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THE IMPACT OF R&D ACTIVITY ON THE BUSINESS PERFORMANCE OF HIGH-TECHNOLOGY COMPANIES

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Abstract. *This paper aims to examine the influence of R&D activity on the business performance of high-technology companies. In order to provide an empirical investigation of the impact of R&D activity on the business performance of high-technology companies, correlation and regression analyses have been utilized.*
This study discovered that investment in R&D has a positive influence on EBIT, net earnings, EBITDA, and total assets, while its influence on ROA was confirmed to be statistically significant and negative. Additionally, the influence of R&D intensity performance indicator (RDI) on ROA as a short-term financial performance indicator was not confirmed. The study revealed that return on R&D investment (RORDI) has a statistically significant and positive influence on ROA in the current, observed year.
The evaluation of the obtained results can be a basis for drawing more detailed conclusions, contributing to the future R&D strategy and existing literature, and emphasizing the importance of R&D investment for various business performances.
The originality of this study is reflected in the comprehensive analysis of the influence of specific indicators of R&D activity, such as RORDI, on the business performance of high-technology companies. This paper is also beneficial because none of the existing studies have explored the impact of investment in R&D on EBITDA.

Keywords: *R&D activity, R&D investment, business performance, profitability*

JEL Classification: O32, O34, M41

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INTRODUCTION

Research and development (R&D) are vital activities for the economic growth of companies through enhanced technological innovation and efficiency. R&D has gotten a lot of attention recently from academic, commercial, and political circles (Jung & Kwak, 2018). Due to the increasingly rapid technological progress, expansion of the globalization process, and intense rivalry (Jovanović et al., 2021), R&D activities are a critical precondition for preserving a competitive edge and improving the profitability of a company. In the era of a knowledge-based economy, R&D investments are not only essential for the success and survival of the companies, but also for the construction of conditions necessary for the prosperity of the national economy (Krstić & Rađenović, 2018). The knowledge-based economy is propelled by investments in R&D and various kinds of innovations.

R&D investment is a crucial factor in creating, maintaining, and strengthening the company's competitive advantage (Janjić & Rađenović, 2019). By conducting R&D activities, the company gets a chance to gain a competitive advantage, which will be reflected in the growth of profitability through the sale of new products and services and the introduction of efficient production methods, enabling entry into new markets or reducing production costs. On the other hand, companies do not always have adequate R&D capabilities (David et al., 2008). R&D investments are risky; hence the return on investment is unpredictable. Every investment in R&D represents a risk for the company. It has been suggested that technological advancement is the engine that drives capitalism. Firms that invest in R&D and innovate will prosper, while those that do not will stagnate (Rzakhanov, 2004).

The motive of the study is to investigate the impact of R&D activities and its indicators on certain business performances (Earnings before interest and tax - EBIT, Net earnings, Earnings before interest and tax, depreciation and amortization – EBITDA, Total assets, and return on assets - ROA), which were not the focus of relevant literature. The rationale for exploring the influence of R&D activities on certain business performances is that R&D investments are very significant for strategic positions and financially challenged, therefore the management of any organization has to continuously monitor all potential future benefits and effects. R&D investments are not contributing to the achievement of economic results for the current period. However, over a longer period, R&D investments should have an impact through the visible development and growth of the portfolio company's resources, i.e. total assets. To implement the corporate strategy, the business unit strategy, and the R&D strategy, R&D investments must have an impact on profitability indicators in the future period.

Having in mind the beneficial effects of R&D expenditures on the company's sustainable development, the purpose of this paper is to test the influence of R&D investment indicators on business indicators of high-tech companies that are leaders in R&D investments. Therefore, this study focuses only on one industry (Information and Communications Technology - ICT) and the most famous high-technology companies, such as Apple (ICT producers and services), Intel (ICT producers and services), Microsoft (ICT services), Samsung (ICT producers), Cisco (ICT producers and services), IBM (ICT producers), Oracle (ICT services), Philips (ICT producers) and SAP (ICT services). The current study utilizes bivariate correlation and panel regression analysis to test the proposed hypotheses. The study focuses only on one industry or more precisely nine high-tech companies and the data from eight years. Therefore, the overall results could be biased, but also very indicative of the theory and practice on this topic.

The structure of this study is organized as follows. Firstly, after the introduction, an overview of the relevant literature is given – the relevance of R&D activity for improving business performance and competitiveness, as well as the indicators of R&D activity. The theoretical aspect and the existing literature on the relationship between R&D activity and business performance are also presented. The second section presents the sample, researched variables, and methodology of research. The third section gives an overview of the results and their discussion. At the end of the paper, a summary of the conclusions is presented.

1. LITERATURE REVIEW

1.1. The relevance of R&D activity for improving business performance and competitiveness

The term *research and development* refer to the activities that businesses engage in creating new products and services, which in turn have an impact on a company's financial and non-financial performance. The concept of R&D is divided into two parts. In general, *research* is conducted to achieve a new scientific advance, enhance knowledge and discover and invent new methods, systems, and products, whereas "development" is the process of translating the outcomes of research and other information into a commercial product, or an improved design or plan for a new product or service (Zhao, 2002).

In today's world of fierce competition, companies have to recognize the dangers of imitation and the critical role of innovation and devote appropriate resources to R&D (Guo et al., 2016), resulting in competitive strength and affecting profitability levels. Due to the quick technological advancements and increasingly sophisticated consumer markets, companies are forced to consistently invest in R&D and innovation, which are regarded as the primary strategic factors for their success (Marković et al., 2020). The degree of innovation of these companies can be identified based on the part of the realized sales revenues that are invested in R&D. For the competitive advantage of innovative companies, it is very important not only to invest significantly in R&D, but also to have the highest intensity of investment in R&D and realize the high efficiency of investment in R&D. To boost revenues, earnings, labour productivity, profitability, technical innovation, and competitiveness, every company aims to increase the effectiveness and efficiency of R&D investment (Veselinović & Veselinović, 2019). Continuous growing investments in R&D lead to the efficiency of the use of these funds, which implies the creation and implementation of product and process innovations, which should contribute to the growth of the profitability of the companies.

The significance of R&D arises from its capability to encourage a company's economic growth by resulting in the innovation of new technologies that can improve a company's competitive advantage and strengthen its position in the market. R&D is regarded as the foundation for developing new products, processes, and services, giving companies a competitive advantage in terms of product and service innovation, and allowing them to become market leaders (Hall & Oriani, 2006). Companies can improve organisational knowledge and ability, the technical degree of accumulation, or develop new knowledge, by implementing R&D activities, which may ultimately affect business performance. Investing in R&D yields a higher-than-average rate of return on R&D investment and gives a company a distinct and long-term competitive advantage (Hsieh, et al., 2003).

1.2. Indicators of R&D activity

The majority of empirical research focuses on *R&D investment* and *R&D intensity (RDI)*, as very important indicators of R&D activity. Additionally, a significant measure of the realization of R&D activity is the achieved *Return on R&D investment (RORDI)*.

R&D investment, which is a crucial driver and cornerstone of sustainable and economic development in the twenty-first century, can have an impact on a company's viability and growth. R&D investments are vital for the long-term survival and success of every company. Investment in R&D is regarded as a critical component of high-technology investment (Karl-Heinz, 2005) and presents a significant source and basis of innovation (Wang et al., 2013). R&D investments include the entire process of developing new products and services towards the stage of commercialization (Wesley & Wonglimpiyarat, 2020, p. 5). Failure and irreversibility are unavoidable parts of the R&D investment process. Beside that, the future rewards and short-term effectiveness of R&D investments are usually unpredictable and uncertain.

R&D intensity (RDI) has been of great interest to academics, policymakers, practitioners and corporations during the last few decades. Furthermore, RDI is one of the most commonly used R&D indicators and in many studies, RDI represents the innovation levels of the companies and their sectors (Sher & Yang, 2005; Gui-long et al., 2017; Ameer & Othman, 2020). RDI can be defined as an enterprise's R&D expenditure divided by its sales revenue (Ortega-Argiles & Brandsma, 2010). RDI is a critical factor for evaluating a company's technological efficiency and innovative activities (Chao & Kavadias, 2013), as well as RDI is acknowledged as a significant measure for identifying a firm's strategic use of R&D (Lin et al., 2006). In semiconductor companies in Taiwan, higher RDI has been demonstrated to be a predictor of enhanced business performance (Sher & Yang, 2005).

The return on R&D investment (*RORDI*) has been the subject of significant literature from both theoretical and empirical perspectives (Lev & Sougiannis, 1996; Kothari et al., Leone, 2002; Anagnostopoulou & Levis, 2008). Investing in R&D does not always yield instant results and returns (Petković et. al, 2021). The fact that certain inventions appear slowly and are short-lived, while others are long-lasting or utilised in future R&D, is a factor that contributes to a disparity between R&D investments and returns. Companies that can turn the results of their innovative projects and creative initiatives into meaningful sales growth should expect future returns on their R&D investment (Cohen et al., 2013). The importance of the rate of return on R&D investment (RORDI) is represented in improving economic performance by increasing efficiency, developing and disseminating new knowledge and increasing the potential for economic growth. According to Shah (2008), as R&D expenses increase, the volatility of returns also increases. The rate of return on R&D investment (RORDI) can be analysed at many different levels of aggregation, including individual research projects, enterprises, industries and national economies. The profit in future consumption units generated by an increase in current R&D expenditure is known as the R&D social return rate. In the meantime, the private return rate is proportional to the increase in profits resulting from increased business innovation (Benavente et al., 2006).

The time-lag period has always been a significant factor to consider when examining R&D activities and processes. The required time to perform R&D activities causes a time lag; hence, R&D spending in the current period has not immediately impacted the financial performance of the company (Rao et al., 2013). Unlike other investments, R&D investment has a temporal lag and contributes to R&D results in the following periods. Some researchers have discovered the existence of a lag period when evaluating the impact of R&D expenditure on the financial

performance of a company. Lee and Lee (2007) used a time-lag model to assess the effects of explanatory variables such as R&D intensity and accounting profit rate ratio on corporate performance in 63 pharmaceutical companies from 2001 to 2006. They found that R&D intensity in the previous year had a beneficial impact on the current year's ordinary profit ratio, whereas R&D expenditures in the preceding two years had a negative impact.

1.3. The link between R&D activity and business performances

In the era of scientific-technological and technical progress, firms that decide to distribute a higher level of investment in R&D are predicted to earn more and achieve higher levels of business performance than organizations that invest less in R&D (Chao, 2011). R&D investments are critical since they show future growth potential in a company's performance. To generate and improve business performance in the future, many companies choose to invest in R&D as a valuable resource.

Therefore, this study investigates the link between the following:

- R&D investments, RDI and Earnings as valuable business performances which reflect economic results i.e., the numerator of profitability ratio (ROA);
- R&D investments and Total Assets i.e. denominator of profitability ratio (ROA);
- R&D investments, RDI, Return on R&D investment and profitability ratio (ROA).

Alarcon and Sanchez (2013) used a sample of more than 400 firms from 2000 to 2008, to investigate the impact of internal and external R&D expenditures on the business performance of agri-food firms. The results showed the positive influence of external R&D on business performance. Jaisinghani (2016) examined the association between RDI and business performance. Using dynamic panel data and a generalized method of moments, the results of conducted research revealed that RDI and business performance are positively correlated. According to the empirical results of Jin and Choi (2019), R&D investment and innovation activities have a considerable influence on corporate performance. Guo et al. (2020) demonstrated that R&D expenditures improve and have a positive impact on business performance.

1.3.1. The link between R&D investments, RDI and Earnings

Sougiannis (1994) examined whether R&D investments may be beneficial to the company. According to the findings, every dollar spent on R&D resulted in a two-dollar rise in earnings over seven years. The research on the companies that have technology-based growth companies listed on "Neuer Markt" leads to the conclusion that RDI has positive effects on sales growth (Wöhrl et al., 2009). The growth of sales revenue in the current period, logically, can contribute to the earnings growth in the same period.

Some researchers found that in R&D-intensive companies, R&D contributes more to the subsequent operating earnings than physical assets (Amir et al., 2007). Ciftci and Cready (2011) concluded that RDI increases operating earnings and stock returns. Jui et al. (2013) investigated the link between R&D and the financial performance of Taiwanese high-tech firms from 2000 to 2011. In their study, R&D expenditures raise the operating costs, which in turn, result in a decrease in operating earnings, despite increased net sales. Kiraci et al. (2016) studied the influence of R&D expenditures on a firm's short and long-term profitability of 46 publicly traded manufacturing enterprises listed on the Borsa Istanbul from 1998 to 2012. Their empirical evidence demonstrates a positive influence of R&D expenses on firms' operating earnings and net earnings in the long term. Caglar and Nisel (2017) state that marketing and

R&D expenses in the manufacturing industry hurt Earnings before interest and tax (EBIT) and net earnings. Xu et al. (2022) explored the effect of R&D input on the operating earnings of the wastewater companies listed on the Shanghai and Shenzen stock exchanges for the period from 2013 to 2020. The findings showed that R&D input has a positive and significant effect on company operating income.

1.3.2. The link between R&D investments and Total Assets

The existing literature does not analyze the impact of R&D investments on total assets. Total assets consist of current and long-term assets. These assets are material (physical and financial) and nonmaterial (intangible). This relationship between R&D investments and total assets is a very important research area, because R&D investments i.e., R&D cost (expense) that are realized over a certain period do not immediately increase total assets. R&D investments are "converted" into total assets, or capitalized, for varying numbers of years, depending on the industry. Capitalizing expenses is beneficial as companies provide new assets. R&D investments i.e., R&D expense over a certain period should contribute to the growth of a portfolio of resources i.e. total assets. The total assets of the company in the current period are a function of capitalized R&D investments in previous years (Abrahamas & Sidhu, 1998). Studies by Sougiannis (1994) and Ballester et al. (2003) stated that a period of 2 years is necessary for R&D investments to be capitalized. Some researchers (Awano et al., 2010) proved that R&D investments produce results after 4-7 years. The term *R&D investment* is used to point out the relevance of effectiveness and efficiency of R&D activity for increasing resources (assets) and value for shareholders.

According to Isaac et al. (2021), there is a statistically significant link between firms' total assets and R&D investment decisions. Zhou and Zhang (2022) investigated the impact of R&D investment on stock performance in a sample of 61 automotive companies from 2011 to 2020. The results of regression analysis revealed that R&D investment has a positive effect on stock returns for companies with higher total assets.

1.3.3. The link between R&D investments, RDI, Return on R&D investment and Profitability

Since the 1970s and 1980s, various studies have been conducted to determine the relationship between R&D expenses and corporate profitability (Branch, 1974; Schoeffler, 1977; Hirschey, 1982; Roberts & Hauptman, 1987; Grabowski & Mueller, 1988). Several studies suggest that R&D spending has a consistent and favourable impact on a company's profitability (Chan, 2001; Roberts, 2001; Shah, 2008; Ehie, 2010; Pindado, 2010).

Chen et al. (2005) discovered a link between R&D spending and ROA and ROE. Many other academics have examined the impact of R&D spending on company profitability using various profitability measures – the return on assets (ROA) and return on equity (ROE) (Yeh et al., 2010; Vijayakumar & Devi, 2011; Delmar et al, 2013; Vithessonthi et al., 2016) since it accurately reflects the company's positions. ROA indicates the earnings generated by the company's total assets. ROA presents a classic metric for determining a company's profitability and efficiency (Helfert, 2000). ROE shows how a company's profits correspond to its equity (Yeh et al., 2010).

The factors that determine profitability were investigated by Nunes and Serrasqueiro (2015). They analysed 187 companies in Portugal from 2002 to 2009 and concluded that R&D spending has a large and beneficial impact on profitability. Phuong and Manh (2017)

researched a sample of 359 listed firms on the Hanoi Stock Exchange from 2012 to 2016. The regression analysis results showed that R&D spending, dividend pay-out ratio and firms' size are considerably and positively influenced by ROA.

According to Archarungroj and Hoshino (1999), an increase in RDI leads to an increase in profitability, and when profitability increases, corporations will spend additional dollars on implementing R&D activities, resulting in an increase in R&D expenditure. High-tech companies in G8 countries when tested only for an influence of RDI show that when RDI increases, ROE, ROA and profit margin decrease, while an influence of RDI and RDI squared has an inverted U-shaped relationship with ROA and profit margin (Bloemendaal, 2020).

On the other hand, Chen et al. (2019) state that RDI does not always have a positive relationship with a company's performance. In their study, ROA is negatively correlated with RDI in the first period when investment in R&D was made, while the influence of RDI on ROA is negative. These results can be attributed to the lagged effect of R&D investments in the semiconductor industry that come in the succeeding years. The results of the conducted research revealed that RDI has a negative impact on profitability (short-term financial performance) and a favourable effect on firm value (long-term financial performance). Kounnou and Kyrkilis (2020) concluded that the impact of RDI on profitability has no statistical relevance.

Sinha and Mondal (2020) analysed 69 pharmaceutical companies in India from 2008 to 2017. The results of the conducted research reveal the negative and insignificant impact of the lagged value of RDI on ROE. On the other hand, many studies indicate that the positive relationship of RDI on companies' profitability is the most commonly found in the long-term analysis, and the effect can be interpreted with the inversed U-shape. Ozkan (2022) analysed 500 industrial firms in Turkey for the period 2013-2019. According to his findings, R&D expenditures have a negative impact on the current year's financial performance measured by ROE, ROA and ROS (Return on Sales) and this influence will turn positive after a year.

Cincera and Veugelers (2014) conducted a study on a sample of 1000 firms that belong to the European Union and non-EU for the period 2004-2009. The results revealed that the rate of return to R&D is positive for US young firms and statistically insignificant for average European firms in high technology-intensive sectors. Rocha et al. (2019) researched the effect of innovative efforts on the financial performance of firms on a sample of 2000 enterprises covering 40 sectors in 46 countries. In comparison to less efficient enterprises, the most efficient organizations generate better returns with the same level of R&D investment.

2. Methodology of Research

This paper aims to investigate the influence of R&D activity indicators on the profitability of high-tech companies. The research is based on the data of the following indicators: *R&D investment*; R&D intensity (*RDI*), Return on R&D investment (*RORDI*); Earnings before interest and tax (*EBIT*), Net earnings; Earnings before interest and tax, depreciation and amortization (*EBITDA*); Total assets, and Return on assets (*ROA*).

Therefore, the research model is presented in Figure 1.

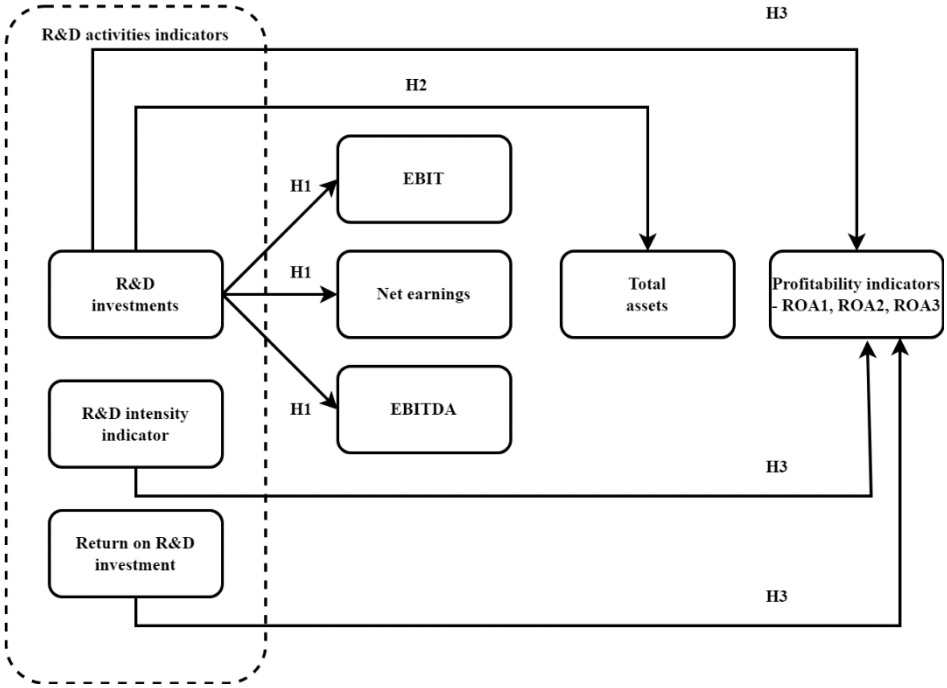

Fig. 1 Research conceptual framework
Source: Authors' presentation

In the following text, the computation process of researched variables is presented.

The R&D intensity indicator is different in various industries and is more valuable in high-tech enterprises (Milkovich et al., 1991). It is defined as expenditures in research and development divided by the company's sales. The following formula (Savrul & Incekara, 2015) is used to compute it:

$$R\&D\ intensity\ indicator = \frac{R\&D\ expenditures}{Sales\ revenue} \quad (1)$$

Return on R&D investment (RORDI) indicates how much of the company's gross profit in the current year was obtained from the prior year's R&D spending. RORDI is calculated using the formula below (Christensen & Van Bever 2014):

$$Return\ on\ R\&D\ investment = \frac{Gross\ profit_t}{R\&D\ expenditures_{t-1}} \quad (2)$$

Return on assets (ROA) is a traditional measure of company profitability. The profitability measure known as Return on Assets (ROA) is calculated in three different ways (Shapiro and Balbirer, 2000; Krstić & Bonić, 2016; Sardo & Serrasqueiro, 2017):

$$ROA_1 = \frac{Net\ earnings}{As} \quad (3)$$

and

$$ROA_2 = \frac{EBIT}{As} \tag{4}$$

where *EBIT* denotes the earnings before interest and tax, *As* denotes Total Assets. EBIT is calculated in the following way:

$$EBIT = Net\ earnings + Income\ tax + Other\ taxes \pm Net\ financial\ loss\ (earnings) \tag{5}$$

For the purpose of comparative analysis of a set of companies from different countries with different tax systems, as well as companies from different industries and different material and intellectual resources, it is desirable to use the term:

$$ROA_3 = \frac{EBITDA}{As} \tag{6}$$

where *EBITDA* stands for earnings before interest and tax, depreciation and amortization. *EBITDA* is calculated in the following way:

$$EBITDA = EBIT + Depreciation + Amortization \tag{7}$$

EBITDA is an analytically better indicator because it enables comparative analyses of companies operating in different countries and industries, with different internal financing policies and fiscal systems, as well as accounting policies for the depreciation of tangible and amortization of intangible assets.

Based on the previously given literature review, the following hypotheses are stated:

Hypothesis H1:

The R&D investments have a positive impact on the EBIT, net earnings and EBITDA.

Hypothesis H2:

The R&D investments have a positive impact on the total assets.

Hypothesis H3:

The R&D investments, R&D intensity (RDI) and Return on R&D investments (RORDI) of the current year have a negative impact on the ROA_1, ROA_2, and ROA_3 as short-term financial performance indicators.

In the research of this paper, data was obtained from the financial statements of the most famous high-technology companies, such as Apple, Intel, Microsoft, Samsung, Cisco, IBM, Oracle, Philips, and SAP. By studying the annual reports of named companies, secondary data was obtained from the websites of the companies and other publicly available databases to calculate research variables and conduct analysis. The analysed period covers the data from 2012 to 2019. Due to the global COVID-19 pandemic, 2020 is not included in the research. Therefore, the analysis covers 72 observations.

In the first seven models, R&D investment is an independent variable, while *EBIT*, net earnings, EBITDA, total assets, ROA_1, ROA_2 and ROA_3 are dependent variables. In the eighth-tenth model, the influence of RDI on ROA_1, ROA_2 and ROA_3 is assessed. The last three models examine the influence of return on R&D investment on ROA_1, ROA_2 and ROA_3 as the dependent variable.

The proposed model was tested using the program Stata (version 13.0).

Firstly, a descriptive statistic was calculated for the analysed variables. Furthermore, all raw data were transferred in natural logarithm values. This procedure was undertaken in order to overcome the problem of incompatibility of research variables and to achieve normal distribution of data.

Secondly, correlation analysis was conducted to assess the extent and direction of the relationships between the researched variables.

Lastly, panel regression analysis was used to evaluate the influence of the independent variable on the dependent variable in seven research models. After the identification of a balanced dataset and the assumptions are met, the fixed-effect model (FEM) and random-effect model (REM) were tested. Afterwards, the Hausman test for every model was performed to select FEM or REM. The Hausman test had a significance cut-off point of p = 0.05. Therefore, all values statistically significantly less than 0.05 indicate the selection of FEM, otherwise, REM was interpreted.

3. RESULTS AND DISCUSSION OF EMPIRICAL RESEARCH

Table 1 presents the descriptive statistics of the researched sample. The data on R&D investments implies that the mean value of the variable is 8,573.263 (SD = 6,495.203). RDI varies between 0.022 and 0.219 with a mean value of 0.125 (SD = 0.050). RORDI has a mean of 6.337 (SD = 3.801). Average values of dependent variables are: EBIT (mean = 20,709.346, SD = 17,944.585), EBITDA (mean = 27,185.620, SD = 21,913.647), net earnings (mean = 15,862.457, SD = 14,378.361), total assets (mean = 139,496.622, SD = 87,895.407). Lastly, average values of proxy indicators of ROA are: ROA_1 (mean = 0.099, SD = 0.045), ROA_2 (mean = 0.131, SD = 0.053) and ROA_3 (mean = 0.173, SD = 0.060).

Table 1 Descriptive statistics

Variable	Minimum	Maximum	Mean	SD
R&D investment (millions of $)	1,854.380	33,200.510	8,573.263	6,495.203
RDI	.022	.219	.125	.050
RORDI	2.332	28.268	6.337	3.801
EBIT (millions of $)	646.039	71,230.000	20,709.346	17,944.585
EBITDA (millions of $)	2,251.830	82,487.000	27,185.620	21,913.647
Net earnings (millions of $)	-39.000	59,531.000	15,862.457	14,378.361
Total assets (millions of $)	28,613.550	375,319.000	139,496.622	87,895.407
ROA_1	-.001	.237	.099	.045
ROA_2	.017	.314	.131	.053
ROA_3	.053	.332	.173	.060

Source: Authors' calculations

Table 2 presents the pair-wise correlations (Pearson Correlation) among all the analysed variables. The correlations between independent and dependent variables have medium to high practical effects. The investment in R&D is positively and significantly correlated with EBIT ($r = .532$, $p < .01$), EBITDA ($r = .675$, $p < .01$), Net earnings ($r = .519$, $p < .01$), Total asset ($r = .702$, $p < .01$). Moreover, R&D investment is positively correlated with profitability indicators ROA_1 ($r = .249$, $p < .01$), ROA_2 ($r = .251$, $p < .05$) and ROA_3 ($r = .387$, $p < .01$). On the other hand, RDI is only statistically significantly and negatively correlated with ROA_1 ($r = -.234$) at the level of significance of 5%. RORDI has a positive and significant relationship with ROA_1 ($r = .612$, $p < .01$), ROA_2 ($r = .661$, $p < .01$) and ROA_3 ($r = .467$, $p < .01$).

Table 2 Bivariate Correlation Matrix

Variable	1	2	3	4	5	6	7	8	9	10
1.R&D inv.	1									
2.RDI	.173	1								
3.RORDI	-.212	-.577**	1							
4.EBIT	.532**	-.431**	.541**	1						
5.EBITDA	.675**	-.367**	.432**	.978**	1					
6.Net earnings	.519**	-.427**	.517**	.984**	.962**	1				
7.Total assets	.702**	-.306**	.290*	.905**	.938**	.892**	1			
8.ROA_1	.249**	-.234*	.612**	.722**	.672**	.759**	.496**	1		
9.ROA_2	.251*	-.227	.661**	.748**	.693**	.728**	.497**	.930**	1	
10. ROA_3	.387**	-.122	.467**	.638**	.650**	.606**	.430**	.811**	.885**	1

Note: Significance at 5% is indicated by *, while significance at 1% is indicated by **.
All significance tests are two-tailed.
Source: Authors' calculations

In the following part, the research models are investigated by employing panel regression analysis of the data. Firstly, the results of R&D investment influence are presented in Table 3.

Table 3 Panel regression results – R&D investment as a predictor

Independent variable	Research models						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	lnEBIT	lnNet Income	lnEBITDA	lnTotal Assets	ROA_1	ROA_2	ROA_3
	FEM	FEM	FEM	REM	FEM	FEM	FEM
Constant	7.103	6.959	6.953	6.333	.437	.586	.735
	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.019)	(0.014)
lnR&D investment	.274	.255	.328	.601	-.038	-.051	-.063
	(0.011)	**(0.003)**	**(0.002)**	**(0.000)**	**(0.012)**	**(0.052)**	**(0.043)**
Hausman test	81.48	6.32	10.13	1.74	16.22	25.25	38.56
	(0.000)	(0.012)	(0.001)	(0.187)	(0.000)	(0.000)	(0.000)
F / χ^2	10.66	17.09	20.41	30.7	10.4	5.2	5.75
	(0.011)	**(0.003)**	**(0.001)**	**(0.000)**	**(0.012)**	**(0.052)**	**(0.043)**
R^2	0.086	0.013	0.258	0.593	0.120	0.184	0.187

Note: p-value in the parentheses.
Source: Authors' calculations

According to the previously defined methodological assumptions of the panel regression analysis, models 1-5 and 7 are statistically significant. On the other hand, model 6 did not meet the assumptions of statistical significance but it is indicative because its significance is at the level of 10%.

Model 1: In this model, the influence that investment in R&D has on EBIT has been measured. It was hypothesized that the influence is positive. The Hausman test indicates χ^2 of 81.48 ($p = 0.000$) so the FEM should be assessed. Model fit is significant at the level of $p < 0.05$ ($F = 10.66$, $p = 0.011$). R^2 indicates that the independent variable explains 8.6% of the variance of the dependent variable. Independent variable: lnR&D investment has a positive effect (.274) on lnEBIT and its effect is statistically significant.

Model 2: In this model, the influence that investment in R&D has on net earnings has been measured. It was hypothesized that the influence is positive. The Hausman test indicates χ^2 of 6.32 (p = 0.012) so the FEM should be assessed. Model fit is significant at the level of p < 0.05 (F = 17.09, p = 0.003). R^2 indicates that the independent variable explains only 1.3% of the variance of the dependent variable. Independent variable: lnR&D investment has a positive effect (.255) on lnNetEarnings and its effect is statistically significant.

Model 3: In this model, the influence that investment in R&D has on EBITDA has been measured. It was hypothesized that the influence is positive. The Hausman test indicates χ^2 of 10.13 (p = 0.001) so the FEM should be assessed. Model fit is significant at the level of p < 0.05 (F = 20.41, p = 0.001). R^2 indicates that the independent variable explains 25.8% of the variance of the dependent variable. Independent variable: lnR&D investment has a positive effect (.328) on lnEBITDA and its effect is statistically significant. Therefore, the research hypothesis H1 is supported.

Model 4: In this model, the influence that investment in R&D has on total assets has been measured. It was hypothesized that the influence is positive. The Hausman test indicates χ^2 of 1.74 (p = 0.187) so the REM should be assessed. Model fit is significant at the level of p < 0.05 (χ^2 = 30.7, p = 0.000). R^2 indicates that the independent variable explains 59.3% of the variance of the dependent variable. Independent variable: lnR&D investment has a positive effect (.601) on lnTotalAsset and its effect is statistically significant. Therefore, the research hypothesis H2 is supported.

The results of the first four models indicate that an increase in R&D investments would lead separately to an increase in *EBIT*, net earnings, *EBITDA* and total assets if other factors' influence is constant.

Model 5: In this model, the influence that investment in R&D has on ROA_1 has been measured. It was hypothesized that the influence is negative. The Hausman test indicates χ^2 of 16.22 (p = 0.000) so the FEM should be assessed. Model fit is significant at the level of p < 0.05 (F = 10.4, p = 0.012). R^2 indicates that the independent variable explains 12% of the variance of the dependent variable. Independent variable: lnR&D investment has a negative effect (-.038) on ROA_1 and its effect is statistically significant.

Model 6: In this model, the influence that investment in R&D has on ROA2 has been measured. It was hypothesized that the influence is negative. The Hausman test indicates χ^2 of 25.25 (p = 0.000) so the FEM should be assessed. Model fit is significant at the level of 10% (F = 5.2, p = 0.052). R^2 indicates that the independent variable explains 18.4% of the variance of the dependent variable. Independent variable: lnR&D investment has a negative effect (-.051) on ROA_2 and its effect is statistically significant at the 10% level. Therefore, the results of this analysis are only indicative.

Model 7: In this model, the influence that investment in R&D has on ROA3 has been measured. It was hypothesized that the influence is negative. The Hausman test indicates χ^2 of 38.56 (p = 0.000) so the FEM should be assessed. Model fit is significant at the level of p < 0.05 (F = 5.75, p = 0.043). R^2 indicates that the independent variable explains 18.7% of the variance of the dependent variable. Independent variable: lnR&D investment has a negative effect (-.063) on ROA_3 and its effect is statistically significant. Therefore, the research hypothesis H3 is supported in this part of the analysis.

If all other influential factors unchanged, an increase in R&D investment would lead to a decrease in ROA_1, ROA_2 and ROA_3.

It should be noted that the panel analysis of the RDI effect on ROA indicators revealed (models 8-10) a negative sign of influence but not statistically significant. Therefore, the results of the analysis are not interpreted in the tables. Furthermore, the research hypothesis H3 is not confirmed in this part of the analysis.

The following table indicates the results of panel regression where the return on R&D is a predictive variable of ROA_1, ROA_2 and ROA_3.

Table 4 Panel regression results – Return on R&D investment (RORDI) as a predictor

Independent variable	Research models		
	Model 11	Model 12	Model 13
	ROA_1	ROA_2	ROA_3
	REM	REM	REM
Constant	.064	.084	.129
	(0.000)	(0.000)	(0.000)
Return on R&D investments	.001	.007	.007
	(0.000)	**(0.000)**	**(0.000)**
Hausman test	1.03	0.40	0.01
	(0.311)	(0.527)	(0.904)
F / χ^2	**56.08**	**95.23**	**65.68**
	(0.000)	**(0.000)**	**(0.000)**
R^2	0.172	0.313	0.190

Note: p-value in the parentheses.
Source: Authors' calculations

Model 11: In this model, the influence that returns on R&D investments have on ROA_1 has been measured. It was hypothesized that the influence is negative. The Hausman test indicates χ^2 of 1.03 ($p = 0.311$) so the REM should be assessed. Model fit is significant at the level of $p < 0.05$ ($\chi^2 = 56.08$, $p = 0.000$). R^2 indicates that the independent variable explains 17.2% of the variance of the dependent variable. Independent variable: return on R&D investment has a positive effect (.001) on ROA_1 and its effect is statistically significant but very small.

Model 12: In this model, the influence that returns on investment in R&D have on ROA_2 has been measured. It was hypothesized that the influence is negative. The Hausman test indicates χ^2 of 0.40 ($p = 0.527$) so the REM should be assessed. Model fit is significant at the level of $p < 0.05$ ($\chi^2 = 95.23$, $p = 0.000$). R^2 indicates that the independent variable explains 31.3% of the variance of the dependent variable. The independent variable: return on R&D investment has a positive effect (.007) on ROA_2 and its effect is statistically significant but very small.

Model 13: In this model, the influence that investment in R&D has on ROA_3 has been measured. It was hypothesized that the influence is negative. The Hausman test indicates χ^2 of 0.01 ($p = 0.904$) so the REM should be assessed. Model fit is significant at the level of $p < 0.05$ ($\chi^2 = 65.68$, $p = 0.000$). R^2 indicates that the independent variable explains 19% of the variance of the dependent variable. The independent variable: return on R&D investment has a positive effect (.007) on ROA_3 and its effect is statistically significant but very small. Based on the previous results, the research hypothesis H_3 is only partially supported in this research. Moreover, when the return on R&D investments would increase the ROA1, ROA2, and ROA3, also, respectively, and under the condition that other factors' influence is unchanged.

CONCLUSION

In today's global marketplace, R&D is the core determinant of sustaining competition. R&D is increasingly being linked to a company's profitability, growth and competitiveness in the market. Therefore, this paper's aim was to examine and explain the influence of R&D activity on business performance in the example of high-technology companies. The leading indicators of R&D activity that are widely used in the previous research and consequently in current research are R&D investments, RDI and RORDI. This research encompassed nine high-tech companies, their indicators of R&D activity and relevant business performances such as EBIT, net earnings, EBITDA, total assets and ROA were examined and confronted in the analysis.

Considering the data of the eight years, the panel regression analysis in this study of the high-technology companies has revealed that R&D investments have a positive influence on EBIT, net earnings, and EBITDA. Similarly, Aytekin & Özçalık (2018) detected a positive relationship between R&D investments and EBIT. Furthermore, the results of this study are in line with VanderPal (2015) who has found that R&D spending had a considerable and positive impact on net earnings. Some researchers (Sun et al., 2019) stated that higher R&D investments reduce EBITDA. Our results are, also, consistent with the findings of Dyrnes & Friestad (2020), who found that R&D was positively related to EBITDA margin.

In addition, conducted research confirms that R&D investments have a positive impact on total assets. There have been no comparable results or similar studies that have examined the association between R&D and total assets. Moreover, there is a gap and lack of consensus in terms of the effect of R&D on total assets, thus, we explored this area that has not been investigated before.

Based on the obtained empirical results, this study reveals that the influence of R&D investments on short-term financial performance indicators (ROA_1, ROA_2, and ROA_3 in the current year) is negative. Similar research conducted by Su et al. (2021) implies that R&D investments are a long-term characteristic of ROA and its influence on ROA is negative in the first year, but with a 2 or 3-year lag effect, the sign of influence turns positive. Additionally, the hypothesis in our study that RDI has a negative influence on three indicators of ROA was not confirmed. Contrary to our results, Wang and Chen (2022) revealed that there is a negative relationship between RDI and corporate performance (ROA and ROE). Bloemendaal (2020) found mixed results in the literature on how RDI influences companies' ROE and ROA. Moreover, his research indicates a negative correlation between RDI and profitability indicators of high-tech companies and the negative influence of RDI on the same indicators which supports the findings of our study. Lastly, this study reveals that RORDI has a statistically significant and positive influence on ROA_1, ROA_2, and ROA_3, but very small in scope. In addition, many studies (Nandy, 2020; Hazarika, 2021) have proven that a longer period is needed for R&D investments to start to pay off.

By emphasizing the significance of R&D spending on corporate performance, the paper substantially contributes to the literature that investigates the influence of R&D activity on the companies' profitability. The *originality* of this study is in this dimension of analysis – the impact of RORDI on ROA. The paper points out that not only investment in R&D has an impact on profitability indicators, but also return on investment in R&D (RORDI) has an influence on the companies' ROA. The influence of RORDI on ROA as a measure of

short-term financial success has not been studied, and there are no clear and concrete specific empirical conclusions in the literature. Our study will offer a unique and different viewpoint on the entire issue of estimating the impact of R&D expenditure on a company's profitability. The analysis of the relationship between R&D and ROA_3 is also novel because it uses EBITDA to improve the analytical capability of this indicator. That sheds light on the new approach to accessing the influence of R&D on ROA. Through EBITDA, it is possible to compare companies across different industries and countries. The effects of R&D investment on total assets have not been explored in the literature yet. This presents a substantial research challenge for the study and provides at the same time a new research perspective on the relevant literature. Therefore, the paper makes a contribution to the contemporary literature on this topic. This research is beneficial and provides practical implications and recommendations, giving guidelines for decision-making to corporate managers, potential R&D investors as well as implementers of R&D strategies.

The limitation of this study comes out from the size of the database and the number of analysed years. Moreover, the shortcoming of this research study arises from the fact that it examines the influence of R&D indicators on a company's short-term profitability, without taking into consideration lagged effect of these predictors on dependent variables. Lastly, the current study is focused only on one sector (ICT), so the results could not be generalized to other sectors.

The direction for future research is primarily reflected in extending the research period. Therefore, this might give additional empirical background for this issue. The time-lag period has always been a significant factor to consider when examining R&D activities and processes. While R&D investments have a negative effect on ROA indicators, the positive influence of return on R&D investment (RORDI) on ROA could be justified by the lag period. The consideration of the effect of the lagged value of R&D on performance is very logical, so the possible direction for future research stems from that investigators can conduct an analysis of time-lagged R&D on return on investment (ROI). By expanding the number of analysed companies and introducing additional industries into analysis, and especially through a comparative analysis of different sectors in order to see the differences, future research on this topic will generate more generalised conclusions and grounded recommendations for practice.

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UTICAJ ULAGANJA U ISTRAŽIVANJE I RAZVOJ NA POSLOVNE PERFORMANSE VISOKO-TEHNOLOŠKIH KOMPANIJA

Cilj ovog rada je da se ispita uticaj aktivnosti I&R na poslovne performanse visoko tehnoloških kompanija. Kako bi se izvršila empirijska analiza uticaja aktivnosti I&R na poslovne performanse visoko tehnoloških kompanija, korišćene su korelaciona i regresiona analiza.

Ova studija je otkrila da ulaganja u I&R imaju pozitivan uticaj na EBIT, neto dobit, EBITDA i ukupnu aktivu, dok je njihov uticaj na ROA pozitivan i statistički značajan. Pored toga, uticaj intenzivnosti I&R na ROA kao kratkorčnog indikatora finansijskih performansi nije potvrđen. Studija je otkrila da povraćaj ulaganja u I&R ima statistički značajan i pozitivan uticaj na ROA u tekućoj, posmatranoj godini. Evaluacija dobijenih rezultata može biti osnova za donošenje detaljnijih zaključaka, doprinoseći budućoj strategiji istraživanja i razvoja i postojećoj literaturi, naglašavajući značaj ulaganja u I&R za poslovne performanse preduzeća. Originalnost ove studije ogleda se u sveobuhvatnoj analizi uticaja specifičnih indikatora aktivnosti I&R na poslovne performanse visoko tehnoloških kompanija. Ovaj rad je takođe koristan zbog činjenice da nijedna od postojećih studija nije istraživala uticaj ulaganja u I&R na EBITDA.

Ključne reči: *Aktivnosti I&R, ulaganja u I&R, poslovne performanse, profitabilnost*