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THE IMPACT OF INNOVATION ON THE PROFITABILITY OF SLOVAK PHARMACEUTICAL COMPANIES

Abstract. *In conditions of the knowledge economy and innovations, research and development activities are among the most important factors affecting companies' financial performance. This study aims to investigate the impact of research and development activities on the profitability of Slovak pharmaceutical companies. The panel dataset consists of 37 sample pharmaceutical companies for 2015-2019. Panel data regression analysis was used as the main research method of the study. Profitability was measured with the return on assets indicator, chosen as the dependent variable. The independent variables are leverage, research and development intensity, research and development intensity squared, size, and high-tech dummy. The empirical analysis includes descriptive statistics, normality test, autocorrelation test, and panel regression models (random effect model) followed by F-statistics test, Hausman test, and Breusch-Pagan test. The hypothesis that there is a significant positive impact of research and development activities on the profitability of knowledge-intensive enterprises has been partly confirmed. Only the research and development intensity squared has a significant positive impact on the profitability of Slovak pharmaceutical companies at a 1% level. On the contrary, the research and development intensity has a significant negative relation. According to the analysis results, control variables (leverage, size, and high-tech dummy) have no significant influence on profitability. The existence of an inverted-U relationship between research and development activities and the profitability of Slovak pharmaceutical companies has been established. Investing in innovations of Slovak pharmaceutical companies has a positive effect on profitability only from a certain amount and has an upper limit on the amount of profitable investment. Thus, to formulate recommendations on the adjustment of investment*

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policy in research and development activities, it is necessary to conduct future research to determine the entry points and exit points from the area of best profitability on inverted-U function.

Keywords: financial performance, pharmaceutical companies, profitability, research and development.

Introduction. Based on IAS/IFRS, in which the principles of accounting of research and development (R&D) costs and internally generated intangible assets are defined, the financial statements do not always accurately reflect R&D activities. There is also quite conservative current accounting practice of capitalization of R&D costs as intangible assets of the enterprise (Monahan, 2005). This contributes to information asymmetry and does not ensure the efficient distribution of capital between sectors of the economy. Therefore, to determine the role of R&D in the enterprise and establish their efficiency, it is necessary to conduct additional empirical research, which would take into account the industry specifics and regional context. It will improve the information support of stakeholders, acting as an additional prerequisite for improving financial performance and long-term investment in R&D activities. R&D intensity (RDI) is one of the most common variables used by many researchers to represent the innovation level of R&D activities of the company (Natasha and Yanthi, 2009; Nord, 2011; Fortune and Shelton, 2012; Ayaydin and Karaaslan, 2014; Lome, Heggeseth and Moen, 2016; Erdogan and Yamaltdinova, 2019; Eldawayaty, 2020; Ozkan, 2022). The research is based on enterprises from Slovak pharmaceutical sector data for 2015-2019. The government of the Slovak Republic widely supports the development of the national pharmaceutical industry, stimulating and expanding the collaboration between academics, scientific institutions, and pharmaceutical companies, creating a favourable climate for investors. It enables a swift knowledge transfer from the academic environment to the pharmaceutical business.

According to representatives of governmental bodies, Slovak Republic should be a preferred location for the pharmaceutical business. In particular, biomedicine and biotechnology, including pharmacological and industrial biotechnologies, are one of the three priorities of the R&D strategy of the Slovak Republic. For additional stimulation of potential investors to the pharmaceutical sector in the Slovak Republic, a special program of investment incentives is implemented that motivates investors to place their new projects in regions with higher unemployment and to attract projects with higher added value (Pharmaceutica, 2022). One of the types of eligible costs of pharmaceutical companies, for which different forms of investment incentives can be applied, is the creation of long-term intangible assets. Thus, for Slovak pharmaceutical companies, the study of the impact of R&D on its profitability is especially relevant both due to the general trend of investment and the presence of additional mechanisms of investment incentives for the pharmaceutical sector in Slovakia.

This article is organized as follows. Section 1 reviews prior related literature. The second section presents the data and methodology of conducted research. Section 3 provides the results. Section 4 discusses the findings. The last section draws conclusions.

Literature Review. Profitability is the ability of an enterprise to make a profit compared with other characteristics of the enterprise (assets used, employees involved, equity involved, etc.). It is the subject of research by many scientists from the standpoint of analysing the impact of various factors. One such factor is the enterprise R&D activities, which are reflected in the enterprise's financial statements in the form of R&D costs or capitalized internally generated intangible assets.

One of the first to draw attention to the need for research returns of R&D was Griliches, who built the theoretical foundation of the economics of technological innovation. Such foundations allowed to consider R&D from the standpoint of the enterprise not only as costs but as capital (Griliches, 1979), which could be measured by calculating the average return on it, and which role could be established in ensuring the profitability of the enterprise depending on the industry where it operates. Developed by Griliches foundations also allowed scientists to further consider R&D as one of the factors influencing the

enterprise's profitability, considering the adjustment of firm behavior and economic growth strategy. In particular, the main focus of scientists was to determine what exactly is such an impact (positive or negative, weak or strong), as well as what types (basic or applied) and types of R&D (public or private) provide such influence.

Based on Griliches's research, Del Monte and Papagni (2003) analyzed the effect of R&D intensity on the growth of firms using panel data of 500 Italian manufacturing firms. The authors used descriptive analysis and a panel unit root test to establish that the growth indicators of firms with R&D are higher than that of firms without R&D. At the same time, the authors found no significant relationship between R&D intensity and the rate of profits because a certain part of R&D-intensive firms mimics the process of creating innovations. Natasha and Yanthi (2009) examined the relationship between R&D with operating profit margin and market performance using data about 32 non-finance firms listed on Indonesia Stock Exchange for 2004-2007. Using a multiple regression model, they found no relationship between R&D and the Indonesian firm's operating performance. They justified these results by saying that the R&D activities impact the firm's long-run performance, as R&D investments have a long-term impact on companies 'performance due to the time lag from R&D investment to growth.

Ayaydin and Karaaslan (2014) analyzed the influence of R&D investment on the financial performance of 145 manufacturing firms registered Istanbul Stock Market for the 2008–2013 period. They used an R&D intensity as a criterion for classification of enterprises into 3 types (high-, medium- and low-technology) together with other factors (capital structure, liquidity, efficiency, and firm size) to establish their impact on Return on Assets (ROA). They evidenced a positive effect of R&D intensity on the firm performance, especially for high-technology sectors, which is evidence of their high role in a company's competitive advantage. Varahrami (2015) examined the effects of R&D costs on the ROA of producers of 14 oil productions on the Tehran stock exchange using panel data from 2004 to 2014. The scholar used the fixed-effects model. The findings showed that R&D cost positively and significantly affects oil firms.

Lome et al. (2016) empirically analyzed the effect of a high R&D intensity on performance during a financial crisis. They tested the activity of 247 Norwegian manufacturing companies for the 2004-2009 periods using binary logistic regression. The scholars found that firms with higher R&D investments had higher efficiency (annual growth rate and aggregate growth) than other firms. The authors' conclusion confirms that companies engaged in R&D handle a financial crisis better than those companies that make such investments insufficiently.

Rafiq et al. (2016) investigated the impact of R&D on the profitability of mining firms in China and the United States (US) using a panel of 168 major US and Chinese mining firms from 2009 to 2013. They proved a significant positive relationship between R&D activities and generating profits for US and Chinese mining firms. In particular, it was found that a relatively R&D active firm (over 37 years) generates 4.4% more profit than a younger non-innovative firm. Erdogan and Yamaltdinova (2019) explored the relationship between R&D expenditures and the financial performance of 62 production companies listed in Borsa Istanbul from 2008 to 2017. They used panel data methods and found that financial performance positively interacts with R&D intensity.

Lahmini et al. (2020) analysed the relation between immaterial capital in Moroccan companies listed on the Casablanca Stock exchange and their performance (market capitalization, ROA). Brimah et al. (2020) studied the influence of innovative management approaches on pharmaceutical company's' performance in Nigeria. Shasha (2021) examined the effect of R&D expenses on profitability (ROA, Profit Margin) of Chinese listed companies from 2015 to 2017 and confirmed that the intensity of investment in R&D positively affects the profitability of enterprises. Ozkan (2022) investigated the impact of R&D spending on the financial performance of the 500 largest Turkish industrial firms for the 2013-2019 periods using 12 panel data models. He found that current year R&D spending affects financial performance

negatively. Besides, this impact turns positive only after a year. However, in the long run, the negative effects of an investment in R&D are re-emerging.

The analysis of the scientific literature revealed the issue of different approaches concerning the R&D impact on enterprise profitability worldwide. There are examples of positive and negative influences of different strengths, which may also change over time and depend on the industry affiliation of enterprises. It confirms the need for such research within companies in the same industry and country, which has its institutional constraints and specific features for implementing R&D activities.

Several scientists paid attention directly to the study of the analysis of the impact of R&D on the profitability of enterprises operating in the pharmaceutical sector in different countries. Archarungroj and Hoshino (1999) investigated the impact of R&D investments on a firm's profitability using a regression analysis of 170 Japanese firms in the chemical and pharmaceutical industry. They found that the R&D expenditure and R&D intensity are positively and significantly related to profitability indicators. In larger companies, the strength of this connection is higher than in other companies. Using regression analysis, Nord (2011) analysed the influence of R&D investments on the profitability of the top 16 companies in the pharmaceutical sector in the US. She found a positive and significant relationship between R&D expenditures and profitability (Market Value/Revenue). With the growth of such expenditures, pharmaceutical companies will have a higher indicator of profitability. Other scholars investigated financial aspects in health and innovations in terms of bests European experience (Serpeninova et al., 2020; Lipkova & Braga, 2016; Holobiuc, 2021).

Fortune and Shelton (2012) tested the activity of 303 global firms in the pharmaceutical industry and found that R&D efforts have a small positive effect on profitability (pre-tax income). At the same time, the effectiveness of those efforts is yielding innovative output that has a stronger impact. It confirms the conclusions of Del Monte and Papagni (2003). Thus, in order to increase the return on R&D, their qualitative level should be ensured, rather than quantitative imitation. Freihat and Kanakriyah (2017) investigated the impact of R&D expenditures on the performance of Jordanian pharmaceutical companies listed on the Amman Stock Exchange in Jordan from 2006 to 2015. The researchers found a significant impact of R&D expenditures on performance.

Dalvadi and Mansuri (2018) analysed 16 Indian pharmaceutical companies from 2005 to 2015. The scholars found a linear correlation between R&D and profitability indicators. Indian pharmaceutical companies also were the subject of research by Nandy (2020), who also found a significant positive impact of R&D activities on their financial performance.

Eldawayaty (2020) examined listed pharmaceutical companies on the Egyptian stock market for the period between 2000 to 2019 and found a significant negative relationship between R&D intensity and current performance and insignificant negative relation with ROA.

Summing up, based on previous research on the impact of R&D on the profitability of pharmaceutical companies, the study found a sophisticated correlation and mixed or contradictive results. Most scientists confirm the positive impact of R&D on profitability, and the other is that R&D has a negative impact on it. This study ascertains the nature of this impact on pharmaceutical companies from the European environment, where a more developed and structured market of pharmaceutical goods and services exists. Thus, this study aims to investigate the impact of R&D activities on the profitability of Slovak pharmaceutical companies.

Methodology and research methods. Sample selection. For testing the hypothesis highlighted in the article, the activities of 37 companies in the Slovak pharmaceutical sector (Table 1) for 2015-2019 were analysed. The sources of information for the formation of the panel data array for the period 2015-2019 are the annual financial reporting and the Slovak database «FinStat». According to the classification of SK NACE, 2 enterprises belong to group 21100 «Manufacture of basic pharmaceutical products», 3 – to group 21200 «Manufacture of pharmaceutical preparations», and 32 – to group 46460 «Wholesale of

pharmaceutical goods». Regarding the type of ownership of pharmaceutical companies, most of the observed population (87%) are private domestic entities.

Table 1. Sample for panel data regression model: reporting data of 37 Slovak pharmaceutical companies

№	Company	№	Company
1	Alfamedica s.r.o.	20	NETPHARMA, s.r.o.
2	ASCO International s.r.o.	21	NEURIS, s.r.o.
3	AZ CHROM s.r.o.	22	NOBLE – CAN SLOVAKIA, s.r.o.
4	Biotika a.s.	23	ORTHOTRADE, s.r.o.
5	CEEMED, s. r. o.	24	PASTUS, spol. s r.o.
6	ČERVENÝ s.r.o.	25	Pharm s.r.o.
7	DENTIN, spol. s r.o.	26	Pharma Products, s.r.o.
8	EIDOS spol. s r.o.	2	PLATAN, s.r.o.
9	Fanorg s.r.o.	28	PROFIMED, s.r.o.
10	FIX - výroba zdravotníckych potrieb, s.r.o.	29	PROXAMED, s.r.o.
11	ICE - M s.r.o.	30	S.A.B. Slovakia s. r. o.
12	iDent Slovakia, s.r.o.	31	SLOVAKIA ALTIS GROUP, s.r.o.
13	Izomedact, spol. s r.o.	32	Slovenská zooveterinárna homeopatická spoločnosť, s.r.o.
14	KONEX MEDIK, spol. s r.o.	33	TriAmiga, s.r.o.
15	Liečivé rastliny, s. r. o.	34	UNIMED PHARMA, spol. s r.o.
16	LV DISTRIBUTION s.r.o.	35	UNIMEDICA s.r.o.
17	MEDICAL BUSINESS & CONSULTING SLOVAKIA, spol. s r.o.	36	VITAL LIFE diagnostics, s.r.o.
18	Molecule of life spol. s r.o.	37	WellFor s.r.o.
19	M-Plus Medical, s.r.o.		

Sources: developed by authors.

In this research, one independent variable is tried to be explained by two dependent variables and controlled by three variables. Table 2 presents the variables used in the analysis and the calculations for these variables.

Table 2. Variable definitions and abbreviations

Variable	Empirical Definition	Abbreviation
	Dependent Variables	
Return on Assets	Net turnover divided by total assets	ROA
	Independent Variables (R&D Variables)	
Research and Development Intensity	Capitalized R&D divided by total sales	RDI
Research and Development Intensity Squared	Squared function of R&D	RDI2
	Control Variables	
Leverage	Total liabilities divided by total assets	LEV
Size	Logarithm of total assets	l_S
High-tech dummy	1 for high tech, 0 for non high-tech	DHT

Sources: developed by authors.

The suggested research uses the panel data regression model. The choice of ROA as a characteristic of the enterprise's profitability is justified by the extensive use of this indicator by scientists for investment analysis. ROA is a direct characteristic of the profitability of the enterprise. At the same time, it is a dependent variable in establishing the relationship with the R&D of the enterprise proposed by Archarungroj and Hoshino (1999), Ayaydin and Karaaslan (2014), Varahrami (2015), Freihat and Kanakriyah (2017), Erdogan and Yamaltdinova (2019), Eldawayaty (2020), Kliestik et al. (2020), Nandy (2020), Shasha (2021), Ozkan (2022).

The independent variables used in this study were calculated by using financial statements of companies from the Slovak pharmaceutical sector. Independent variables are divided into two sub-groups: R&D variables and control variables.

R&D intensity (RDI) is calculated by dividing the annual R&D by the company's total sales for this year. The second R&D variable is the R&D intensity squared, which helps to check the existence of a non-linear relationship between R&D and companies' ROA. In line with the scientific literature on the study topic (Archarungroj and Hoshino, 1999; Natasha and Yanthi, 2009; Nord, 2011; Ayaydin and Karaaslan, 2014; Varahrami, 2015; Ievdokymov et al., 2020; Eldawayaty, 2020) to control for a significant effect of additional variables, it was included several control variables in the panel data regression model: leverage (LEV), size of a company (l_S), and high-tech dummy variable (DHT). LEV and l_S are used to determine how much financing through debts and a company's size could influence ROA. As companies in the pharmaceutical sector have different levels of R&D intensity in different sub-sectors (high or non-high), this study employs a dummy variable for sub-sectors. For this sample, that means that all companies with SK NACE 2 codes 21100 and 21200 are indicated as 0 and 1 for more high-tech pharmaceutical companies. Figure 1 shows the conceptual framework of the article.

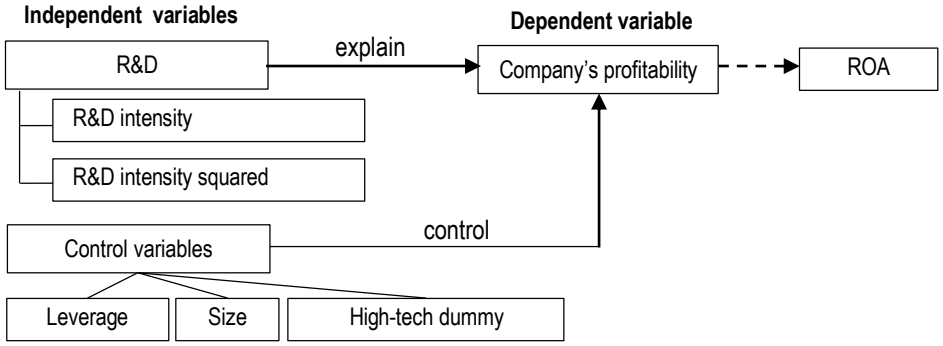

Figure 1. Conceptual framework of the article

Sources: developed by authors.

Panel data analysis is used to examine the effect of R&D on the profitability of Slovak pharmaceutical companies. The equation of the basic panel data model formed in the paper is as follows:

$$ROA_{it} = \alpha + \mu_{it} + \beta_1 RDI_{it} + \beta_2 RDI_{2it} + \beta_3 LEV_{it} + \beta_4 l\_S_{it} + \beta_5 DHT_{it} + \varepsilon_{it} \quad (1)$$

where: ROA – dependent variables, where i = entity and t = time; α – Identifier; μ – Variance introduced by the unit-specific effect for unit i; β – Regression coefficient; RDI, RDI2, LEV, l_S, DHT – independent variables, where i = entity and t = time; εit – error term.

Selection of Estimate Panel Data Parameter. In order to determine the method of regression analysis of panel data most suitable for the selected model, the F-statistics test was used. As a result of its application, it was found that the value of F (35, 144) = 36,619 p-value (1,21255e-055) is greater than 0.05, which indicates against the null hypothesis regarding the adequacy of the pooled OLS model and indicates the feasibility of using Fixed effects method (FEM) as an alternative. The Breusch-Pagan and Hausman test use revealed that the random-effects method (REM) is more appropriate than the pooled OLS model and FEM. In particular, the Hausman test showed that for the value of chi-square (8) (1.64125), the p-value (0.801361) is greater than 0.05, which confirms the null hypothesis that REM estimates are consistent. The use of REM allows identifying individual, time-invariant factors that affect the dependent variable. To confirm the adequacy of the constructed model with data on the activities of pharmaceutical companies and to find ways to improve it, its diagnosis was performed using the Normality test and Autocorrelation test.

Testing the normality of the proposed model residues distribution using the Gretl software package allowed establishing the abnormality of the error distribution. Thus, the value of Chi-square (2) = 977,206 p-value = 0,00000, which is less than 0.05 and does not confirm the null hypothesis of a normal distribution of residues. Autocorrelation testing was performed based on the Wooldridge test for autocorrelation in panel data, establishing the absence of first-order autocorrelation. The value F (1, 36) = 1.80825 with p-value = P (F (1, 36)> 1,80825) = 0.18713, which is greater than 0.05, resulting in a null hypothesis of no first-order autocorrelation (rho = -0.5). Since the conducted test results show incomplete adequacy of the constructed model with the data, it is proposed to estimate models with robust standard errors to improve it, which is also suggested by other scientists (Ozkan, 2022).

The study's hypothesis is to check the existence of a significant positive impact of R&D activities on profitability. Since the strength of such influence depends on the specifics of the industry and the region in which the company operates, such research should be conducted on the example of a group of companies belonging to one industry and a particular country.

Results. ROA dynamics of Slovak pharmaceutical companies. Figure 2 shows the development of ROA of pharmaceutical companies in the Slovak Republic for 2015-2019.

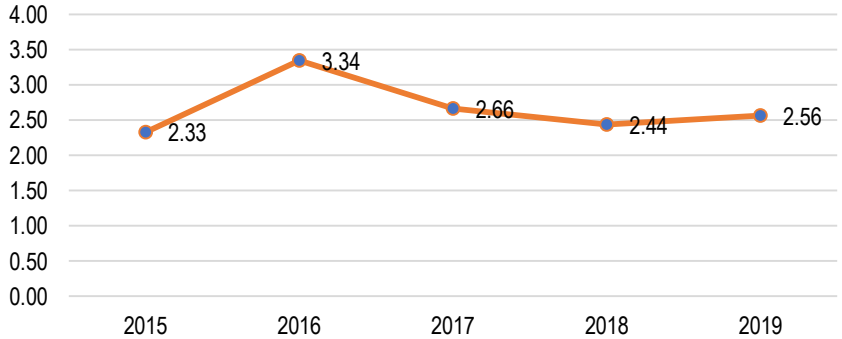

Figure 2. Development of ROA of Slovak pharmaceutical companies for the 2015-2019 period
Sources: developed by authors.

Figure 2 shows that the average meaning of ROA during the 2015-2019 period experienced movements or fluctuations. 2014 to 2015 and from 2018 to 2019 were the periods of ROA increase, and 2016-2018 – ROA reduction. The fluctuations were caused by the decrease in the total value of pharmaceutical sales in Slovakia from 2016 to 2018.

Table 3 summarizes the descriptive statistics of all variables used in the model. It calculates the studied sample's basic numerical characteristics (mean, median, standard deviation, minimum, maximum).

Table 3. Numerical characteristics, based on observations 1:1 - 37:5

Variables	Mean	Median	St. Dev.	Minimum	Maximum
ROA	2,67	1,15	6,05	0,000	50,9
RDI	0,271	0,0518	0,797	6,34e-005	7,35
RDI2	0,706	0,00269	5,13	4,02e-009	54,1
LEV	0,590	0,610	0,344	0,0300	1,90
I_S	12,3	12,3	1,53	8,48	17,6
DHT	0,135	0,000	0,343	0,000	1,00

Sources: developed by authors.

Table 3 shows that the largest deviations in variables are related to ROA and RDI2. Although ROA also has a wide span of values (ranges from 0 to 50,9), a mean value for ROA is positive – 2.67. The span of values of companies' size and leverage measure is rather low, indicating similarity among observed companies from these variables. It is established that the mean value is greater than the standard deviation for individual variables (LEV, RDI2, I_S). Thus, the data in these variables have a small distribution.

As a result of constructing a correlation matrix (Fig. 3) of dependent and independent variables, the common multicollinearity problem was not identified. The correlation between RDI and RDI2 is high (0.9), but this is normal for regression analysis to check the relationship between interrelated variables and profitability.

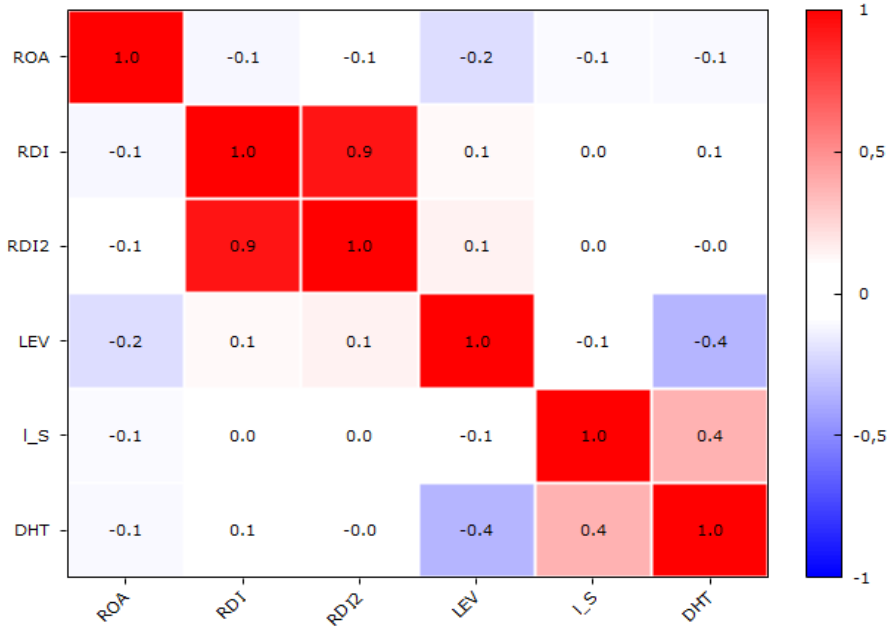

Figure 3. Correlation matrix of a Model

Sources: developed by the authors.

Panel Data Regression Results. Tables 4-5 show the analysis performed using the Robust standard errors (REM). It demonstrates the extent to which the independent variable will affect the dependent variable, taking into account the influence of omitted or unobserved variables that characterize the individual characteristics of the objects under study.

Table 4. REM, using the observations 1-185

Indicator	Coefficient	Standard error	z	P-value	Significance by t-statistics
const	8,82542	3,17363	2,781	0,0054	***
RDI	−2,01426	0,632224	−3,186	0,0014	***
RDI2	0,256203	0,0809692	3,164	0,0016	***
LEV	−2,25360	1,64321	−1,371	0,1702	
I_S	−0,342020	0,371091	−0,9217	0,3567	
DHT	−1,94123	2,06005	−0,9423	0,3460	

Sources: developed by authors.

Table 5. REM, using the observations 1-185

Indicator	Value	Indicator	Value
Mean dependent var.	2,665240	**S.D. dependent var.**	6,052092
Sum squared resid.	6108,061	**S.E. of regression**	5,825262
Log-likelihood	−585,9770	**Akaike criterion**	1183,954
Schwarz criterion	1203,276	**Hannan-Quinn**	1191,785
RHO parameter	−0,567672	**Durbin–Watson statistic**	2,520036

Sources: developed by authors.

The adequacy of REM application to the data was verified using the Joint test on named regressors and the Breusch-Pagan test. Conducting a Joint test on named regressors, which resulted in the value of Chi-square (5) = 23.4462 and p-value = 0.000277309, which is less than 0.05, confirms that all independent variables are jointly significant in influencing or explaining ROA. As a result of the Breusch-Pagan test, it was found that the variance of the unit-specific error is significant in explaining the dependent variable. The obtained values of «between» variance (33.2526) and «within» variance (4.16772) allowed to establish the fraction of the total variance that could be attributed to unit-specific random effect - 88.8%. The large size of the random effect also indicates that the REM is suitable for this data set. Therefore, it is necessary to consider the unit-specific effects of omitted and not observed variables, which will allow for obtaining more statistically significant estimates.

Suggested in the study Model could be demonstrated through the following equation:

$$\hat{y} = 8{,}82542 - 2{,}01426x_1 + 0{,}256203x_2 - 2{,}25360x_3 - 0{,}342020x_4 - 1{,}94123x_5 \qquad (2)$$

where ŷ – ROA; x_1 – RDI; x_2 – RDI_2; x_3 – LEV; x_4 – 1_S; x_5 – DHT.

For the suggested model, the independent variables RDI and RDI_2 are statistically significant, confirmed by the presented data in a table. 4. In particular, it is RDI (P-value = 0.0014) and RDI_2 (P-value = 0.0016) with the corresponding P-value values that are most influential on ROA. The absence of asterisks in the cells of the significance column by t-statistics for other independent variables indicates their insignificant effect on ROA. The content of the coefficients of the regression equation of the model is as follows: 1) in case of increase of RDI by 1, ROA will decrease by 2.01426; 2) in case of increase of RDI2 is increased by 1, ROA will increase by 0.256203; 3) in case of increase of LEV 1 value, ROA will decrease by 2,25360; 4) in case of increase of I_S by 1, ROA will decrease by 1.94123.

The equation of the model demonstrates that of the proposed parameters, RDI2 has a direct effect on ROA, and most parameters (RDI, LEV, I_S, DHT) have an inverse impact. In particular, increasing investment in RDI to a certain level, based on the obtained panel data regression results, will significantly impact ROA. There is also no significant positive impact of company size and sub-sector affiliation on ROA. Thus, as the pharmaceutical company increases or moves to another sub-sector, profitability would not increase.

Conclusions. The scientific results obtained in the article contradict most of the conclusions of the analysed papers of scientists on the presence of a significant positive impact of R&D on profitability. The results of panel data regression analysis showed a significant negative relation between R&D intensity and profitability of Slovak pharmaceutical companies. The results of the study support the finding of Eldawayaty (2020). It was also found that R&D intensity squared significantly and positively impacted profitability at a 1% level. It means that the impact of R&D on profitability is determined by the volume of R&D activities of the company. Accordingly, such an effect is non-linear. It is characterized by an inverted-U relationship, which reflects diminishing scale effects. The existence of the same option of inverted-U relationship, when R&D intensity has a negative impact and R&D intensity squared – a positive, is confirmed by other scientists (Fortune and Shelton, 2012; Qi and Deng, 2019), who studied the impact of R&D on the profitability in different sectors of the economy. The content of an inverted-U function could be interpreted as the fact that as the R&D of pharmaceutical companies increases, their profitability increases to a certain point. However, after that, an R&D increase leads to a profitability decrease. Accordingly, the value of RDI2 found using the generated model got to that zone of inverted-U function, which provides profitability growth (Fig. 4).

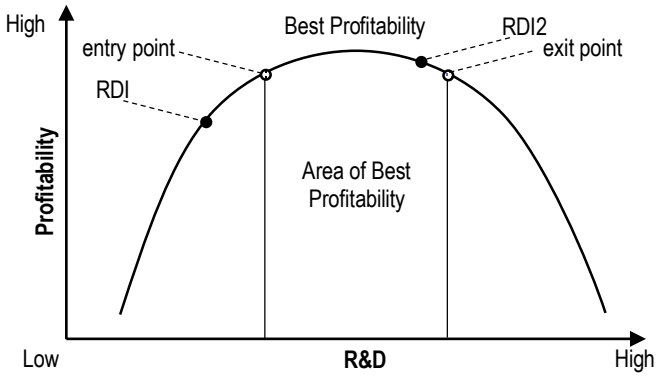

Figure 4. The inverted-U function: R&D and profitability aspect

Sources: developed by authors.

Identified inverted-U relationship between R&D and indicates a partial confirmation of the study hypothesis concerning the existence of a significant positive impact of R&D activities on profitability. As such, influence exists not for all R&D activities and only for their separate volume, which in inverted-U function provides the formation of the area of best profitability. Jen Huang and Ju Liu (2005), Erdogan and Yamaltdinova (2019) found a significant positive impact of R&D and a negative impact of R&D squared on the ROA. It indicates that for the enterprises they studied (largest companies in Taiwan and production companies listed in Borsa Istanbul), the entry point to the area of best profitability was lower than the R&D intensity value, and the exit point was higher than the R&D intensity squared. Therefore, from the standpoint of future research and the formation of practical recommendations for enterprises, it is

important to determine the features of building an inverted-U function, as well as find entry and exit points from the area of best profitability, which would determine a clear scope of R&D activities in a particular country, for example, for Slovak pharmaceutical companies. Understanding all the parameters of the inverted-U function that characterize the optimal level of R&D would allow business owners to adjust their investment policy regarding their R&D activities.

This study has some limitations. Firstly, the focus of research on one economic sector increases the likelihood that the findings are only relevant to the pharmaceutical sector and cannot be fully applied to other knowledge-intensive enterprises. Future research aimed at confirming the study's hypothesis should focus not only on the R&D activities of Slovak pharmaceutical companies but also on other types of knowledge-intensive enterprises by using alternative industry samples. Secondly, in this study, ROA was chosen as an indicator of the profitability of pharmaceutical companies. The results could be supplemented by studies that use alternative indicators of enterprise profitability, such as ROE, EBIT, NPM, etc. Thirdly, future research could be carried out not only according to the classical approach (Griliches, 1979), when current R&D costs and investments impact the enterprise's profitability from the same year. However, it is also possible to analyze the impact of lagged R&D effects on financial performance, which will explain how R&D activities in previous periods affect the current profitability.

This paper examines the effect of R&D activities on the profitability of Slovak pharmaceutical companies using panel data of 37 companies over the period 2015-2019. Such research is especially relevant for investors based on the policy of the Slovak Government for the development of biomedicine & biotechnology in the country, supported by the creation of an investment incentives program for the pharmaceutical sector. A panel data regression analysis was used for the research, which provided for constructing a regression model with one dependent variable - Return on Assets, and five independent variables – Research and Development Intensity, Research and Development Intensity Squared, Leverage, Size, High-tech dummy.

The choice of the random effects method as an estimated parameter was justified for the proposed panel data regression model based on the Breusch-Pagan and Hausman tests. The adequacy of REM application to the data was also confirmed based on using the Joint test and the Breusch-Pagan test. The result of the regression model demonstrates partial confirmation of the study hypothesis about the existence of a significant positive impact of R&D activities on profitability. Only the RDI2 has a significant positive impact on the profitability of Slovak pharmaceutical companies at 1% level, and the RDI, on the contrary, has a significant negative relation. According to the analysis results, there is no significant influence of control variables (LEV, I_S, DHT) on the profitability.

According to the study's empirical results, an inverted-U relationship between R&D activities and profitability was established. Investing in the R&D of Slovak pharmaceutical companies positively affects profitability only from a certain amount (entry point). Besides, it has an upper limit on the amount of profitable investment (exit point). In order to form recommendations for the management of the companies on the adjustment of investment policy in R&D activities, it is necessary to conduct future research, which would determine the entry points and exit points from the area of best profitability on inverted-U function.

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References

Archarungroj, P., & Hoshino, Y. (1999). Firm size and R&D on profitability: An empirical analysis on Japanese chemical and pharmaceutical industry. *Japanese Journal of Administrative Science*, 13(2), 71-86. [Google Scholar] [CrossRef]

Ayaydin, H., & Karaaslan, I. (2014). The effect of research and development investment on firms' financial performance: evidence from manufacturing firms in Turkey. *The Journal of Knowledge Economy & Knowledge Management*, 9, 43-59. [Google Scholar]

Brimah, B. A., Bamidele, A. G., Rabiu, R. O., & John, I. S. (2020). The Connexus of Management by Objectives and Organisational Performance: Evidence from Tuyil Pharmaceutical Limited, Ilorin. *SocioEconomic Challenges*, 4(2), 90-98. [Google Scholar] [CrossRef]

Dalvadi, Y. M., & Mansuri, S. I. (2018). A Study on Impact of Profitability and R&D Intensity on R&D Expenditure in Selected Pharmaceutical Companies. *Al-Barkaat Journal of Finance & Management*, 10(1), 25-33. [Google Scholar] [CrossRef]

Del Monte, A., & Papagni, E. (2003). R&D and the growth of firms: empirical analysis of a panel of Italian firms. *Research policy*, 32(6), 1003-1014. [Google Scholar] [CrossRef]

Eldawayaty, D. M. A. (2020). The Impact of Research and Development (R&D) Intensity on Financial Performance and Firm Value: An Empirical Study on Pharmaceutical Companies Listed on Egyptian Stock Exchange. *Alexandria Journal of Accounting Research*, 4(3), 1-55. [Link]

Erdogan, M., & Yamaltdinova, A. (2019). A panel study of the impact of R&D on financial performance: Evidence from an emerging market. *Procedia Computer Science*, 158, 541-545. [Google Scholar] [CrossRef]

Fortune, A., & Shelton, L. (2012). R&D effort, effectiveness, and firm performance in the pharmaceutical sector. *Journal of business and management*, 18(1), 97-115. [Google Scholar]

Freihat, A. R. F., & Kanakriyah, R. (2017). Impact of R&D expenditure on financial performance: Jordanian evidence. *European Journal of Business and Management*, 9(32), 73-83. [Google Scholar]

Holobiuc, A.-M. (2021). Determinants of economic growth in the European Union. An empirical analysis of conditional convergence. *SocioEconomic Challenges*, 5(2), 26-34. [Google Scholar] [CrossRef]

Griliches, Z. (1979). Issues in Assessing the Contribution of Research and Development to Productivity Growth. *The Bell Journal of Economics*, 10(1), 92-116. [CrossRef]

Ievdokymov, V., Ostapchuk, T., Lehenchuk, S., Grytsyshen, D., & Marchuk, G. (2020). Analysis of the impact of intangible assets on the companies' market value. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu*, 3, 164-170. [Google Scholar] [CrossRef]

Jen Huang, C., & Ju Liu, C. (2005). Exploration for the relationship between innovation, IT and performance. Journal of Intellectual Capital, 6(2), 237-252. [CrossRef]

Kliestik, T., Nica, E., Suler, P., & Valaskova, K. (2020). Innovations in the Company's Earning Management: The Case for the Czech Republic and Slovakia. *Marketing and Management of Innovations*, 3, 332-345. [CrossRef]

Lahmini, H. M., Mialed, K., & Mokhlis, C. E. (2020). Management of Companies Performance: Impact of Immaterial Capital. Marketing and Management of Innovations, 3, 45-58. [CrossRef]

Lipkova, L., & Braga D. (2016). Measuring commercialization success of innovations in the EU. *Marketing and Management of Innovations*, 4, 15-30. [Link]

Lome, O., Heggeseth, A.G., & Moen, Ø. (2016). The effect of R&D on performance: Do R&D-intensive firms handle a financial crisis better? *The Journal of High Technology Management Research*, 27(1), 65-77. [Google Scholar] [CrossRef]

Monahan, S. (2005). Conservatism, Growth and the Role of Accounting Numbers in the Fundamental Analysis Process. *Review of Accounting Studies,* 10, 227-260. [Google Scholar] [CrossRef]

Nandy, M. (2020). Is There Any Impact of R&D on Financial Performance? Evidence from Indian Pharmaceutical Companies. *FIIB Business Review,* 9(4), 319-334. [Google Scholar] [CrossRef]

Natasha, I. E., & Yanthi, R. I. H. (2009). The analysis of R&D impact on the public listed companies' performance in Indonesia. *Journal of Applied Finance and Accounting,* 1(2), 339-350. [Google Scholar] [CrossRef]

Nord, L.J. (2011). R&D Investment Link to Profitability: A Pharmaceutical Industry Evaluation. *Undergraduate Economic Review*, 8(1), 1-6. [Google Scholar] [Link]

Ozkan, N. (2022). R&D spending and financial performance: an investigation in an emerging market. *International Journal of Management Economics and Business*, 18(1), 38-58. [Google Scholar] [CrossRef]

Pharmaceutical & Life Sciences Sector in Slovakia (2022). Slovak Investment and Trade Development Agency. English edition. 19 p. [Link]

Qi, E., & Deng, M. (2019). R&D Investment Enhance the Financial Performance of Company Driven by Big Data Computing and Analysis. *Computer systems science and engineering*, 34(4), 237-248. [Link]

Rafiq, Sh., Salim, R., & Smyth, R. (2016). The moderating role of firm age in the relationship between R&D expenditure and financial performance: Evidence from Chinese and US mining firms. *Economic Modelling,* 56, 122-132. [Google Scholar] [CrossRef]

Serpeninova, Yu., Makarenko, I., Plastun, A., Babko, A., & Gasimova, G. (2020). Mapping of the responsible investments instruments in sdg 3 'good health and well-being' financing: EU and US experience. *Health Economics and Management Review*, 1(1), 106-115. [Google Scholar] [CrossRef]

Shasha, L. (2021). The Influence of Technological Innovation on the Profitability of Enterprises. *2020 International Conference on New Energy Technology and Industrial Development (NETID 2020). E3S Web of Conferences,* 235. [Google Scholar] [CrossRef]

Varahrami, V. (2015). Effects of R&D Costs on Profit of Producers of Oil Productions in Tehran Stock Exchange. *Journal of Social and Administrative Sciences,* 2(3), 132-134. [Google Scholar] [CrossRef]

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Вплив інновацій на прибутковість словацьких фармацевтичних компаній

В сучасних умовах розвитку економіки інновації та науково-дослідна діяльність є одними з найважливіших факторів, що впливають на фінансові результати компанії. Метою статті є дослідження впливу науково-дослідної діяльності на прибутковість словацьких фармацевтичних компаній. Емпіричне дослідження проведено на основі панельних даних, сформованих для вибірки з 37 фармацевтичних компаній за період 2015-2019 років. В якості основного методу дослідження використано регресійний аналіз панельних даних. Прибутковість вимірювалася за допомогою показника рентабельності активів і була обрана як залежна змінна. Незалежними змінними було визначено фінансовий важіль, інтенсивність досліджень і розробок, інтенсивність досліджень і розробок у квадраті, розмір і фіктивна змінна високотехнологічності. До емпіричного аналізу входять описова статистика, тест нормальності, тест автокореляції та панелі регресійних моделей (модель випадкових ефектів), за якими слідують тест F-статистики, тест Хаусмана, тест Брейша-Пагана. За результатами дослідження частково підтверджено гіпотезу про значний позитивний вплив науково-конструкторської діяльності на прибутковість наукомістких підприємств. При цьому лише інтенсивність досліджень та розробок у квадраті має значний позитивний вплив на прибутковість словацьких фармацевтичних компаній на рівні 1%, а інтенсивність досліджень та розробок, навпаки, має значне негативне співвідношення. За результатами аналізу суттєвого впливу незалежних змінних (фінансовий важіль, розмір та фіктивна змінна високотехнологічності) на прибутковість немає. Встановлено наявність перевернутого U-зв'язку між науково-дослідною діяльністю та прибутковістю словацьких фармацевтичних компаній. Інвестування в інновації словацьких фармацевтичних компаній позитивно впливає на прибутковість лише з певної суми і має верхню межу суми вигідних інвестицій. Таким чином, для формулювання рекомендацій щодо коригування інвестиційної політики в науково-дослідній діяльності необхідно провести майбутні дослідження, які б визначали точки входу та виходу із зони найкращої прибутковості на оберненій U-функції.

Ключові слова: фінансові результати, фармацевтичні компанії, прибутковість, дослідження та розробки.