INVESTING IN INNOVATION: THE RELATIONSHIP BETWEEN R&D SPENDING AND FINANCIAL PERFORMANCE IN THE EUROPEAN PHARMACEUTICAL INDUSTRY

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ABSTRACT

The pharmaceutical industry is highly capital and knowledge-intensive, spending approximately 15% of its total revenue on research and development (R&D). This study aims to find the relationship between pharmaceutical businesses' financial performance and investments made in drug research and development in Europe. The study employs regression analysis with a time-lag effect of R&D spending on operating earnings. It is hypothesised that the investment expenditure of the previous year's R&D investment will significantly and concurrently impact the economic-financial performance of the country and the findings show a strong and positive link between the previous year's R&D expenditure and the current year's operating profit in the European countries, providing convincing evidence that R&D investments will pay off financially in the years ahead for the development of pharmaceuticals. The study also conducted diagnosis tests for the validation of the estimated models.

Keywords: R&D investment; financial performance; pharmaceutical industry; Europe

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INTRODUCTION

The pharmaceutical industry is a highly capital and knowledge-intensive industry that spends approximately 15% of its total revenue on research and development (R&D), (Downs & Velamuri, 2018). The European Union (EU) has the world's second-largest market in terms of sales, and the total investment in pharmaceutical sector has more than doubled since the pre-pandemic period (Azierta, 2019). In fact, in 2019, 8.3% of GDP had been spent on health sector, and pharmaceutical production costs accounted for nearly one-sixth of total health expenditures. The retail pharmaceutical bill was approximately Euro 190 billion in 2018 (OECD, 2020), and it is a significant contributor to innovation investment (European Commission, 2021). According to le Deu & Santos Da Silva (2019), the increase in total investment in Europe's biotech firms more than doubled; it was $5.1 billion during the seven years from 2005 to 2011, but increased more than twice in the following seven years, 2012 to 2018, to $11.9 billion. That is why the general public expects to have access to safe, effective, and affordable medicines, therapies, and vaccinations, even if the benefits vary across

European countries (European Commission, 2021).

Pharmaceutical companies' investment in research has increased, resulting in a greater number of applications for new drug approvals (Dubey & Dubey, 2010; Horrobin, 2000), and therefore, the traditional model of pharmaceutical innovation is being challenged by an increase in R&D costs (Gassmann, Reepmeyer, & von Zedtwitz, 2008). Pharmaceutical R&D is a highly competitive field that seeks cutting-edge solutions to global health issues. A major issue confronting this industry is the wide disparity in R&D funding allocated to various illnesses and pharmaceutical research areas (Hanekom, Bam, & Kock, 2019. Due to the uncertainty in pharmaceutical R&D, European pharmaceutical R&D has been preoccupied with several problems and challenges, such as financial portfolio risk and ineffective portfolio management capacities, while companies spend a large sum of money on R&D each year from revenue (Leten et al., 2011; Cowlrick et al., 2011; Timmerman, et al., 2013; Chaudhuri, 2013; Magazzini et al., 2016; Banerjee & Siebert, 2017; OECD, E.U. 2020). In addition to these challenges, there is mismanagement in collaboration between European and other regional companies (Towse, & Sharma, 201; Sieg et al., 2019), R&D productivity in Europe is declining (Goldman, 2012), and there is a lack of studies on orphan drug development research (Logviss, Krievins, & Purvina, 2014; Houez, 2020), which make it challenging to compare R&D spending with competitors. Importantly, there is a high risk in pharmaceutical innovation, and because the cost of R&D activities is high, it is essential to justify how much innovation spending contributes to the business in emerging countries in Europe. Furthermore, it is critical to determine whether developed countries are experiencing satisfactory growth in terms of financial performance and reasonable R&D investment, which has been uncovered by researchers extensively in Europe.

Bockova, & Zizlavsky, (2016) found that R&D expenditures are positively related to the growth of selected pharmaceutical companies in the Czech Republic. Boldeanu and Pugna (2014) stated that pharmaceutical companies in Europe rely heavily on R&D activities for financial development, but they were unable to identify any econometric relationship between these factors. While Europe may lag behind in pharmaceutical research, many countries, including Turkey, Jordan, and India have examined the impact of R&D on company financial development in several studies, such as (Ayaydın & Karaaslan, 2014; Freihat, & Kanakriyah,2017; Nandy,2020).

This study aims to find the relationship between pharmaceutical businesses' financial performance and investments made in drug research and development in Europe. The study employs regression analysis with a time-lag effect of R&D spending on the operating earnings. It is hypothesised that the investment expenditure of the previous year's R&D investment will significantly and concurrently impact the economic-financial performance of the country. Results are then estimated using both descriptive and empirical statistics and diagnosis of the validity of the models. Finally, it ends with discussions and conclusions. The empirical result shows that there is always a positive and a very highly significant correlation between the one-period lag R&D expenditure and current-year operating performance. This implies that the number of funds businesses spend on R&D increases the business's operating profit.

THE SCENARIO OF R&D INVESTMENT AND OPERATING PROFIT OF THE EUROPEAN PHARMACEUTICAL INDUSTRY

The pharmaceutical industry generates 1.2 trillion dollars in revenue worldwide. With so much money on the line and the rate at which technology is changing, the pharmaceutical business must embrace new technologies, patient design and innovations, and place a larger emphasis on prevention and digital health (Mesko, 2021).

The majority of EU nations report positive operating profits, however firm-level results are very dissatisfactory, as most companies are suffering from negative operating profits. For example, in 2020, 53 pharmaceutical companies out of 147 had positive operating profits, but in 2018, it was 66 out of 169, and in 2015 it was 48 out of 133. Table 1 in the annex shows the country-by-country operating profit due to the presence of a few large companies in Europe generating the maximum income share of the respective counties. Before Brexit, the UK was a significant player in the EU's operation profit

growth, particularly when it came to the profits generated by firms like GlaxoSmithKline and AstraZeneca. Germany, France, and Denmark are the other major contributors in addition to the UK. The three biggest pharmaceutical companies in Germany are Boehringer Sohn, Bayer, and Merck De. Bayer experienced negative operating profit in both 2018 and 2020, which had a detrimental impact on Germany's pharmaceutical business. However, Merck De and Boehringer Sohn's consistent operating profit performance revived the country's pharmaceutical and biotechnology sectors during those years.

Sanofi has contributed about 90% of operating profit in France out of 100% over the years. The stability of Sanofi's business is also encouraging, even during pandemic periods when several large companies failed to achieve their goals, such as Bayer from Germany, which had a negative 10821.0 million euro operating profit in 2020. Novo Nordisk is the largest contributor in Denmark, equivalent to Sanofi. There are also some new businesses there, such as Novozymes, Chr Hansen, and H Lundbeck.

The R&D expenditure is quite high in countries such as the United Kingdom, Germany, France, Denmark, and Ireland. Despite the fact that Ireland pharmaceutical firms have almost always had a negative operating profit, R&D spending is quite high, at around 3000 million euro per year. Further study needs to be conducted to determine Irish inefficient R&D spending (see details in Table 2, also in the Annex.)

LITERATURE REVIEW

The literature review section has been developed to demonstrate an in-depth study on the significance of R&D Investment in the pharmaceutical industry and challenges in European pharmaceutical R&D investments and expenditures. The study has assembled articles from the Web of Science and Scopus databases, as well as journals ranked by the Chartered Association of Business Schools (CABS), to search for the following key terms: “the importance of R&D Investment in the pharmaceutical industry” and “challenges in European pharmaceutical R&D investments and expenditures”. The terms were searched in the titles, abstracts, and keywords of the publications.

THE IMPORTANCE OF R&D INVESTMENT IN THE PHARMACEUTICAL INDUSTRY

Pharmaceutical innovation necessitates the novelty of effectiveness. Pharmaceutical innovations add value to society by enabling previously unattainable improvements in patient health. It is essential that health policymakers and practitioners evaluate, adopt, and procure products in ways that recognize, encourage, and give priority to truly valuable pharmaceutical innovations. (Morgan, Lopert, & Greyson, 2008; Baranov & Muzyko, 2015). The search of the Web of Science (WOS) database found 42 papers on the importance of R&D investment in the pharmaceutical industry, and 11 papers were tentatively reviewed (Table 3 and Figure 1). Table 3 shows that several factors, including process management, alliances, patents, and policy levers, are essential for pharmaceutical R&D operations. Studies on these elements' effects on R&D spending and their influence on pharmaceutical company performance, however, have both positive and negative, as well as neutral, aspects, as is shown in Figure 1.

According to the literature, pharmaceutical companies invest in R&D to stimulate business innovation in the majority of cases. Examples include investments in process management, patent protection for newly approved drugs, research alliances with inbound or outbound partners, policy intervention, and others. Throughout these activities, R&D investments turn a positive impact on pharmaceutical business performance, (Cockburn, & Long, 2015; Mazzola, Bruccoleri & Perrone, 2016; Rake, 2017; Zambuto, Lo Nigro & O'Brien,2017; Chit, & Grootendorst, 2018; Frigyesi, Laget, & Boden, 2019; Leten, Kelchtermans, & Belderbos, 2022). Only very few papers suggest a negative or unclear relationship between R&D investment and business performance. For example, Paranhos, & Hasenclever (2011) explained that company strategies and government support are insufficient for drug innovation due to the limits of modern infrastructure. Therefore, the investment in R&D stimulates the entire pharmaceutical process and business development, which adds value to the financial performance of the company.

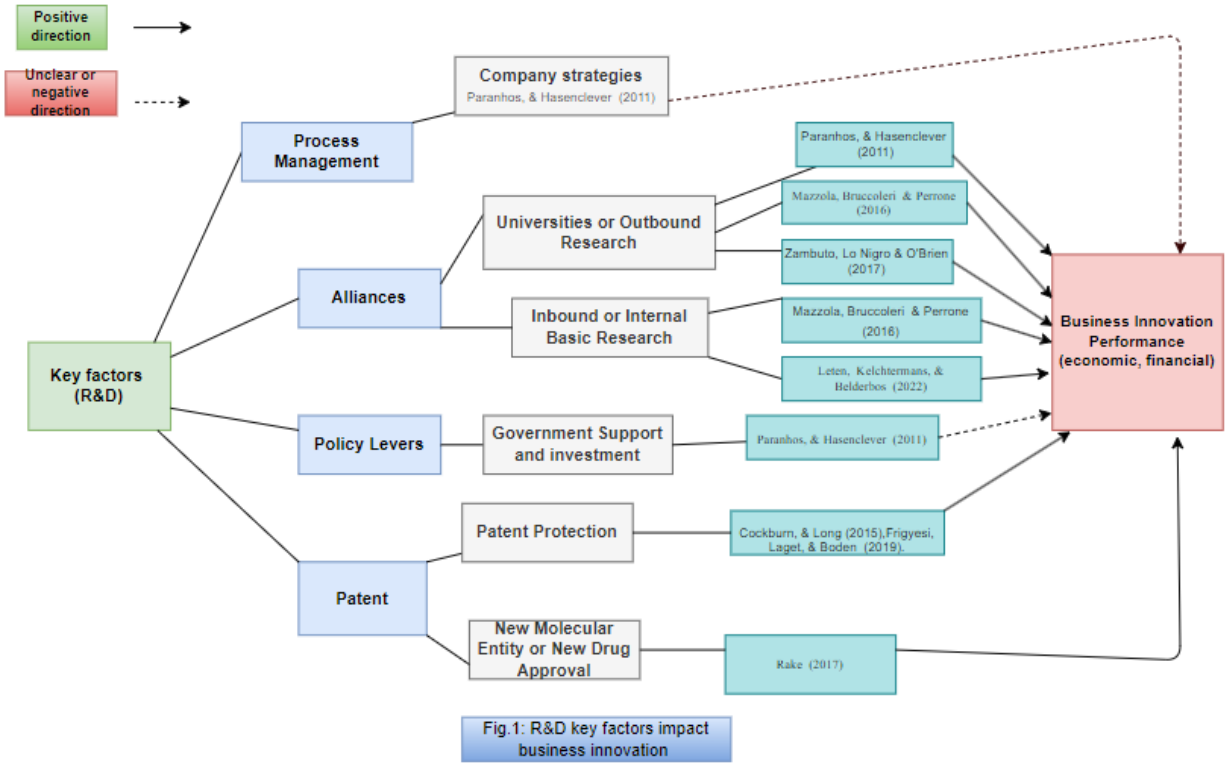

Figure 1: The key factors of R&D impact business innovation
Source: Authors (2023).

THE HYPOTHESIS OF THE STUDY

It is expected that the investment expenditure of the previous year's R&D investment will impact significantly and concurrently the economic-financial performance of the country. However, the literature represents both positive and negative relationships among these variables. There is a positive relationship between R&D deployment intensity in the previous years (t-1, and t-2) and current economic returns (t) year for the technology-based entrepreneurial medical, surgical, and dental instruments industry (Kor, & Mahoney, 2005). R&D activities had a significant positive impact on the financial performance of Indian pharmaceutical companies, where both dependent and independent variables were estimated at the current period, (Nandy,2020). Researchers identified R&D expenditures that are positively related to the growth of selected branches of the manufacturing industry. Innovative pharmaceutical companies in the Czech Republic have created higher value in most years (Bockova, & Zizlavsky, 2016). In addition, the intellectual capital of a company has a positive impact on its market value and financial performance, and it may be an indicator of future financial performance. R&D expenditure may capture additional structural capital information and has a positive effect on firm value and profitability (Chen, Cheng, & Hwang, 2005).

Table 3: The Importance of R&D Investment in the Pharmaceutical Industry

Author(s) and years	Objectives	Key factors	Findings
Paranhos, & Hasenclever (2011)	The role of industry-university R&D in pharmaceutical innovation in Brazil.	Strategies conducted by companies, the universities' approach, and the government's action .	Company strategies and government supports are insufficient for drug innovation due to the limits of modern infrastructure; however, it becomes effective when firms and universities collaborate in R&D activities for innovation.
Cockburn, & Long (2015).	To find out the importance of patents to drug innovation.	Patents as an indicator of pharmaceutical innovation.	There is a differential and high importance of patents to biopharmaceutical innovation.
Mazzola, Bruccoleri & Perrone (2016).	The influence of open innovation on pharmaceutical company performance.	Inbound, outbound, and coupled open innovation practices	When open innovation is separately counted rather than aggregative, it is more effective on economic-financial and innovation performance.
Rake (2017).	To understand the determinants of pharmaceutical innovation.	A new molecular entity and new drug approvals are indicators of drug innovation.	The quantity of new pharmaceuticals—new molecular entities or new drug approvals—has a fairly strong and significantly favorable relationship with market size and technological prospects.
Zambuto, Lo Nigro & O'Brien (2017).	To examine the role of alliances in the capital investment decisions of pharmaceutical firms.	Alliance in R&D activities	Businesses should reduce leverage to encourage alliance partners to invest and demonstrate sustained commitment.
Frigyesi, Laget, & Boden (2019).	How patent contributes to having effective R&D output.	Patents as a determinant of R&D output	A patent is important since R&D for pharmaceutical products can take longer time.
Leten, Kelchtermans, & Belderbos (2022).	The impact of basic research on enhancing the performance of innovation at the leading pharmaceutical companies in the world.	Firms' innovative performance through two strategies, internal basic research to improve the absorption of external research, and basic research in serving as an input for its technology development.	These two methods considerably mediate the positive association between internal basic research and innovation performance.

Source: Authors (2023)

On the other hand, managers are encouraged to cut discretionary spending (R&D and advertising) in the previous year(s) in order to increase accounting earnings and compensation (Murphy, & Zimmerman, 1993). ROA is also negatively related to R&D investment, implying that when a company invests in R&D, its short-term performance suffers (Tang, Hull, & Rothenberg, 2012). The intensity of internal research and development (R&D) has been found to have an indirect relationship with the diversity of the technology alliance portfolio and product innovation performance (Faems, et al. 2010).

Patents as an output determinant of pharmaceutical innovation (Cockburn, & Long, 2015; Frigyesi, Laget, & Boden, 2019), a new molecular entity and new drug approvals as indicators of drug innovation (Rake, 2017), and alliance firms' investment in R&D activities (Zambuto, Lo Nigro, & O'Brien, 2017) are examples of R&D indicators. The impact of basic research on improving the performance of innovation at the world's leading pharmaceutical companies is determined by internal and external or mixed modes of research; in these R&D programs, stakeholders such as industry, university, and alliance institutions play significant roles, which has a substantial effect on pharmaceutical business strategies and performance (Paranhos, & Hasenclever, 2011; Mazzola, Bruccoleri, & Perrone, 2016; Zambuto, Lo Nigro, 2016).

CHALLENGES IN EUROPEAN PHARMACEUTICAL R&D INVESTMENTS AND EXPENDITURES

A search of the Web of Science and Scopus databases, as well as the ranked journals in the Chartered Association of Business Schools (CABS), generated 19 articles on "challenges in European pharmaceutical R&D investments and expenditures" (See Table 4).

Pharmaceutical R&D is a highly competitive activity that seeks cutting-edge solutions to global health issues. A major issue confronting this industry is the wide disparity in R&D funding allocated to various illnesses and pharmaceutical research areas. This variety results in some diseases receiving money that appears to be disproportionally large when compared to the burden of disease, while other diseases are ignored (Hanekom, Bam, & Kock, 2019). Additionally, pharmaceutical R&D spending is quite high, in spite of the risk and uncertainty of achieving a low output rate. As a result, the sector's R&D system is fraught with obstacles. Europe, for example, invests the most in pharmaceutical R&D (Greer et al., 2014; European Commission, 2021). Downs and Velamuri (2018) calculated R&D spending as 15% of the company's revenue. According to the research of Banerjee and Siebert (2017) and Cowlrick et al. (2011), the early stage of a pharmaceutical company is challenged by high demand, profit, and technological uncertainties, which improves the chances of completing drug development. R&D collaborations formed later in the R&D phase are motivated less by these delays and more by a lack of R&D funding. While Spain is an example of a country with extremely low R&D spending as a percentage of GDP, with only 1% of GDP allocated to it, the country ranks 24th out of 30 OECD member countries in terms of R&D investment, according to Desmet et al. (2004).

Importantly, Sieg et al. (2019) investigated the managerial finance challenges that businesses face when collaborating with an innovation intermediary to solve R&D problems. Researchers have investigated three managerial challenges: enlisting internal scientists to collaborate with the innovation intermediary, selecting the right problems, and formulating problems so that they can be solved. In the opinion of Magazzini et al. (2016), there is a lack of knowledge from project portfolio managers about the effectiveness of different methods in selecting target markets, as well as a lack of knowledge about project R&D costs and how companies can completely contribute to their failed research projects. In the study by Leten et al. (2011), pharmaceutical R&D investment was shown to be unpredictable due to a lack of portfolio management skills.

Some studies have raised concerns about the use of R&D design in the pharmaceutical industry. For example, Chaudhuri (2013) investigated that generic pharmaceutical product production presents unique challenges, and businesses must develop a well-designed method to reduce development costs and time while maintaining product quality. Desmet and colleagues (2004) Spain's National Pharmaceutical Research Program, which used detailed firm-level data, focused on design rather

than implementation. The outcome suggests that excessive attention may have been paid to analyzing the design's optimality or the achievement of the objectives. At the same time, too little attention is paid to the actual execution or implementation of the design. Even if the selection criteria are ideal, the plan will fail if it is not properly implemented; more information is provided in Table 4.

Furthermore, (Theuretzbacher,2012) discussed the growing challenges of the multidrug-resistant (MDR) pandemic. MDR creates a barrier to disease control by increasing the likelihood that resistant pathogens will grow, decreasing the effectiveness of therapy, and causing patients to be infected for a longer period of time (Wang et al., 2020). There is little interest in Orphan Drug (OD) production and R&D spending, despite the fact that these medications are referred to as "orphans" because, under normal market conditions, the pharmaceutical industry has little interest in creating and promoting goods for only a small number of patients suffering from extremely rare illnesses (Logviss, Krievins, & Purvina, 2014; Houez, 2020).

Table 4: Summary of the Challenges in European Pharmaceutical R&D.

Author/s	Challenges in European pharmaceutical R&D.
(Leten et al., 2011)	Due to a lack of portfolio management skills, pharmaceutical R&D investment is unpredictable.
(Towse, & Sharma, 2011).	A delayed agreement on antimicrobial resistance R&D collaboration between the US and Europe was reached.
(Cowlrick et al., 2011)	There are many uncertainties and risks in the early stages of pharmaceutical development.
(Goldman, 2012)	R&D productivity in the European pharmaceutical industry is declining.
(Theuretzbacher,2012)	The growing challenges of a multidrug-resistant (MDR) pandemic.
(Timmerman, et al., 2013)	In response to investing capital in newly invented bio-pharmaceutical technologies, the pharmaceutical industry has become increasingly risk averse.
(Chaudhuri, 2013)	Generic pharmaceutical products face significant challenges during the manufacturing process.
(Logviss, Krievins, & Purvina, 2014; Houÿez, 2020).	There is little interest in orphan drug production and R&D spending.
(Magazzini et al., 2016)	Project portfolio managers are unaware of the effectiveness of various strategies.
(Parsons, et al., 2016)	PPI (patient and public involvement) in drug research and development must be improved.
(Mennini, et al., 2016; Chan, et al., 2019).	In terms of pharmaceutical R&D expenditures, Italy lags behind the rest of Europe.
(Banerjee & Siebert, 2017)	High uncertainty and low likelihood of success in pharmaceutical research phases, as well as frequent R&D funding scarcity.
(Downs & Velamuri, 2018)	Pharmaceutical companies spend about 15% of their total revenue on research and development (R&D), but the outcomes are highly uncertain.
(Sieg et al., 2019)	Managerial challenges that businesses face when collaborating with an innovation intermediary to solve R&D issues.
(OECD, E.U. 2020)	EU countries have a high rate of investment in the pharmaceutical industry.
(European Commission, 2021; Greer, et al. 2014).	The European pharmaceutical industry makes a significant contribution to innovation investment.

Source: Authors (2023).

METHODOLOGY

The Steps in the Research Process

Figure 2 describes the steps involved in the research process. First, extensive literature reviews from remarkable databases like Web of Science, Scopus, and others have been conducted to identify the contemporary challenges in the European pharmaceutical industry in regard to R&D investment, and what has been discussed in previous research for R&D investment and its relationship with business performance.

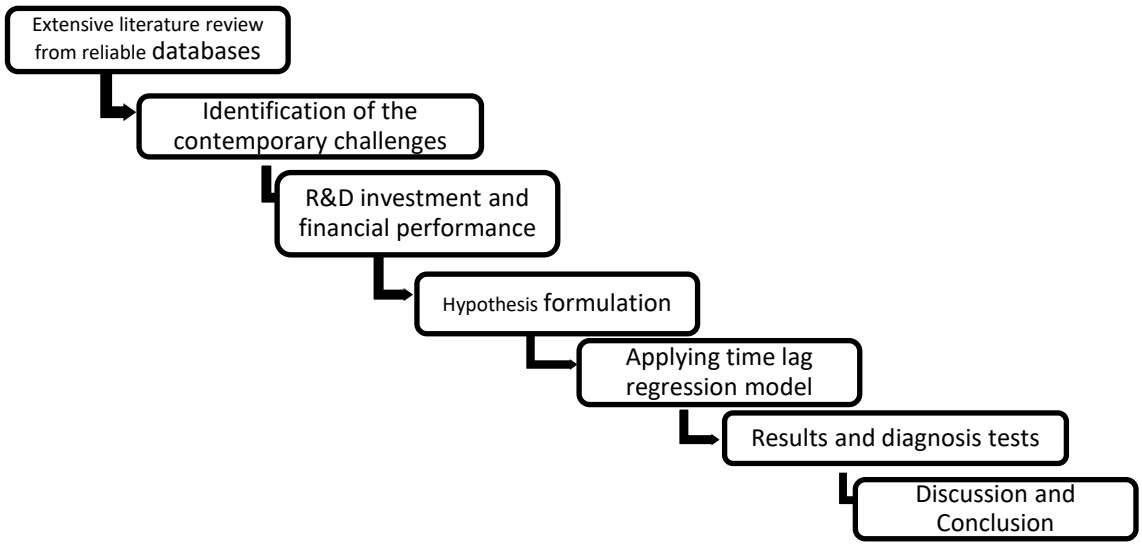

Figure 2: The steps in the research process.
Source: Authors (2023).

After the intensive literature review, the study formulates the hypothesis that the investment expenditure of the previous year's R&D investment will impact significantly and concurrently the economic-financial performance of the country. The study collected country-level data from EU Industrial R&D Investment Scoreboard data from the European Commission and used a regression model considering the time-lag effect of R&D spending on operating earnings. The study obtained results from the econometric software STATA-14. It also ran diagnostic tests of the model through the skewness/Kurtosis test for normality (Schilling & Nelson, 1976; Bai, & Ng, 2005) and tested heteroskedasticity using the Breusch-Pagan and Cook-Weisberg tests for heteroskedasticity (Breusch, & Pagan, 1979). Finally, the significance of the results is discussed compared with other studies in the discussion part, and, in the conclusion, the main insights of the research are presented.

HOW LITERATURE REVIEW HAS BEEN CONDUCTED

An extensive literature review was conducted to find out "the importance of R&D Investment in the pharmaceutical industry" and "challenges in European pharmaceutical R&D investments and expenditures". The study obtained articles from the Web of Science and Scopus databases, as well as journals ranked by the Chartered Association of Business Schools (CABS), to search for the following key terms noted above. The terms were set to be searched in the titles, abstracts, and keywords of the publications. The critical literature review is associated with background knowledge of the research and was used to postulate the conceptual framework and hypothesis. The hypothesis of the study is identified as "The investment expenditure of the prior year's R&D investment is anticipated to have a substantial impact on the nation's economic and financial performance."

DATA COLLECTION

Secondary data was collected to estimate the hypothesis's outcome (Grassano, et al., 2022). EU Industrial R&D Investment Scoreboard data from European Commission was obtained to conduct the research. The main goal of the EU Industrial R&D Investment Scoreboard (the Scoreboard) is to benchmark the performance of European innovation-driven industries against major global counterparts, as well as to provide an R&D investment database for companies, investors, and policymakers to compare individual company performances against the best global competitors in their respective sectors. The data set included the time horizon between 2015 to 2020 to understand the present impacts of R&D on the operating performance of pharmaceutical companies in Europe.

First, descriptive statistics were calculated through means, maximum and minimum values, and standard deviation. Then, a time lag model where current operating profit is the dependent variable and R&D spending from pharmaceutical and biotechnology companies across European countries is the independent variable was estimated.

MODEL AND VARIABLES

Different authors have used regression models to understand the relationship between financial performance as operating income and R&D spending, such as VanderPal (2015), Pazarzi and Sorros (2018), who used operating income as current income with R&D as an independent variable in the current year. As a proxy for company performance, Return on Assets (ROA), Return on Equity (ROE), and Earnings Per Share (EPS) were used by Freihat, & Kanakriyah (2017); (Nandy,2020). and these studies further estimated regression models while R&D expenditure were treated as a regressor.. In the study by Endri et al. (2020), four independent variables—the Current Ratio (CR), Fixed Asset Turnover (FATO), Total Asset Turnover (TATO), and Debt ti Equity ratio (DER)—as well as one dependent variable—Return on Assets (ROA)—were estimated.In addition, (Kor, & Mahoney, 2005) used time lags to analyze the relationship between R&D deployment intensity in the previous years (t-1, and t-2) and current economic returns (t) year.

A time-lag effect of R&D spending on operating earnings is shown in the model as follows.

$$\boldsymbol{OP_t = \partial_1 + \delta_2 R\&D\ Exp_{\,t-1} + \in_1} \quad (1)$$

Where, OP_t = Operating profit at period t

$R\&D\ Exp_{\,t-1}$ = Research and Development expenditure at period (t-1)

$\in_1$= Error term

Each period regression was calculated using cross-sectional data on pharmaceutical OP and R&D spending from different European countries. Econometric software, such as Microsoft Excel, STATA 14, and R Studio was used to analyze the results.

RESULTS

DESCRIPTIVE STATISTICS

The United Kingdom, France, Denmark, and Germany are significant contributors to the operating profits of the pharmaceutical industry in Europe. Other nations like Spain, Italy, Belgium, Netherlands, Finland, Slovenia, Hungary, Sweden, Portugal, and Greece also are producing positive operational profits. There is a significant disparity in values, however; Portugal and Greece had only about 23.0 million euros operating profit in the pharmaceutical sector during that time while Spain and Italy had about 1 billion euros operating profit on average over the previous five years. Poland, Austria, and Ireland all have negative profits; Ireland, however, is in a severe deficit from 2015 to 2020, losing an average of 3.5 billion euros. Table 5 details the descriptive statistics of pharmaceutical operating profit in European countries (€ million), and Table 6 displays the descriptive statistics of pharmaceutical R&D expenses in European countries (€ million).

Table 5: Descriptive Statistics of Pharmaceutical Operating Profit in European Countries (€ million)

Country	Obs.	Max Value	Min Value	Std. Dev.	Mean
United Kingdom	4	18574.4	6697.4	5647.438	10205.2
France	5	15264.4	3762.6	4437.944	7848.24
Denmark	5	8130.2	6354.5	723.3379	7516.4
Germany	5	11920.7	-2395.2	5940.611	7064.18
Spain	5	1405.6	1030.6	160.8343	1189.7
Italy	5	1240.3	506.3	308.9594	880.54
Belgium	5	1007.5	640.3	144.386	843.84
Netherlands	5	1348.9	-476.3	688.5006	491.68
Finland	5	367.4	240.8	48.90207	284.36
Slovenia	5	389.8	121.6	99.09961	242.74
Hungary	5	311.8	117.3	76.81307	192.14
Sweden	5	293.3	35	93.8733	164.04
Portugal	5	55.4	6.3	19.53696496	23.76
Greece	2	28.1	19.1	6.363961031	23.6
Poland	3	-11.8	-14.9	1.609348	-13.1
Austria	5	-24.5	-100.1	27.54863	-61.22
Ireland	5	333.8	-7884.1	3081.267	-3476.4

Source: Authors(2023)

From Table 5 and Table 6, we can instantly see which nations spend more on research and development activities and which companies generate higher operating profits over time. Ireland stands out as the main exception, with an average R&D expenditure of about 3 billion euros per year but an average loss of 3.5 billion euros per year. Additionally, despite spending roughly 26.9 million and 8.6 million euros respectively each year, Austria and Poland also generate negative operating profitability (albeit much less than Ireland). Other nations, though, make positive operational profits by spending what they are worth.

Table 6: Descriptive Statistics of Pharmaceutical R&D Expenses in European Countries (€ million)

Country	Obs.	Max Value	Min Value	Std. Dev.	Mean
Germany	6	15201.1	9878.1	1870.9	11749.2
France	6	8256.3	6777.3	578.3	7484.7
Denmark	6	3645.9	2639.4	374.7	3221.7
United Kingdom	5	12273.3	10984.1	493.5	11678.5
Spain	6	501.8	363.9	54.7	438.8
Italy	6	642.7	370.3	90.6	527.8
Belgium	6	1685.6	1017.8	232.8	1271.8
Netherlands	6	1117.2	840.7	114.0	996.1
Finland	5	125.4	103.4	8.5	117.2
Hungary	6	147.9	111.6	15.8	129.2
Slovenia	6	153.4	115.0	16.7	132.6
Sweden	6	490.3	192.6	112.5	306.2
Greece	4	49.9	32.3	8.3	44.1
Portugal	6	54.2	33.0	7.5	42.6
Poland	4	9.6	6.3	1.5	8.6
Austria	6	39.3	13.8	11.6	26.9
Ireland	6	3932.1	1342.5	881.1	2993.5

Source: Authors(2023)

EMPIRICAL FINDINGS: A TIME-LAG EFFECT OF R&D SPENDING ON OPERATING EARNINGS

The findings of the regression between current operating profit and R&D spending from pharmaceutical and biotechnology companies across European countries are shown in the following table. Each finding was calculated using cross-sectional data on pharmaceutical OP and R&D spending from different European countries.

$$\boldsymbol{OP_t = \partial_1 + \delta_2 R\&D\ Exp_{\,t-1} + \in_i} \quad (1)$$

Where, OP_t = Operating profit at period t

$R\&D\ Exp_{\,t-1}$ = Research and Development expenditure at period (t-1)

$\in_i$= Error term

The empirical result shows that, whereas the R&D 2019 and OP 2020 regression produced only insignificant findings, there is always a positive and a very highly significant correlation between the one-period lag R&D expenditure and current year operating performance. That implies that the number of funds businesses spend on R&D increases the business's operating profit.

Table 7: Empirical Findings

Models (1-5)	Intercept	Coefficient and Std.Dev	P-value	$Adjusted\ R^2$	Countries as obs.
$\boldsymbol{OP_{2016} = \partial_1 + \delta_2 R\&D\ Exp_{\,2015} + \in_1}$	144.5709	0.8617795*** [0.18146]	0.000	0.5896	16
$\boldsymbol{OP_{2017} = \partial_1 + \delta_2 R\&D\ Exp_{\,2016} + \in_2}$	-1.746339	0.9628587 *** [.2237526]	0.001	0.5226	17
$\boldsymbol{OP_{2018} = \partial_1 + \delta_2 R\&D\ Exp_{\,2017} + \in_3}$	-3.97237	0.5521942* [0.1992215]	0.015	0.3082	16
$\boldsymbol{OP_{2019} = \partial_1 + \delta_2 R\&D\ Exp_{\,2018} + \in_4}$	-110.8161	0.8281801*** [0.1828354]	0.001	0.5823	15
$\boldsymbol{OP_{2020} = \partial_1 + \delta_2 R\&D\ Exp_{\,2019} + \in_5}$	860.6257	0.4005357 [0.330165]	0.248	0.0350	14

Note: *, **, and *** are the significant level at 5%, 1%, and 0.1% respectively.

Source: Authors' calculation (2023)

Based on the availability of data, around 17 European countries are considered in the cross-sectional data, namely the United Kingdom, France, Denmark, Germany, Spain, Italy, Belgium, Netherlands, Finland, Slovenia, Hungary, Sweden, Portugal, Greece, Ireland, Poland, and Austria. From the coefficients, undoubtedly the investment in R&D activities in the pharmaceutical industry in Europe positively correlated with operating profit, for instance, the period R&D 2016 and OP 2017 has the highest coefficient in the model with a value, of 0.963, meaning a 1 million euro increase in R&D investment in 2016 would generate 0.963 million euros in operating profit in 2017. The other coefficients also indicate positive profit stimulation. The coefficient in model (5), the impact of R&D expenditure in 2019 on operating profit in 2020, is the only insignificant coefficient in models 1 to 5). Models 1,2 and 4 have higher coefficients with highly significant values, such as 0.862, 0.963 and 0.828, respectively. The results assist in forecasting that the investment in R&D investment in European pharmaceutical companies, generates higher operating profit in the following years.

The high value of adjusted R^2 is due to the participation of large biotechnological firms in Europe, as large firms have the capacity to invest a high amount and reach the highest profit. R&D expenditures can range from minor to billions for big businesses. R&D spending is typically highest in the industrial, technological, healthcare, and pharmaceutical sectors (Boldeanu, & Pugna, 2014;Bockova, & Zizlavsky,2016).The results have some validity in that when the study

concentrates on a firm basis rather than a country basis, it shows some interesting results. The majority of income ia generated from large companies as per the EU Industrial R&D Investment Scoreboard by Grassano et al. (2022); at least 90 firms out of 143 have either zero or negative operating profit in 2020. The identical picture holds true for previous years.

In pharmaceutical policy formulation, the fundamental sectors are the manufacturing, sale, import, export, licensing, pricing, investments, and R&D, in which clinical research, innovation, patents, and drug regulatory affairs is included (Geer, 2023). Policies must engage in research and development that responds to global health priorities and includes access planning at an early stage of development, which is also beneficial to company profit (Rollet, Lemoine, & Dunoyer, 2013). European pharmaceutical R&D investment must be justified not only by ensuring their investments, but also by generating a healthy profit to ensure the business's long-term viability. R&D spending is often viewed as a long-term investment with the goals of fostering innovation, enhancing goods and services, and strengthening a business's competitive advantage. Prior period R&D investment generates operating profit through a variety of activities, including the improvement of already-existing pharmaceutical products and solutions, the lowering of production costs, the creation of intellectual property through patents, trademarks and copyrights, and the establishment of a dominant market position through the use of novel therapies, medications, and technologies (Kale, & Little, 2007; Yousefi et al. 2017; Deng et al. 2019).

DIAGNOSTIC CHECKING FOR MODELS

The study also conducted diagnostic checking through the skewness/Kurtosis test for normality (Schilling & Nelson, 1976; Bai, & Ng, 2005) and the heteroskedasticity test through Breusch-Pagan and Cook-Weisberg tests for heteroskedasticity (Breusch, & Pagan, 1979). Model 1 and Model 2 do not have either of the problems, however that means these modes were having normally distributed residuals and constant variances. As a result, we accepted the estimation results from Table 4. The rest of the models contained non-normality and heteroskedasticity problems, however, and therefore we first transformed the dependent variable of Models 3 to 5 to get a normal distribution and conducted further estimation to check the validity of base results (details in Figure 3).

Table 8: Diagnostic Checking for Models

Diagnostic Checking	Model 1	Model 2	Model 3	Model 4	Model 5
Normality Test	Residuals are normally distributed	Residuals are normally distributed	Residuals are not normally distributed	Residuals are not normally distributed	Residuals are not normally distributed
Heteroskedasticity Test	Not Exists	Not Exists	Exists	Exists	Exists
Acceptance of model	Accepted, no further treatment is required	Accepted, no further treatment is required	If not accepted, further treatment required	If not accepted, further treatment required	If not accepted, further treatment required

Source: Authors' calculation (2023)

For instance, Models 3 and 4 have been converted to a normal distribution when the dependent variable identity transformation was transformed and the identical estimation was derived as follows.

Table 9: Models Estimated after Transformation (3-4)

Models estimated after transformation (3-4)	Intercept	Coefficient and Std.Dev	P-value	$Adjusted\ R^2$	Countries as obs.
$OP_{2018} = \partial_1 + \delta_2 R\&D\ Exp_{2017} + \in_3$	-3.97237	0.5521942* [0.1992215]	0.015	0.3082	16
$OP_{2019} = \partial_1 + \delta_2 R\&D\ Exp_{2018} + \in_4$	-110.8161	0.8281801*** [0.1828354]	0.001	0.5823	15

Source: Authors' calculation (2023)

Atkinson, Riani, & Torti's (2016) robust methods for heteroskedastic regression are also used to remove the heteroscedasticity problem and get the following results.

Table 10: Models Estimated after Handling Heteroscedasticity (3-5)

Models estimated after transformation (3-5)	Intercept	Coefficient and Robust Std.Dev	P-value	$Adjusted\ R^2$	Countries as obs.
$OP_{2018} = \partial_1 + \delta_2 R\&D\ Exp_{2017} + \in_3$	-3.97237	0.5521942*** [0.0524912]	0.000	0.3543	16
$OP_{2019} = \partial_1 + \delta_2 R\&D\ Exp_{2018} + \in_4$	-110.8161	0.8281801*** [0.1327533]	0.000	0.6121	15
$OP_{2020} = \partial_1 + \delta_2 R\&D\ Exp_{2019} + \in_5$	860.6257	0.4005357 [0.6588552]	0.555	0.1092	14

Source: Authors' calculation (2023)

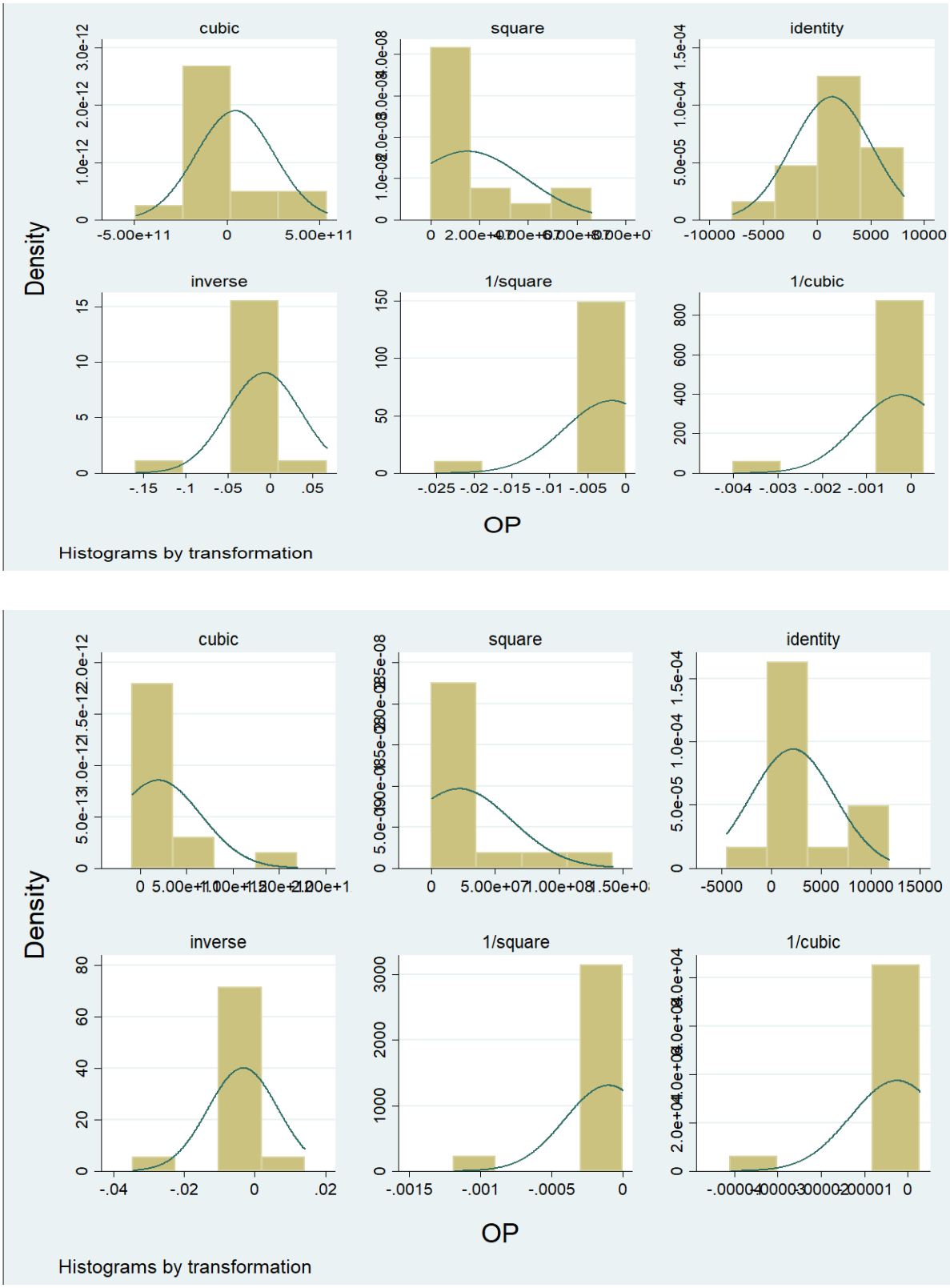

Figure 3: The transformation of dependent variable operating profit for being normal distribution to models 3-4.

Source: Authors (2023).

DISCUSSIONS

Existing research suggests that a pharmaceutical company's R&D spending has a beneficial impact on its profitability. Since it involves yearly budget choices and may be accounted for by yearly variations in regressions, many studies have claimed that there is a direct relationship between profitability and R&D spending, (Kounnou, & Kyrkilis, 2020;Tyagi, Nauriyal & Gulati, 2018; Tyagi, & Nauriyal, 2017; Jaisinghani, 2016). R&D investment was positively influenced by the current ratio, negatively influenced by the debt ratio, and was not significantly influenced by return on investment or net sales growth rate (Lee, & Choi, 2015).To support our study, a wide range of literature that has covered the significance of R&D investment in producing the financial performance of pharmaceutical firms was used (Mazzola, Bruccoleri & Perrone,2016; Rake, 2017 & Leten, Kelchtermans, & Belderbos, 2022). In this analysis, R&D spending was employed as an independent variable with a one-period lag because it was anticipated that it would take some time for this expenditure to have a favorable impact on the financial performance of the pharmaceutical industry (Campbell, 2012; Xie, et al. 2020; Leten, Kelchtermans, & Belderbos, 2022).

The present study supports the result of time-lag R&D stimulating the future operating profit of the pharmaceutical sector in European countries. Moreover, the empirical analysis has examined the mechanism underlying the time-lag effect of R&D expenditure on the value of a few chosen companies in China across the years of the time-lag and also makes industry comparisons. The findings indicate that corporate value is positively impacted by R&D spending and that this impact has a long-time lag (Xie, et al. 2020). In addition, a distributed lag model was used by Lee, & Kim, (2006) to investigate the relationship between IT investment and business performance considering the information intensity of the industry. Findings show that investments in IT have both a favorable immediate benefit and a beneficial lag effect. Therefore, time lag R&D investment significantly improves the business performance of pharmaceutical businesses as well as some other highly knowledge-based enterprises. Moreover, the positive impact of firm size on profitability may imply that larger firms take advantage of all the advantages of being large, such as economies of scale and scope, enjoy strong brand recognition, and have more skilled managers/employees due to the possibility of offering more attractive salaries and bonuses (Pervan, & Kramaric, 2020).

Endri et al. (2020) found that Return on Assets (ROA) is only positively related to Fixed Asset Turnover(FATO), while negatively related to other independent variables, such as Current Ratio (CR), Total Asset Turnover (TATO), and Debt Equity Ratio (DER) for the pharmaceutical industry in Indonesia. Importantly, depending on the sector and business, there may be a difference in the relationship between ROA and FATO. The two ratios can, however, generally be positively correlated with one another. When a business uses its fixed assets to generate sales successfully (high FATO), it has the potential to produce larger profits (high ROA) if it can properly control its costs and expenses. This is because increased revenue generation and profitability are facilitated by the effective use of fixed assets. According to Lim & Rokhim (2021), businesses with strong market positions, solid liquidity, and managed sustainable growth rates generate higher operational income, which eventually boosts pharmaceutical profitability from sales in Indonesia, and operational income, operating costs, return on equity, and total liabilities are among the particular factors that the regression output from Islan & Ihan (2019) shows have a substantial impact on the profitability of Bangladeshi pharmaceutical businesses.

CONCLUSION

Investment in R&D for industrial development has become a hot topic all over the world to generate future profit. Without question, the pharmaceutical industry is a research-focused sector where significant financial investments are necessary to develop new processes, secure patents, develop new technologies, engage in alliance partners, and more. However, there are several challenges in the R&D activities of the European pharmaceutical industry, and our findings show a strong and positive link between the previous year's R&D expenditure and the current year's operating profit in the European countries, providing convincing evidence that R&D investments will pay off financially in the years ahead for the development of

pharmaceuticals. The statements can be supported by the aggregate country-level data as well as an additional examination of the company-level data in this problem. This will broaden the current investigation and offer both theoretical and empirical justification for pharmaceutical R&D. Further study can be conducted on some countries in which huge sums of money are invested in pharmaceutical R&D but positive gains over the years have not been generated. For-instance, Ireland, despite the fact that it has almost always had a negative operating profit, R&D spending has been quite high, at around 3000 million euro per year. Further study needs to be conducted to determine why Irish R&D spending is inefficient. Moreover, why pharmaceutical SMEs have negative operating profit needs to be further studied within this framework.

This study has some limitations. Because it has been conducted on the data set from 2015 to 2020, more years can expand the study and test the validity of results. Additionally, the broader implications of the study's findings beyond the pharmaceutical industry can be conducted with a comparative analysis on how how R&D investments might impact other knowledge-based sectors such as IT, automobiles, computers and others.

Pharmaceutical R&D is highly competitive with numerous challenges in Europe. At every stage of the drug development process, accurate, timely clinical and business insights are required. R&D productivity is vital, and it is claimed that the traditional pharmaceutical business model is becoming obsolete. In addition to new business strategies, it is critical to constantly update R&D technologies and policies to ensure long-term development during this period of rapid evolution from artificial intelligence.

REFERENCES

Atkinson, A. C., Riani, M., & Torti, F. (2016). Robust methods for heteroskedastic regression. Computational Statistics & Data Analysis, 104, 209-222. https://doi.org/10.1016/j.csda.2016.07.002

Ayaydın, H. & Karaaslan, I. (2014). The Effect Of Research And Development Investment On Firms' Financial Performance: Evidence From Manufacturing Firms In Turkey . Bilgi Ekonomisi ve Yönetimi Dergisi , 9 (1) , 23-39 . Retrieved from https://dergipark.org.tr/en/pub/beyder/issue/3470/47199

Azierta (2019), Pharmaceutical market in EU, Roma – 08940 Barcelona, available at: www.azierta.com/en/blog/azierta/pharmaceutical-market-in-EU

Bai, J., & Ng, S. (2005). Tests for skewness, kurtosis, and normality for time series data. Journal of Business & Economic Statistics, 23(1), 49-60. https://doi.org/10.1198/073500104000000271

Banerjee, T. and Siebert, R. (2017), Dynamic impact of uncertainty on R&D cooperation formation and research performance: evidence from the biopharmaceutical industry, Research Policy, Vol. 46 No. 7, pp. 1255-1271. https://doi.org/10.1016/j.respol.2017.05.009

Baranov, A., & Muzyko, E. (2015). Valuation of compound real options for investments in innovative projects in pharmaceutical industry. Procedia Economics and Finance, 27, 116-125. https://doi.org/10.1016/S2212-5671(15)00980-6

Bockova, N., & Zizlavsky, O. (2016). Innovation And Financial Performance Of A Company: A Study From Czech Manufacturing Industry. Transformations in business & economics, 15(3).

Boldeanu, D. M., & Pugna, I. B. (2014). The analysis of the influence factors affecting the performance of pharmaceutical companies. Theoretical & Applied Economics, 21(7).

Breusch, T. S., & Pagan, A. R. (1979). A simple test for heteroscedasticity and random coefficient variation. Econometrica: Journal of the econometric society, 1287-1294. https://doi.org/10.2307/1911963

Campbell, M. (2012). What a difference a year makes: time lag effect of information technology investment on firm performance. Journal of Organizational Computing and Electronic Commerce, 22(3), 237-255. https://doi.org/10.1080/10919392.2012.696944

Chan, H.S., Shan, H., Dahoun, T., Vogel, H. and Yuan, S. (2019), Advancing drug discovery via artificial intelligence, Trends in

Pharmacological Sciences, Vol. 40 No. 8, pp. 592-604. https://doi.org/10.1016/j.tips.2019.06.004

Chaudhuri, A. (2013), Simultaneous improvement in development time, cost and quality: a practical framework for generic pharmaceuticals industry, R&D Management, Vol. 43 No. 3, pp. 227-241. https://doi.org/10.1111/j.1467-9310.2012.00675.x

Chen, M., Cheng, S. and Hwang, Y. (2005). An empirical investigation of the relationship between intellectual capital and firms' market value and financial performance, Journal of Intellectual Capital, 6 (2), 159-176. https://doi.org/10.1108/14691930510592771

Chit, A., & Grootendorst, P. (2018). Policy to encourage the development of antimicrobials. International Journal of Health Governance, 23 (2), pp. 101-110. https://doi.org/10.1108/IJHG-12-2017-0062

Cockburn, I., & Long, G. (2015). The importance of patents to innovation: updated cross-industry comparisons with biopharmaceuticals. Expert opinion on therapeutic patents, 25(7), 739-742. https://doi.org/10.1517/13543776.2015.1040762

Cowlrick, I., Hedner, T., Wolf, R., Olausson, M. and Klofsten, M. (2011), Decision-making in the pharmaceutical industry: analysis of entrepreneurial risk and attitude using uncertain information, R&D Management, Vol. 41 No. 4, pp. 321-33. https://doi.org/10.1111/j.1467-9310.2011.00649.x

Deng, P., Lu, H., Hong, J., Chen, Q., & Yang, Y. (2019). Government R&D subsidies, intellectual property rights protection and innovation. Chinese Management Studies, 13(2), 363-378. https://doi.org/10.1108/CMS-02-2018-0422

Desmet, K., Kujal, P., and Lobo, F. (2004). Implementing R&D policies: An analysis of Spain's pharmaceutical research program. Research Policy, Vol.33, No.10, pp.1493–1507. https://doi.org/10.1016/j.respol.2004.07.007

Downs, J.B. and Velamuri, V.K. (2018), Business model innovation in a knowledge revolution: an evolutionary theory perspective, Managerial and Decision Economics, Vol. 39 No. 5, pp. 550-562. https://doi.org/10.1002/mde.2926

Dubey, J. and Dubey, R. (2010), "Pharmaceutical innovation and generic challenge: recent trends and causal factors", International Journal of Pharmaceutical and Healthcare Marketing, Vol. 4 No. 2, pp. 175-190. https://doi.org/10.1108/17506121011059777

E., Lisdawati, D. S., Hakim, L., & Sugianto, S. (2020). Determinants of profitability: Evidence of the pharmaceutical industry in Indonesia. Systematic Reviews in Pharmacy Endri,, 11(6), 587-597. DOI: 10.31838/srp.2020.6.89

European Commission (2021), "A pharmaceutical strategy for Europe: challenges facing the sector", available at: https://ec.europa.eu/health/human-use/strategy_en.

European Commission (2022). EU Industrial R&D Investment Scoreboard, available at: https://iri.jrc.ec.europa.eu/data

Faems, D., De Visser, M., Andries, P., & Van Looy, B. (2010). Technology alliance portfolios and financial performance: value-enhancing and cost-increasing effects of open innovation. Journal of Product Innovation Management, 27(6), 785-796. doi:10.1111/j.1540-5885.2010.00752.x

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.

Frigyesi, V., Laget, P., & Boden, M. (2019). Exploitation of patent information in R&D output analysis for policymaking. Scientometrics, 121(3), 1717-1736. https://doi.org/10.1007/s11192-019-03236-3

Gassmann, O., Reepmeyer, G., & von Zedtwitz, M. (2008). Innovation: key to success in the pharmaceutical industry. Leading Pharmaceutical Innovation: Trends and Drivers for Growth in the Pharmaceutical Industry, 1-18. https://doi.org/10.1007/978-3-540-77636-9_1

Geer, M. I. (2023). Stakeholders in Pharmaceutical Policy Development.

IntechOpen. doi: 10.5772/intechopen.105606

Goldman, M. (2012), The innovative medicines initiative: a European response to the innovation challenge, Clinical Pharmacology & Therapeutics, Vol. 91 No. 3, pp. 418-425. https://doi.org/10.1038/clpt.2011.321

Grassano, N., Hernandez Guevara, H., Fako, P., Nindl, E., Georgakaki, A., Ince, E., Napolitano, L., Rentocchini, F. and Tübke, A. (2022) The EU Industrial R&D Investment Scoreboard (2022). European Commission. Retreived from: https://iri.jrc.ec.europa.eu/scoreboard/2022-eu-industrial-rd-investment-scoreboard

Greer, S.L., Rozenblum, S., Fahy, N., Brooks, E., Jarman, H., de Ruijter, A. and Wismar, M. (2014), Everything you always wanted to know about European union health policies but were afraid to ask, European Observatory on Health System and Policies, UK. ISBN 978 92 890 59 022

Hanekom, N., Bam, L. and Kock, I. d (2019), What makes diseases and drug research and development attractive for the pharmaceutical industry, 2019 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC), pp. 1-9. doi: 10.1109/ICE.2019.8792645.

Horrobin, D. F. (2000). Innovation in the pharmaceutical industry. Journal of the Royal Society of Medicine, 93(7), 341-345.

Houÿez, F. (2020). High Price Medicines and Health Budgets: The Role Patients' and Consumers' Organisations Can Play, European Journal of Health Law, 27(3), 309-323. doi: https://doi.org/10.1163/15718093-BJA10008

Jaisinghani, D. (2016), Impact of R&D on profitability in the pharma sector: an empirical study from India, Journal of Asia Business Studies, Vol. 10 No. 2, pp. 194-210. https://doi.org/10.1108/JABS-03-2015-0031

Kale, D., & Little, S. (2007). From imitation to innovation: The evolution of R&D capabilities and learning processes in the Indian pharmaceutical industry. Technology Analysis & Strategic Management, 19(5), 589-609. https://doi.org/10.1080/09537320701521317

Kor, Y.Y. and Mahoney, J.T. (2005). How dynamics, management, and governance of resource deployments influence firm-level performance. Strat. Mgmt. J., 26: 489-496 https://doi.org/10.1002/smj.459

Kounnou, V., Kyrkilis, D. (2020). Competitiveness, Profitability and R/D Intensity: The Case of the Domestic Pharmaceutical Industry in Greece. In: Horobet, A., Polychronidou, P., Karasavvoglou, A. (eds) Business Performance and Financial Institutions in Europe. Contributions to Economics. Springer, Cham. https://doi.org/10.1007/978-3-030-57517-5_3

le Deu, F. and Santos Da Silva, J. (2019), Pharmaceuticals and medical products biotech in Europe: a strong foundation for growth and innovation. Available at: https://www.coursehero.com/file/78032517/mckinsey-Biotech-in-Europepdf/

Islam, M. S., & Khan, M. S. (2019). The determinants of profitability of the pharmaceutical industry of Bangladesh: A random effect analysis. International Journal of Financial Research, 10(2), 68-74. doi:10.5430/ijfr.v10n2p68

Lee, S., & Kim, S. H. (2006). A lag effect of IT investment on firm performance. Information Resources Management Journal (IRMJ), 19(1), 43-69. DOI: 10.4018/irmj.2006010103

Lee, M., & Choi, M. (2015). The determinants of research and development investment in the pharmaceutical industry: focus on financial structures. Osong public health and research perspectives, 6(5), 302-309. https://doi.org/10.1016/j.phrp.2015.10.013

Leten, B., Belderbos, R. and Van Looy, B. (2011), Technological diversification, coherence and performance of firms, SSRN Electronic Journal, pp. 567-579. https://doi.org/10.1111/j.1540-5885.2007.00272.x

Leten, B., Kelchtermans, S., & Belderbos, R. (2022). How does basic research improve innovation performance in the world's major pharmaceutical firms?. Industry and Innovation, 29(3), 396-424. https://doi.org/10.1080/13662716.2021.1997723

Lim, H. and Rokhim, R. (2021). Factors affecting profitability of pharmaceutical company: an

Indonesian evidence, Journal of Economic Studies, Vol. 48 No. 5, pp. 981-995. https://doi.org/10.1108/JES-01-2020-0021

Logviss, K., Krievins, D. and Purvina, S. (2014), Trends in individual reimbursement of orphan drugs in Latvia in 2008–2011, SHS Web of Conferences, Vol. 10, p. 21. https://doi.org/10.1051/shsconf/20141000021

Magazzini, L., Pammolli, F. and Riccaboni, M. (2016), Real options and incremental search in pharmaceutical R&D project portfolio management, Creativity and Innovation Management, Vol. 25 No. 2, pp. 292-302. https://doi.org/10.1111/caim.12119

Maja Pervan, M. & Kramaric, T.P. (2020). Impact Of Research and Development Expenditure on Firm Performance. The 14th International Days of Statistics and Economics, Prague, September 10-12, 2020

Mazzola, E., Bruccoleri, M., & Perrone, G. (2016). Open innovation and firms performance: State of the art and empirical evidences from the bio-pharmaceutical industry. International Journal of Technology Management, 70(2-3), 109-134.

Mennini, F.S., Gitto, L., Scrivo, R., Drago, F., Iezzi, M., Terranova, L. and Cicchetti, A. (2016), The promotion of drug innovation in Italy: critical aspects and unsolved problems, Global & Regional Health Technology Assessment, Vol. 3 No. 1, pp. 42-47. https://doi.org/10.5301/GRHTA.5000216

Mesko, B (2021). Future of Pharma. The Medical Futurist. Retrieved from: https://medicalfuturist.com/category/future-of-pharma/

Morgan, S., Lopert, R., & Greyson, D. (2008). Toward a definition of pharmaceutical innovation. Open medicine, 2(1), e4. Epub 2008 Jan 30. PMID: 21602949; PMCID: PMC3091590.

Murphy, K. J., & Zimmerman, J. L. (1993). Financial performance surrounding CEO turnover. Journal of Accounting and Economics, 16(1-3), 273-315. doi:10.1016/0165-4101(93)90014-7.

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. DOI: 10.1177/2319714520981816.

OECD, E.U. (2020), "Health at a glance: Europe 2020: state of in the EU cycle", Health at a Glance 2007.

Paranhos, J., & Hasenclever, L. (2011). Is industry–university interaction promoting innovation in the Brazilian pharmaceutical industry?. Industry and Higher Education, 25(5), 397-407. DOI:10.5367/ihe.2011.0060

Parsons, S., Starling, B., Mullan-Jensen, C., Tham, S.G., Warner, K. and Wever, K. (2016), What do pharmaceutical industry professionals in Europe believe about involving patients and the public in research and development of medicines? A qualitative interview study, BMJ Open, Vol. 6 No. 1, pp. 1-12. http://dx.doi.org/10.1136/bmjopen-2015-008928

Pazarzi, G., & Sorros, J. (2018). The effect of R&D expenses on earnings and market value. SPOUDAI-Journal of Economics and Business, 68(2/3), 39-47. http://hdl.handle.net/10419/195213

Rake, B. (2017). Determinants of pharmaceutical innovation: the role of technological opportunities revisited. Journal of Evolutionary Economics, 27(4), 691-727. https://doi.org/10.1007/s00191-017-0524-6

Rollet, P., Lemoine, A., & Dunoyer, M. (2013). Sustainable rare diseases business and drug access: no time for misconceptions. Orphanet journal of rare diseases, 8(1), 1-9. https://doi.org/10.1186/1750-1172-8-109

Schilling, E. G., & Nelson, P. R. (1976). The effect of non-normality on the control limits of X charts. Journal of Quality Technology, 8(4), 183-188. https://doi.org/10.1080/00224065.1976.11980743

Sieg, J. H., Wallin, M. W., & Von Krogh, G. (2010). Managerial challenges in open innovation: a study of innovation intermediation in the chemical industry. R&d Management, 40(3), 281-291. https://doi.org/10.1111/j.1467-9310.2010.00596.x

Tang, Z., Hull, C.E. and Rothenberg, S. (2012), How Corporate Social Responsibility Engagement Strategy Moderates the CSR–Financial Performance Relationship. Journal

of Management Studies, 49: 1274-1303. https://doi.org/10.1111/j.1467-6486.2012.01068.x

Theuretzbacher, U. (2012), Accelerating resistance, inadequate antibacterial drug pipelines, and international responses, International Journal of Antimicrobial Agents, Vol. 39 No. 4, pp. 295-299. https://doi.org/10.1016/j.ijantimicag.2011.12.006

Timmerman, P., Henderson, N., Smeraglia, J., Mulder, H., Ingelse, B., Brudny-Kloeppel, M. and Companjen, A. (2013), Managing scientific, technical and regulatory innovation in regulated bioanalysis: a discussion paper from the European bioanalysis forum, Bioanalysis, Vol. 5 No. 2, pp. 139-145. https://doi.org/10.4155/bio.12.267

Towse, A. and Sharma, P. (2011), Incentives for R&D for new antimicrobial drugs, International Journal of the Economics of Business, Vol. 18 No. 2, pp. 331-350. https://doi.org/10.1080/13571516.2011.584434

Tyagi, S. & Nauriyal, D.K. (2017). Firm level profitability determinants in Indian drugs and pharmaceutical industry. International Journal of Pharmaceutical and Healthcare Marketing, Vol. 11 No. 3, pp. 271-290. https://doi.org/10.1108/IJPHM-03-2016-0016

Tyagi, S., Nauriyal, D. K., & Gulati, R. (2018). Firm level R&D intensity: evidence from Indian drugs and pharmaceutical industry. Review of Managerial Science, 12, 167-202. https://doi.org/10.1007/s11846-016-0218-8

VanderPal, G. A. (2015). Impact of R&D expenses and corporate financial performance. Journal of Accounting and Finance, 15(7), 135-149.

Xie, H., Yang, J., Yu, W., Yang, Y., & Wu, W. (2020). The Time-lag Effect of R&D Investment on the Value of Listed Companies in China: A Cross-industry Analysis. Journal of Creating Value, 6(2), 217-231. https://doi.org/10.1177/2394964320923543

Yousefi, N., Mehralian, G., Rasekh, H. R., & Yousefi, M. (2017). New Product Development in the Pharmaceutical Industry: Evidence from a generic market. Iranian journal of pharmaceutical research: IJPR, 16(2), 834. PMID: 28979339; PMCID: PMC5603895.

Zambuto, F., Lo Nigro, G., & O'Brien, J. P. (2017). The importance of alliances in firm capital structure decisions: evidence from biotechnology firms. Managerial and Decision Economics, 38(1), 3-18. https://doi.org/10.1002/mde.2735

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Annex

Table 1: Sum value of Operating Profits in the Pharmaceutical and Biotechnology Industry in Europe (€ million)

Country	2015	2016	2018	2019	2020
United Kingdom	18574.4	6697.4	6903.9	8645.1	-----
Germany	8538.0	11871.4	5386.0	11920.7	-2395.2
France	6596.7	8105.3	5512.2	3762.6	15264.4
Denmark	6354.5	7499.5	8130.2	8120.0	7477.8
Netherlands	1348.9	669.9	766.4	149.5	-476.3
Spain	1128.4	1030.6	1074.1	1309.8	1405.6
Belgium	873.1	764.7	1007.5	933.6	640.3
Italy	506.3	822.8	686.0	1147.3	1240.3
Finland	268.0	283.7	367.4	240.8	261.9
Hungary	216.4	176.4	138.8	117.3	311.8
Slovenia	198.9	121.6	230.5	272.9	389.8
Sweden	173.1	35.0	129.7	293.3	189.1
Greece	28.1	19.1	-----	-----	-----
Portugal	15.6	12.5	6.3	29.0	55.4
Luxembourg	-18.2	-----	-----	-----	-----
Austria	-24.5	-52.2	-100.1	-70.6	-58.7
Ireland	-1746.4	-3597.0	-7884.1	-4488.3	333.8
Poland	-----	-12.6	-14.9	-----	-11.8

Source: Grassano, et al (2022).EU Industrial R&D Investment Scoreboard, European Commission.

Table 2: R&D Expenses in the Pharmaceutical and Biotechnology Industry in Europe (€ million)

Country	2015	2016	2017	2018	2019	2020
Germany	9878.1	10639.6	11179.5	11286.5	12310.4	15201.1
France	6777.3	6892.6	7377.2	7880.6	8256.3	7724.2
Denmark	2639.4	2922.3	3249.2	3439.6	3434.0	3645.9
United Kingdom	11431.9	12273.3	11944.8	10984.1	11758.4	---
Spain	363.9	379.3	501.8	458.8	472.4	456.5
Italy	370.3	498.8	561.7	560.3	533.1	642.7
Belgium	1017.8	1134.8	1179.6	1254.1	1359.0	1685.6
Netherlands	884.2	1091.8	981.3	1061.3	1117.2	840.7
Finland	103.4	122.7	118.2	116.4	125.4	---
Hungary	111.6	113.6	128.6	126.0	147.6	147.9
Slovenia	115.0	118.0	125.9	130.7	152.4	153.4
Sweden	228.7	192.6	235.6	310.0	379.9	490.3
Greece	44.3	49.9	49.9	32.3	---	---
Portugal	33.0	38.7	38.0	54.2	45.1	46.7
Poland	---	9.2	9.6	9.2	---	6.3
Austria	20.8	39.3	36.9	35.5	15.1	13.8
Ireland	3284.0	3932.1	2903.8	3410.4	3088.1	1342.5

Source: Grassano, et al (2022).EU Industrial R&D Investment Scoreboard, European Commission.