STOWARZYSZENIE EKONOMISTÓW ROLNICTWA I AGROBIZNESU
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R&D EXPENDITURES AND MARKET VALUE OF BIOTECHNOLOGY FIRMS

WYDATKI NA PRACE BADAWCZO-ROZWOJOWE A WARTOŚĆ RYNKOWA FIRM BIOTECHNOLOGICZNYCH

Key words: R&D, biotechnology, market value, innovation

Słowa kluczowe: prace badawczo-rozwojowe, biotechnologia, wartość rynkowa, innowacje

Abstract. The aim of this paper is to conduct an analysis of R&D investments and their impact on a biotechnology firm's value. The sample consists of the top 52 R&D investors from the European biotechnology sector. The data were obtained from "EU Industrial R&D Investment Scoreboard". The multiple linear regression was applied to find the answer to the research question. The main findings of the study reveal that there is a positive relationship between the firm's investment in R&D and the market value.

Introduction

A biotechnology sector is regarded as a testament to the value of scientific research. Hine and Kapeleris [2006] portray the biotechnology sector as one that needs extensive skill sets and technological knowledge. Biotechnology is generally defined as the application of science and technology to living organisms, as well as parts, products and models therefore, to alter living or non-living materials for the production of knowledge, goods and services [OECD 2009]. According to the above definition, the application of biotechnology encompasses both traditional application (e.g. fermentation) and modern application (e.g. genetic modification).

Modern biotechnology sector can be broadly classified into the following three sub-sectors: the red – biomedical and human health, green – agricultural and white - industrial biotechnology which differ considerably in R&D activities and performance. In the first sector, biotechnology firms, including both large diversified firms – LDFs and dedicated biotechnology firms - DBFs, search for new knowledge and applications and sell/transfer their intellectual property to pharmaceuticals companies. The value chain in red biotechnology is mostly based on networks of relationships in product development between LDFs, DBFs and public research institutes. In case of the second sector, biotechnology firms develop new varieties of animals and plants, diagnostic tools and animals therapeutics. As suggested by Blank [2008], the life of an agricultural biotech product or technology is relatively short, since a patent owned by another company can block the development of a product, or the creation of new intellectual property which replaces the original technology. Finally, biotechnology can be used in industrial production in the wide scope, i.e. from the application of enzymes in food manufacturing to the production of chemicals and bio-plastics [OECD 2009].

When comparing R&D expenditures of dedicated biotech firms, the red biotechnology is far ahead of the other two sectors [Enzing 2011]. It is worth noting that much biotech research conducted in DBFs is basic research which is expensive and fraught with uncertainty. In the context of biotechnology, the challenges of high risk and uncertainty cause that financial returns from biotechnology vary dramatically across firms and by investment stage [Pisano 2006]. For these reasons, the value-relevance of R&D in a specific context such as the biotechnology industry is still a matter of some debate [Xu et al. 2007]. On the one hand, Al-Laham et al. [2011] suggest that a biotechnology firm operates in knowledge – intensive, dynamic settings in which R&D expenditures and patents indicate innovative success, on the other hand the biotechnology firm often has little or no revenues and consequently generates losses in the short run due to the expensing of R&D. For example, Intercell ranked 4th among EU biotech companies, invested in 2010 more than twice the value of its net sales in R&D.

As shown by Hand [2004], the elasticity of biotech firms' equity market values with respect to R&D is significantly larger the earlier is the R&D expenditure in the value chain, and the greater is the growth rate in R&D spending. However, the relationship between R&D and the firm's market value may be more complex. According to the S – curve theory [Foster 1986], this relationship may be portrayed by the U-shaped curve which implies that a threshold level of investments in R&D must be reached in order to contribute to a firm's market value. In other words, if the firm invests enough to reduce the scientific risk, it may convince investors that the potential rewards outweigh the risks.

Based on the considerations in this section with regard to the impact of R&D on the firm's financial performance – market valuation, the purpose of the paper is to find an answer for the following research question: What is the relationship between R&D expenditures and the biotech firm's market value?

Material and methods

The study uses a dataset covering data on R&D and financial performance of the top 52 R&D investors from biotechnology sector whose registered offices are in the EU. According to the sectoral classification as defined by the Financial Times Stock Exchange Index (ICB classification), the firms belong to a subsector: 4573 Biotechnology consisting of companies engaged in research into and development of biological substances for the purposes of drug discovery and diagnostic development, and which derive the majority of their revenue from either the sale or licensing of these drugs and diagnostic tools. The focus on the red biotechnology subsector allows us to analyse the firms which from relatively homogenous group (with inherent diversity) and share a common economic context and value drivers. In the line with Shevlin's [1996] arguments, this approach has the advantage over cross-sectoral studies.

The R&D figures along with financial data (in million €) were derived from the 2011 "EU Industrial R&D Investment Scoreboard", which had been issued by the European Commission. The following variables were included in the study:

1. Market capitalization (*MV*): the share price multiplied by the number of shares issued at a given date.
2. Research and Development investments (*RD*): cash investment in original and planned investigation undertaken with the prospect of gaining new scientific or technical knowledge and understanding and the application of research findings or other knowledge to a plan or design for the production of new or substantially improved materials, devices, products, processes, systems or services before the start of commercial production or use.
3. Capital expenditures (*CE*): the expenditure used by a company to acquire or upgrade physical assets such as equipment, property, industrial buildings.
4. Number of employees (*L*): the average number of employees.

To find the answer for the research question, we applied the market value function which assumes that a firm's value is shaped by investments in tangible and intangible assets [Griliches 1981, Hall 2000, Kijek 2014]. Under efficient-market hypothesis [Fama 1991], the pool of assets at the firm's disposal, is priced by the financial markets on the level of the present discounted value of the future cash flows generated by those assets. In this approach the market value function takes the following form:

$$MV_i = CE_i + RD_i + (RD_i)^2 + \ln(L_i) + \varepsilon_i\,,\ i = 1...52$$

In the above model, the variables that affect the firm's market value are presented as flows, since – due to data availability – we assumed that the R&D investments and the capital expenditures in a given year were proportional to their stocks. To address an issue of the non-linear relationship between R&D and market value, we incorporated the squared term of *RD* into the proposed model. Since the model contained *RD* and $(RD)^2$, there might be concerns relating to multicollinearity. In response to this problem, we mean-centered the variables for R&D and its squared term as suggested by Aiken and West [1991]. Moreover, a control variable, i.e. a logarithm of the number of employees, was introduced to the model in order to mitigate the coefficient bias. As asserted by Barth and Kallapur [1996] including a scale proxy as an independent variable is more effective than a deflation of the regression equation.

Results of research

Table 1 shows descriptive statistics of the variables included in the model. The first conclusion to be drawn from the data presented is that the sample biotechnology firms invests more in intangible capital than in physical assets. However, it is important to note that R&D investments by biotechnology companies grew by 6.2 % in 2010, slightly more than in 2009. The average firm of our sample is a large-sized firm with a market capitalization about 377 million €. It is likely to be diversified firm which perform R&D and is also endowed with manufacturing capabilities. As expected, the correlation between R&D and its squared term is high enough to indicate a multicollinearity problem, which confirms the necessity for variables standardization.

Table 1. Descriptive statistics and correlation matrix for the variables
Tabela 1. Statystyki opisowe oraz macierz korelacji dla zmiennych

Variable/ *Zmienna*	Min/ *Minimum*	Max/ *Maksimum*	Mean/ *Średnia*	Standard Deviation/ *Odchylenie standardowe*	1.	2.	3	4.	5.
MV	11.18	6447.90	377.04	967.28	1	0.92	0.84	0.94	0.92
CE	0.007	179.82	7.55	27.81		1	0.77	0.88	0.95
RD	4.53	156.07	22.47	26.26			1	0.93	0.81
$(RD)^2$	20.56	24358.00	1181.50	3627.10				1	0.88
L	16.00	5357.00	361.46	906.41					1

Notes: *RD* and *CE* variables are expressed in million €, critical value of Pearson's correlation coefficient (for two-tailed test at a 5% level) = 0,27/*Uwagi: Zmienne RD i CE są przedstawione w milionach Euro, wartość krytyczna współczynnika korelacji Pearsona (przy dwustronnym 5% obszarze krytycznym)= 0,27*
Source: own study
Źródło: opracowanie własne

Table 2 presents the empirical results of the market valuation model. The parameters of the model were estimated using the ordinary least squares (OLS) method with robust standard errors that correct for heteroskedasticity. In order to identify a set of explanatory variables which have considerable predictive capability, the backward elimination procedure was employed. This increases the precision of

Table 2. Parameters estimates for the market valuation model
Tabela 2. Oszacowania parametrów modelu wyceny wartości rynkowej

Variable/ *Zmienna*	Coefficient/ *Współczynnik*	Standard error/*Błąd standardowy*	t-Student/ *t-Studenta*	P-value/ *Wartość p*	*VIF*
CONST	x	-	-	-	-
CE	24.70	5.72	4.32	0.00	2.48
RD	9.73	3.45	2.82	0.00	2.48
$(RD)^2$	x	-	-	-	-
Ln(*L*)	x	-	-	-	-
R^2	0.90				
$F(2,50)$	81.86 ($p = 0.00$)				

Note: x – eliminated variable/*Uwaga: x – zmienna wyeliminowana*
Source: own study
Źródło: opracowanie własne

estimation at the expense of omitted-variables bias. Moreover, the variance inflation factor (VIF) for each variable was estimated in assessing multicollinearity. The rule of thumb describes that VIF<10 is considered to be acceptable in determining low multicollinearity.

As was expected, the R&D stock has a positive and significant impact on the firm's market value in the sample firms. Similar results were obtained by Callen et al. [2010] who proved that there was a positive and significant relationship between R&D expenditures and stock prices using the sample of 282 US red biotechnology companies. It should be noted that the squared term of the R&D stock turns out to be insignificant. This finding suggests that the biotechnology firms do not face problems with R&D over-spending or R&D under-spending. The results also reveal that capital expenditures regarded as equivalent to technical change embodied in new machinery and capital equipment exert an important effect on the market value, even larger than that of R&D spending. It is consistent with findings by Piergiovanni and Santarelli [2013]. They demonstrated that R&D and capital expenditures were complementary forces and determinants in the overall innovation process. According to their results biotechnology firms invested in physical capital in one period to conduct R&D in the subsequent ones.

Conclusions

This paper produces a few important contributions for the theory and practice on the market valuation of R&D investments. First of all, it focuses solely on the biotechnology companies. The peculiarities of biotechnology make a debate on the value relevance of R&D in this sector still open. To our knowledge this study is one of the few studies focusing on European biotechnology firms which analyze the market value of R&D. Moreover, the paper goes beyond most of prior studies, which assume the linear relationship between the market value and R&D and tests possible nonlinearity in this relationship.

The research results show that R&D expenditures and capital expenditures have the linear and positive relationships with the market value. It is worth noting that R&D has weaker impact on the market value than investments in physical assets. These findings suggest that the biotechnology firms should devote to the creation of market value on the basis of embodied (new machinery and equipment) and disembodied (R&D) technical change, rather than simply focusing on R&D. As such innovation policy should pay more attention to supporting the firms' investments in new machinery and equipment, since these investments allows firms to start production in the short run and enhance research productivity in the long run.

The paper is not exempt from some limitations. The main drawback pertains to the limited sample size. It is mainly a result of missing data on R&D expenditures in the case of European firms which are not required to report these expenditures [Hall et al. 2007]. Another shortcoming of the paper concerns the lack of substitution/complementarity analysis of market value drivers. In order to overcome these limitations future research should be based on a larger sample including green and white biotechnology and explore the simultaneous impact of R&D and capital expenditure on market performance.

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Streszczenie

Celem opracowania było określenie wpływu inwestycji w działalność badawczo-rozwojową (B+R) na wartość rynkową firm biotechnologicznych. Próba badawcza składała się z 52 firm biotechnologicznych będących największymi inwestorami w działalność B+R. Dane wykorzystane w opracowaniu pochodzą z Europejskiego Rankingu Inwestorów w B+R. W badaniu wykorzystano model regresji wielorakiej. Uzyskane wyniki wskazują, że inwestycje w B+R mają pozytywny wpływ na wartość rynkową badanych przedsiębiorstw.

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