The chief financial officer (CFO) profile and R&D investment intensity: evidence from listed European companies

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Abstract

Purpose – This study aims to investigate whether the characteristics of the chief financial officer (CFO) have an impact on the intensity of the corporate research and development (R&D) investment.
Design/methodology/approach – Based on hand-collected data for the CFOs of a sample of the largest European listed companies for the period 2013–2016, this study uses regression analyses to test empirically the association of CFO education, CFO gender and CFO age with R&D investment intensity.
Findings – The presence of female CFOs, CFOs with a Master of Business Administration (MBA) or Doctor of Philosophy (PhD) degree and older CFOs is positively associated with the intensity of R&D investment.
Research limitations/implications – This study relies on some observable characteristics of CFOs and focuses on large listed companies.
Practical implications – The results of this study may help investors, stakeholders and practitioners to understand better which type of CFO characteristics are more likely to result in higher firm-level R&D investment intensity.
Originality/value – This study offers the first insights into the impact of CFOs, as the most prominent *C*-suite executives, on the level of corporate investments in R&D activity.

Keywords R&D, Chief financial officer (CFO), CFO education, CFO gender, CFO age
Paper type Research paper

1. Introduction

Corporate research and development (R&D) investment is increasingly capturing the attention of the academic debate since it is crucial to translate novel technologies into organizational processes, products and services (Almor *et al.*, 2019; Hou *et al.*, 2019; Talke *et al.*, 2010). Decisions concerning corporate investments are typically the responsibilities of chief (*C*-suite) executives (Kor, 2006), who should be accountable to all the stakeholders on the adequate return on whatever they bring to the firm (Bhaumik *et al.*, 2019). Among these executives, chief financial officers (CFOs) play a key role in business decisions, often as the second-in-command to the chief executive officer (CEO) (Caglio *et al.*, 2018). Both the academic literature and the professional community claim that CFOs have expanded their responsibilities from the supervision of financial and accounting processes toward major corporate strategic decision-making (Baxter and Chua, 2008; Bedard *et al.*, 2014; Zorn, 2004). For instance, scholars argue that a CFO contributes to the CEO's corporate strategy on financial plans, the composition of investments and the allocation of resources between

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alternate projects (Firk *et al.*, 2019). Datta and Iskandar-Datta (2014) claim that the CFO is one of the most prominent *C*-suite executives and that his/her attributes represent a matter of increasing interest for the future research agenda, particularly considering that individual-level characteristics are likely to affect a firm's business choices and outcomes (Florackis and Sainani, 2018). At the same time, the role of the CFO in improving business innovation is currently a central theme among practitioners, as the following quote illustrates:

> CFOs and the finance function can help companies successfully deliver on the full potential of a transformation. To do so, they must be judicious about which activities truly add value and embrace their roles in leading the improvement in both performance and organizational health. McKinsey Davies R. and Huey D., February 2017

Hence, we argue that a firm's CFO can be expected to play a decisive role in guiding the CEO's decisions on R&D. Accordingly, a crucial question arises concerning whether the individual-level characteristics of the CFO are likely to affect the corporate investments in R&D. We aim to answer this question by investigating the impact on R&D investment intensity of three main individual-level attributes of a CFO: (1) *educational background*; (2) *gender* and (3) *age*.

We focus on the educational background, gender and age of the CFO drawing from a number of studies (Bamber *et al.*, 2010; Bertrand and Schoar, 2003; Sun *et al.*, 2019b) that suggest that these individuals' characteristics may explain variations in managerial decisions on R&D investment among companies (Barker and Mueller, 2002).

To document the association between CFOs' characteristics and R&D investment intensity, we use hand-collected data for the CFOs of a sample of the largest European listed companies from 2013 to 2016.

We believe that this investigation is important for several reasons. First, corporate R&D investment is a central theme in many countries and especially in Europe, aiming to promote knowledge sharing and sustain national economic growth (Alam *et al.*, 2019). Second, in the modern business landscape, firms are constantly called to increase R&D investment in order to create competitive advantage, leapfrog their competitors and ensure better performance (Chen *et al.*, 2010; Jang *et al.*, 2016; Ruiz-Jiménez *et al.*, 2016). Third, since R&D investment is a risky strategic decision, the specific characteristics of the *C*-suite executives are important in order to understand the conditions under which managers are more likely to build long-term firm value (Coles *et al.*, 2006; Sun *et al.*, 2019a).

Our study offers several important intuitions for the academic debate. First, given that CFOs are currently involved in strategic decisions, but they have received less attention from scholars (Florackis and Sainani, 2018), we contribute to the literature on the top management team, beyond the CEO. In particular, this research allows to tap into the influence of the CFO on R&D investment intensity. Second, by focusing on the individual-level attributes of CFOs, we grasp further determinants of heterogeneity among firms in sustaining R&D investment and therefore respond to the calls for more investigations into the types of *C*-suite executives who are more beneficial for firms' outcomes (Naranjo-Gil *et al.*, 2009; Datta and Iskandar-Datta, 2014).

As for the managerial implications, this study increases the current knowledge about the types of characteristics that are important for the CFO, who is turning away from being the "number guy" of the *C*-suite executives, while starting to act as a focal actor in decision-making processes. Consistent with this, we argue that the role of the CFO goes beyond financial reporting issues and impacts the whole strategic attitude of the organization toward innovation. Accordingly, investors and stakeholders should be more aware that the role of the CFO is crucial, allowing the firm to be agile in its decision-making on R&D investment implementation, promoting innovation and safeguarding the value creation process from risks. Hence, by showing which CFO characteristics are most closely correlated with R&D

investment, this study may enable firms to determine the type of CFO that they should hire when they wish to support the growth of R&D.

The remainder of this study is organized as follows: Section 2 reviews the literature and offers a set of hypotheses; Section 3 illustrates the research methodology with a description of the sample, the data collection, the variables and the empirical model; Section 4 describes the results and offers a series of robustness checks; Section 5 concludes the paper.

2. Theoretical framework and hypotheses

2.1 Top management characteristics and R&D investment

The literature explores several factors associated with R&D investment. For instance, some scholars focus on the firm's industry and on interindustry relationships in determining R&D investment (Barge-Gil and López, 2014). We can also find studies arguing for the influence of external factors (Wang, 2010) and maintaining that a better institutional environment may stimulate R&D investment by providing firms with enhanced collaborative capacity (Srholec, 2011; Wang *et al.*, 2015). Yet other studies devote their attention to the relationship between country-level features and R&D investment (Varsakelis, 2001; Wang, 2010).

Collectively, a growing stream of studies examines the relationship between the characteristics of the top management and R&D investment under the umbrella of upper echelons theory (Hambrick and Mason, 1984). This is because upper echelons theory suggests that organizational outcomes can be considered as the reflection of the values and cognitive bases related to the individual characteristics of top executives (Meyer and Goes, 1998; Barker III and Mueller, 2002). In this regard, studies based on the upper echelons perspective state that the educational background of a manager is an important factor affecting the firm's R&D expenditure (Barker and Mueller, 2002; Harymawan *et al.*, 2020) since a higher educational level leads to improve cognitive ability and opens the mind of an individual to the opportunity for innovation (Naranjo-Gil *et al.*, 2009). Moreover, research asserts that gender is a base on which to understand the managerial orientation in the decision-making process (Adams and Ferreia, 2009; Ruiz-Jiménez *et al.*, 2016; Torchia *et al.*, 2011), even in the case of R&D investment (Almor *et al.*, 2019). Finally, scholars claim that R&D investments are strictly influenced by executives' age because their preferences in business decisions may change over the years due to their risk-taking attitude and career concerns (Holmstrom, 1999; Serfling, 2014).

The present study addresses the impact of the educational background, gender and age of the CFO on R&D investment intensity; although extensive attention has been devoted to CEOs, few studies investigate the decision-making of CFOs on R&D investment, who have progressively switched from having mere financial supervision responsibilities to playing the role of a "business partner" of the CEO (Caglio *et al.*, 2018; Florackis and Sainani, 2018).

2.2 CFO education and R&D investment

Academic research tends to agree that the education of a firm's employees are likely to influence its propensity for innovation, constituting an important part of its absorptive capacity (Cohen and Levinthal, 1990; Sannino *et al.*, 2020; Wenger, 2000) and having an influence in improving both working methods and decision-making. Dahlin *et al.* (2005) suggest that educational diversity may be beneficial for a team, allowing it to absorb and use a novel range of information. Other studies emphasize that employees' educational background plays a relevant role in shaping strategic decisions (Bertrand and Schoar, 2003; Finkelstein and Hambrick, 1990) and has an impact on a firm's competitive posture (Hambrick *et al.*, 1996).

Studies relying on upper echelons theory suggest that better-educated top executives are more likely to absorb new ideas and promote innovation (Naranjo-Gil *et al.*, 2009) and R&D investment (Barker III and Mueller, 2002). Despite the awareness that R&D is not a guarantee of innovation, prior research suggests that R&D investment represents its important trigger.

For instance, investment in R&D is a process that promotes knowledge creation, which entails innovation (Kor, 2006; Wang, 2010), and represents a critical factor for a multinational corporation to sustain an innovative competitive advantage (Kawai and Chung, 2019).

Since there is a link between R&D investment and innovation, we claim that firms in which the CFOs have a higher education level show a more positive attitude toward innovation and thus are more likely to invest in R&D. This is consistent with studies suggesting that a higher level of education positively influences R&D investment both at the firm level (Scherer and Huh, 1992) and even at the country level (Wang, 2010). Hence, we formulate the first hypothesis as follows:

H1. There is a positive relationship between the intensity of R&D investment and CFO education.

2.3 CFO gender and R&D investment

Diversity in the top management team is an important factor that affects the quality of decision-making processes and increases the variety of perspectives among individuals (Murray 1989; Hillmann *et al.*, 2015). Scholars claim that groups with diverse characteristics may generate alternate solutions to problems, show increased levels of creativity and support business model innovation (Van der Vegt and Janssen, 2003; Guo *et al.*, 2018).

The academic literature increasingly investigates the role of gender as a base on which to understand the effects of top management diversity on corporate innovation (Nielsen and Huse, 2010). Miller and del Carmen Triana (2009) find that gender diversity on the board is positively associated with innovation, suggesting that the benefits of gender diversity can be converted into R&D expenditure. Østergaard *et al.* (2010) find that gender diversity among employees positively affects the firm's innovative performance, suggesting that gender diversity is a key variable for understanding the knowledge base of an organization. Torchia *et al.* (2011) suggest that gender diversity of the corporate board leads to a higher level of organizational innovation, while Ruiz-Jiménez (2016) argues that gender diversity in the top executive team is expected to have indirect beneficial effects on corporate innovation.

However, there is also a potential negative impact of gender diversity on R&D investment that scholars explain with reference to a gender effect on individuals' attitude toward risk-taking. For example, prior research suggests that female directors are less risk averse in corporate decisions than male directors (Adams and Ferreira, 2009). Since R&D projects are risky investments, it is plausible that female directors may be less encouraging about investing in R&D (Chen *et al.*, 2016). However, Almor *et al.* (2019) claim that the relationship between female managers and R&D investment is a more complex aspect of a question about individuals' attitude toward risk-taking and managers' cognitive orientations are difficult to measure (Rajagopalan and Datta, 1996). Moreover, Almor *et al.* (2019) claim that female directors encourage long-term R&D processes resulting in organizational innovation.

Despite the existence of contrasting findings, we develop our second hypothesis relying on proponents of the value of diversity who suggest that gender diversity in the top management team provides the firm with greater creativity, enlarges the knowledge pool and encourages investments in innovation (Van der Vegt and Janssen, 2003; Adams *et al.*, 2015; Almor *et al.*, 2019; Guo *et al.*, 2018). This leads to develop the following hypothesis:

H2. There is a positive relationship between the intensity of R&D investment and CFO gender.

2.4 CFO age and R&D investment

Scholars generally agree that age should be considered when investigating how R&D investment varies with the observable characteristics of top executives (Barker and Muller,

2002; Serfling, 2014; Sun *et al.*, 2019b). This is because managerial actions are related to the changes in individual orientation that arise with age (Hart and Mellons, 1970). For example, under upper echelons theory, Hambrick and Mason (1984) suggest that firms with older managers are less likely to pursue risky strategies for three main reasons. First, as their age increases, executives have less mental and physical energy to sustain extensive and long-term investment projects (Child, 1974), such as R&D projects (Barker and Muller, 2002). Second, the preference for a quiet life and the commitment to the organizational status quo tend to increase with age (Bertrand and Schoar, 2003) and thus, older executives avoid increasing the R&D investment (Barker and Muller, 2002), which may change the business model. Finally, Barker and Muller (2002) and Hambrick and Mason (1984) suggest that older executives pay more attention to their financial security, which may lead them to reduce risky investments in R&D.

Conversely, there are empirical works that provide different evidence with regard to the impact of age. Shefrin (2008) finds that individual risk aversion increases until the age of 70 years and then decreases rapidly. Other scholars argue that younger managers pay more attention to their career development and to the scrutiny of the labor market than older managers (Holmstrom, 1999) and thus could avoid risky investments (Chevalier and Ellison, 1999). Zwiebel (1995) suggests that career concerns may influence the corporate choices and therefore, younger executives may avoid innovative investments and pursue less risky projects that are easier to control for external scrutiny.

Hence, on the basis of the perspective of the risk-taking attitude, the age of a CFO is negatively associated with the level of R&D investment. Conversely, if we consider the career concerns and reputation, it is plausible that the age of a CFO is positively associated with the level of R&D investment. Accordingly, it is unclear how CFO age can affect R&D investment, although we believe that a relationship potentially exists. Hence, we formulate our third nondirectional prediction as follows:

H3. There is a relationship between the intensity of R&D investment and CFO age.

3. Research design

3.1 Data, sample and variables

The sample-selection process began by choosing from ORBIS *Bureau van Dijk* (ORBIS) all 163 nonfinancial listed firms included in the S&P350-Europe index from five European countries (Italy, France, Germany, Spain and the United Kingdom). Using this sample allows us to consider larger listed companies that operate in countries representing a significant portion of the European capital markets but having differences in market conditions and legal systems (Devalle *et al.*, 2010).

To test the hypotheses, we collected and merged data from different sources. First, we used the ORBIS database to obtain data related to firm-level characteristics (i.e. size, leverage, profit, R&D expenses, intangible assets, etc.). Next, we completed our data set by searching for information (i.e. age, gender and educational background) in the CFOs' biographies on the companies' websites and through LEXIS/NEXIS database. Firms with CFOs whose biographies were not found were deleted from our sample.

After removing observations with missing R&D expenditure (61) and other firm-level data (5), as well as firms for which we were unable to find information on the CFO's profile (16), we obtained a final sample of 81 firms (and 324 firm-year observations). By including data for the same firm covering the fiscal years 2013–2016, we obtained balanced panel data. In Appendix 1, we report the sample composition by country.

3.1.1 Dependent variable. The level of R&D investment undertaken by companies can be operationalized by using different proxies. For instance, the firm-level R&D investment can

be measured as (1) *the absolute value of R&D investments*; (2) *the level of R&D expenditure standardized to firm sales* and (3) *R&D outcomes expressed in the form of technologies developed and intellectual capital measures* (i.e. patents and copyrights) [1]. In this study, we follow research that determines the firm-level R&D investment intensity (RD_INV_INT) as the R&D expenditure divided by the total sales (Chen *et al.*, 2010; David *et al.*, 2001; O'Brien, 2003; Kor, 2006; Sun *et al.*, 2019a).

3.1.2 Main independent variables. To test our hypotheses, we calculate variables related to the CFO's profile through reference to prior literature (Barker and Mueller, 2002). More precisely, the CFO's age (CFO_AGE) is measured as the natural logarithm of his/her age in years (Serfling, 2014), while the CFO's educational stage (CFO_ED) is an indicator variable that equals 1 if the CFO holds a Master of Business Administration (MBA) or a Doctor of Philosophy (PhD) degree and 0 otherwise (Hiebl *et al.*, 2017). The gender of the CFO is measured using a dummy variable (CFO_GENDER) that equals 1 if the CFO is female and 0 when the CFO is male (Francis *et al.*, 2013).

3.1.3 Control variables. We include a set of firm-level control variables to account for other potential determinants of variations in R&D_INV_INT. First, we control for firm size (SIZE) since prior research suggests that larger firms may have more resources to invest in R&D projects than smaller ones (Kor, 2006). However, Barker and Mueller (2002) claim that in larger firms, the top managers may have less incentive to invest in R&D projects to avoid risky investments and maintain their power with the organization's status quo. Additionally, we include profitability (PROFIT) since prior studies indicate that firm's profitability is related to decisions on R&D expenditures (Barker and Mueller, 2002; Kor, 2006; Sun *et al.*, 2019a). At the same time, we include leverage (LEV) because scholars claim that more leveraged firms are likely to avoid onerous long-term investments in R&D to protect their risky financial condition (Barker and Mueller, 2002; Long and Ravenscraft, 1993). Like Sun *et al.* (2019a), we also take into account the firm's cash flow volatility (CASH_VOL) as a proxy for its financial risk, which can affect the managerial decisions on the R&D investment. Furthermore, we consider the level of intangible assets (INTAG) because scholars suggest that investments in intangible activity would explain the higher or lower propensity of a firm to invest in R&D projects (Honorè *et al.*, 2015). Another control variable that we consider is the firm's growth, measured by the market-to-book (MTB) ratio, because research asserts that firms with greater growth opportunities usually engage more in R&D investment (Kuo *et al.*, 2018; Sun *et al.*, 2019a). Finally, we control for the industry type (TECH), distinguishing whether the firm operates in a high-technology sector or in more traditional business (David *et al.*, 2001; Kuo *et al.*, 2018; Sun *et al.*, 2019a). Our view is that high-technology firms are likely to invest more in R&D projects than firms operating in another business sector.

The description of the variables used in the analysis is reported in Table 1.

3.2 Empirical model

To test our hypotheses, we assess whether the fixed-effect (FE) model or random effect (RE) is more appropriate with panel data by employing the Hausman test (Khor, 2006; Onali *et al.*, 2017). This approach suggests that the RE model is more efficient and thus, we use the generalized least squares (GLS) estimation technique.

Specifically, we first enter the control variables and run Model (1):

$$\text{R\&D\_INV\_INT} = \beta_0 + \beta_1 \,\text{SIZE} + \beta_2 \,\text{LEV} + \beta_3 \,\text{PROFIT} + \beta_4 \,\text{CASH\_VOL} + \beta_5 \,\text{INTAG} + \beta_6 \,\text{MTB} + \beta_7 \,\text{TECH} + \varepsilon \quad (1)$$

Variable	Description	Source
R&D_INV_INT	R&D expenditure divided by total sales at the end of the fiscal year	Authors' calculation based on data from ORBIS
CFO_ED	Dummy variable which equals 1 if a CFO holds an MBA or PhD and 0 otherwise	CFO's profile via firm website, Google or Linkedin
CFO_GENDER	Dummy variable which equals 1 if the CFO is female and 0 when CFO is male	CFO's profile via firm website, Google or Linkedin
(log) CFO_AGE	Natural logarithm of CFO age	CFO's profile via firm website, Google or Linkedin
SIZE	Natural logarithm of total assets at the end of the fiscal year	Authors' calculation based on data from ORBIS
LEV	Financial leverage, calculated as long-term debt. divided by total assets at the end of the fiscal year	Authors' calculation based on data from ORBIS
PROFIT	Return on assets, measured as net income divided by total assets at the end of the fiscal year	Authors' calculation based on data from ORBIS
CASH_VOL	SD of operating cash flow to assets over the last three fiscal years	Authors' calculation based on data from ORBIS
INTAG	Intangible intensity calculated as intangible assets divided by total assets at the end of the fiscal year	Authors' calculation based on data from ORBIS
MTB	Market capitalization to common equity book value at the end of the fiscal year	Authors' calculation based on data from ORBIS
TECH	Dummy variable that takes 1 if the firm is in one of the (NAICS) codes related to technology-intensive industries and 0 otherwise	Authors' calculation based on data from ORBIS

Table 1.
Variables description

Then, we enter the variables relative to the CFO's individual-level characteristics in Model (2):

$$\begin{aligned} \text{R\&D\_INV\_INT} = {} & \beta_0 + \beta_1 \text{SIZE} + \beta_2 \text{LEV} + \beta_3 \text{PROFIT} + \beta_4 \text{CASH\_VOL} + \beta_5 \text{INTAG} \\ & + \beta_6 \text{MTB} + \beta_7 \text{TECH} + \beta_8 \text{CFO\_ED} + \beta_9 \text{CFO\_GENDER} \\ & + \beta_{10} \text{CFO\_AGE} + \varepsilon \end{aligned} \tag{2}$$

4. Results of estimations

Table 2 reports the descriptive statistics for the variables used in the analysis. Our sample of firms shows, on average, the value of R&D_INV_INT is around 0.03, with a maximum of 0.14. With regard to the main variables of interest, Table 2 shows that the average age (in years) of CFOs of listed European firms is 51years, and these firms have a low number of female CFOs (around 7%). Further, Table 2 shows that 36% of our sample presents CFOs with high post-university education (i.e. an MBA and/or a PhD).

Table 3 reports the correlations among the variables, showing that R&D_INV_INT is positively correlated with CFO_ED, confirming our prediction that companies hiring top executives educated with higher post-university invest more in R&D. Moreover, the R&D_INV_INT is positively correlated with the level of intangible resources (INTAG) and with the firm being in the high-technology sector (TECH). The correlations among the other variables are generally in line with our expectations.

Table 4 presents the results of the regression analysis. In model (1), we find that leverage (LEV) has a negative impact on R&D_INV_INT, while cash flow volatility (CASH_VOL) has the opposite effect, meaning that a firm's financial condition and firm's financial risk are important factors when the top management decides to invest funds in R&D (Sun *et al.*, 2019a). Moreover, the results indicate a negative relationship between PROFIT and

Variable	Obs	Mean	Std.dev	Min	Max
R&D_INV_INT	324	0.0271	0.0374	0	0.1478
CFO_ED	324	0.3611	0.4810	0	1
CFO_GENDER	324	0.0740	0.2622	0	1
CFO_AGE (years)	324	51.4104	5.2758	41	63
SIZE	324	16.859	1.1114	14.3837	19.3085
LEV	324	0.6533	0.1479	0.2667	1.1163
PROFIT	324	6.0771	5.8090	18.153	52.855
CASH_VOL	324	0.0204	0.0234	0	0.1880
MTB	324	2.7715	4.6231	−50.762	45.384
INTAG	324	0.2967	0.2080	0.0082	0.7722
TECH	324	0.2222	0.4163	0	1

Table 2.
Descriptive statistics

Note(s): Refer to Table 1 for variables description

R&D_INV_INT, suggesting that firms with higher profitability invest less in R&D. Our results document that firms from high-tech industry (TECH) are more sensitive to investment in R&D than companies that operate in other sectors. In relation to the other control variables, we find that SIZE, MTB and INTAG are not significantly associated with R&D_INV_INT.

The results of model (2) confirm the significant impact of LEV, PROFIT and TECH on R&D_INV_INT. As we predicted in the first hypothesis, the regression results show that CFO_ED is significantly and positively associated with R&D_INV_INT (p-value < 0.05), suggesting that a higher level of post-university education enhances the CFO's inclination to invest in R&D. This is in line with the literature that suggests that education is a distinctive attribute of a top manager who promotes innovation because greater knowledge increases the manager's "acumen" and facilitates R&D investment (Hambrick and Mason, 1984; Meyer and Goes, 1988; Kor, 2006; Scherer and Huh, 1992).

Our results provide evidence that CFO_GENDER is significantly and positively associated with R&D_INV_INT (p-value < 0.1), meaning that firms with a female CFO are more prone to pursue investment in R&D. This result supports the argument that the business case for gender diversity among the top management team is not only a matter of quotas or social fairness (Østergaard *et al.*, 2010; Hilmann *et al.*, 2015) but is above all a driving force for promoting investments in R&D. Moreover, these results pave the way to the idea that a relationship between gender diversity and R&D investment is not only a question of risk-taking approach (Almor *et al.*, 2019) but requires a more comprehensive investigation.

With reference to the third hypothesis, CFO_AGE is significantly and positively associated with R&D_INV_INT (p-value < 0.05), suggesting that older CFOs increase the investment in R&D. This result is in contrast with studies contending that younger top managers are more prone to engage in risky strategies such as R&D investment, but we suggest that there are circumstances under which firms with older CFOs may increase R&D spending. In particular, based on the perspective of career's concerns and opportunity, a younger CFO may be scared of the risk of R&D projects since a future adverse performance may harm his or her position in the labor market (Zwiebel, 1995; Andreou *et al.*, 2017), while an older one may be more prone to engage in risky investments as he or she wants to appear dynamic and to defeat the stereotype of being reluctant to change.

Our results may also mean that, in the current knowledge economy, there is a tendency for older CFOs to show a proactive approach to R&D investment since they are constantly under scrutiny by investors (Zimmerman, 2013) and market. However, it is important to highlight that the CFOs in our sample are, on average, 51 years old, meaning that they are not close to

Table 3. Correlation matrix

	R&D_INV_INT	(log) CFO_AGE	CFO_ED	CFO_GENDER	SIZE	LEV	PROFIT	CASH_VOL	INTAG	MTB	THEC
R&D_INV_INT											
(log) CFO_AGE	−0.0585										
CFO_ED	0.1729*	−0.1149*									
CFO_GENDER	0.0157	−0.2104*	0.1309								
SIZE	0.0856	0.2233*	0.0371	−0.0026							
LEV	−0.1077	0.011	−0.0460	−0.1132*	0.1161*						
PROFIT	0.1024	0.0385	−0.0030	0.0836	−0.2861*	−0.3496*					
CASH_VOL	0.1045	−0.0101	0.1201*	−0.0764	−0.2421*	0.0624	0.2806				
INTAG	0.2862*	−0.0104	−0.0513	0.1423*	−0.0788	−0.1549*	0.2933*	−0.056			
MTB	0.0961	0.011	−0.0226	0.0488	−0.1273*	0.0856	0.2006*	0.1701*	0.1378*		
THEC	0.4351*	−0.1614*	0.0618	−0.0378	0.2022*	0.0793	−0.0014	0.0162	0.1325*	0.0390	

Note(s): *$p < 0.05$. Refer to Table 1 for variables description

	Dependent variable	
	R&D_INV_INT (model 1)	R&D_INV_INT (model 2)
CFO_ED		0.0040** (0.0019)
CFO_GENDER		0.0052* (0.0028)
(log) CFO_AGE		0.0143** (0.0071)
SIZE	−0.0016 (0.0020)	−0.0026 (0.0020)
LEV	−0.0204** (0.0092)	−0.0196** (0.0091)
PROFIT	−0.0001* (0.0001)	−0.0002** (0.0001)
CASH_VOL	0.0439* (0.0238)	0.0361 (0.0239)
MTB	−0.0000 (0.0000)	−0.0000 (0.0007)
INTAG	0.0042 (0.0085)	0.0022 (0.0085)
TECH	0.0419*** (0.0086)	0.0430*** (0.0086)
INTERCEPT	0.0574* (0.0341)	0.0168 (0.0429)
# of observations	324	324
R^2 (overall)	0.23	0.23
Wald chi-square	35.09***	44.98***

Table 4. Regression results

Note(s): *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$. Standard errors are reported in parenthesis. Refer to Table 1 for variables description

retirement and, thus, that their career horizon may not necessarily play a negative impact on their investment decisions (McClelland *et al.*, 2012).

4.1 Additional analyses

We carry out additional tests to increase the robustness of our results. First, we reestimate model (2) by using the FE model, and we obtain similar results (which we do not report here to preserve the space). Second, in line with McClelland *et al.* (2012), by entering the square of CFO_AGE in model (2), the regression results (untabulated) exclude any curvilinear effects of CFO_AGE on R&D_INV_INT [2].

Finally, we investigate whether our results are sensitive to the inclusion of additional firm- and country-level factors that potentially have an impact on R&D investment. More specifically, we include in the baseline regression model (2) variables related to corporate governance quality (David *et al.*, 2001; Honoré *et al.*, 2015), corporate tax incentives (Dyreng *et al.*, 2010), the rule of law in the country (Alam *et al.*, 2019) and the country's legal system (Devalle *et al.*, 2010).

We use the BvD independence indicator from ORBIS [3] as a proxy for ownership quality (OW_QUAL), and we control for the impact of tax incentives by using the effective tax rate (ETR), calculated as the income tax divided by the pre-tax income. As in prior research, the values for the rule of law in the country (RULE_LAW) are gathered from the *Worldwide Governance Indicators* (World Bank), while we use a dummy variable for the country's legal system (COUNTRY) to distinguish between civil law (1) and common law (0) systems. As shown in Table 5, the results suggest that only tax incentives affect corporate R&D_INV_INT, whereas the impacts of our main variables of interest (i.e. CFO_ED, CFO_GENDER and CFO_AGE) remain unaltered.

5. Conclusions

R&D investment at firm level has received increasing attention in the current academic and policy debate because R&D represents a primary resource for firms wishing to stay competitive in the era of a digital and tech-based business environment. Using a sample of 81 of the largest listed firms from European countries, this study developed three hypotheses on

	Dependent variable			
	R&D_INV_INT (model 3)	R&D_INV_INT (model 4)	R&D_INV_INT (model 5)	R&D_INV_INT (model 6)
CFO_ED	0.0039** (0.0019)	0.0127** (0.0071)	0.0040** (0.0019)	0.0040** (0.0019)
CFO_GENDER	0.0047* (0.0028)	0.0048* (0.0028)	0.0048* (0.0028)	0.0048* (0.0028)
(log) CFO_AGE	0.0130* (0.0072)	0.0127 * (0.0071)	0.0124* (0.0073)	0.0126* (0.0073)
SIZE	−0.0037* (0.0022)	−0.0039* (0.0022)	−0.0039** (0.0022)	−0.0044* (0.0022)
LEV	−0.0196** (0.0091)	−0.0194** (0.0090)	−0.0192** (0.0091)	−0.0186** (0.0091)
PROFIT	−0.0002** (0.0001)	−0.0001* (0.0001)	−0.0001* (0.0001)	−0.0001* (0.0001)
CASH_VOL	0.0289 (0.0245)	0.0256 (0.0243)	0.0252 (0.0244)	0.0254 (0.0244)
MTB	−0.0000 (0.0000)	−0.0000 (0.0000)	−0.0000 (0.0000)	−0.0000 (0.0000)
INTAG	0.0024 (0.0085)	0.0024 (0.0085)	0.0024 (0.0085)	0.0027 (0.0085)
TECH	0.0436*** (0.0086)	0.0437*** (0.0087)	0.0435*** (0.0088)	0.0414*** (0.0090)
OW_QUAL	−0.0012 (0.0009)	−0.0012 (0.0009)	−0.0013 (0.0010)	−0.0013 (0.0010)
ETR		−0.0008*** (0.0004)	−0.0008** (0.0004)	−0.0008** (0.0004)
RULE_LAW			−0.0010 (0.0041)	−0.0001 (0.042)
COUNTRY				0.0085 (0.0079)
INTERCEPT	0.0404 (0.0466)	0.0448 (0.0465)	0.0489 (0.0492)	0.0483 (0.0491)
# of observations	324	324	324	324
R^2 (overall)	0.23	0.23	0.22	0.23
Wald chi-square	47.52***	50.71***	50.38***	51.55***

Note(s): *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$. Standard errors are reported in parenthesis. Refer to Table 1 for variables description

Table 5. Regression (robustness) results

the relationship between CFO-specific attributes and R&D investment intensity. Exploring the impact of these factors allows us to gain a better understanding of the heterogeneity among firms in promoting R&D activity.

More specifically, this study offers three important contributions to the top management literature, beyond the CEO, by looking specifically at the role of the CFO. First, our findings suggest that CFOs with a higher education background are more likely to deliver more financial resources to R&D activities. Second, we find that firms led by a female CFO show superior R&D investment intensity to those led by a male CFO, meaning that increasing the gender diversity among top executives is beneficial for sustaining R&D projects. This result leads to a call for more comprehensive investigations into the effect of managers' gender diversity beyond the theoretical perspective of individual attitudes toward risk-taking. Finally, the findings of this study question the strand of the literature suggesting negative effects of managers' age on R&D since older CFOs are associated with a higher level of R&D investment intensity.

The contribution of this study is also of interest for managerial practice. First, the paper fills an important gap in terms of the understanding of the current role of CFOs in the strategic decision-making processes for R&D investment. Indeed, although some articles have contended that there is a progressive enrichment of CFOs' tasks and professional standing, few have shown practically how this unfolds in organizations. Thus, in depicting the significant relationships between the attributes of CFOs and R&D investment, we lay the basis for greater awareness by firms and investors about the effects of CFOs on corporate policies. Furthermore, being aware of the fact that CFOs are no longer the "numbers men" only but play an active role in shaping the strategic attitude of the firm, we can also contend that this constitutes an aspect that it is essential to consider, in terms of the chance of managing efficiently and avoiding any problems of strategic discontinuity even when there is

a CEO turnover event. In particular, it is important to highlight that new discoveries or ideas in the market may rapidly shift the resources allocated to one R&D project to meet the needs of another. In this scenario, we argue that R&D investment is a matter of the governance organization in which the CFO has a key role in allowing a firm to be far more agile in managing R&D projects, removing the obstacles that do not allow its implementation and guarding against related risks in the best interests of investors and stakeholders. Collectively, our results may be useful for capital providers and practitioners who are interested in identifying the best combination of the CFO's characteristics and the business model that is likely to result in higher firm-level R&D investment.

Our study is not free from limitations. First, this research relies on the observable characteristics of CFOs and does not consider the potential impact of other managerial traits (i.e. ethnics, experience, tenure) that may affect the decision on the level of investment in R&D. Second, our sample consists of firms included in the S&P350-Europe and is thereby limited to largest listed companies, which are subject to greater scrutiny by investors than smaller ones.

Future research is needed to corroborate our results by the in-depth collection of more data about the individual attributes of CFOs. Second, we call on researchers to increase the number of studies identifying factors that may endanger the willingness of CFOs to pursue innovation. For instance, it could be useful to explore the impact of the role of owners (i.e. family vs nonfamily firms) and of any potential conflicts within the board of directors or between the board and the CFO.

Notes

1. We thank the reviewer for this suggestion.
2. We also reestimate model (2) and model (6) by using the variable CFO_AGE measured in years and the main results remain unaltered.
3. This is a dummy variable that is equal to 1 if the BvD independence indicator is rated as A−, A or A+ (i.e. higher ownership quality) and 0 otherwise.

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Appendix 1
Sample composition by country

	Country	Firms
1	France	21
2	Germany	17
3	Italy	7
4	Spain	4
5	The United Kingdom	32
	Total	*81*

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