017). This approach answers to the financial-accounting perspective of the concept, and its followers consider the intellectual capital as formed by those elements of intangible assets that explain the difference between the company's market value and its market to-book value (excluding intangible assets or the purchased goodwill). Although not explicitly presented in the financial-accounting reports, the intellectual capital exists and influences the value of a company. This is recognized as the "excess" of the established market value over the company's accounting value (Sharabati, Naji Jawad and Bontis, 2010; Krstić and Bonić, 2016).

Another group of authors define the intellectual capital concept in relation to its component items, namely: human capital, structural capital, and relational capital (Ting and Lean, 2009; Amin and Aslam, 2017; Pereira-Rodrigues and Santos-Rodrigues, 2017). According to them, the intellectual capital represents the whole knowledge, abilities and experience of the human resource, and exploited by the company in accordance with its internal and external organizational structure. Human capital is considered to be the most important component of the intellectual capital however its endowment to influence the company's performance also definitely depends on the firm's support infrastructure. It is not enough to

have a higher qualified human resource in the firm, and the optimal way of using its knowledge and the innovative spirit in order to create value is to be found.

Most authors agree that "intellectual capital is a form of knowledge which creates competitive advantage and displays the intangible value of a company" (Chizari et al., 2016, p. 292). The World Intellectual Capital/Assets Initiative (2016, p. 12) considers the intellectual capital as "the internal (competencies, skills, leadership, procedures, know-how etc.) and external (image, brands, alliances, customer satisfaction, etc.) stock of dynamically interrelated intangibles available to an organization, which allows the latter to transform a set of tangible, financial and human resources into a system capable of pursuing sustainable value creation". The intellectual capital represents the determinant of the companies' performance, which uses intensive knowledge, and, in the current global competition, knowledge is the fundamental element of success. Even though there isn't a single unanimously accepted concept definition, once its importance has been acknowledged, many methods have been developed to evaluate it.

Thus, the literature states the following *methods of assessing the intellectual capital* (Amin et al., 2014, p. 437; Urbanek, 2016) as relevant: Market to-book ratio (MTB); Tobin's Q ratio; Calculated intangible value; Balanced scorecard; Skandia IC Navigator; Intellectual capital services' IC-index; Economic value added, market value added; Value Added Intellectual Coefficient. Researchers, also, haven't consent to a single, best method, of assessing the intellectual capital (Goebel, 2015; Dženopoljac, Janoševic and Bontis, 2016), still they consider that a good proxy for the intellectual capital value is "the Market to-book ratio" (Forte et al., 2017).

The role of intellectual capital in maintaining a company's competitiveness is, in particular, the most highlighted in companies that are strongly oriented towards the research and development of innovative, environmentally friendly products.

The pharmaceutical industry holds such an intensive research capacity, in which the intellectual capital plays the central role (Mehralian et al., 2012; Amin et al., 2014). The innovative character of this industry is also reflected in the fact that many companies in the pharmaceutical industry have become biotech companies, assuming the development of new biopharmaceuticals. In fact, the development of the whole biotech industry is mainly due to applications in the pharmaceutical and medical industry, which have facilitated the development of health and diagnosis services, biopharmaceuticals and related products (Lokko et al., 2018).

In the complexity of biotech industries, increasing of the financial performance depends increasingly on the quality of intellectual capital and its innovative capacity. In this type of companies, the intellectual capital represents one of the main production factors, and the understanding of the causal link between the two categories of indicators (financial performance and intellectual capital) is the basis for optimal managerial decisions.

The financial performance can also be quantified by many indicators, but in the context of analyzing its link with the intellectual capital, the most commonly used indicators are: Return on Assets (ROA) (Amin et al., 2014; Urbanek, 2016; Amin and Aslam, 2017); Return on Equity (ROE) (Amin et al., 2014; Urbanek, 2016; Amin and Aslam, 2017; Forte, 2017); Earnings Per Share (EPS) (Amin et al., 2014; Amin and Aslam, 2017); economic profit (Urbanek, 2016). **In our research, we have approached the financial performance through the following indicators:** Return on Asset Rate (ROA), determined as the ratio

between the net profit and the total asset; Return on Equity (ROE), determined as the ratio between net profit and total equity; Debt to Equity (DE), determined as a ratio between total debt and equity.

The link between intellectual capital and financial performance of companies has been analyzed and debated in numerous scientific papers, gaining valuable knowledge of the concepts and the practical interaction between them. Researchers at the level of various industries, both in developed and developing economies, concluded (for the most of them) that *the financial performance is positively influenced by intellectual capital*.

Forte et al. (2017) proved that, at the level of 140 Italian companies listed on the Milan Stock Exchange, the intellectual capital (measured by MTB) is positively correlated with the intangible assets, ROA, leverage effect, industry type and ownership of the companies. Measuring the intellectual capital through MTB has been used in recent years in various studies (Goebel, 2015; Tseng et al., 2015). Applying the Value Added Intellectual Capital (VAIC), as the intellectual capital measure, Amin et al. (2014) analyzed its relation with the financial performance of pharmaceutical companies in Pakistan. The results indicated a significant positive impact of VAIC on ROA, ROE and EPS. A significant impact of intellectual capital (VAIC) on performance (accounting value of assets and Tobin's Q rate) was also obtained by Chizari et al. (2016) for pharmaceutical companies listed on the Tehran Stock Exchange. Other studies, too, upon the pharmaceutical companies have demonstrated the positive impact of the intellectual capital on their financial performance (Sharabati et al., 2010; Mehralian et al., 2012).

By adding the R&D expenses as innovation statement, Amin and Aslam (2017) analyzed the relation between the intellectual capital, innovation and financial performance of companies listed on the London Stock Exchange. The results indicated a positive impact of VAIC on R&D, ROA, ROE and EPS. The positive relationship between the intellectual capital and financial performance was also proved at the level of the companies listed on the Warsaw Stock Exchange (Urbanek, 2016).

2. Data applied and research methodology

2.1. Statistical population (database)

The high dependency of biotech companies on intellectual capital, as source of their innovation, turns them into *real subjects of the analysis of how intellectual capital influences financial performance indicators*.

Over the past decade, the number of biotech companies has steadily grown up at worldwide level, with pharmaceutical industry topping the list. The key regions for the biotech drugs development are the United States of America (USA), the European Union (EU) and Japan (Niosi, 2017). In spite of the boom in this sector, the collection of data that characterizes the activity of these companies has raising real problems for researchers.

According to the available data in the Thomson Reuters database (accessed on 28.02.2018), 24 biotech companies and 90 non-biotech companies were comprised in the pharmaceutical industry (3430 "Ethical Drug Manufacturers" sector). We selected on the total 1482 observations regarding various result indicators from all 114 companies. The information obtained for each company covers only the 2002-2014 time span. Of the 1482 observations,

only those related to biotech companies (311 observations) were selected, companies which correspond to the scientific objective of the paper. We mention that all the 24 companies that compose the statistical population are in the "Top 100 Biotechnology Companies" (considering the turnover for 2014) (PharmaLive, 2015).

The territorial distribution of the 24 companies is focused on the North America, Western and Northern Europe and Australia (figure no. 1).
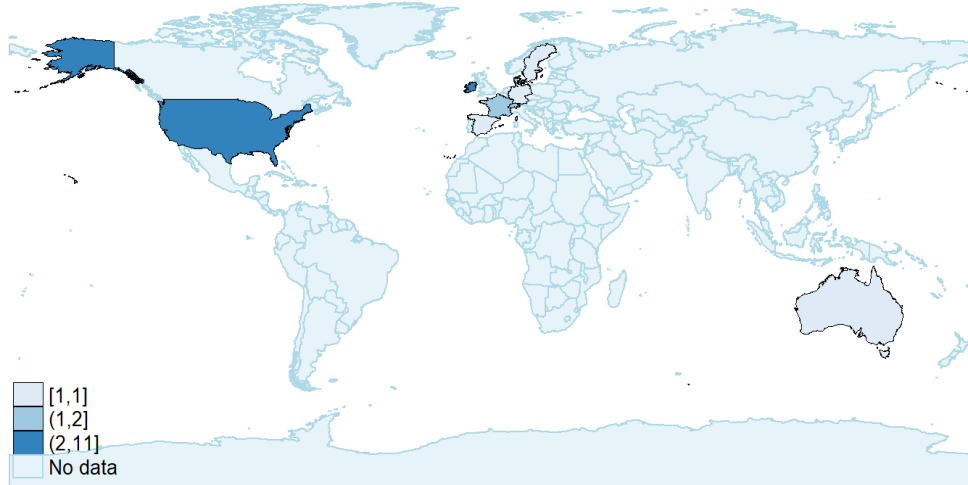
Figure no. 1: Territorial distribution of pharmaceutical biotech companies worldwide
Source: Authors' processing based on centralized data from the Thomson Reuters database

As we can see in figure no. 1, the 24 analysed companies are only from 9 countries, namely: United States of America (USA) (11 companies), Australia (AUS) (1), Denmark (DNK) (2), Switzerland (SWZ) (2), Ireland (IRL) (3), Germany (DEU) (1), France (FRA) (2) and Sweden (SWE) (1). We note that there are 12 companies in the EU and the European Economic Area (EEA).

2.2. Methods of quantification for the intellectual capital. Dynamics of intellectual capital within the investigated biotech companies

Given the premise of that the intellectual capital is the "hidden value" of a business, we consider that the difference between the company's "visible" value, that offered by accountancy, and its "real" value, assigned by the market investors, represents the nearest one to the core of the intellectual capital, as shown in equation (1). Therefore, the "market to-book ratio" (used with the acronym MTB) is preferred to appreciate the value of the intellectual capital.

$$MTB = VP - VC, \tag{1}$$

where:

    MTB – market to-book ratio;
    VP   – market value;
    VC   – accounting value.

The Market to-book ratio methodology (MTB) is "well-established in the literature and, although broad, readily identifies those organizations doing a better job with their knowledge assets" (Bramhandkar, Erickson and Applebee, 2007, p. 359).

Expressed by market to-book ratio (MTB), the intellectual capital registered a fluctuating evolution in the 24 biotech pharmaceutical companies over the entire analyzed period, 2002-2014 (figure no. 2). However, there is a much stronger oscillation in the period 2002-2008. Disparities between companies are also more pronounced over this time frame. In the second part of the analyzed period, 2008-2014, MTB values recorded much lower oscillations, both in time and between companies (figure no. 2)
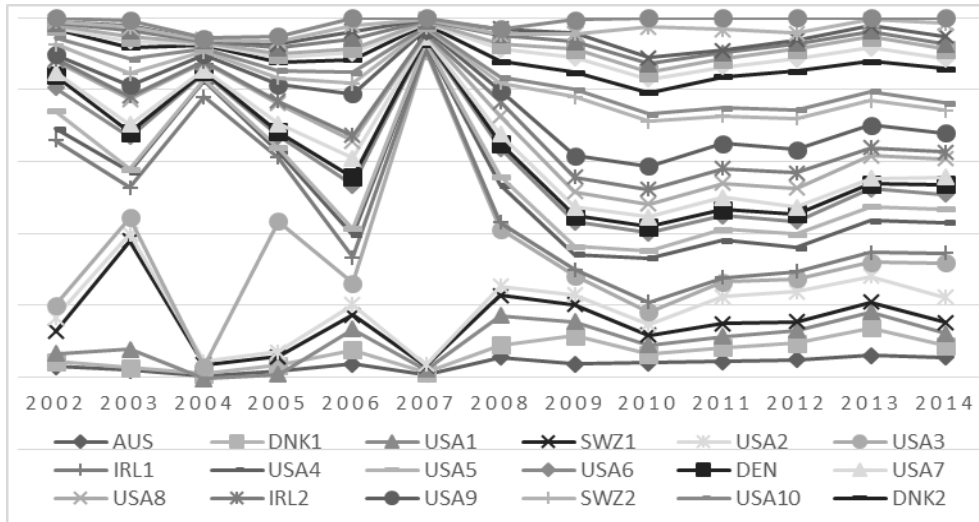
**Figure no. 2: Dynamics of the intellectual capital appreciated through MTB
at the level of biotech pharmaceutical companies, 2002-2014**
Source: Authors' processing based on centralized data from the Thomson Reuters database

On the framework of the general aim of this research, namely to analyse the intellectual capital's impact upon the biotech companies' performance, a new approach of quantitative instruments for intellectual capital is required. They have to take into account and integrate elements that characterize the innovative character of the companies' activity, their dependence on the highly qualified human resource, the research and development and the technological evolution. The very high innovative degree of biotech companies is determined by constant combinations of new accumulations of knowledge and new technologies (Moreira, Torkomian and Soares, 2016). This makes skills, capacity and research-development infrastructure (R&D), innovation to be primary in determining the performance of this type of companies.

Taking into account all of these aspects, we consider as a good candidate for assessing the intellectual capital value for biotech companies, **the R&D expenditure efficiency** (ECD), as shown in equation (2). In determining of ECD, we recommend the introducing a 1-2 year gap between revenue and expenditure items, depending on the complexity of research and development projects.

$$ECD = V/CD, \tag{2}$$

where:

ECD – the R&D expenditure efficiency;
V   – sales income;
CD   – R&D expenditure.

In the literature, R&D expenses are mainly used as an instrument of innovation and analyzed from this perspective (Madsen and Wu, 2016; Moreira et al., 2016; Schuhmacher Gassmann and Hinder,, 2016; Amin and Aslam, 2017). The quality of R&D influences the accounting and market performance of companies (Huang et al., 2018). In the case of intensive knowledge-based pharmaceutical companies, the process of knowledge creating and integrating, innovation risk management of the new products and selling them becomes indissoluble, acting as a whole. The efficiency of R&D can be regarded as an efficiency of the entire intellectual capital.

Considered through the efficiency of R&D expenses (ECD), the intellectual capital had a less oscillating trend over the analyzed period (figure no. 3). However, there is a major downward trend in the period 2006-2012, followed by an upward trend.
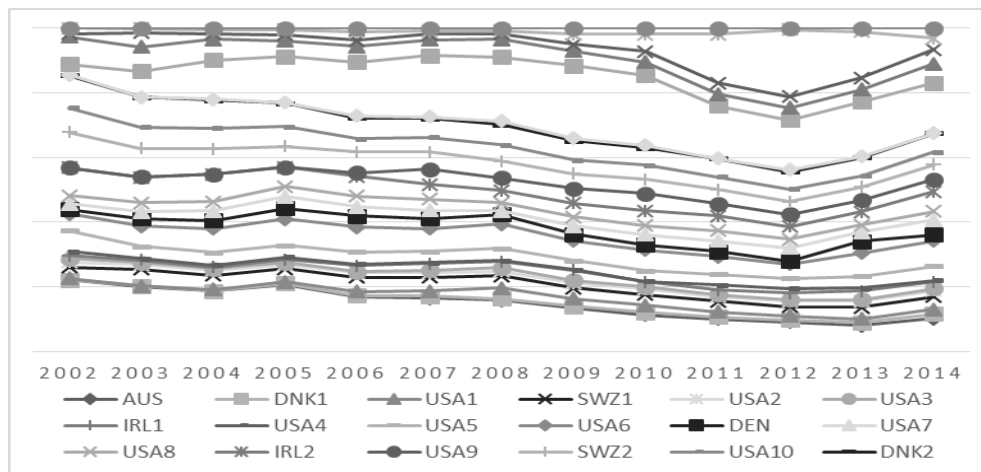
**Figure no. 3: Dynamics of the intellectual capital appreciated through ECD
at the level of biotech pharmaceutical companies, 2002-2014**
Source: Authors' processing based on centralized data from the Thomson Reuters database

Viewed in antithesis, the values of the two indicators show slightly different patterns of the intellectual capital at the level of analysed companies (figures no. 2 and 3). MTB dynamics highlights oscillations in the first part of the analyzed period (2002-2008), while EDC values tend to vary in the second part of the range.

The approaching method of the intellectual capital is very significant in understanding the financial performance (Amin et al., 2014) and, implicitly, of its optimization procedures. For the biotech companies, this significance is even more relevant, as almost their entire activity depends on the intellectual capital. As such, taking into account these companies specifics, the intellectual capital is appreciated and analyzed in our paper in its relationship of interdependence with the financial performance, through two indicators, namely: MTB (from the scientific literature), and ECD (indicator proposed by the authors). For the

analysis of causal dependence, the financial performance is expressed by classical indicators, already described in the literature review, ROA, ROE and DE.

2.3. Methodology of econometric research

Based on literature review results on the relation between the intellectual capital and the financial performance (predominantly positive), and the general objective outlined in the introduction section of the paper, we have drawn the following two sets of main hypotheses (H):

- H_1. There is a positive relationship between MTB and financial performance, measured by ROA, ROE and DE;

- H_2. There is a positive relationship between ECD and financial performance, measured by ROA, ROE and DE.

Each of the main scientific hypotheses, H_1 and H_2, will be analyzed as a set composed of three secondary hypotheses, corresponding to the pairs comprising the intellectual capital indicator and each of the three indicators of financial performance measurement.

The dependence between the intellectual capital and financial performance of biotech pharmaceutical companies is firstly analyzed through ***the correlation method and the linear regression*** (Mehralian et al., 2012; Urbanek, 2016; Forte et al., 2017), performed on the robust regression method configuration that allows for endogeneity control inherent in standard regression models, thus ensuring a high level of accuracy for the estimated coefficients. Thus, based on this method, before the actual estimation, the Cook's D distance is being determined in order to remove the differences within the panel, while two types of iterations are further applied, namely, Huber and Biweight. The resulting coefficients of these procedures have a high level of robustness and significance.

For testing the scientific hypotheses, it is used the model from equation (3).

$$Y_{i,t} = a_{i,t} + b_{i,t}X + c_{i,t}Z + \varepsilon_{i,t}, \tag{3}$$

where:

$Y_{i,t}$ – the vector of dependent variables (ROA, model 1; ROE, model 2; DE, model 3);
$X_{i,t}$ – the vector of independent variables (MTB, panel 1; ECD, panel 2);
$Z_{i,t}$ – the vector of control variables (company's size, natural logarithm of total sales, *LnV*; General solvency ratio, *SG,* as ratio between Total Debt and Total Asset);
$\varepsilon_{i,t}$ – random errors.

Deepen of the research methodology, we also applied *the structural equations modelling (SEM)* to include and highlight the interdependencies (direct, indirect, and total) among the determinants of the intellectual capital (measured by MTB and ECD), and their consequences upon the financial performance of biotech firms in the pharmaceutical field. SEM is an advanced multivariate analysis technique used to design, test, and estimate the causal relationships among selected variables. The general representation of SEM models is shown in the equation system (4).

$$
\begin{cases}
b_{11}y_{2t} + \ldots + b_{1m}y_{mt} + c_{11}x_{1t} + \ldots + c_{1n}x_{nt} = \varepsilon_{1t} \\
b_{21}y_{2t} + \ldots + b_{2m}y_{mt} + c_{21}x_{1t} + \ldots + c_{2n}x_{nt} = \varepsilon_{2t} \\
\ldots\ldots\ldots \\
b_{m1}y_{1t} + \ldots + b_{mm}y_{mt} + c_{m1}x_{nt} + \ldots + c_{mn}x_{nt} = \varepsilon_{mt}
\end{cases} , \tag{4}
$$

where:

t – number of observed time periods;
b_{ij} – parameters of endogenous variables y_{ij};
c_{ij} – parameters of exogenous variables x_{ij};
$i=1, \ldots , m; j=1, \ldots, n$.

The structural form of the SEM model represents the structure of the analyzed economic process, described in terms of components and links. The SEM model provides an integrated analysis frame of reference from a dual perspective, respectively the impact-determinant interactions.

3. Results and discussions

Table no. 1 centralizes the summary statistics results (mean, standard deviation – DS) and the correlation matrix for the analysed variables. Within the panel formed by 24 pharmaceutical biotech companies, ROA has a mean of 0.09196 and a standard deviation of 21.9717, while the mean value of the return on equity (ROE) has a negative sign (-6.754, DS being of 69.3628). MTB mean is 9.1373 and highlights that the market value of these companies significantly outruns their accounting value. In other word, the average company out of the entire population has an intellectual capital value of 8.1373 monetary units for each one monetary unit of net asset. The second indicator developed to appreciate the value of the intellectual capital, ECD, registered a mean value of 5.0608.

Table no. 1: Descriptive statistics and the correlation matrix

	Mean	Standard deviation	ROA	ROE	DE	MTB	ECD	LnV	SG
ROA	.09196	21.9717	1						
ROE	-6.7541	69.3628	.763** (.000)	1					
DE	147.339	1251.15	-.149* (.014)	-.323** (.000)	1				
MTB	9.1373	60.0413	-.157* (.014)	-.368** (.000)	.834** (.000)	1			
ECD	5.0608	5.97186	.542** (.000)	.375** (.000)	-.053 (.353)	-.047 (.427)	1		
LnV	12.6667	3.42857	.633** (.000)	.0458** (.000)	-.051 (.381)	-.052 (,470)	.501** (.000)	1	
SG	22.3405	21.4960	-.146** (.001)	-.293** (.000)	.210** (.000)	.153** (.027)	-.040 (.616)	-.046 (.419)	1

*Note: significant at * p < 0.05; ** p < 0.01.*
Source: Authors' own process

The results of the ***correlation analysis*** reveal a first image on the linkages between the intellectual capital (MTB, ECD) and the financial performance (ROA, ROE, DE) of

pharmaceutical biotech companies. Pearson correlation coefficient calculated for MTB-ROA and MTB-ROE pairs of indicators shows a negative (indirect) relation between them, while MTB-DE are positively correlated and extremely significant ($p < 0.01$). For the first pair, the association is less significant ($p < 0.05$). Nevertheless, the negative inter-linkages between ROA, ROE and MTB partially invalidate H_1 and contradict the results of previous studies (Amin et al., 2014; Amin and Aslam, 2017; Forte et al., 2017). The first hypothesis H_1 remains however partially confirmed by the *positive relationship between MTB and DE.*

In the case of ECD-ROA, ECD-ROE pairs, the results of the correlation analysis point out a positive and significant interrelation ($p<0.01$), while for the ECD-DE pair, the relationship is negative, but insignificant from a statistical point of view. As we've expected, in the case of pharmaceutical companies that are knowledge intensive, the efficiency by which the research and development expenditures are processed on the entire chain (from research, design, testing, authorization-patent biotechnological innovative product and until the final sale) have a direct and proportional influence on the financial performance (ROA, ROE). These results validate our *proposal to use the ECD as a proxy for the value of intellectual capital in the case of pharmaceutical biotech companies.* H_2 is also partially confirmed.

The next step in testing the hypotheses H_1 and H_2 was to estimate multiple regression models, based on the robust regression configuration. The models were estimated in an organized manner within two panels. Panel 1 tests the dependency between MTB and the financial performance, quantified alternatively through ROA (model 1), ROE (model 2), DE (model 3) (table no. 2). Panel 2 tests the dependency between ECD and the financial performance ROA (model 1), ROE (model 2), DE (model 3) (table no. 3). The estimated coefficients for MTB (-0.0391 and -0.415) reaffirm the negative relation between ROA, ROE and the intellectual capital of pharmaceutical biotech companies (table no. 2).

**Table no. 2: Panel 1 robust regression analysis
(the intellectual capital is expressed through MTB)**

Independent variables	Dependent variable		
	Model 1 – ROA	Model 2 – ROE	Model 3 – DE
Constant	-59.12*** *(4.310)*	-115.5*** (8.227)	2.236 (1.814)
MTB	-0.0391** *(0.0132)*	-0.415*** (0.0252)	0.334*** (0.0585)
LnV	4.830*** *(0.310)*	9.158*** (0.594)	-0.421** (0.131)
SG	-0.140*** *(0.0365)*	-0.0674 (0.0809)	1.917*** (0.0161)
R^2 value	0.515	0.673	0.983

*Note: N=311; Significant at * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.*
Source: Authors' research

The intellectual capital generates a market value above the net (accounting) value of these companies, but this isn't enough to induce an increase in their immediate financial performance. On the contrary, the results of our econometric procedures show a decrease in firm profitability under the impact of MTB, opposite to what was previously shown in the specialized literature. Within the context of high risk and complexity of the emergent activity performed to develop and produce biopharmaceutical medicines (drugs), the stakeholders recognise the value of intangible assets investment, however, in the lack of

their connection with concrete results, the impact upon the financial performance is negative. MTB is positively correlated with DE, thus confirming H_1 hypothesis.

According to the results of the first regression model, ROA is positively correlated only with the firm size, proxied through sales amplitude (natural logarithm of total sales, LnV). The situation is similar for model 2, where ROE is the dependent variable. Model 3 reveals a negative interdependency between DE and the firm size (LnV), and positive connections with the other independent variables. Model 3 has the largest prediction power in terms of the prediction intensity of developed and processed models, as reflected by the R^2=0.983 (table no. 2). When the ECD is used to measure the intellectual capital, the estimated coefficients for the interlinkages with ROA (0.667) and ROE (1.057) are positive and extremely significant (table no. 3). For the connection with DE the estimated coefficient is negative (-0.298).

**Table no. 3: Panel 2 robust regression analysis
(the intellectual capital is expressed through ECD)**

Independent variables	Dependent variable		
	Model 1 – ROA	**Model 2 – ROE**	**Model 3 – DE**
Constant	-50.37*** _(4.181)_	-99.82*** _(7.903)_	-1.277 _(2.457)_
ECD	0.667*** _(0.140)_	1.057*** _(0.264)_	-0.298*** _(0.0864)_
LnV	3.929*** _(0.327)_	7.514*** _(0.620)_	-0.0235 _(0.194)_
SG	-0.145*** _(0.0344)_	-0.106 _(0.0741)_	2.154*** _(0.0214)_
R^2	0.518	0.487	0.972

_Note: N=311; Significant at * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$._
Source: Authors' research

The specific features of the extremely pronounced dependency of the biotech companies on knowledge, research-development and innovation, require the use of an indicator that integrates both the company effort (research and development expenditures), and the effects/final output (sales). _ECD is thus an adequate indicator to appreciate the intellectual capital within the biotech companies, particularly in the pharmaceutical industry._ An increase in ECD leads to an associated increase in the profitability (return) of these companies. The prediction power of the first two models isn't however so strong (R^2 = 0.518 for model 1 and R^2 = 0.487 for model 2) (table no. 3). It is possible therefore that in the case of these companies, the classical performance indicators to be less representative, being necessary an adjustment with the innovative aspects (innovative performance) of the developed activity (Moreira, Torkomian and Soares, 2016; Amin and Aslam, 2017).

As a further methodological endeavour, we've designed and applied a new _model based on structural equations (Structural Equations Modelling, SEM)_ (figure no. 4), that includes and highlights the interdependencies (direct, indirect, total) between the intellectual capital and the financial performance of biotech companies in the pharmaceutical industry (for the 2002-2014 period).

The SEM model allowed us to analyse the interdependencies between the intellectual capital (measured through MTB and ECD) and the financial performance (as revealed by ROA, ROE and DE) of pharmaceutical biotech companies from an integrated approach, on

a three-fold basis, regarding the direct, indirect and total effects captured during the estimation. The maximum likelihood method (MLE, Maximum Likelihood Estimator) is used to estimate the SEM model, while for its validation we've applied Wald tests for each equation (chi2=184.50, p=0.000), along with the goodness-of-fit tests (chi2=159.416, p=0.000), finally calculating the values for Cronbach's Alpha for each item and total scale (0.7362) (figure no. 4).
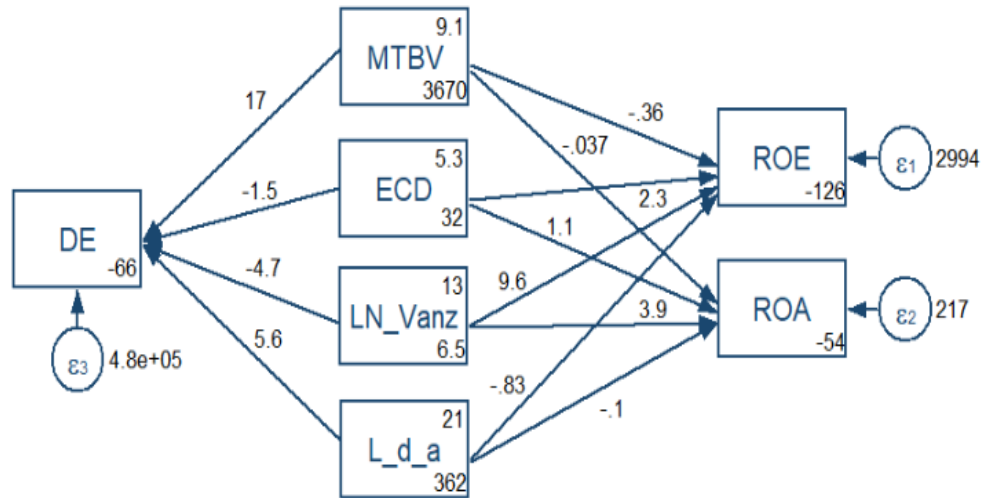
Figure no. 4: Results and configuration of the SEM model developed to analyse the inderdependencies between the intellectual capital and the financial performance of biotech companies from an integrated perspective
Source: own research

The results obtained after processing the SEM model reconfirm our previous estimations and highlight the positive effects that the intellectual capital and the research-development activity, measured through the ECD, have on the financial performance of biotech companies (especially upon ROA, the estimated coefficient being 1,1 and extremely significant from a statistical point of view at 0.1%, but also upon ROE, the estimated coefficient is 2.3 also with a high level of statistical significance), while the MTB generates a negative impact on ROA and ROE (the estimated coefficients being -0.36 and -0.037, extremely significant at the 0.1% level).

Conclusions

The intellectual capital is the catalyst of developing and spreading new techniques and technologies based on the use of renewable resources. At a global level, the sector of biotech companies presents a major growth potential with a vital relevance for humanity, even though it is in a preliminary stage. The major changes induced in the technological and management processes (strongly based on knowledge and intellectual capital) of these companies' outset new challenges for researchers in various fields (mangers, accountants, financial analysts etc.). The coordination and optimization of the financial performance accounted by these companies reveal the problem of identifying the existing causal interrelations between the performance indicators and the new performance determinants, whilst the intellectual capital is identified as such a shaping factor.

Even though it has been at the core of many studies and debates, the intellectual capital still soars within an emergent area, without a commonly recognized definition and methodology. The present paper contributes to the specialized literature through a pertinent analysis of the relationship between the intellectual capital and the financial performance of biotechnological (biotech) companies acting in the pharmaceutical industry at a global level. In addition, a new tool for measuring the intellectual capital is proposed at this type of biotech companies. The latter, efficiency of research and development expenditures (ECD), is developed in the context of specific credentials of the biotech pharmaceutical companies. The essential role played by the intellectual capital within their activities to innovate biotechnological drugs based on renewable resources, therefore necessary determines a compulsory instrument capable to reflect in a broader perspective the efficiency of the economic processes. Judging the size of research-development expenditures (CD) by reporting to total income deployed by the company, respectively the efficiency of CD is proposed as a measure of the intellectual capital of biotech pharmaceutical companies.

By using the Thomson Reuters database, there has been gathered information about the activity performed by 24 companies in the area of biotechnological drugs production, during 2002-2014. The reduced dimension, due to data unavailability, of the analyzed time series represents a limit of this research that influences the quality of the results, but not in a dominant way. The analysis of causal dependency between the financial performance (ROA, ROE and DE) and the intellectual capital (MTB and ECD) was performed based on the correlation method, robust regression and structural equations model (SEM). Pearson correlation coefficients determined for MTB-ROA and MTB_ROE pairs have highlighted a negative dependency between them, while for the MTB-DE pair, the dependency is positive. These results contradict the specialized literature regarding a positive connection between the intellectual capital and the financial performance (ROA, ROE), thus signaling that the traditional measures of performance aren't enough relevant to express the efficiency of invested capital within the biotech companies, respectively that MTB isn't sufficiently adequate to express the intellectual capital for these companies. As we've anticipated, the extremely complex and knowledge intensive activity of biotech companies requires a new instrument to measure the intellectual capital. When we've used the ECD as a proxy for the intellectual capital, the Pearson correlation coefficients have shown a positive linkage between the ECD-ROA and ECD-ROE pairs and a negative one for ECD-DE. The results obtain reconfirm our proposal, thus confirming the superior informational utility of ECD for the biotech pharmaceutical companies. The complexity of this type of companies raises questions about the informational relevance of the classical performance indicators. Thus, we are addressing as a future research direction, the challenge of developing new financial performance tools, capable of integrating the particular, highly innovative and knowledge-based aspects of biotech pharmaceutical companies.

The causal links were also confirmed by the regression models estimated through the robust regression method. The analysis was performed on two panels, the first for the indicators of financial performance (ROA, ROE, DE, alternatively, as dependent variables) and the independent variables: MTB (as an expression of the intellectual capital), the size of the firm (LnV, natural logarithm of total sales), general solvability (SG). The second panel also implied a successive use of the performance indicators as dependent variables, while the intellectual capital was appreciated through the ECD, as independent variable, along with LnV and SG (stated as independent variables of control). The estimated coefficients for MTB (-0.0391 in relation with ROA and -0.415 in relation with ROE) confirm the negative

linkage between these variables, while the positive coefficients estimated for ECD (0.667 in relation with ROA and 1.057 in relation with ROE) reconfirm and support the conclusion that ECD is a much better instrument to measure the intellectual capital for the biotechnological pharmaceutical companies. The results obtained after processing the SEM model lead to the same conclusion.

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