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THE PROFITABILITY DETERMINANTS OF THE GLOBAL PHARMACEUTICAL & BIOTECHNOLOGY COMPANIES DURING THE COVID-19 PANDEMIC

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Abstract

In today's chaotic, complex, unpredictable, and extremely dynamic business environment, it is more than ever essential to operate in a way that will ensure sustainable operations and demand for companies' goods or services. Employing contemporary corporate governance, advanced information technology, and adequate financial management are significant foundations for sustaining high profitability and adequate financial stability as crucial objectives that ensure adding value for companies' owners. Covid-19 is an excellent stress test for every entity, as for micro-companies, so for the largest multinational corporations. Nowadays, in the era of the world Covid-19 pandemic, companies challenge to maintain business operations and going concern assumption. However, in every crisis or adverse situation, some companies take enormous benefits of it. Pharmaceutical and biotechnology companies can be characterized as the major players during this last, still actual crisis. Their role can be observed from two angles, first as a provider of necessary drugs for curing Covid-19 patients and from the other side, as a developer of effective and efficient vaccine which will 'save the world' and brought us back to the 'old normal'. This paper seeks to investigate financial determinants that are the most significant for the profitability of the pharmaceutical and biotechnology companies. The question is how those companies coped with the Covid-19 crisis, and what is the impact on their profitability in 2020 compared to previous operating years? Another question is how is the development of the vaccine financed and are R&D expenses significantly increased in 2020? Therefore, the objective of the paper is to investigate the impact of the Covid-19 crisis on the profitability of global pharmaceutical and biotechnology companies. The research covers 52 entities on the global level for the period from 2010 to 2020. Data will be analysed by applying adequate panel data analysis and moderator regression analysis.

Keywords: *profitability ratios, pharmaceutical and biotechnology companies, Covid-19*

1. INTRODUCTION

Ultimate objectives of successful companies' financial management are to ensure adequate long-term financial stability and high profitability of their businesses, or taken together, to increase companies' value. In times of financial crisis, the achievement of these objectives is greatly under question. Global financial and overall economic crisis triggered by the Covid-19 pandemic is different from past crises (Ding, et al., 2020, p. 1), in terms of its cause, scope, and severity (Reinhart, 2020, as cited in Ding, et al., 2020, p. 1). Covid-19 is a disruption that irreversibly changed in the past, still changes, and will change in the future the internal and external environment of companies, regardless of their size, activity, country, region or continent where they operate. In contemporary era, more than ever before, successful managers also need to plan and prepare in advance for possible financial and nonfinancial crisis and disasters, and establish disaster recovery and business continuity plans, but, nevertheless, no one could anticipate lockdown, risks, and damages that Covid-19 pandemic caused in the first year of its appearance, that still causes in the present, and that will cause in the future. Every crisis has its winners and losers or, in other words, companies whose management better reacts and copes with crisis, and companies whose management is not able to appropriately align its business and deal with crisis in real time.

Economies around the world are stagnating and suffering from the impact of Covid-19 pandemic, population mobility dropped sharply, businesses are experiencing losses, workers are without jobs, etc. (GlobalData Healthcare, 2020; Shen, et al., 2020), but companies that are taking centre stage in the Covid-19 fight are pharmaceutical companies (GlobalData Healthcare, 2020), as well as, biotechnology companies. These companies "are seeing positive growth on the stock market and a new burst of innovation in the infectious disease landscape as the race for treatment approval for a Covid-19 therapy takes off" (GlobalData Healthcare, 2020). Therefore, it can be concluded that pharmaceutical and biotechnology companies are companies whose role in the Covid-19 health pandemic is critical, because they develop, produce, and/or distribute vaccines that are essential for fighting with this deadly virus, and in that sense they can be seen, from the perspective of financial performance management, as winners.

Considering all that, in this paper we investigated what are the most important financial determinants that influence the profitability of the pharmaceutical and biotechnology companies. The research questions of this paper can be stated as follows: 1) how pharmaceutical and biotechnology companies coped with the Covid-19 crisis, and what is the impact on their profitability in 2020 compared to previous operating years, 2) how is the development of the vaccine financed and are R&D expenses significantly increased in 2020? The research objective of the paper was to investigate the impact of the Covid-19 crisis on the profitability of global pharmaceutical and biotechnology companies.

This paper is organized into five sections. After the introduction, in section 2, we review relevant literature and results of previous research studies in order to structure our research hypotheses. Furthermore, in section 3 we explain the data and research methodology, in section 4 we present research results and interpret them, and in section 5 we conclude the paper.

2. LITERATURE REVIEW

Profit maximization represents one of the essential objectives in business (Schmidlin, 2014; Fenyves, et al., 2019; Hristova, et al., 2019; Lim & Rokhim, 2020), and "therefore an important success measure in company valuation" (Schmidlin, 2014, p. 41). The profitability is determined by the company's market position, as well as, its cost management (Schmidlin, 2014, p. 102). In terms of companies' financial analysis, calculation of profitability ratios is very important part of the whole analysis (Fenyves, et al., 2019, p. 100). According to Lim & Rokhim (2020), understanding profitability determinants is the foundation of a company's strategic direction. Among profitability

ratios, the most important are profit margin (PM), return on assets (ROA), and return on equity (ROE) (Žager, et al., 2017, p. 52).

“The global pharmaceutical industry is constantly growing and is expected to grow more in the future in connection with demand factors, such as an aging society and chronic diseases and supply factors, such as the expansion of bioresearch” (Lim & Rokhim, 2020, p. 2). Furthermore, this industry is “one of the most profitable industries in the world, despite the very high proportion of the required research and development (further in text: R&D) costs that determine the activity itself and the high risks involved in investing in them” (Fenyves, et al., 2019, p. 99). Companies in the pharmaceutical industry “tend to develop new drugs to treat new diseases through R&D, in order to create a next-generation profit source or develop relatively cost-effective drugs to maximize enterprise value. Due to its exceptionally high R&D to sales ratio, the pharmaceutical industry is often characterized as the technology- and science-driven sector” (Lim & Rokhim, 2020, p. 2). Their important and indispensable role of development of new drugs, primarily vaccines, was seen in the fight against the Covid-19 pandemic.

From the outbreak of the Covid-19 pandemic, several studies have examined the impact of this pandemic on the corporate performance. Study that was among the first that examined this impact was study conducted by authors Shen, et al. (2020) on a sample of listed Chinese companies in period from 2013 to 2019, and in the first quarter of 2020. Results of Shen, et al.'s (2020, p. 2228) study revealed that “the Covid-19 outbreak has a significant negative impact on the performance of listed Chinese companies by decreasing investment scales and reducing the total revenue.” The most affected industries by the Covid-19 pandemic are tourism, catering, and transportation, and the pandemic had the most negative impact on their production, operation, and sales, which is consequently reflected in the negative return rates (Shen, et al., 2020, p. 2228). Authors Ding, et al. (2020) investigated the characteristics that shaped corporate immunity to the COVID-19 pandemic on a sample of over 6,000 companies across 56 economies during the first quarter of 2020. Their results revealed that (Ding, et al., 2020, pp. 30-31):

- companies with stronger pre-2020 financial conditions like, for example, more cash, less debt, and larger profits, experienced better stock price reactions to Covid-19 pandemic
- companies' international exposure to Covid-19 pandemic mattered, meaning that drop in stock prices due to the pandemic was larger among companies that were more exposed to the pandemic through their international supply chains and customer locations
- companies' stronger corporate social responsibility policies and activities prior to the Covid-19 pandemic experienced superior stock price performance in response to pandemic
- companies with less entrenched executives performed better in response to Covid-19 pandemic
- identity of companies' large owners are strongly associated with stock price reactions to Covid-19 pandemic, meaning that the stock prices of companies owned by hedge funds perform worse, while the stock prices of companies owned by non-financial corporations perform better.

This studies did not focused explicitly on the pharmaceutical and biotechnology companies. Furthermore, there is still scarce evidence of studies that explicitly focused on the impact of Covid-19 pandemic on the performance, as well as profitability, of pharmaceutical and biotechnology companies. So, this study is, to the best of our knowledge, among the first one that attempts to investigate and determine the impact of the Covid-19 crisis on the profitability of global pharmaceutical and biotechnology companies. In order to do that, we further analysed previously conducted studies, meaning prior to Covid-19 pandemic, which examined the corporate performance, and especially determinants of the profitability of pharmaceutical and/or biotechnology companies, to establish theoretical grounds for our empirical research. Several

authors (for example, see Roberts, 1999; Scherer, 2001; Koku, 2011; Leahy, 2012; Mohammadzadeha, et al., 2013; Bayazidi, et al., 2016; Fenyves, et al., 2019; Hristova, et al., 2019; Farhan, et al., 2020; Gupta, et al., 2020; Lim & Rokhim, 2020) investigated the various aspects of profitability and profitability determinants in the pharmaceutical sector in times before the Covid-19.

Analysing the profitability of pharmaceutical companies in Indonesia, on a sample of ten pharmaceutical companies listed on the Indonesia Stock Exchange covering the period of 2014 to 2018, authors Lim & Rokhim (2020) concluded that in general there exist strong and positive relationships between liquidity and sustainable growth rate with profitability, except earnings per share (EPS) for liquidity. They measured profitability by ROA, ROE, and EPS (Lim & Rokhim, 2020). Furthermore, it has been confirmed that company size and market power have significant and positive relationships with ROA, but significant and negative relationships with EPS, while sales growth and company efficiency, measured by assets turnover ratio, have no significant relationship with profitability (Lim & Rokhim, 2020).

Authors Gupta, et al. (2020) analysed the impact of intellectual capital on companies' profitability on a sample of 26 pharmaceutical companies listed on the National Stock Exchange in India for the time period of 2009 to 2018. The results revealed a significant relationship between intellectual capital and companies' profitability (Gupta, et al., 2020). It was also found that human capital, relational capital, and physical capital positively influence the profitability of a company (Gupta, et al., 2020). Profitability was measured by ROA, ROE, and EBITDA (Gupta, et al., 2020, p. 6). Intellectual capital "which is generally known as intangible assets covers the substantial components such as information, knowledge, copyrights and patents, research and development, human capital and innovation", and was measured by modified version of *Value Added Intellectual Coefficient* (VAIC™) (Gupta, et al., 2020, pp. 6-7).

In evaluating the effect of credit policy on the profitability of pharmaceutical companies listed on the Bombay Stock Exchange in India, using a sample data of 82 pharmaceutical companies from 2008 to 2017, authors Farhan, et al. (2020, p. 146) revealed that "the number of days' collection period and the number of days' payable deferral period have a negative and significant effect on the profitability of the pharmaceutical companies, while the control variables leverage, company size, and age negatively impact the profitability of pharmaceutical companies." For measuring companies' credit policy, number of days' collection period and number of days' payable deferral period were used, and for measuring companies' profitability, ROA was chosen (Farhan, et al., 2020).

Authors Fenyves, et al. (2019) conducted study, on a sample of companies from the Czech Republic, Hungary, Poland and Slovakia, covering the period of 2015 to 2017, whose objective was to examine whether the innovation policies of a country might have a significant impact on the profitability of pharmaceutical companies in the Central and Eastern European region. The ROE was used as a proxy for profitability (Fenyves, et al., 2019). According to the results, authors concluded that the more profitable pharmaceutical companies are able to utilize their assets more efficiently, while companies in the latter category financed their operations with external capital to a lower extent (Fenyves, et al., 2019, p. 99).

Authors Hristova, et al. (2019) conducted research in which they examined the liquidity-profitability trade off in pharmaceutical sector in the Republic of North Macedonia on a sample of two pharmaceutical companies listed on the Macedonian Stock Exchange over the period from 2006 till 2016. The obtained results revealed that there is no significant relationship between profitability and liquidity determinants (Hristova, et al., 2019). For measuring liquidity, current ratio (CR), quick ratio (QR), and cash ratio (CAR) were used, while for measuring profitability, ROA and ROE were used (Hristova, et al., 2019).

Authors Bayazidi, et al. (2016) conducted study on a sample of 27 pharmaceutical companies listed on the Tehran Stock Exchange for the time period from 2001 to 2013, in order

to investigate the effects of marketing and costs and R&D investments on profitability of pharmaceutical companies in Iran. Results revealed that company size, capital-to-total asset ratio and debt-to-asset ratio have an effect on profitability, while company life, advertising cost and R&D investment are ineffective on profitability (Bayazidi, et al., 2016). Profitability was measured by ROA (Bayazidi, et al., 2016).

For examining the determinants of profitability for a segment of the U.S. pharmaceutical industry on a sample of 2,001 pharmaceutical manufacturers, author Leahy (2012) measured profitability using gross margin, operating margin and Berry ratio, and confirmed that profitability is related to the functions performed and risks assumed by a company, and that the results vary with the industry examined.

Aligning to the major research questions we managed to develop the following research objectives. Firstly, to be able to determine the impact of the Covid-19 crisis on the profitability of pharmaceutical and biotechnology companies the first objective was to assess profitability determinants of those companies by focusing on their publicly available financial data. Considering the results of the conducted literature review the first research hypothesis is as follows: (H1) *Profitability of pharmaceutical and biotechnology companies is determined by their liquidity, solvency, and investments.* Furthermore, the focus of this research was to investigate how the Covid-19 pandemic scratched the financial results and profitability of pharmaceutical and biotechnology companies. Therefore, the second research hypothesis is structured as follows: (H2) *The relationship between profitability and profitability determinants of the pharmaceutical and biotechnology companies is moderated by the Covid-19 crisis.* Regarding their business operations, the question is how they financed diagnostics, medicines, and vaccine research, and how it was reflected in their financial statements. Although the effects of the crisis are yet to come to fruition in the next years, but undoubtedly, they should be noticed in the annual financial statements for 2020.

3. DATA AND METHODOLOGY

To be able to conduct the research, we decided to obtain the following data needed for calculating chosen financial ratios: total assets, total current assets, total current liabilities, total equity, operating revenues, cost of goods sold, R&D costs, interest expenses, earnings before taxation, net earnings, the trading volume of securities, daily prices, number of employees. Gathered data is sufficient to calculate all major financial indicators. A total of 14 variables are calculated to be used in preliminary panel analysis to test two research hypotheses. In the final analysis, not all variables were used, but most appropriate considering preliminary results. Also, following previous studies we included three control variables in the model (log of total assets, log of market volume, and industry measured by proportion of long-term assets in total assets).

To make conclusions regarding profitability determinants of global pharmaceutical and biotechnology companies, we obtained 11-year data (2010-2020) for the 52 globally largest listed companies observed by yearly generated net sales. Prepared database consists of two groups, company (*id*) with $= 1, \dots, N, N = 52$, and year (*time*) with $t = 1, \dots, T, T = 11$. Dataset that has both cross-sectional (*id*) and time-series (*time*) dimensions is known as panel data or longitudinal data (Wooldridge, 2020; Baltagi, 2005). Most authors that investigated determinants affecting profitability assumed linear relationships between independent variables (Lim and Rokhim, 2020; Gupta et al., 2020; Najib et al., 2020; Hristova et al., 2019; Fenyves et al., 2019; Mohammadzadeh, 2013; Leahy, 2012; Koku, 2011). Assuming linearity, general form of the regression model for panel data can be written as (Wooldrige, 2010) (1):

$$E(y_{it} | x_{it}, \alpha_i) = \beta_0 + x_{it}\beta_i + \alpha_i \quad (1)$$

where $\mathbf{x}_i\boldsymbol{\beta}$ is $\beta_1x_{it} + \dots + \beta_kx_{ik}$ and β_k represents parameters that should be estimated. Furthermore, the crucial assumption is that α_i has a constant partial effect over time. "An unobserved, time-constant variable is called an unobserved effect in panel data analysis." (Wooldridge, 2010, p. 282) In case when t represents period included in the research, α_i represents unobserved characteristics for each i company which can be considered as constant over time sometimes called an individual effect or individual heterogeneity (Wooldridge, 2010, p. 282). Model written in error (ε_{it}) form is as follows (2):

$$y_{it} = \beta_0 + x_{it}\beta_i + \alpha_i + \varepsilon_{it} \quad (2)$$

where, by definition, $E(u_{it}|x_{it}, \alpha_i) = 0$, and ε_{it} represents idiosyncratic errors or idiosyncratic disturbances because these change across t as well as across i (Wooldridge, 2010, p. 285).

The following question is which method of panel data transformation should be used to estimate β_k parameters. There are several widely used approaches, but the most popular are the fixed effects (FE) and random effects (RE) approaches. From the economic point of view FE effects should be used when results could be related only to the research sample, and in the case when we want to make general conclusions regarding population RE approach should be applied. In our case, the research sample covers all major companies in the pharmaceutical and biotechnology industry by which FE should be used. Each approach involves specific methods for estimating unobserved effects as differencing or time-demeaning and includes different assumptions. Application of pooled OLS is justified in the case when for each time period covered by the sample employed different observations i . In that case, the model may appear to be over-restrictive because β is the same in each time period and errors must be homoscedastic (variance of the error is constant for all observations) and there should not be a first-order correlation (Wooldridge, 2010, p. 191). Before the final choice of appropriate approach, we will test results for heteroscedasticity and auto-correlation problems.

To test the second research hypothesis to investigate the existence of effects of the pandemic crisis on the profitability of pharmaceutical and biotechnology companies we applied hierarchical multiple regression analysis, i.e. we included moderator variable into the regression equation. Moderator is used to test the effects of moderators on the interaction between dependent and independent variables (Hayes, 2017). The general form of the model is (3):

$$y_i = \beta_0 + \beta_1x_i + \beta_2z_i + \beta_3x_iz_i + \varepsilon_i, \quad i = 1, 2, \dots, n \quad (3)$$

where y_i is a dependent variable, x_i is the independent variable, z_i is a moderator and ε_i is an error term. As in the case of panel data regression, profitability as a dependent variable (y_i) will be measured by return on assets (ROA) and the independent variable (x_i) list will depend on the results of panel regression.

4. RESEARCH RESULTS

Nowadays, as a result of the Covid-19 pandemics, pharmaceutical and biotechnology companies take a leading role in directing and determining for how long this crisis is going to last. One of the most significant preconditions of new diagnostics, drugs, or vaccine development is an available source of financing. In most cases, biotechnology companies are those that research and develop new products in association with large pharmaceutical corporations that provide them needed production capacities and distribution logistics.

Half of the collected and distributed funds in 2018 were invested in R&D of Ebola (33%) and Zika (19%) diseases (Policy Cures Research, web). As expected, as a consequence of the Covid-19 pandemic, from the beginning of 2020 the priority and all investments are redirected to R&D of new efficient drugs, vaccines, and diagnostics of newly imposed coronavirus. It is more than clear that the Covid-19 crisis caused tremendous economic disruption with a price tag of over 4 trillion USD (CEPI, web). But coronaviruses are not something new, and they are a family of

numerous viruses that usually cause a mild cold. In 2012 world encountered the most fatal type of coronavirus known as Middle East Respiratory Syndrome (MERS) with a 34% case fatality ratio, and in 2002 Severe Acute Respiratory Syndrome (SARS) with 10% case fatality ratio (WHO, 2021a). Although vaccine research for SARS and MERS did not progress beyond the pre-clinical phase, “COVID-19 vaccine development efforts have benefited from the work previously done on MERS and SARS, as evidenced by the fact that the most advanced COVID-19 vaccine is based on a platform already investigated for MERS” (Chapman et al., 2020, p. 25). Although the trustworthiness and efficiency of developed Covid-19 vaccine are widely questioned, primarily because of accelerated research and approval process, the confidence can be justified by the fact that Covid-19 R&D investments in 2020 are over 9 billion USD, and they are almost 224 times higher than investments in coronaviruses R&D in 2018 or 1.36 times higher than total R&D investments in neglected diseases, sexual & reproductive health, and EIDs in 2018. Furthermore, over 70% of Covid-19 R&D investments are directed to vaccine development (WHO, 2021b).

Over 44% of total R&D investments for Covid-19 are from the US government (88%), mainly BARDA and NIF. The companies in which the US government directed most of the funds are the partnership of *GSK & Sanofi* (1 billion USD or 26%), *Moderna* (0.96 billion USD or 24%), and *Janssen* (0.61 billion USD or 15%). German government invested 12% of total R&D funds, which are in the largest proportion invested in *CEPI*¹ (14%). Most of the funds (0.45 billion USD) German government gave to *BioNTech* to accelerate vaccine development (Griffin and Armstrong, 2020). Finally, the UK government invested 7% of total R&D funds, of which 47% is given to *CEPI* and 17% to the *University of Oxford* which in cooperation with *AstraZeneca* produced two-dose viral vector non-replicating vaccine. Until today (April 27, 2021) FDA authorized three vaccines for emergency use (*Pfizer-BioNTech*, *Moderna*, and *Janssen*) (FDA, 2021a, n.a.) and EMA authorized four vaccines (*Pfizer-BioNTech*, *AstraZeneca*, *Moderna*, *Janssen*) (EMA, 2021a, n.a.).

Of the total number of companies in the sample, 20 or 38% of them are classified either as a provider of necessary drugs for curing Covid-19 patients or as a developer of effective and efficient vaccine or diagnostics (*Pfizer*, *AstraZeneca*, *GlaxoSmithKline PLC*, *Merck & Co., Inc.*, *Moderna, Inc.*, *Sanofi S.A.*, *Sinopharm Group Co., Ltd.*, *BioNTech SE*, *Sinopharm*, *CureVac NV*, *Dynavax Technologies Corp*, *Novavax Inc*, *Regeneron Pharmaceuticals Inc*, and others). The average value of total assets (TA) for all observations is 39.8 billion USD and of sales revenues (REV) 18.7 billion USD (Table 1). Furthermore, average results show that companies in the sample are not profitable, but the median of the return on assets (ROA) indicates that 50% of observations generate profit, i.e. they are yearly able to return 6.2% of total assets measured by net earnings and interest expenses. Furthermore, obtained data is noisy considering what, results does not include outlier observations.

¹ The Coalition for Epidemic Preparedness Innovations (CEPI) is founded in 2017 aftermath of the 2014–2015 Ebola outbreak in west Africa as a foundation that takes donations from public, private, philanthropic, and civil society organisations, to finance independent research projects to develop vaccines against emerging infectious diseases (EID) (Gouglas et al., 2019).

Table 1 Descriptive statistics of chosen variables for all observations, where appropriate in million USD (n=515)

	AVG	SD	MED	MIN	MAX
TA	39,812	43,365	23,251	0	195,014
TCA	12,922	13,517	8,252	0	65,032
TCL	8,231	8,919	4,864	0	45,135
REV	18,867	18,289	14,045	0	82,584
R&D	2,579	3,202	1,096	0	14,751
ROA	-0.097	1.013	0.062	-16.399	0.863
PM	-8.378	120.993	0.100	-2616.27	37.064
REV/COGS	3.98	11.88	2.51	0.00	219.34
REV/R&D	9.57	14.30	6.12	0.00	149.97
WCR	1.418	2.381	0.701	-0.898	30.118
TOR	0.555	0.402	0.488	0.000	2.978
DTA	0.600	0.575	0.556	0.070	11.266
log_R&D	2.930	0.968	3.150	-0.456	4.169
log_TA	4.002	1.166	4.366	-0.831	5.290
FAS	0.572	0.218	0.628	0.011	0.931
log_vol	8.092	1.410	8.530	2.943	10.142

Legend: TA – total assets, EQ – Equity; REV – operating revenues; R&D – research and development costs; ROA – return on assets; WCR – working capital ratio; TOR – total assets turnover; DTA – debt-to-assets ratio; log_R&D – natural logarithm of R&D; log_TA – natural logarithm of TA; FAS – long-term assets proportion (industry indicator); log_vol – natural logarithm of number of traded shares; AVG – mean; SD – standard deviation; MED – median; MIN – minimum; MAX – maximum; ID - Industry difference (p-value of Kruskal-Wallis Test); RD - Region difference (p-value of Kruskal-Wallis Test); VD - Vaccine developer difference (p-value of Mann-Whitney U Test)

Source: Authors' calculation

Coefficients of Pearson correlation show a significant relationship between chosen variables (Table 2). The table shows that the return of assets (ROA) of the pharmaceutical and biotechnology companies is significantly negatively related with solvency measured with debt-to-assets ratio (DTA) ($\rho=-0.763$ with p-value 0.000 at the level of 1%). Furthermore, profitability (ROA) is positively related to R&D costs (log_R&D), total assets (log_TA), and share of long-term assets in total assets (FAS). All those relationships are significant at the level of 1%.

Table 2 Pearson Correlation of chosen variables for all observations (n = 515)

	ROA	PM	WCR	TOR	DTA	log_R&D
ROA	1.000	0.217**	-0.025	-0.052	-.763**	.444**
PM	0.217**	1.000	-0.084	0.094*	-0.203**	.050
WCR	-0.025	-0.084	1.000	-.292**	-.219**	-.400**
TOR	-0.052	0.094*	-.292**	1.000	.122**	0.032
DTA	-.763**	-0.203**	-.219**	.122**	1.000	-.114*
log_R&D	.444**	0.050	-.400**	0.032	-.114*	1.000

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Source: Authors' calculation

Table 3 shows regression results for panel data and determinants that influence the profitability of pharmaceutical and biotechnology companies. To analyse data, we applied robust standard errors for fixed-effects panel regression (FE) (Hoechle, 2007) on the one side, and regression with Driscoll and Kraay (1998) standard errors (D-K FE) (Hoechle, 2006) on the other. Both models handle heteroskedasticity and autocorrelation problems found within the data. Results confirm the significance of both robust models

(Chi-square is 7.720 and 490.290 with p-values 0.000). By observing independent variables, equal coefficients but different p-values can be noticed.

Table 3 Regression results of factors affecting profitability.

	FE		D-K FE	
	Estimate	p-value	Estimate	p-value
WCR	-0.00255	0.875	-0.00255	0.765
TOR	0.22919	0.038	0.22919	0.407
PM	0.00038	0.032	0.00038	0.000
DTA	-0.54677	0.000	-0.54677	0.001
log_R&D	-0.55501	0.003	-0.55501	0.018
log_COGS	-0.31066	0.080	-0.31066	0.006
log_TA	1.12709	0.006	1.12709	0.003
FAS	-0.31826	0.160	-0.31826	0.029
log_vol	-0.09460	0.091	-0.09460	0.054
_cons	-0.83218	0.102	-0.83218	0.083
F	7.720	0.000	490.290	0.000
R ²	0.498		0.498	
no of obs	421		421	
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

Source: Authors' calculation

Both models show a significant relationship of return on assets (ROA) with profit margin (PM), debt-to-asset ratio (DTA), and the logarithm of R&D costs (log_R&D). According to the obtained results, the decrease of indebtedness and decrease of R&D costs has the most significant impact on the profitability increase. Furthermore, although there is a positive relationship of the profit margin (PM) with the return on assets (ROA), the variable has a negligible effect, i.e. if the profit margin increase by 1, the return on assets would increase by 0.00038. In the Driscoll-Kraay model, next to those two variables, a significant relationship with profitability has a logarithm of costs of goods sold (log_COGS), but that is not the case in a regular robust model, so the result must be taken with caution. The same story is with total assets turnover in the case of the robust model. Furthermore, it is interesting to notice that liquidity (measured by working capital ratio) is not significantly related to the profitability of pharmaceutical and biotechnology companies. Thus, although according to the results, liquidity is not a profitability determinant of analysed companies, the first research hypothesis can be accepted. Therefore, the assumption that the profitability of pharmaceutical and biotechnology companies is determined by its solvency and investments can be accepted.

Table 4 Results of hierarchical multiple regression analysis

Model	R	R ²	Adj. R ²	Change Statistics			Durbin-Watson
				R ² Change	F Change	Sig. F Change	
Model 1	.541	0.292	0.278	0.292	21.062	0.000	
(DTA)	.640	0.410	0.393	0.118	20.198	0.000	1.636
Model 2	.531	0.282	0.267	0.282	18.101	0.000	
(R&D)	.614	0.377	0.356	0.094	13.763	0.000	1.802
Model 3	.549	0.302	0.288	0.302	21.831	0.000	
(COGS)	.614	0.376	0.358	0.075	11.961	0.001	1.887
Model 4	.255	0.065	0.046	0.065	3.535	0.033	
(PM)	.263	0.069	0.042	0.004	0.487	0.487	1.756

Source: Authors' calculation

The effects of the Covid-19 crisis on the financial results of pharmaceutical and biotechnology companies are tested by regression analysis with included moderator variable. As it was stated in the methodology section, a moderator is a dichotomous variable where pandemic year (2020) is coded with 1 and corona-free year (2018) with 0. Results of the previous part of the research showed that the most important profitability determinants of pharmaceutical and biotechnology companies are debt-to-assets ratio (solvency), R&D costs (investments), and additional variables as profit margin and cost of goods sold (Table 4). Considering those results, we prepared four regression models with moderating variables. Statistical significance of the change in R^2 is present for three of four analysed variables. Change in R^2 represents the effect of the addition of the moderator effect. The moderator variable statistically significantly moderates the relationship between independent and dependent variables. By including moderator into regression analysis, in case of debt-to-assets ratio, variation explained by the moderator is increased by 11.8%, in case of R&D is increase by 9.4%, and for costs of goods sold by 7.5%. The relationship between return on assets (ROA) and profit margin (PM) did not significantly changed in the Covid-19 year compared to 2018. Considering results, the hypothesis that the relationship between profitability and profitability determinants of the pharmaceutical and biotechnology companies is moderated by the Covid-19 crisis can be accepted.

5. CONCLUSION

Comprehensive analysis of external factors related to the corona crisis gave us an answer to the research question how is the development of the vaccine financed and are R&D expenses significantly increased in 2020? Investment in research of SARS-CoV-2 in 2020 surpasses overall R&D investments in previous years multiple times. Record high investments of over 9 billion USD, mostly from US, UK, and German governments, are directed to the most significant pharmaceutical and biotechnology companies (*Moderna, J&J, BioNTech, Pfizer*). But, although those amounts are record high in sense of publicly tracked sources, they are not so significant in the context of average yearly investments of major players. For example, the 10-year average of *Roche* R&D cost is over 11.9 billion USD, *J&J, Merk & Co., Pfizer* invest around 9 billion USD yearly, *GSK, AstraZeneca, Bristol Myers* around 6 billion USD in R&D. Nevertheless, research results show that government investment in Covid-19 research was especially significant for biotechnology companies.

The results of conducted fixed-effects panel data regression show that the most important profitability determinant of the pharmaceutical and biotechnology companies is its solvency measured by the debt-to-assets ratio. We found a statistically significant and negative relationship between solvency and profitability indicating that analysed companies do not use financial leverage adequately. Additionally, results indicate that R&D costs also negatively affect profitability. Although the result is under accounting foundation, the question is if the effect would be different by including time-dimension into the equation. A parallel conclusion can be made for the solvency effects. Future research could investigate if there exist 'belated' effects of using debt to increase shareholders' earnings, or if R&D investments have lagged effect on the profitability. Next to solvency and investment, we found that cost of goods sold, and profit margin are significant determinants of companies' profitability. Our results are in accordance with research results of analysed empirical studies which was conducted in literature review section.

In the last part of the research, we investigated the effect of the Covid-19 crisis on the relationship between companies' profitability and determining profitability factors. Results indicated that the pandemic has a significant effect on the relationship between return on assets and debt-to-assets, R&D costs, and cost of goods sold. For biotechnology companies the Covid-19 crisis brought enormous beneficial changes in financial position and improvements in business performance. For the pharmaceutical companies effects in 2020 are twofold. Their operations stayed stable, but average profitability decreased from 9% to 6%, indebtedness increased, activity

and liquidity decreased. Therefore, the overall effects of the Covid-19 crisis will be evident after ending it. It could be said that the decrease of financial ratios in 2020 is only temporary and, by taking into account all circumstances on the global level, their blooming time is yet to come.

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