

The impact of investment in research and development on the company's profitability - a case study of the Algerian company Sonatrach

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Abstract:

The purpose of this study is to assess the nature of the relationship between investment in research and development. (R&D) and corporate profitability. Evidence suggests that R&D has a strong and positive impact on corporate profitability and performance. Sonatrach, an Algerian oil and gas company, was selected to study the impact of R&D investment on its profitability, Measured using a set of financial metrics : profit margin, return on assets (ROA), return on investment (ROI), and return on equity (ROE). This study uses data from Sonatrach's annual financial reports for the period 2007-2023, analyzed using multiple linear regression in SPSS v26. The results of this study indicate a moderate negative relationship between R&D indicators (R&D intensity and average number of training days per employee per year) and corporate profitability, Defined by profitability metrics. A greater investment in R&D leads to lower profitability.

Keywords: Research and development investments; Company profitability; Research and development intensity; Algerian Sonatrach Company.

JEL Classification Codes: O32; L25; L71.

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Introduction:

In a volatile, fast-evolving, and highly competitive business environment, organizations are obligated to elevate their operational efficiency and profitability to secure greater revenue streams, maintain elevated profitability levels, and consequently, strengthen and expand their standing in the marketplace and ensure sustainability. These goals can only be realized through a continuous commitment to satisfying consumer needs, refining existing products, launching new offerings, and innovating production processes. Leading firms in developed economies recognize R&D as a cornerstone of profitability and sustainable growth. This recognition has fueled a continuous rise in R&D investment over the years. U.S. firms, in particular, dominate in terms of R&D intensity, with figures rising from 3.7% in (1991) to an average of 18.54% by (2022). Major corporations in Europe, China, and Japan have also embraced this trajectory, acknowledging the strategic importance of sustained investment in R&D (Bonaglia, León, & Nindl, 2024).

Numerous researchers have demonstrated, Based on studies that analyze the link between R&D investment and financial performance in firms within advanced economies, it is clear that R&D investment represents the most effective strategy for improving corporate performance and increasing profitability. Such investment enables firms to deliver superior, non-imitable products and to compete successfully on an international scale (Jin & Sang Ok Choi, 2019).

Aims of the study :

The core aim of this study is to conduct an empirical evaluation of the link between investment in research and development and corporate profitability, while also exploring the dynamics and significance of this relationship. Sonatrach, Algeria's largest enterprise and a major global player in the oil and gas industry, was selected for its strategic significance. Functioning in a sector where sustained research and technological innovation in exploration, refining, transportation, and related operations are essential, Sonatrach is compelled to invest heavily in R&D to uphold profitability in a challenging and uncertain global marketplace.

Research problem :

To achieve the objectives of this study, we raised the following problem :

- Is there a statistically significant relationship between R&D investment and profitability at Sonatrach, Algeria's foremost oil and gas corporation ?

The following hypotheses are developed to provide an answer to this research question :

- Sonatrach allocates a significant budget toward research and development activities.
- There exists a strong and positive relationship between R&D investment and profitability at Sonatrach.

Research methodology :

As part of exploring the research question, the study starts with a theoretical analysis of the core concepts related to research and development activities and assess the connection between R&D metrics and profitability measures. For the empirical component, we rely on Sonatrach's annual financial reports that cover the period from (2007 - 2023). Using multiple linear regression analysis is conducted in SPSS v26 statistical software, we conduct a descriptive analysis of R&D indicators to assess the company's level of investment in this domain.

Subsequently, we investigate the relationship between R&D indicators represented by variables such as R&D intensity, employee training ratio, We also examine average training days alongside key profitability metrics, including profit margin, return on assets (ROA), return on investment (ROI), and return on equity (ROE). and we present and interpret the empirical findings.

Previous studies :

-Shih-Yung Wei and Li-Wei Lin (2021), in their article "Long-term Effects of Research and Development on Firm Performance – Taking Taiwan as the Example (2001–2017)," investigated the nature of the relationship between R&D activities and firm performance in Taiwan between (2001-2017). Their results revealed that R&D investment produces both positive and negative effects, with the distinction between these effects being primarily attributed to the time lag factor. Specifically, the early years of R&D investment are often marked by negative returns, whereas positive performance effects typically begin to

manifest after five years and may endure for several years thereafter. The researchers also noted that additional factors including factors like firm size and average firm age, influence how strongly R&D investment correlates with financial performance.

-Novićević Čečević, B., Milenović, J., & Rađenović, T. (2023), In their academic paper, "The Impact of Investment in Research and Development Activities on the Profitability of Pharmaceutical Companies: A Cost Accounting Approach," examined the link between R&D investment and the profitability of a selection of global pharmaceutical firms over the period (2010–2020). Their results demonstrated that R&D investments positively influence net income, EBIT, and earnings per share. Nonetheless, the study's scope could be broadened to include other industries, as the pharmaceutical sector is traditionally among the most R&D dependent sectors.

-Under the title "The Impact of Investing in Research and Development on Performance : Evidence from Jordan," Fuad N. Al-Shaikh and Ahmad Hagen (2023) explored the link between R&D investment and the financial performance of Jordanian companies during the period (2013-2019). The researchers measured R&D investment using R&D intensity and the number of researchers, financial performance was measured using the indicators of return on assets (ROA), return on equity (ROE), and earnings per share (EPS). The empirical analysis found no statistically significant relationship between R&D spending and firm performance. The study suggests that this result stems from the constrained size of Jordan's economy and managerial reluctance to invest heavily in R&D due to concerns over potential risks and the extended period required for returns to materialize.

Firstly : Theoretical framework of the study

In the last quarter of the twentieth century, the economies of major countries witnessed significant development and intense competition among firms that hold a competitive advantage through intangible assets, commonly known as research and development activities. In this section, we will present a definition of R&D and the various methods used to measure it. We will then examine several empirical studies that investigate the relationship between R&D investment and corporate profitability.

1. Fundamental concepts of research and development

R&D activities are closely linked to innovation, knowledge creation, and the transformation of research outcomes into real-world projects.

They also play a crucial role in the development of products and processes in ways that generate higher returns and provide organizations with a competitive advantage.

1.1. Definition of research and development

As per International Accounting Standard (IAS) 38, paragraph 8, set forth by the International Accounting Standards Board (IASB), research is characterized as: “an original and systematic investigation undertaken to gain new scientific or technical knowledge and understanding.” The standard also defines development as: “The use of research outcomes or other knowledge to develop plans or designs for creating new or significantly enhanced materials, tools, products, methods, systems, or services, before they enter commercial production or application” (IASB, 2012, p. 1493).

The Frascati Manual, published by the Organisation for Economic Cooperation and Development (OECD), outlines research and development activities as creative work carried out in a structured manner to increase the stock of knowledge, including scientific and technological advancements, and to utilize this knowledge in developing new applications (OECD, 2002). The Frascati Manual (OECD, 2015) identifies the key criteria that distinguish research and development activities as follows :

- **Novel** : Aimed at generating new knowledge and outcomes.
- **Creative** : Involves new concepts and ideas that enhance existing knowledge.
- **Uncertain** : The final results and outcomes are not guaranteed or predictable.
- **Systematic** : Conducted according to a pre-planned and organized method.
- **Transferable and/or reproducible** : Provides the opportunity for others to reuse and replicate the outcomes.
- It covers fundamntal research, applied research, and the development of experimental processes aimed at creating new materials, products, or devices, as well as designing new processes, systems, and services, or notably enhancing the current ones (Salim & Bloch, 2009).

Consequently, increasing R&D activities within firms is expected to contribute not only to economic growth but also to broader

economic welfare. According to Statement of Financial Accounting Standards No. 2 (SFAS, 1974), research and development expenses include the following elements :

- Employee salaries, wages, and other expenses related to employees working on research and development projects.
- The expenses associated with materials and services used in research and development activities.
- The reduction in value of physical assets such as buildings, equipment, and facilities, along with intangible assets like patents and licenses, utilized in R&D activities.
- Overall expenses associated with R&D activities, as well as payments to external organizations. (such as research laboratories and universities etc.) for research and development projects related to the organization.
- Expenses incurred in obtaining patents for new products / processes.
- Other expenses directly linked to R&D activities, which can be assigned to specific projects. This excludes routine product testing, quality control, market research, patent application legal fees, and costs associated with the sale or licensing of patents.

1.2. Methods of measuring investment in research and development

Companies must have methods to track and monitor the changes and Progress achieved through R&D activities, in conjunction with the effectiveness of R&D programs. One of the foremost challenges in implementing R&D metrics Is ensuring these measures are in line with the various levels and roles within the R&D department, on one side, and the executives at higher managerial levels on the other. (Schwartz et al. 2011). In fact, performance metrics related to research and development, in the early stages of their adoption starting from the 1970s, focused on three main elements (Kulatunga et al. 2006) :

- Purely technical products (patents, technical publications, or citations of technical publications) ;
- Financial returns from research and development (profits and sales);
- Offers reports on the performance of individual R&D projects.

Companies rely on several methods to measure research and development activities, primarily based on historical data of inputs and

outputs recorded in financial records. A set of indicators has been used to measure the value generated by these R&D activities. Researchers have classified R&D metrics into several groups, each representing a particular perspective on R&D activities (Soderquist & Godener, 2004).

- **From a financial perspective :** This includes a set of financial indicators that provide insight into the return on investment in research and development, measured quantitatively.
- **From a customer satisfaction perspective :** This measures the performance resulting from R&D activities, which should exceed customer expectations or at least meet them.
- **From a strategic management perspective :** This means that investment in R&D should align with the objectives set in strategic planning.
- **From an operations management perspective:** In this case, investment in R&D should align with improvements in quality, delivery time, cost, and ensuring that the project progresses according to the operational goals.
- **From a technology management perspective :** Investment in R&D should ensure effective management of product technology to generate a continuous flow of competitive products.
- **From an innovation management perspective :** The efforts of R&D activities should be expected to successfully translate into new products, through the creative application and integration of new or existing knowledge.
- **From a knowledge management perspective :** Qualitative investment in R&D allows for the creation, transfer, and utilization of knowledge, leading to enhanced R&D capabilities.

Below is a table summarizing the essential measures for assessing investment in R&D :

Table N°01: The indicators used to measure investment in research and development in the company

Financial considerations	Indicator
-Survival (R&D effectiveness indicator)	-Present value of R&D achievements / R&D expenditure
-Success	-Percentage of sales from new products to total sales
-R&D intensity	-R&D expenses / Total sales
Customer considerations	Indicator
-Customer satisfaction level (Product adoption rate)	-Number of customers adopting the project or product / Total potential customers
-Design efficiency rate and corrective actions	-Work hours on new projects and troubleshooting / Total project work hours
-R&D success rate	-Number of projects that completed development / Total R&D projects
Internal operations considerations	Indicator
-Productivity	-R&D work hours / Total project work hours
-Speed of time-to-market	-Actual completion time / Reference completion time
-Relative efficiency and adaptability index	-Total product modification time / Number of modified products
-Reliable delivery of outputs	-Total time of completed projects / Total planned duration
Innovation and learning considerations	Indicator
-Technological capability	-Number of patents / R&D expenditure
-High absorptive capacity	-Percentage of projects completed in collaboration with external parties
-Learning organization	-Percentage of ideas implemented in new projects
-Ratio of employees in R&D	-Number of R&D staff / Total employees in the organization

Source : Drafted by the researchers based on Soderquist (Klas Eric), Godener (Armelle), (2004), Performance Measurement in R&D and New Product Development : Setting the Scene .International Journal of Business Performance Management : (2)6, p 112.

2. The relationship between investment in research and development and the profitability indicators :

The existence of a relationship between R&D investment and profitability has been underscored in numerous studies, most of which have concentrated on companies that function in developed countries such as the United States of America and the EU, which showcased the significance of R&D and raised their expenditures on R&D activities. However, these studies did not provide definitive results about the nature of the relationship (positive or negative) and its degree of strength.

The complex and often ambiguous relationship between R&D investment and profitability continues to generate uncertainty has led to continued exploration in this domain. While some empirical studies have shown a strong positive relationship, others have found either no connection or even a negative one. The observed differences are commonly ascribed to variables including the developmental stage of the country, firm size, operational nature, and industry to which it belongs. However, the underlying reason is that R&D investment is cumulative by nature, marked by greater uncertainty and risk at every stage, compared with other types of investments.

Many researchers agree that investments in research and development do not yield immediate results or returns. R&D expenditures are often not matched by equivalent returns in the short term. In certain cases, the benefits of such investments are not reflected in firm performance during the same year. These effects may only become evident within a period ranging from two to seven years thereafter, and in some sectors, the benefits may take even longer to materialize (Wei & Lin, 2021).

The study conducted by Vithessonthi and Racela on a large group of high-tech American companies revealed that, in the short term, the intensity of research and development is negatively correlated with the company's operational performance and sales value. However, in the long term, it is positively associated with the company's value, as reflected in stock prices. Furthermore, when considering the large size of the company and its high level of R&D expenditure, the study suggests that the effect may have a moderate positive impact on profit margins in the short term (Vithessonthi & Racela, 2016).

The study conducted by Tamara Rađenović and colleagues on a sample of 24 high-innovation companies, which were among the top 50 global spenders on research and development from (2013-2021), supported the existence of a positive effect between key R&D indicators

and return on assets (ROA). The study revealed a statistically significant positive impact on ROA in R&D-intensive companies. However, it is important to note that the duration of this study was relatively short, and it does not allow for an examination of the cumulative impact of R&D investment over several years on return on assets (Rađenović, Krstić, Janjić, & Jovanović Vujatović, 2023).

The study by Tung and Quan Minh on a large sample of Vietnamese industrial companies indicated that investments in research and development, represented by intangible assets, can significantly enhance the company's value by boosting its stock price. This effect is particularly evident in high-performing companies, as they have more resources to engage in R&D activities (Tung & Quan Minh, 2020). Similar findings were reported in the study by Rahman and Howlader, which focused on a sample of Asian pharmaceutical companies. The study revealed a significant positive relationship between R&D spending and company performance and value, even though these companies operate in an emerging economy (Rahman & Howlader, 2022).

The researcher Sabri M'kimah demonstrated that research and development activities can contribute to enhancing the competitive advantage of a company and solidifying its presence in the national market, based on his study of the Condor Electronics Company in Algeria (M'kimah, 2019). In contrast, the study conducted by N. Ouarib and S. Bouzid drawing on data from industrial firms in Algeria (2017–2020), the study investigates the role of R&D in driving new product development and its subsequent impact on company performance. The study showed that R&D has a positive impact on company performance, but the effect is very weak. The limited timeframe of the study likely accounts for this. (Ouarib & Bouzid, 2021).

In fact, the impact of investment in research and development on a company's profitability and performance may be negative, as demonstrated in several empirical studies conducted on many large companies (Zhu & Huang, F., 2012). For example, the study by researchers Tahinakis and Samarinas on a large sample of Greek companies during the period (2005-2010) found a strong negative relationship between R&D spending, which is intended to foster innovation, and the company's growth, future development, and, in turn, its value, as indicated by stock prices on the Athens Stock Exchange. The scholars ascribed this negative relationship to Greece's ongoing severe economic crisis, with investors viewing R&D spending as an additional cost that companies are unable to leverage to foster creativity

and achieve future growth. Therefore, considering the poor financial condition of these companies, the less they spent on R&D, the better it was for them (Tahinakis & Samarinas, 2013).

Consistent with the previous findings, the study conducted by He and Estébanez on a group of companies operating in the information and communication technology services sector in China during the period (2011-2020) found that investment in research and development negatively impacts company performance, this was reflected across a range of financial indicators, such as : return on assets, return on equity, liquidity ratio, debt-to-assets ratio, and interest coverage ratio, along with the companies' current market value. The authors associated the observed negative impact to the fact that the companies in the study were small and medium-sized enterprises (SMEs), which typically require more time to convert their R&D investments into market value growth, unlike firms in more developed Western countries. Furthermore, these SMEs in China face greater uncertainty and risk when developing products or services (He & Estébanez, 2023).

The same results were found in the study by Al-Shaikh and Hagen on a group of industrial companies in Jordan (Al-Shaikh & Hagen, 2023), which attributed the negative impact to the weakness of companies in the country and their fear of taking risks by making R&D investments that may not show results for many years. As a result, these companies tend to prefer a strategy of imitation over innovation.

It can be concluded that investments in research and development, which are relied upon to improve a company's profitability, must take into account that the positive effects on profitability may only appear in the long term. The reasons for this include the gap between R&D investments and the returns on those investments, caused by the slow pace of some R&D outputs that are used in the future over a relatively long period.

Secondly : Applied study

The main goal of this study is to examine the relationship between research and development investments and profitability. For this purpose, we chose Sonatrach as a case study Algeria's national company for research, production, transport, transformation, and marketing of hydrocarbons. Sonatrach is a prominent public entity in Algeria, frequently ranked among the top oil companies in both Africa and globally by numerous specialized industry magazines. In our study, we

relied on the data provided in the annual financial reports published by Sonatrach for the period from (2007- 2023).

1. Model description :

The multiple linear regression method is applied in our study, using SPSS v26 statistical software to analyze the relationship between the variables.

1.1. Variables of the study :

The independent variable "investment in research and development" is incorporated in the model and is measured using the following indicators :

- **R&D** : The research and development intensity rate is used as an indicator, which is calculated as the ratio of R&D expenditure (represented by intangible assets) to sales revenue. Intangible assets have been used to represent R&D spending because Sonatrach's annual financial reports indicate that intangible assets primarily consist of development costs, royalties, patents, licenses, and trademarks (Sonatrach, 2023). Furthermore, according to the International Accounting Standard IAS-38, R&D expenditures are recorded under "intangible assets" (IFRS, 2024).
- **Fr** : The formation rate indicator is calculated by dividing the number of employees receiving training annually by the total number of employees.
- **MoyF**: The average training days indicator represents the average number of training days employees receive annually in various specialties, which aim to enhance their skills, expertise, and ability to use different programs and production processes. As a result, this training positively impacts labor productivity and, in turn, the profitability of the company.

Profitability, the dependent variable, is measured through the following indicators :

- **PM** : This indicates the profit margin, calculated by dividing net income by sales.
- **ROA** : The return on assets is represented by the ratio of net income to total assets.
- **ROI** : This indicates the return on investment, determined by dividing net income by total investments, with total investments expressed as non-current assets.

- **ROE** : The return on equity is represented by the ratio of net income to total equity.

1.2. Study hypotheses :

To test the relationship between investment in research and development (R&D intensity, training rate, and the average number of days allocated for training) and the indicators of profitability (profit margin, return on assets, return on investment, and return on equity), we use the multiple linear regression method in the SPSS v26 statistical software.

The null and alternative hypotheses are presented as follows :

H0 : No significant association is found between the variables of investment in R&D and profitability indicators.

H1 : There is a significant relationship between the variables of investment in R&D and profitability indicators.

2. Results of the applied study :

This study's results present descriptive data on the R&D variables. Then, through the empirical analysis using multiple linear regression, we investigated the nature of the relationship between the R&D indicators and those of profitability.

2.1. Descriptive data analysis :

The descriptive analysis of the data related to the measures of investment in research and development is provided in Table (2) below, represented by the R&D intensity rate (RD), the formation rate within the company (Fr), and the average number of training days (MoyF) during the period from (2007-2023).

Table N°02: R&D intensity, formation rate, and average training days in Sonatrach during the period (2007–2023)

	N	Minimum	Maximum	Mean	Standard deviation
R&D Intensity (RD)	17	0,03	2,50	0,5122	0,73020
Formation rate (Fr)	17	17,04	52,99	36,1868	9,04922
Average training days (MoyF)	17	4	72	26	20,028

Source : Compiled by the researchers using SPSS v26 statistical software outputs.

Table (2) shows that the average R&D intensity rate is 0.51% with a standard deviation of 0.73. The minimum R&D expenditure rate is 0.03%, while the maximum is 2.50%.

The analysis shows that the average R&D intensity rate at Sonatrach between (2007- 2023) was 0.51%, which surpasses the global average for oil and gas companies 0.3% in (2022) and declining further to 0.19% in (2023). However, this figure remains lower than the expenditure observed in other sectors such as software and technology services. The oil and gas industry has experienced a steady downward trend in R&D intensity over the past 20 years, with a rate that did not exceed 1.17% in (2016). For example ; Exxon reported an average R&D intensity of 0.37% over the period (2016–2023), while companies like Chevron, Petrobras, and China Petroleum & Chemical Corporation recorded rates around 0.3%. Saudi Aramco’s R&D intensity similarly averaged 0.37% during the same period (IRI, 2024). According to the OECD report, this decline is primarily attributed to fluctuations in oil and gas prices in recent years, particularly during 2014 and 2015, which led to revenue instability. As a result, investment in research and development dropped by 16% (Kahil et al. 2016). Furthermore, a growing focus has also emerged on promoting research and development in renewable and clean energy, reducing focus on traditional energy industries (Galindo-Rueda & Verger, 2016).

According to the same table, the average training rate is approximately 36.19%, while the average number of training days received annually by Sonatrach employees is 26 days. Although there is a lack of available data regarding the average training rate in global oil and gas companies, the general trend in recent years has been toward training employees in the field of renewable and clean energy, and encouraging qualified workers to transition into this emerging sector. According to the Global Energy Talent Index (GETI), there has been a decline in training rates within the oil and gas sector due to the growing focus on renewable energy. Therefore, companies operating in the oil and gas industry need to demonstrate a stronger commitment to decarbonization efforts by improving employee training and recruitment to enhance their overall performance (GETI, 2023).

2.2. The multiple linear regression results for the relationship between R&D investment and profitability indicators :

To study the effect of investment in research and development (represented by : R&D intensity rate, training rate, and the average number of training days assigned to each employee) to assess the impact of the independent variables on Sonatrach's financial performance indicators (profit margin, return on assets, return on investment, and return on equity) during 2007-2023, a multiple regression analysis was performed. The findings are presented below in Table (3).

Table N°03: Multiple regression analysis of the impact of R&D investment on profitability in Sonatrach during (2007–2023)

Dep variable	Indep variable	R	R ²	F	Sig	Beta	T	Sig level	VIF
PM	RD	0.714	0.51	4.514	0.022	- 0.505	- 2.458	0.029	1.120
	Fr					0.337	1.467	0.166	1.402
	MoyF					- 0.556	- 2.519	0.026	1.294
ROA	RD	0.738	0.545	5.185	0.014	- 0.503	- 2.540	0.025	1.120
	Fr					0.222	1.002	0.334	1.402
	MoyF					- 0.651	- 3.059	0.009	1.294
ROI	RD	0.791	0.625	7.235	0.004	- 0.464	- 2.585	0.023	1.120
	Fr					0.288	1.434	0.175	1.402
	MoyF					- 0.756	- 3.917	0.002	1.294
ROE	RD	0.783	0.614	6.884	0.005	- 0.487	- 2.671	0.019	1.120
	Fr					0.267	1.310	0.213	1.402
	MoyF					- 0.730	- 3.720	0.003	1.294

Source : Compiled by the researchers using SPSS v26 statistical software outputs.

The findings of the multiple linear regression model, assessing the relationship between the independent variables (R&D investments) and the dependent variable (profit margin), reveal statistical significance, as evidenced by an F-value of 4.514 and a p-value of 0.022, which is below the 0.05 significance threshold. This confirms that the model is valid for analyzing the relationship between the variables.

As shown in Table (2), the coefficient of determination (R^2) indicates that the independent variables (R&D investment variables) account for 51% of the variance in the profit margin. The Beta value provides insight into the relationship between the profit margin and R&D intensity, is -0.505 (a negative relationship) and is statistically significant, as can be concluded from the T-value and its associated significance level. This means that whenever R&D intensity increases by one unit, the profit margin reduces by 0.505 units. The Beta value for the relationship between the profit margin and the training ratio is 0.337, showing a positive relationship, though it is not statistically significant. The Beta value for the relationship between the profit margin and the average number of training days per employee is -0.556 (a negative relationship) and is statistically significant. This means that whenever the number of training days per employee increases by one unit, the profit margin reduces by 0.556 units.

In examining the relationship between R&D investment variables and return on assets, it shows the significance of the model through an F-value of 5.185 with a significance level of 0.014, which is less than the 0.05 significance threshold. It can be inferred that the linear regression model is appropriate for illustrating the relationship between return on assets and R&D variables. The coefficient of determination (R^2), estimated at 0.545, indicates that 55% of the variance in return on assets is explained by the R&D variables. The Beta value was -0.503 (a negative relationship) and statistically significant, meaning that for every one-unit increase in R&D intensity, the return on assets decreases by 0.503 units. Meanwhile, the Beta coefficient indicating the relationship between return on assets and the training ratio is 0.222, suggesting a positive but statistically insignificant relationship. In contrast, the Beta value for the relationship between return on assets and the average number of training days per employee is -0.651, indicating a statistically significant negative relationship. This implies that for every one-unit increase in the average number of training days per employee, the return on assets decreases by approximately 0.556 units.

The study that examines the association between research and development expenditures and ROI shows that the model is significant, with an F-value of 7.235 and a significance level of 0.004, which is below 0.05. The coefficient of determination (R^2) was 0.625, Showing that 63% of ROI variation is explained by R&D factors. The Beta value is -0.464 (a negative relationship) and statistically significant, and indicates that for every one-unit increase in R&D intensity, the return on investment reduces by 0.464 units. Meanwhile, the Beta coefficient

representing the relationship between return on investment and the training ratio is 0.288, indicating a positive but statistically insignificant relationship. In contrast, the Beta value for the relationship between return on investment and the average number of training days per employee is -0.756, reflecting a statistically significant negative relationship. This suggests that for every one-unit increase in the average number of training days per employee, the return on investment decreases by 0.756 units.

Table (2) shows that the relationship between R&D investment and return on equity is statistically significant, with an F-value of 6.884 and a p-value of 0.005, which is below 0.05. The R^2 value of 0.614 means that R&D variables explain 61% of the variance in return on equity. It is found that the Beta value for the relationship between return on equity and R&D intensity is -0.487, indicating a statistically significant negative relationship. This suggests that for every one-unit increase in R&D intensity, return on equity decreases by 0.487 units. The Beta value between return on equity and the training ratio is 0.267, reflecting a positive relationship, but it is not statistically significant. Meanwhile, the relationship between return on equity and the average number of training days per employee is clarified by a Beta value of -0.730, which is statistically significant, meaning that each one-unit increase in training days leads to a decrease of 0.730 units in return on equity.

Table (2) also shows that there is no multicollinearity problem among the variables, as evidenced by the variance inflation factor (VIF) values, which do not exceed 3.

Based on these results, it can be stated that the relationship between investment in research and development, represented by the variables : R&D intensity, training ratio, and the average number of training days per employee on one side, and the profitability variables, represented by : PM, ROA, ROI, and ROE on the other, is as follows :

A statistically significant negative relationship is found between R&D intensity and the average number of training days per employee, on one side, and the four profitability variables, on the other side. As a result, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. Based on the findings, it can be concluded that greater investment in research and development (indicated by R&D intensity and the average number of training days per employee) corresponds to a decrease in profitability at Sonatrach Company.

Meanwhile, a positive relationship exists between the training ratio variable (the ratio of employees who received training to the total number of employees), although it is not statistically significant.

3. Discussion

This study aims to explore the relationship between research and development investment—captured through three key indicators : R&D intensity, training ratio, and the average number of training days—and the profitability of Sonatrach Company, assessed using profit margin, return on assets, return on investment, and return on equity, over the period from 2007 to 2023. The findings indicate a moderately strong and statistically significant negative relationship with R&D intensity, suggesting that a one-unit increase in R&D intensity is associated with an approximate 50% decrease in profitability indicators. It is significant to point out that the intensity of R&D in the company is higher than the global average, which has declined due to the fluctuations in global oil and gas prices, as well as the global trend towards investing in R&D in the field of renewable and clean energy.

It can be observed that Sonatrach's managers continue to allocate substantial resources to R&D expenditure, despite the absence of positive effects on the company's profitability. Although the literature reviewed in the theoretical framework suggests that the impact of R&D on profitability is cumulative, often requiring several years, for results to materialize, and that short-term effects may be negative in certain sectors but generally turn positive and sustainable after approximately nine years (Wei & Lin, 2021), the case of Sonatrach presents a contrasting scenario. It is clearly noticeable that R&D spending produces adverse results despite a long period of up to 17 years. Nevertheless, the company continues to spend significantly on R&D, even amid a sharp decline in its revenues during the years (2015-2016) and (2020) due to the drop in global oil and gas prices. This may be due to the company's awareness of the importance of R&D in providing long-term benefits and solutions, such as finding ways to increase production and exploration activities, enhancing operational efficiency, and reducing costs. The absence of positive impacts of R&D on profitability could be linked to the reduction in sales value resulting from the decline in global oil and gas prices, a variable outside of Sonatrach's control. Nonetheless, the company strives to mitigate the revenue shortfall caused by falling prices by boosting its oil and gas production and increasing its exploration activities, hence its ongoing commitment to R&D spending.

It is worth mentioning here that the company has initiated research and development activities in the field of renewable and clean energy (green hydrogen and solar energy) within pilot projects in cooperation with German partners, making use of the vast area of the Algerian desert (Sonatrach, 2023).

Also, we notice that the average number of training days per employee also has a statistically significant negative relationship, ranging between 55% and 75%, which is considered a moderate to strong negative relationship. The average number of training days per employee increased annually, even during the years in which the company recorded its lowest sales levels. All employees benefited from this training, in both the core and support departments, whether they were long-serving staff or newly recruited employees. The number of training days only declined during the COVID-19 health crisis, which necessitated a shift to remote training for more than two years. Meanwhile, the relationship between the training ratio and all profitability indicators was positive but not statistically significant, meaning that there is no relationship between the percentage of employees benefiting from training and the profitability indicators. Despite this, all employees equally benefit from training, which, according to the company's annual reports, is characterized by high-quality, world-class training programs delivered in partnership with foreign experts, targeting all professional categories according to the company's needs. The company also offers academic training programs for its specialized and technical employees to obtain advanced diplomas (Sonatrach, 2014). Unfortunately, we do not have statistics on the training ratios and global training programs implemented by companies operating in the same sector, which would have allowed us to compare them with those of Sonatrach.

Conclusion :

In this study, we sought to examine the potential impact of three key indicators of research and development investment on the profitability of Sonatrach, Algeria's state-owned oil and gas company, using data extracted from its annual reports covering the period from (2007-2023).

Upon completion of the analysis, the study revealed the following insights :

- The share of investment in R&D activities (R&D intensity) at Sonatrach is high (0.51%) and exceeds the global average of companies operating in the oil and gas sector. These companies tend

to reduce R&D spending due to fluctuations in their revenues caused by the volatility of oil and gas prices, which tend to decline, in addition to a general shift by these companies towards investing in R&D related to clean and renewable energy.

- The regression analysis confirms a significant relationship between R&D intensity and profitability indicators, consistent with the study's hypothesis. However, this relationship has a moderate negative effect (0.50%). This negative relationship is contrary to expectations, especially given that the study covered a time span of 17 years, which is a relatively long period which would typically provide sufficient time for the positive impact of R&D investments on profitability to materialize. However, the results we obtained make the R&D activity appear as a large intangible expense that burdens the company's budget without contributing to its profitability.
- With regard to the variable of the average number of training days: there is a statistically significant relationship between it and the profitability indicators, but it has a moderately strong negative effect reaching up to (0.75%).
- The relationship between the training ratio and the profitability indicators was positive but not statistically significant.
- This study showed that the high degree of risk and uncertainty associated with investment in R&D, which may prevent the emergence of positive effects on the company's profitability, could increase further if the company operates in a sector characterized by price instability, such as the oil and gas sector, which is subject to international policies beyond the control of producing companies.
- Sonatrach shows an understanding of the significance of investing in alternative energies, as evidenced by its recent partnerships with leading international companies in this domain. However, the company seems to be progressing more slowly than expected. Thus, regardless of the level of investment in R&D, whether in traditional or renewable energy, Sonatrach's executives should assess the effectiveness of these projects to ensure they contribute positively to the company's profitability and overall performance.

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