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CEO's Education Level and Investments in R&D

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Abstract

The paper evaluates the influence of a CEO's education level and their experience on the amount invested in R&D in the pharmaceutical industry. The sample consists of 270 high-tech pharmaceutical companies from the S&P BMI index in 1999–2018 from 23 countries, both developed and emerging. The pharmaceutical industry is of particular interest since the projects in this sphere require specialized education to understand and manage business processes. Therefore, the investment payback period is long. As a result, there is a high rate of intangible assets in pharmaceuticals compared to other sectors.

At the first glance, according to the results of regression analysis, a degree in business, finance, management and economics has no significant impact on investments. However, education in a specific sphere, i.e., physics, chemistry, biology, or mathematics, has a significant positive impact on R&D expenses. We can see a similar effect for CEOs with two or more degrees in different fields. These results are in line with the findings of previous studies regarding CEO's education.

At the next stage, a CEO's educational level and major are analyzed simultaneously. A degree obtained in an industry-specific field or a degree supplemented by a degree in finance or management education has a positive impact on R&D expenses, while a standalone financial degree, on the contrary, has a negative effect.

Thus, this study contributes to academic literature by introducing the concept that to get unbiased results in similar studies we should account not only for the degree, but also for the major. In the practical sphere, the results may be useful for those choosing the educational track on their career path to a CEO position, as well as for HRs, boards of directors, and other stakeholders who are making a decision on CEO turnover. Moreover, the results provide insights that could be useful for market analysts' and investors' predictive models.

Keywords: CEO, CEO's education, R&D, investments, MBA, PhD, management

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Introduction

A CEO's personality, in particular the observed characteristics and the decisions made by them personally (stock buyback/purchase, interviews, etc.) are often used by researchers to explain internal corporate decisions. Education as an observed characteristic allows not just to evaluate the cognitive capacities of a person, but is also used as a variable capable of explaining risk attitude. In these cases, the primary emphasis is placed not so much upon the educational level [1–5], as on the major [6–7]. For instance, C. Yang et al. [8] used the Chinese market as an example to demonstrate how CEOs' financial education decreased corporate innovative activity by 17.5%, explaining it by a lower proneness of CEOs with a financial degree to make risky decisions. At the same time, some authors assert that neither the education level nor the major is of importance, while the quality and status of the CEO's higher education institution prove essential [9].

Based on the current information about CEOs of pharmaceutical companies with the highest revenues (top 50), one may conclude that business has no prevailing opinion concerning CEO's education, which ranges from incomplete higher education to doctoral degrees in medical sciences. The prevalent education is an MBA degree followed by a Doctor of Science, Doctor of Medicine and Doctor of Law. As the CEO vacancy market grows, the issue of the optimal characteristics of candidates for this position becomes increasingly relevant. Thus, while it is common to assign specialists in a particular sphere and/or those who have experience in the company to this position, the idea of the need for a degree in management is gaining popularity. It allows to direct the team instead of delving into technical details, which often leads to missing the company's primary objectives – building a successful team and establishing effective teamwork [10]. At the same time, the issue of choosing the optimal education of a CEO (degree, major and their combination) that influences their behaviour patterns and decision-making models remains undetermined for the pharmaceutical sector.

On the basis of the conclusions made in previous studies, we start our analysis with a separate study of the educational level and major, verifying the hypotheses of the previous studies, and subsequently creating a complex indicator that takes into consideration both aspects of education: its level and major.

Literature Review

Modern economic science is increasingly shifting away from the reasonable individual paradigm, blurring the boundaries of its subjects which allow its models to be augmented with increasingly more parameters that may be more characteristic of sociological and psychological sciences than of conventional economics with strict mathematical models. Behavioural economics and finance, which were hardly heard of half a century ago, have already gained their place among scientific disciplines, and are strengthening their position in the programs offered by the leading universities and heralding a new epoch in economic theory with new Nobel Prize winners who are researching this cross-disciplinary subject.

Such changes were inevitable. As the amount of data available for analysis increased and technical facilities for its processing improved, the issues of model residuals became more obvious, requiring a more detailed analysis of the phenomena that used to be explained by "culture" and other notions previously undefined, let alone quantified by the science of economics. Apart from that, explicit contradictions were revealed with the fundamental decision-making model – a reasonable individual relying on a clearly defined utility function, who always evaluates all available information accurately in order to achieve the only correct resolution. Analysis of investors' behaviour in the financial market, decisions of top managers and boards of directors on risky investments and many other things finally proved that non-inclusion in the model of human "irrationality" in all its multiplicity provides the results that alienate us from real life.

In management and finance, the CEO's personality is often the main explanation for the decisions made by the company. Their experience, preferences, skills and specific approaches to decision-making influence the attitude to risk within the business, thus, exerting impact on the amount and quality of investments made by the company, among other things [11].

Education is often added to the analysis as a variable that helps to assess a CEO's human capital and risk proneness. Apart from an expansion of knowledge, which indisputably influences the capability and desire to consider and accept new ideas for development, in the researchers' opinion one of its aspects, namely, the major, may have an impact on the attitude to decision-making [12].

The increasing popularity of adding a CEO's education to analysis is explained by a relative availability of data (unlike special behavioural characteristics and other factors measured by means of direct interviews, educational data is often available on corporate websites and in reports), the possibility of evaluation and comparison of the educational level and higher education institutions' rank, as well as by the possibility of widespread use.

The upper echelon theory presumes that a CEO's actions are conditioned by their limited rationality. Thus, a well-educated CEO is more likely to monitor market trends and invest in innovation development, while CEOs with a narrow area of expertise with vast experience prefer more conservative way of enhancing efficiency of the already functioning processes [3; 11; 13].

CEO's Education and Risk Attitude

What is the CEO's role in corporate decision-making? We will try to answer this question based on the results of previous studies.

Apart from the apparent role in the transfer of knowledge and fundamental skill formation, education plays an important role in creating the thinking pattern of future can-

didates for the CEO's position. The selected education type may assist the CEO in the future to get a grasp on the details of a business and to mitigate the potential inefficiency in decision-making caused by other factors, as well as lead to the selection of non-optimum strategies, i.e., when the obtained knowledge stimulates a focus on only one part of the issue (technical or commercial), overlooking the other part. Therefore, the issue of a CEO's education provokes a particular interest of researchers, entailing the optimal choice of a major, or a possible combination of majors and the role of the degree in the future work in a particular business sphere.

Recent research by S.N. Kaplan and M. Sorensen [14] dedicated to study of selection of CEO candidates showed that interviewers considered candidates with an MBA degree to be less attractive and more prone to risk. A.J. Daboub et al. [15] also indicate that a business degree (MBA, business schools) causes a decline in moral values, making the graduates more inclined to pursue personal goals, which often results in fraud and illegal activity. M. Bertrand and A. Schoar [16] in their research also arrive at the conclusion that an MBA degree forecasts a more "aggressive" CEO's behaviour.

However, the paper by S.N. Kaplan and M. Sorensen [14] emphasizes that appointed CEOs with an MBA degree are more talented and more oriented to the strategic result. At the same time, research conducted by T. King et al. [6] showed that if there was a certain contract and incentive format, CEOs with a management degree managed banking companies more efficiently. Additionally, A.Yu. Manyushis [10] states that a degree in management is mandatory for companies' heads because an industry-specific profession and experience does not make up for the absence of people management and decision-making skills.

On the basis of conclusions made in previous studies, we presume that a CEO's MBA degree leads a director to choose a riskier strategy that is also more personally rewarding. On the other hand, this may cause a decrease in the amount of investment in development due to the pursuit of short-term goals in order to obtain a greater personal benefit i.e., increased premiums and improved reputation in the market. This is in line with the results by S. Bhagat et al. [17], wherein one of such results shows a positive influence of hiring a CEO with an MBA in the short term and no results on a long-term horizon.

On the one hand, financial education provides skills for the efficient management of complex companies (such as banks), which allows to achieve better results [18]. At the same time, results are often achieved by decreasing excessive investments in innovation [8]. C. Custódio and D. Metzger [19] confirm that financial experts acting as CEOs handle the corporate financial policy more efficiently, attracting external capital even in difficult economic conditions, and ensure the optimal investment of such capital. The same explanation may be applicable in case of smaller amounts of investment in R&D among CEOs with a degree in management. Based on the above, our hypothesis is as follows:

H1. A CEO's financial degree or an MBA degree leads to decreased investments in research and development in the company they manage.

In spite of the wide availability of management education, companies are often headed by technical professionals who typically have a good knowledge of the industry where their company operates. Irrespective of a possible lack of team management skills, technical professionals have a better understanding of the practical aspects of business (technical nuances, marketability, probable risks), which simplifies communication, interaction and decision-making procedure on investment in high-priced and high-risk R&D projects [20].

Technical experience (measured by the authors as experience in senior positions according to the selected major and in the selected industry) has a positive influence on the readiness to invest in innovation, and in this case both engineering and scientific experience is taken into consideration. At the same time, technical expertise also expands the CEO's planning horizon, which is of particular importance for research activities where projects may last longer than a typical director's tenure [21].

H2. A CEO with a technical/science degree is more involved in internal corporate processes and has a greater desire to undertake research projects, thus bringing about increased investments in research and development within the company.

H3: A CEO with a technical/science degree and financial/management education has a better understanding of a company's processes and goals, and is more effective in organizing and financing its operations. Due to this, the amount of investment in research and development in their company will be higher than in the companies managed by a CEO with only a technical/science degree.

Higher education is often used as a measure of an individual's cognitive capacities [1]. A doctoral degree as the highest level of the educational system, and should presumably be indicative of greater intellectual abilities in comparison with those without such a degree. For instance, the paper by D. Gounopolous et al. [22] states that this degree is a positive signal for investors in case of IPO.

A study of Chinese companies by L. Wang et al. [23] showed that academic experience has a positive impact on a company's sustainable growth due to innovation and internal control within the company.

Thus, our next hypothesis is as follows:

H4. CEO's academic degree entails an increase in investment in research and development in a company.

Other (Non-educational) Characteristics of CEO's Experience

Role of International Experience

The current globalization trend leads to a greater number of people graduating from foreign higher education insti-

tutions and increases the probability of appointment of a CEO from another country or with training or experience obtained in another country. As long as foreign experience frequently entails a CEO's training, we believe that the addition of this variable to the analysis when studying the role of education is logical, as it clarifies the role of education in the formation of a CEO's personal qualities and attitude to risk.

Managers with foreign experience usually have better education, more developed skills, are more innovative and deal more easily with long-lasting failures which are often characteristic of the innovative process [21]. At the same time, the effect of foreign experience is similar in cases of both foreign education and foreign experience [24]. The most recent papers show that contrary to popular belief, a CEO's foreign experience results in a reduction of risks of fraud and financial collapse and an improvement of corporate performance [25–26].

H5. A CEO with foreign education or experience is more likely to consider financing of innovative activity, which leads to increased investments in research and development in the company they manage.

Company Founders

One of the variables frequently added to the analysis is the role of the CEO in company foundation. There is a belief that making a company founder its CEO or appointing them CEO again ensures a better understanding of a company's strategic objectives by its head and results in a better economic performance of the company [27]. A study of high-tech companies' management demonstrated that founders are more enthusiastic about investing in development [28].

At the same time, the next generations of the founders' family face the risk of being psychologically biased in the role of the company head. Anchoring and the desire to preserve the company's current state for passing it on to heirs are among the most common problems [29]. Assuming that the presence of a CEO who is also the company founder leads to a better understanding of objectives by top managers, ensuring more effective teamwork and better performance, and also considering that company founders typically have an entrepreneurial mindset and in case of listed companies – have the skills to organize the work and convince the board of their efficiency – we hypothesize a positive influence of this situation on the amount of investments irrespective of education.

H6. Companies managed by their founders will invest more than others in research and development.

H7. The next generations performing the functions of a CEO will invest less in innovation than the founder, but investments will remain at the market level in order to retain the company's current position.

Data and Methodology

In this empirical study, we sought to analyze the impact of different aspects of education: the level, the major and the combination of these factors. We use the standard STATA regression analysis tools, version 12.1.

Data

The research material comprises the data on 261 pharmaceutical and biotechnology companies from the S&P Global BMI index from 23 developed and emerging countries. Companies' financial indicators were obtained from Capital IQ, while the data on CEO's education, their participation in the company foundation and foreign experience was collected manually from corporate web sites, annual reports, interviews and other publicly available sources. After we eliminated the companies with unavailable information (both financial and partial information on CEO's education and other characteristics relevant to our research), we obtained 3485 observations for 1999–2018. The data is an unbalanced panel, i.e., there may be no information on some companies within the period indicated.

Study Design

The dependent variable in this research is the logarithm of the ratio of the funds invested in research and development to the last year's revenue which, according to our assumption, is indicative of the company's fund allocation decisions and the readiness to accept risks of investing shareholders' funds in new projects that are not always successful.

$$RDRev = log\left(\frac{R\,\&\,D\,exp}{Revenues_{t-1}} + 1\right), \quad (1)$$

where $RDRev$ is the dependent variable that equals the logarithm of the ratio of R&D investments ($R\,\&\,D\exp$) to the last year's revenue ($Revenues_{t-1}$).

We used a series of dummy and categorical variables that characterize a CEO's education, their affiliation with the founder's family, foreign experience and a range of control variables: quantitative and dummy variables that characterize the company (company's age, revenue logarithm to control for company size, operation in the developed or emerging market, debt load level) as explanatory variables (Table 1).

Table 1. Variables, used in studies

Independent Variables	
Phd	The dummy takes on the value of 1 if the CEO has a doctoral degree
PhD spec	Categorical variable 1 – management/financial degree if the major is not indicated, 2 – technical/science degree

Independent Variables	
Educ	Categorical variable: 0 – no degree, 1 – major is not indicated, 3 – management and financial, 4 – technical/science sphere, 5 – combination of the degree with a technical/science major and management education
MBA	The dummy takes on the value of 1 if the CEO has an MBA degree OR has other financial, business or management education
Found	The dummy takes on the value of 1 if the founder is also the CEO, 0 – otherwise
Internexp	The dummy variable, 1 – if the CEO has worked or studied abroad, 0 – otherwise
Control Variables	
Age	Logarithm of company's age (as control of the life cycle stage)
Duality	The dummy variable, 1 – if the CEO is the chairman of the Board of Directors, 0 – otherwise.
CEOonplace	CEO's tenure
rev	Logarithm of the prior period revenue, USD mln.
DEq	Logarithm of the ratio of debt to share capital
RD	Logarithm of previous year's investment in research and development in USD mln.

In order to verify the proposed hypotheses, the following model was used in the regression analysis:

$$RDRev = \alpha_0 + \alpha_1 education + \alpha_2 founder + \\ + \alpha_3 intern.exp + \alpha_4 age + \alpha_5 rev + 6emerg + \\ + \alpha_7 DEq \quad , \quad (2)$$

where $RDRev$ is the dependent variable that equals the logarithm of the ratio of R&D investments ($R\&D\exp$) to the last year's revenue ($Revenues_{t-1}$); $education$ – the explanatory categorical variables responsible for the degree and (or) education level; $founder$ – the categorical variable which takes on the value of 1 if the CEO is the company founder and 2 – if the CEO is a representative of the founder's family next generations; $intern.exp$ – the dummy variable which takes on the value of 1 if the CEO has foreign education or foreign experience; age, rev, $emerg$, DEq – control variables responsible for the company's age (company's age logarithm), size (revenue logarithm), a dummy for emerging and developed markets and the leverage ratio.

Descriptive Statistics

As Table 2 demonstrates, CEOs with an industry-specific degree prevail in pharmaceutical companies: CEOs with a doctoral degree related to their job profile without an additional management and/or financial education are most common, followed by CEOs with non-technical/science degree and with a master's degree in management or finance or an MBA, CEOs with both technical/science and management or financial education are less numerous. In addition, when we summed up various education levels, we did not reveal a significant difference between the shares of CEOs with only industry-specific degree and CEOs with only management and/or financial degree (shares of both amount to ~37% of the selection), only the share of CEOs with combined education (15%) or an irrelevant profession (~11%) is smaller. Combined shares of CEOs with an MBA or a similar degree (master's degree in management or finance) amount to 26% of observations. This exceeds the share of CEOs with only an industry-specific education and advanced degree, which is indicative of the trend detected when considering CEOs of top 50 pharmaceutical companies in terms of revenue.

Table 2. Characteristics of CEOs in the sample

Level and major	Number of observations	Share in the sample, %
Bachelor's degree, major unknown	388	9.15
Master's degree and/or bachelor's degree in an irrelevant profession (linguistics, philosophy, arts etc.)	63	1.49
Bachelor's degree in management/finance	250	5.89

Level and major	Number of observations	Share in the sample, %
Bachelor's or master's technical/science degree	534	12.59
Master's degree in management/finance or an MBA	756	17.83
Bachelor's or master's technical/science degree and an education in management/finance and MBA	385	9.08
A doctoral degree in management/finance	84	1.98
A doctoral technical/science degree (including biology and medicine)	1036	24.43
A doctoral technical/science degree and a management/finance degree	261	6.15
A degree in law or the major has not been indicated	380	8.96
A degree in law or the major has not been indicated and a management/finance degree	104	2.45
Others		
A person studied or worked abroad	2571	57.76
Company founders	1623	36.44
The next generations of the founders' family	198	4.45

Results

In order to test the hypotheses regarding the correlation between education and the share of investments in revenue, we used linear regression tools with panel data with adjusted panel standard errors (adjusted standard deviations for heteroscedasticity taking into consideration the correlation between panels and general autocorrelation of AR-1 order). In order to verify the results, we calculated separate models for developed (column 2 in Tables 3–6) and emerging (column 3 in Tables 3–6) markets, as well as with random (column 4 in Tables 3–6) and fixed (column 5 in Tables 3–6) effects. In all versions of regression models, the logarithm of the share of the amount invested in research and development in the previous year's revenue serves as the dependent variable.

First, we tested the models to assess the first three hypotheses concerning the degree major. CEOs' technical/science degree has a positive impact on their readiness to invest large amounts in research and development, while an additional degree in management/finance enhances the effect, which may be related to skills of efficient allocation and raising investment funds. See the analysis results in Table 3: a business degree turned out to be insignificant for all five specifications (first line, columns 1–5), while a technical/science degree showed a significant positive influence on investment in the models with adjusted standard errors in general (column 1) and separately in developed and emerging markets (columns 2–3) and with random effects (column 4) confirming Hypothesis 2. The significance of positive coefficients of the dummy responsible for a combination of majors – a technical/science degree plus a degree in management/finance for specifications with adjusted standard errors (columns 1–3) – also allows not to reject Hypothesis 3 on enhancement of the positive influence of a technical/science degree when a person also has theoretical and practical team management skills and a relationship with the team.

Further on we examine the results of testing Hypothesis 4 on the role of a science degree (PhD) using an additional dummy variable that controls for the presence of a degree, but does not take into account the major of the CEO's entire education (Table 4). Since the data on the CEO's major is not always publicly available, adding a CEO's education to the analysis often results in stating the fact of the presence or absence of a scientific degree because it is a factor more accessible to observation. Analysis shows that education had a significant positive effect only in the linear regression models with panel data with adjusted panel standard errors without division into developed and emerging markets (column 1) or addition of random effects (column 4). In this case, the dummy for emerging countries had a significant negative value surpassing the effect of education, which is indicative of an ambiguous nature of the obtained conclusions. The obtained results may be explained by the conclusions made earlier regarding the non-homogeneous influence of various educational patterns (choosing a major, combination and education irrelevant to the industry).

In order to verify the hypothesis in more detail and to avoid ambiguous results due to model simplification, further on we introduce to the model a categorical variable, which takes into consideration the specialization of the obtained degree (technical/science or otherwise) (Table 5). In this case, a technical/science education in the industry relevant for the company had a significant

positive effect in the linear regression models on panel data with adjusted panel standard errors accompanied by the addition of developed and emerging regions (column 1), as well as separately (columns 2–3). At the same time education unrelated to the company's industry had a significant positive effect only in the random effects model (column 4). Thus, ignoring the difference in majors when analyzing education based on the presence or absence of a scientific degree leads to ambiguous results. The results confirm a positive influence of the CEO's scientific degree related to the company's industry on the share of investment in R&D. At the same time, the ambiguity is preserved when considering the remaining group with a degree, which comprises CEOs with a business education, as well as those with an unknown major.

Table 3. Results of regression analysis with CEO's major as the explanatory variable

VARIABLES	(1) L.lrdrat	(2) L.lrdrat	(3) L.lrdrat	(4) L.lrdrat	(5) L.lrdrat
Spec. Business	0.0116	0.0119	0.0636	–0.0254	–0.0465
	(0.0409)	(0.0612)	(0.0720)	(0.0606)	(0.0735)
Spec. industry	0.115***	0.102*	0.188***	0.127**	0.0674
	(0.0400)	(0.0532)	(0.0635)	(0.0588)	(0.0714)
Spec. industry+business	0.131***	0.122**	0.108*	0.102	0.0983
	(0.0425)	(0.0539)	(0.0645)	(0.0713)	(0.0857)
1.internexp	0.157***	0.0912**	0.289***	0.150***	0.0502
	(0.0323)	(0.0430)	(0.0363)	(0.0472)	(0.0625)
1.Found	0.118**	0.164***	0.0377	0.120**	0.202***
	(0.0510)	(0.0614)	(0.0615)	(0.0554)	(0.0771)
2.Found	–0.0480	–0.0569	–0.0873*	–0.0679	–0.00550
	(0.0417)	(0.0643)	(0.0524)	(0.119)	(0.173)
Duality	–0.0413	–0.0459	–0.0324	–0.106**	0.00623
	(0.0445)	(0.0585)	(0.0440)	(0.0503)	(0.0658)
CEOonplace	–0.00239	–0.00505*	–0.000993	–0.00127	–0.00334
	(0.00174)	(0.00305)	(0.00175)	(0.00237)	(0.00287)
cage	–0.000776	–0.000866*	–0.000652	–0.000655	0.00982***
	(0.000499)	(0.000513)	(0.000468)	(0.000660)	(0.00308)
lrev	–0.378***	–0.390***	–0.318***	–0.367***	–0.279***
	(0.0419)	(0.0431)	(0.0668)	(0.0123)	(0.0132)
ldeq	–0.0118*	–0.000643	–0.0377***	–0.00665	0.0116*
	(0.00620)	(0.00688)	(0.0110)	(0.00611)	(0.00645)
1.emerg	–0.221***			–0.180***	
	(0.0457)			(0.0652)	
Constant	3.407***	3.506***	2.810***	3.331***	2.159***
	(0.286)	(0.293)	(0.491)	(0.109)	(0.171)
Observations	3430	2266	1164	3430	3430
R-squared	0.405	0.397	0.367		0.128
Number of nocomp	252	159	93	252	252

*** – $p < 0.01$ – highly significant influence; ** – $p < 0.05$ – significant influence; * – $p < 0.10$ – statistically significant influence.

Table 4. Results of regression analysis with a dummy responsible for existence of CEO's scientific degree as an explanatory variable

VARIABLES	(1) L.lrdrat	(2) L.lrdrat	(3) L.lrdrat	(4) L.lrdrat	(5) L.lrdrat
PhD	0.0625*	0.0451	0.0925	0.0984**	0.0596
	(0.0329)	(0.0384)	(0.0577)	(0.0418)	(0.0523)
1.internexp	0.138***	0.0842**	0.232***	0.136***	0.0423
	(0.0278)	(0.0376)	(0.0362)	(0.0450)	(0.0604)
1.Found	0.112**	0.152***	0.0594	0.124**	0.209***
	(0.0488)	(0.0582)	(0.0609)	(0.0533)	(0.0735)
2.Found	–0.0175	–0.0444	–0.0330	–0.0586	–0.0204
	(0.0392)	(0.0639)	(0.0516)	(0.117)	(0.170)
Duality	–0.0272	–0.0384	0.000927	–0.102**	0.00624
	(0.0421)	(0.0545)	(0.0433)	(0.0486)	(0.0631)
CEOonplace	–0.00192	–0.00464	0.000176	–0.000722	–0.00319
	(0.00177)	(0.00282)	(0.00188)	(0.00227)	(0.00274)
cage	–0.000832	–0.000944*	–0.000710	–0.000736	0.00981***
	(0.000508)	(0.000545)	(0.000445)	(0.000645)	(0.00293)
lrev	–0.379***	–0.393***	–0.322***	–0.366***	–0.279***
	(0.0419)	(0.0432)	(0.0662)	(0.0120)	(0.0128)
ldeq	–0.0107*	–0.000516	–0.0380***	–0.00576	0.0124**
	(0.00620)	(0.00668)	(0.0108)	(0.00588)	(0.00621)
1.emerg	–0.228***			–0.168***	
	(0.0488)			(0.0636)	
Constant	3.459***	3.565***	2.896***	3.321***	2.136***
	(0.291)	(0.296)	(0.494)	(0.0999)	(0.160)
Observations	3600	2436	1164	3600	3600
R-squared	0.408	0.404	0.369		0.127
Number of comp	261	168	93	261	261

*** – $p < 0.01$ – highly significant influence; ** – $p < 0.05$ – significant influence; * – $p < 0.10$ – statistically significant influence.

Table 5. Results of regression analysis with a dummy responsible for existence of CEO's doctoral degree and its major as an explanatory variable

VARIABLES	(1) L.lrdrat	(2) L.lrdrat	(3) L.lrdrat	(4) L.lrdrat	(5) L.lrdrat
PhD in business/ not stated	0.0234	0.0129	0.00957	0.0954**	0.0572
	(0.0337)	(0.0441)	(0.0651)	(0.0451)	(0.0571)
PhD industry	0.196**	0.136**	0.458*	0.109	0.0670
	(0.0805)	(0.0639)	(0.243)	(0.0721)	(0.0869)

VARIABLES	(1) L.lrdrat	(2) L.lrdrat	(3) L.lrdrat	(4) L.lrdrat	(5) L.lrdrat
Internexp	0.138***	0.0817**	0.251***	0.136***	0.0415
	(0.0278)	(0.0380)	(0.0351)	(0.0453)	(0.0609)
1.Found	0.120**	0.159***	0.0936	0.125**	0.210***
	(0.0479)	(0.0570)	(0.0664)	(0.0536)	(0.0737)
2.Found	–0.0106	–0.0393	–0.0173	–0.0574	–0.0187
	(0.0387)	(0.0633)	(0.0529)	(0.118)	(0.171)
Duality	–0.0377	–0.0476	–0.0160	–0.102**	0.00642
	(0.0440)	(0.0545)	(0.0463)	(0.0486)	(0.0631)
CEOonplace	–0.00178	–0.00460	0.000198	–0.000696	–0.00316
	(0.00176)	(0.00283)	(0.00185)	(0.00228)	(0.00275)
cage	–0.000782	–0.000912*	–0.000358	–0.000738	0.00978***
	(0.000506)	(0.000544)	(0.000450)	(0.000646)	(0.00294)
lrev	–0.379***	–0.392***	–0.323***	–0.365***	–0.279***
	(0.0416)	(0.0430)	(0.0634)	(0.0120)	(0.0129)
ldeq	–0.0112*	–0.000722	–0.0386***	–0.00573	0.0124**
	(0.00619)	(0.00665)	(0.0110)	(0.00588)	(0.00621)
1.emerg	–0.223***			–0.168***	
	(0.0510)			(0.0637)	
Constant	3.455***	3.561***	2.883***	3.320***	2.137***
	(0.289)	(0.295)	(0.471)	(0.0999)	(0.160)
Observations	3600	2436	1164	3600	3600
R-squared	0.411	0.405	0.382		0.127
Number of nocomp	261	168	93	261	261

*** – $p < 0.01$ – highly significant influence; ** – $p < 0.05$ – significant influence; * – $p < 0.10$ – statistically significant influence.

At the last stage, we provide a more precise definition of the nature of the obtained degree and combination of different types of education using the Educ variable, which controls both for the major and determines the group of holders of an industry-specific scientific degree who combined it with an MBA or a similar qualification which, according to the hypotheses put forward earlier, should be distinguished positively among others (Table 6). Based on the results of the majority of models, financial and management education without an additional degree with a technical/science major has a significant negative influence on investments (the conclusion is significant for all offered models except for the model that assesses the developed market separately. At the same time, in the developed markets there is also a negative value of the coefficient for the category of CEOs who have an advanced degree in management or finance). However, one should take into account the fact that our sample contains only 84 observations with CEOs who have an advanced degree in management or finance, which amounts to just 2.5% of the sample.

There is also a positive influence of the industry-specific advanced degree in pharmaceutics both standalone and combined with an MBA in the random effects model, as well as in the general model with adjusted standard errors. The absence of significance for developed and emerging markets considered separately is related both to difference of the shares of CEOs with the selected education strategy in the sample among countries, and to the characteristics of the local corporate governance and the market (share of industry-specific experts on the board of directors, its influence on strategic decision-making related to investments in research and development).

In all applied specifications, CEO's foreign experience (internexp) and role of the founder as CEO of the company (Found) showed a positive influence on the share of investments in research and development and were significant

for the majority of models (significance of the coefficient of the CEO's international experience was not revealed in the fixed effects model, while its value remained positive), as was assumed in proposed Hypotheses 5 and 6 (Tables 3–6). CEO's international experience is indicative of their open-mindedness and readiness to consider and come up with innovative ideas, which is also a characteristic feature of better educated CEOs. A CEO with an experience in establishing a company, in turn, not only better understands the internal company processes, having worked in it since its foundation, but also has the characteristics necessary for successful creation of business, its survival and convincing the corporate management of the effectiveness of being a CEO continuously since the foundation of the company. At the same time, the coefficient of the dummy responsible for the next generations of the founder's family (2.Found) is insignificant, which also confirms Hypothesis 7 and the idea that the founder who is also a CEO of a listed company has the characteristics that influence decision-making on investments in research.

Thus, the importance of a CEO's education in the decision-making process regarding the amount of investment in research and development is confirmed by the obtained results. At the same time, there is also proof of a multidirectional influence of majors (a positive influence of industry-specific education on the share of investments and a negative influence of standalone management or financial education) and a positive role of combining knowledge and skills both in an industry-specific field and in management/finance.

Table 6. Results of regression analysis with an explanatory variable of the presence of CEO's degree and major (including a combination of qualifications). Coefficients for industry-specific education, as well as for its combination with a degree in management, are significant and positive

VARIABLES	(1) L.lrdrat	(2) L.lrdrat	(3) L.lrdrat	(4) L.lrdrat	(5) L.lrdrat
PhD spec not stated	0.0733	0.0333	0.259***	0.0329	0.00230
	(0.0592)	(0.0621)	(0.0913)	(0.0689)	(0.0842)
PhD business	–0.245***	–0.0366	–0.448***	–0.308**	–0.338*
	(0.0564)	(0.0524)	(0.0719)	(0.154)	(0.183)
PhD industry	0.0664*	0.0542	0.110*	0.157***	0.0945
	(0.0369)	(0.0490)	(0.0597)	(0.0544)	(0.0698)
industry PhD+MBA	0.157***	0.131**	0.123	0.153*	0.122
	(0.0554)	(0.0542)	(0.131)	(0.0847)	(0.102)
1.internexp	0.142***				
	(0.0303)				
1.Found	0.119**	0.181***	0.0402	0.116**	0.194**
	(0.0496)	(0.0596)	(0.0705)	(0.0556)	(0.0768)
2.Found	–0.0121	–0.0512	0.0582	–0.0805	–0.0442
	(0.0403)	(0.0701)	(0.0500)	(0.121)	(0.176)
Duality	–0.0296	–0.0232	0.0308	–0.0997**	0.00387
	(0.0448)	(0.0587)	(0.0504)	(0.0505)	(0.0661)
CEOonplace	–0.00227	–0.00707**	0.00225	–0.00153	–0.00359
	(0.00182)	(0.00290)	(0.00179)	(0.00237)	(0.00287)
cage	–0.000768	–0.000844*	–0.000936**	–0.000620	0.00978***
	(0.000498)	(0.000509)	(0.000463)	(0.000667)	(0.00310)
lrev	–0.378***	–0.389***	–0.328***	–0.363***	–0.278***
	(0.0420)	(0.0434)	(0.0674)	(0.0123)	(0.0132)
ldeq	–0.0108*	0.00158	–0.0386***	–0.00515	0.0121*
	(0.00626)	(0.00681)	(0.0114)	(0.00613)	(0.00646)

VARIABLES	(1) L.lrdrat	(2) L.lrdrat	(3) L.lrdrat	(4) L.lrdrat	(5) L.lrdrat
1.emerg	–0.227***			–0.181***	
	(0.0496)			(0.0659)	
Constant	3.445***	3.588***	3.029***	3.403***	2.190***
	(0.291)	(0.299)	(0.499)	(0.0989)	(0.163)
Observations	3430	2266	1164	3430	3430
R-squared	0.405	0.394	0.363		0.129
Number of nocomp	252	159	93	252	252

*** – $p < 0.01$ – highly significant influence; ** – $p < 0.05$ –seriously significant influence; * – $p < 0.10$ – statistically significant influence.

Conclusions

Education certainly plays a significant role in the formation of a CEO's personality and produces an impact on his/her future decisions, in particular, on the acceptance or rejection of research projects and their initiation. In spite of the fact that various educational parameters are often added to studies, there is no clear idea of the general role of education – neither the level of education, nor its sphere. Thus, for example, the conventional concept of the importance of a degree in management for efficient team management contradicts that of excessive riskiness and frequent cases of fraud among people with degrees in management. In pharmaceuticals, where business is based on constant risky investments in research with a long payback period and depends on patents it seems optimal to appoint a person with an industry-specific degree who is capable of understanding the initiatives in detail, evaluating the probability of their implementation and creating a patent portfolio, thus ensuring successful operation. However, the current practice among market leaders suggests otherwise – the majority of CEOs in pharmaceuticals do not have an industry-specific degree, rather, the majority have an MBA qualification.

Based on the results of our research, it is difficult to analyze the influence of education on the amount invested in development while relying on only one characteristic – degree or major. A compound addition of a variable to analysis allows to explain the results which are often contradictory. Based on the results of regression analysis, we can state that control for the presence of a degree only may provide no significant results because the nature of influence of the degree depends on its field – an industry-specific degree, as well as a degree in management/finance supported by a basic technical/industry-specific education provides a positive effect, while a standalone managerial background entails a significant decrease in the amount invested. A positive influence of a degree in management or finance that supplements a technical/science degree confirms the importance of knowing management theory and acquiring skills. At the same time, the negative role of a degree in finance/management, if it is the only degree held by a CEO (no industry-specific degree), remains unrefuted. Thus, in the pharmaceutical industry, where the complexity of investment strategy development depends not just on the compound nature of the studied object, but also on long payback periods characteristic of this business, it is important for a CEO to be knowledgeable in the field and possess the skills of management and evaluation of financial decisions.

Summarizing the above, we believe that when considering the education of a potential or current CEO as a factor forecasting their strategy, one has to take into consideration a combination of parameters – the field of education (including the change of majors in the course of studies), as well as its level (as an indicator of persistence and cognitive capacities). These conclusions may be useful to company managers when selecting candidates for the CEO position, as well as to analysts and investors involved in corporate performance forecasts.

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