Facial structure as facet of biology in management:

An industry-dependent analysis of the CEO

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Marleen Lucks

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Foreword

Strategic management and the broader management literature are traditionally interested in understanding what makes firms more successful, e.g., in terms of their financial profitability but also more innovative or pursuing other activities that are of interest to the firm. The upper echelon theory in this line of research has provided the insight that the characteristics of executives matter to these desired outcomes. Specifically, various demographic factors and personality-related factors have been examined and identified as success factors at the upper echelons of a firm. Only recently, the literature started to integrate research and theories from biology. While this might sound surprising at first, the interface of management and biology offers interesting insights. Biological differences in humans explain how they behave and perceive situations, all of which are highly relevant to the management context. Yet, empirical research at this interface of management and biology is still scarce.

Marleen Lucks recognizes this gap and offers three stand-alone studies and a comprehensive introduction to these three studies that aim to address this gap, especially by shedding light on the executives' facial structures that are closely related to their level of testosterone. The first study investigates the impact of CEO facial masculinity on firm performance in terms of creating product innovation and ensuring future business. The findings indicate that there is a positive association, depending on the industry setting. The second study relates CEO facial masculinity to a firm's corporate venture capital activities and again shows that the industry environment plays an important role. The third study explains the level of compensation by the CEO's facial masculinity. The theoretically derived research models are examined using fWHR measurements of 496 CEOs, combined with secondary data on firms from many different sources. Overall, this dissertation shows that CEO facial structure, and thereby the level of testosterone should be part of upper echelons considerations in strategic management and

broader management research, emphasizing the importance of research at the interface of management and biology.

Marleen Lucks offers a very good and convincing dissertation. The research models she derives and the empirical data she offers advance research at the interface of management and biology in important ways. The empirical approach is very creative and enables interesting insights that can guide future research. I wish the dissertation the large readership it surely deserves.

Prof. Dr. Andreas Engelen

Summary

This dissertation is directed at the recently emerging stream of research at the intersection of management and biology, which argues that facial structure - and the level of testosterone this reflects - is a driver of their managerial behavior. Research around different personality traits and characteristics of the Chief Executive Officer (CEO) and their impact on firm behavior and success has become a focal topic of interest for many management scholars, with growing numbers of publications year by year (see chapter 2.2 for literature review). Without a doubt, researchers view CEOs' personalities as fundamental determinants of firm behavior and performance (Nadkarni & Herrmann, 2010).

However, few studies assess the impact of physical, biological characteristics on firm or personal outcomes. As Nofal et al. (2018) point out in their recent literature review, the dearth of research at the newly emerging interface of biology and management is truly surprising, considering that biology has a central impact on all aspects of human behavior. Hence, ignoring this factor as an explanation for managerial behavior equals missing a vital piece of the puzzle.

One biological aspect has received particular attention as an antecedent of managerial decision-making: Facial masculinity. Facial masculinity, i.e., relative facial width, is largely a consequence of craniofacial bone growth during the pubertal stage of males, which is regulated by testosterone administration (Lefevre et al., 2013). This allows scholars to use the metric facial width-height-ratio (henceforth fWHR) as a proxy for the individual's testosterone level and, thus, assess its relation to firm and personal behaviors or outcomes. According to extant psychology research, a male's level of testosterone drives a complex of associated behaviors and characteristics. Like any character trait, such as narcissism or overconfidence, high levels of testosterone inherit a bright and a dark side (O'Reilly et al., 2014). On the negative side, previous researchers link facial masculinity, and the associated high level of testosterone, to

aggressiveness, risk taking, and egocentrism (e.g., Wong et al., 2011), or financial misreporting (Jia et al., 2014). In contrast, research seems to highlight the bright side of testosterone, which must have driven the evolutionary selection of it, to a lesser extent.

As the literature review of this dissertation reveals, only one article focusing on CEO facial masculinity has been published by a A or A+ rated journal (VHB-JOURQUAL3 Rating). Additionally, as Nofal et.al (2018) point out, "[…] most managerial behavior is likely accounted for by the interaction of human biology and environmental factors, additional research should empirically investigate how environment and biology interplay to influence management" (p. 23). Thus, this dissertation not only integrates recent research at the interface of management and biology and contributes a novel CEO characteristic to determine firm-level and personal outcomes. It also brings to light that a given biological aspect can be beneficial in one specific situation and disadvantageous in another, emphasizing the requirement to contextualize the relation between CEO characteristics and strategic or personal outcome variables.

This dissertation uses three autonomous studies to address most relevant questions and gaps in extant literature. Study I assesses the impact of CEO facial masculinity on firm performance in terms of creating product innovations and future business and how this is influenced by industry dynamism. The second study determines the influence of facial masculinity on firm strategic investing moves in terms of corporate venture capital (CVC) investing activeness and behavior and how is this influenced by industry dynamism. The third study addresses whether facial masculinity influences the CEOs' structure and level of compensation and how this is influenced by competitive intensity.

I examined these questions using the fWHR measurements of 496 CEOs, combined with secondary data of large, publicly listed companies from the United States (US), retrieved from frequently used databases for firm- and executive-level data (Compustat, ExecuComp, Boardex, Ravenpack, Crunchbase).

Study I shows that CEOs' high level of testosterone can positively relate to innovation in terms of new product introductions, and firm value, when industry dynamism is low: High-testosterone CEOs are 7.1% more active in terms of new product launches and 12.4% more successful than their low-testosterone peers. Thus, below-average turbulence is proven to be the sweet spot of high-testosterone 'alpha CEOs', in which they perform the best as the positive effects of testosterone play out while the negative ones are less relevant.

Study II demonstrates that high CEO testosterone negatively influences the company's venture capital (VC) investment activeness when industry dynamism is low. High-testosterone CEOs undertake 9% fewer venture capital investments alongside 5% fewer co-investors than low-testosterone CEOs in undynamic environments. Thus, below-average dynamism proves to be the 'lazy spot' for alpha CEOs, where VC investments do not offer enough predictable return or a spot in the limelight to trigger their interest.

Study III determines that the level of testosterone of a CEO influences his level and structure of compensation. Specifically, alpha CEOs generally achieve a 0.7% higher overall salary than their low-testosterone peers. However, in less competitive environments with more negotiation flexibility, their preference for variable pay components generates 3.3% more incentive pay without converting into a higher total compensation. Thus, study III confirms the findings of previous researchers stating that overly optimistic CEOs do not achieve a higher total compensation as they overestimate the value of their claims in performance-based components.

This dissertation makes a substantial contribution to theory and practice. First and foremost, all three studies add to the still limited research around the impact of facial masculinity of executives. Moreover, study I and II contribute to upper echelons theory by offering a novel CEO characteristic as antecedent for firm behavior and performance. The third study makes a relevant contribution to the growing body of research that assesses compensation not from the

perspective or the firm or directors (agency theory), but from the perspective of the CEO. Finally, all studies illustrate the importance of the environmental context, on which all relationships between CEO facial masculinity and the related outcomes are contingent.

For practitioners, this research illuminates how much the choice of the CEO matters, and that every type of personality delivers both challenges and opportunities. The consequences of testosterone are important to bear in mind when deciding on team setups, governance structures, or incentive schemes.

Overall, this dissertation illustrates that CEO testosterone does have a fundamental influence on both firm and personal outcomes, with the environmental context being decisive for whether the alpha CEO will fail or thrive.

Overview of research studies

Research study I: A Moment to Shine for the Alpha Ego – How Testosterone-fueled CEOs Outperform in Creating Product Innovations and Future Business

Research study II: Not in the Mood for a Unicorn – How Testosterone-fueled CEOs Pursue Less Venture Capital Investments in Undynamic Environments

Research study III: The Great Gamble of Alpha CEOs – How Testosterone-fueled CEOs Negotiate Higher Incentive Payment Components

Part of this research has been presented at the following conference:

- 2022 Western Academy of Management, USA

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List of abbreviations

CEO	Chief executive officer
CSR	Corporate social responsibility
CVC	Corporate venture capital
e.g.	Exempli gratia (for example)
et al.	Et alii (and others)
FFM	Five-Factor Model
fWHR	facial width-height-ratio
GEE	Generalized Estimation Equation
gvkey	Global Company Key in WRDS databases Compustat and ExecuComp
H	Hypothesis
i.e.	Id est (that is)
ITCV	Impact threshold of a confounding variable
JOURQUAL3	Journal quality ranking version 3
M&A	Mergers and acquisitions
N	Number of observations
n/a	Not applicable
OLS	Ordinary least squares
R&D	Research and development
ROA	Return on assets
RQ	Research question
S&P	Standard and Poor’s
SCA	Securities class action
SD	Standard deviation
SE	Standard error

SIC	Standard Industrial Classification
SME	Small- and medium-sized enterprises
TMT	Top management team
US	United States
VC	Venture capital
VHB	Verband der Hochschullehrer für Betriebswirtschaft
VIF	Variance inflation factor

1 Introduction

Section 1.1 of the introduction summarizes my motivation to conduct the research presented in this dissertation. The subsequent section describes the structure of this dissertation.

1.1 Research motivation

In recent years, both practitioners and scholars have been eyeing high-testosterone executives critically: After a plethora of scandals and crises, alpha CEOs find their reputation in a downward spiral in the press and public opinion (Byron, 2004). Also, management scholars have picked up this topic of interest with alarming results. As per their studies, high-testosterone executives take on higher risk (Kamiya et al., 2019), are more likely to engage in financial misreporting (Jia et al., 2014), navigate their banks into high stock volatility (Ahmed et al., 2019), or underperform as hedge fund managers (Lu & Teo, 2018).

On the other hand, Wong et al. (2011) argue, that high-testosterone CEOs deliver superior financial performance, especially when the cognitive complexity of the other TMT members is low. One example of the outperforming alpha male is Jack Welch, who is cherished by the press as the "manager of the century" (Lohr, 2020) or the "most valuable manager on earth" (Colvin, 2020). Welch, who passed away in 2020, was the chair and CEO of General Electric between 1981 and 2001. The manager, who's facial width-height-ratio is higher than of 99% of this dissertation's sample CEOs, started his career with a bang. In the 1960s, the chemical engineer caused an entire factory to detonate while experimenting with the production of plastics – but his superior decided to give him a second chance. He advanced to become one of the most successful CEOs of all times and set General Electric up for growth: the company undertook 600 acquisitions, conquered new markets in Asia and South America, increased revenues from B25$ to B130$, and boosted profits from B1.5$ to B15$. During his time as CEO, the stock valuation of General Electric grew 30-fold, while his unhierarchical management style spread a start-up vibe which elevated him to become a role model for generations of executives

(Beutelsbacher, 2020). Hence, his success story stands in contrast to the mostly negative consequences of testosterone illuminated by extant research.

Testosterone and its link to executive behavior has become a topic of interest to management scholars just recently: Over the last few years, at the newly developing interface of biology and management, more and more scholars have used executives' facial width-height-ratio, representing their facial masculinity and level of testosterone, to predict a variation of behaviors (Ahmed et al., 2019; Jia et al., 2014). These studies link the traits associated with high levels of testosterone, such as aggressiveness and risk-taking (Carré & McCormick, 2008), but also optimism and effective leadership (Galinsky et al., 2008), to a variety of firm outcomes. According to researchers who base their work on upper echelons theory, the characteristics of firm leaders distinctly influence their firms' actions and performance (Hambrick & Mason, 1984) (for details, see section 3.1). However, the research around facial masculinity and its consequences is not only very limited, but it addresses mostly operational tasks and highlights negative outcomes. However, all character traits and personalities come with bright and dark sides (O'Reilly et al., 2018), and so does the complex of characteristics associated with high levels of testosterone. Hence, the negatively connotated recent reputation of high-testosterone leaders might be a too one-sided view.

With this research, I seek to assess the impact of the CEOs' level of testosterone on firm behavior, as well as firm and personal outcomes, and determine in which contexts they show their weaknesses and in which they thrive. To address the gaps identified in extant research, this dissertation examines three questions:

- Research question 1 (RQ 1): Does male CEOs' facial masculinity impact firm performance in terms of creating product innovations and future business and how is this influenced by industry dynamism?

- Research question 2 (RQ 2): Does male CEOs' facial masculinity impact firm strategic investing moves and how is this influenced by industry dynamism?
- Research question 3 (RQ 3): Does male CEOs' facial masculinity impact their structure and level of compensation and how is this influenced by competitive intensity?

To add to the emerging field of research related to facial masculinity and to answer the research questions identified above, I conducted three independent research studies to explore the influence of CEO facial masculinity on firm and personal outcomes.

1.2 Approach and structure

The introductory section of this dissertation (chapter 1) is followed by the literature review including research gaps and the derived research questions this work addresses. Specifically, chapter 2 illustrates the systematic literature review process (2.1.1) as well as the descriptive characteristics of the selected literature (2.1.2). Subsequently, the literature is reviewed, and the findings are presented along three categories: firm outcomes (2.2.1), firm behavior (2.2.2) and personal outcomes (2.2.3). Within each of these categories, the impact of different CEO personality traits on firm or personal outcomes are highlighted. To conclude this chapter, the existing research gaps and resulting research questions as fundament of this dissertation are pointed out (2.3).

Chapter 3 provides a detailed summary of the dissertation's theoretical foundations: upper echelons theory (3.1), facial masculinity (3.2) and agency theory of compensation (3.3).

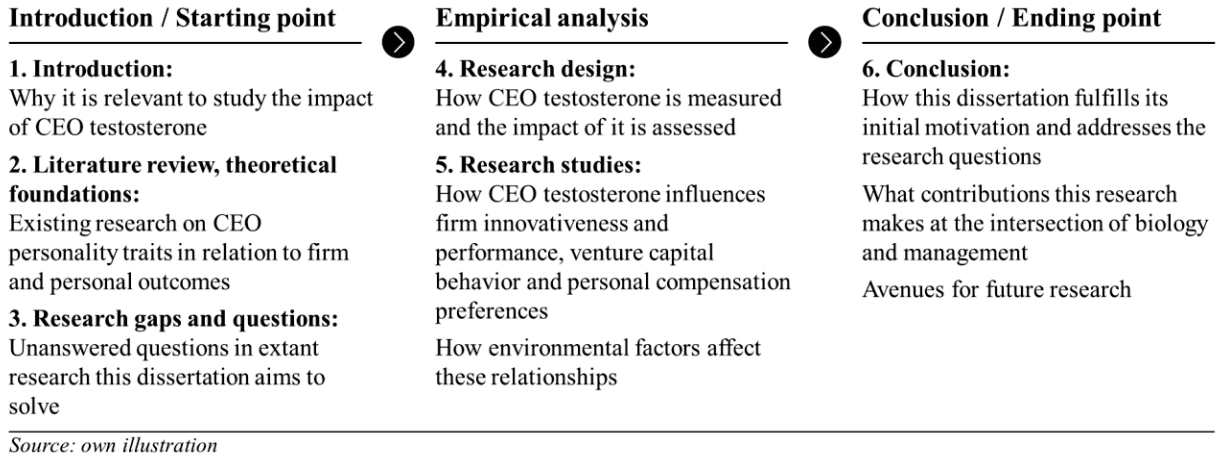
Chapter 4 outlines the research design used to conduct the three studies forming this dissertation, including a detailed description of the sample development and data sources (4.1) as well as the methods of statistical analysis used (4.2). It seems worth noting, that section 4.1.2 clarifies in detail how the CEOs level of testosterone was proxied via their facial width-height-ratio.

Chapter 5 presents the heart of this dissertation, namely the three independent research studies, which address the previously formulated research questions. The full-length studies (4.2-4.4) are preceded by an individual summary (4.1.1-3).

Chapter 6 provides a conclusion to this dissertation by summarizing its findings in relation to the previously formulated research questions (6.1). Section 6.2 summarizes the theoretical and practical contributions of the three individual papers. Finally, chapter 6.3 concludes by illuminating the limitations of this dissertation's research design and points towards the numerous avenues for future research.

The structure of this dissertation is illustrated in Figure 1.

Figure 1 Overview of this dissertation's structure



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2 Literature review, research gaps, and research questions

The second chapter reviews and summarizes extant academic research on the CEO's personality and facial traits and elaborates on the theoretical foundations underlying this dissertation. Section 2.1 describes the process of identifying the relevant literature through a systematic approach. Subsequently, section 2.2 offers an analysis of the findings presented by the identified studies. Finally, section 2.3 illustrates existing gaps in the literature and derives the research questions, which form the core of this dissertation.

2.1 Identification of relevant literature

The following subsections explain the systematic literature review approach (2.1.1) and presents the descriptive characteristics of the relevant research studies (2.1.2).

2.1.1 Process of systematic literature review

The systematic literature review I conducted follows five steps, as displayed in Figure 2.

As a starting point, I search the Business Source Premier database on EBSCOhost for relevant research articles around facial and personality traits of CEOs and the respective personal and company outcomes, requiring that the paper's title, abstract, or keywords include a combination of appearance/personality traits and CEO. First, the search includes terms along the lines of fWHR, facial masculinity or other aspects of appearance – echoing the basis of this dissertation. Additionally, to reflect a broad perspective on CEO personality traits, further characteristics are included in the search, which inherit similar consequences as high levels of testosterone. These incorporate well-established and largely stable traits like overconfidence, narcissism, and hubris (Judge et al., 2002). Moreover, research articles on facial appearance or personality traits are only considered relevant for this literature review when their focus lies on the CEO[1]. This initial search results in 2,519 articles published by December 2021.

[1] The precise search string is: TI fwhr OR AB fwhr OR KW fwhr OR TI facial masculinity OR AB facial masculinity OR KW facial masculinity OR TI facial width* OR AB facial width* OR KW facial width* OR TI appearance OR AB appearance OR KW appearance OR TI personality OR AB personality OR KW personality OR TI narcissi*

Secondly, I ensure the scientific quality and relevance of the remaining articles by applying relevant filters: articles remaining in this literature review are required to be a research article (- 2,017 articles), written in English language (- 17 articles), peer-reviewed (- 12 articles) with a VHB-JOURQUAL3 Rating of A or A+ (- 354 articles). The first filtering results in 119 papers.

In the third step, I filter the remaining journals by content and methodological relevance based on an abstract review. Articles are excluded because they are based on content exclusion criteria and for their methodology. Related to content, I leave out articles which have no impact on firm or personal outcomes (- 12 articles), no focus on the CEO or TMT (- 6 articles), no focus on personality or facial characteristics (- 21 articles), and have a sole focus on new ventures (-5 articles) or on accounting while being entirely unrelated to general business administration and management (- 5 articles). Papers excluded based on methodological criteria are case studies and literature reviews (- 6 articles). After this additional filter step, 64 articles remain and 55 are excluded.

In the fourth step, I conduct a full, detailed review of all remaining papers in terms of content and methodology. A number of relevant filtering criteria results in a deduction of an additional 16 articles. Again, I exclude articles in which CEO personality or appearance is not the independent variable (- 12 articles), which have no impact on firm or personal outcomes (- 1 article), no focus on CEO or TMT (- 1 article), no focus on personality or appearance at all (- 1 article), or lastly, for a misfit of methodology (- 1 article). As a result, 48 relevant articles remain part of the detailed literature review.

Unsurprisingly, because of the nature of the just recently emerging field of testosterone-related research, only one article focusing on fWHR related to firm behavior is included in the

OR AB narcissi* OR KW narcissi* OR TI overconfid* OR AB overconfid* OR KW overconfid* OR TI hubris OR AB hubris OR KW hubris AND TI CEO OR AB CEO OR KW CEO OR TI TMT OR AB TMT OR KW TMT OR TI Chief * Officer OR AB Chief * Officer OR KW Chief * Officer

review at this stage. Therefore, in the fifth step, I add two studies, which were previously excluded due to the filter on journals with a VHB-JOURQUAL3 Rating of A or A+. The studies of Wong et al. (2011) and Ahmed et al. (2019) add crucial, additional perspectives to upper echelon research, especially by adding a testosterone-related interpretation. As these studies also contribute to the fundament of the three papers forming in this dissertation, I include them in this literature review. Thus, the final literature review includes 50 articles which I review in detail in the subsequent chapter to derive the research questions of this dissertation.

Figure 2 Overview of the literature review process

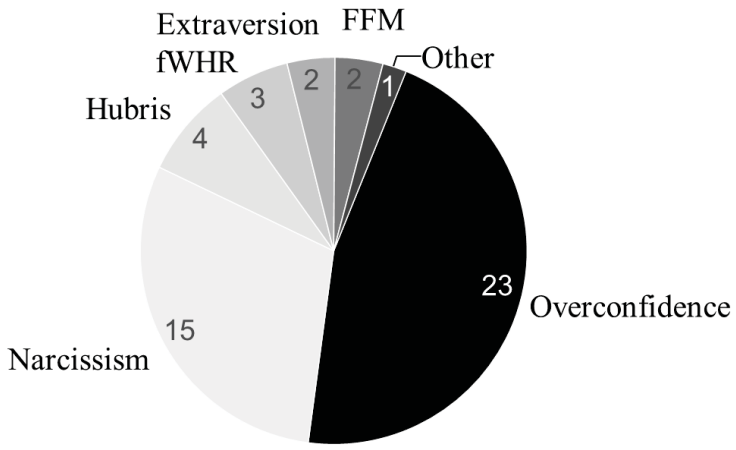
	Step 1: Initial search	**Step 2: First filtering**	**Step 3: Abstract review**	**Step 4: Full text review**	**Step 5: Addition of relevant articles**
Description	Identify all existing articles around the personality of executives via EBSCOhost	Apply high-level filters to ensure journal relevance and scientific quality	Filter journals by content and methodological relevance based on abstract review	In-depth review of content and methodological relevance based on full text	In-depth review of additional papers highly relevant for content but eliminated in step 2
Approach	**Data source:** Business Source Premier **Search terms:** fWHR, facial masculinity, appearance; CEO, TMT; personality, specific personality traits (+ synonyms for all mentioned terms) **Search scope:** matches in title, abstract, and keywords **Retrieval period:** until December 2021	**Type:** research article (-2,017) **Language:** English (-17) **Journal selection:** • Peer-reviewed (-12) • VHB-JOURQUAL3 rating A+/A (-354)	**Content exclusion criteria:** • No impact on firm or personal outcomes (-12) • No focus on CEO/TMT (-6) • No focus on personality or facial charact. (-21) • Focus on new ventures (-5) • Sole accounting focus (-5) **Methodological filter:** • Case studies, lit. reviews (-6)	**Content exclusion criteria:** • No impact on firm or personal outcomes (-1) • No focus on CEO/TMT (-1) • No focus on personality or facial characteristics (-1) **Methodological filter:** • Personality is not independent variable (-12) • Case studies, lit. reviews (-1)	**Extension criteria:** • Relevant testosterone-related research, included in studies of this dissertation (+2)
Number of Papers	2,519	119	64	48	50

Source: own illustration

2.1.2 Descriptive characteristics of the selected literature

The following section illustrates the descriptive statistics of the research reviewed. Considering the very limited amount of extant research focused on CEO fWHR/testosterone, further related personality traits are included. Apart from three papers on facial masculinity, the literature review includes academic papers on overconfidence (23), narcissism (15), hubris (4), extraversion (2), Five-Factor-Model (FFM) (2), and high self-evaluation ('other', 1), as shown in Figure 3.

Figure 3 Distribution by personality trait of studies included in the literature review



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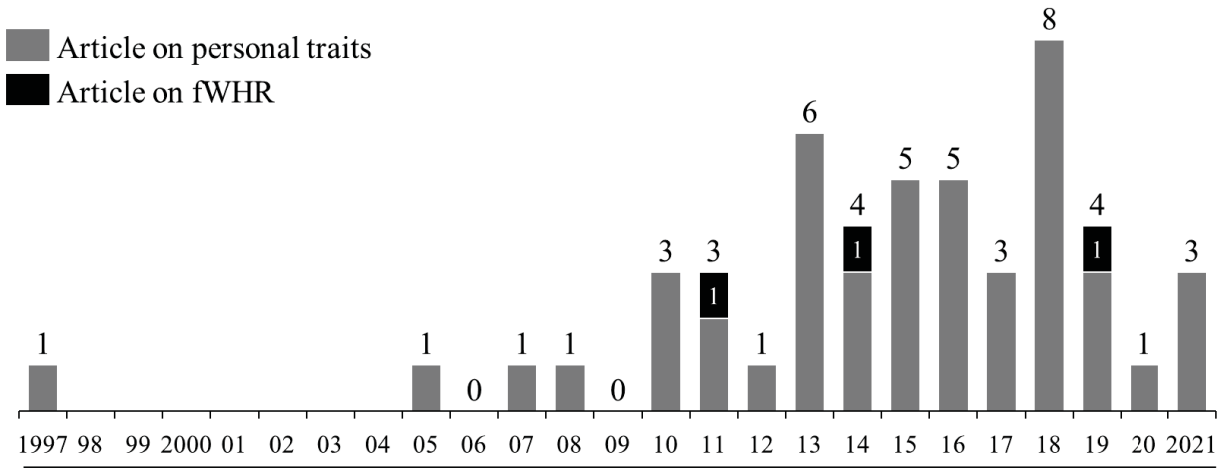
A look at the year of publication of the papers included in this literature review highlights that personality research has just recently been given increasing attention. Only four of the included 50 papers were published before 2010. Especially research focused on the consequences of fWHR have appeared most rarely and only recently in the highly ranked journals.

Figure 4 Temporal development of articles included in the literature review



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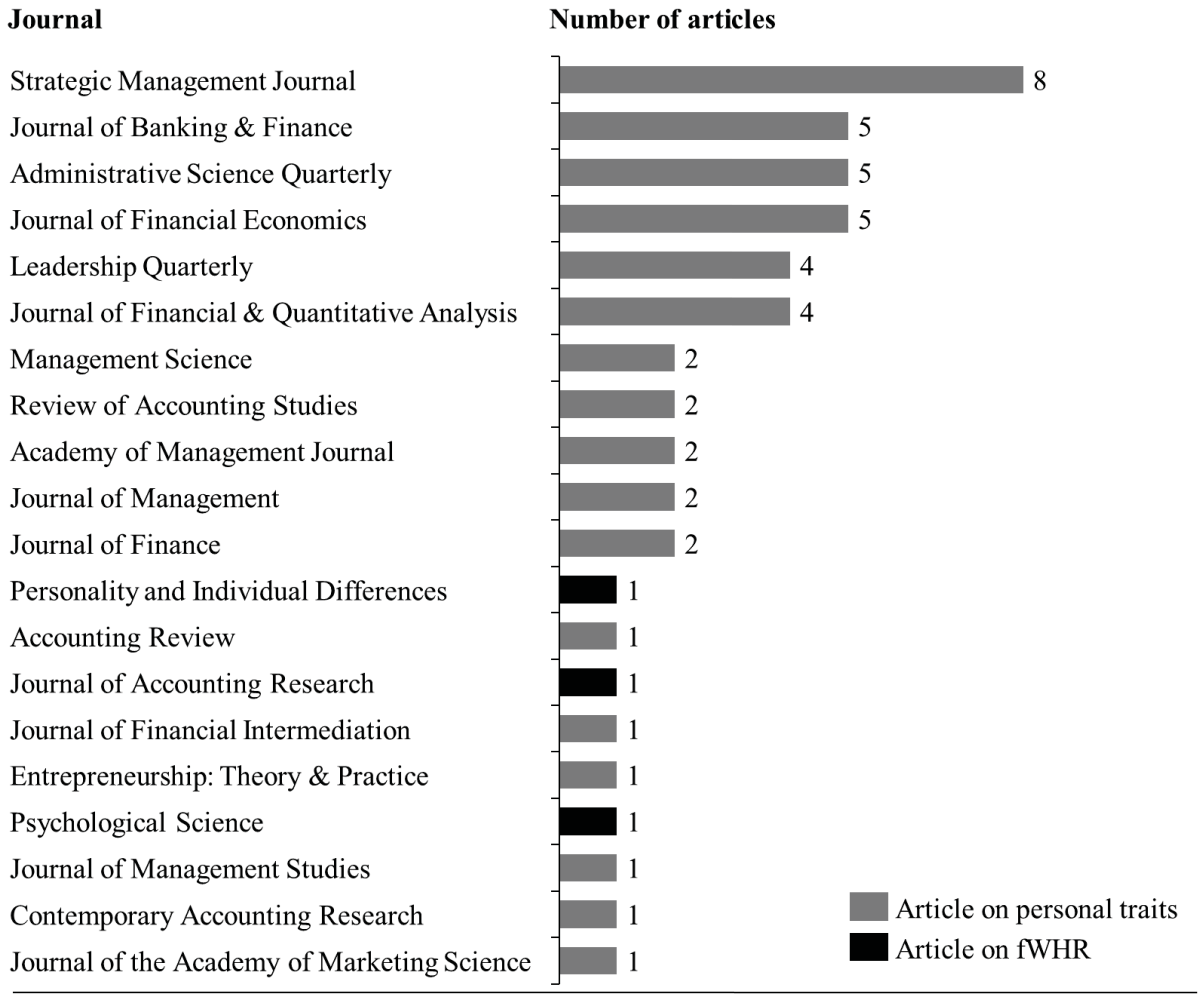
Within this literature review, most articles focused on CEO personality were published by the Strategic Management Journal (8), Journal of Banking & Finance (5), Administrative Science Quarterly (5), and Journal of Financial Economics (5). The three included articles focused on fWHR were published by the Journal of Accounting Research, Psychological Science, and Personality and Individual Differences.

Figure 5 Academic journals of studies included in the literature review



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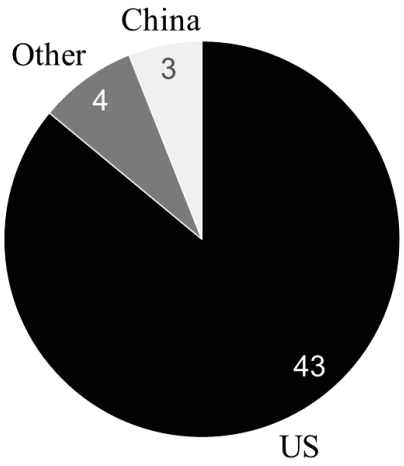
In terms of geography, the majority of articles is based on samples consisting of US-headquartered firms (86%; 43 out of 50). Three articles are based on Chinese survey data, while the remaining articles ('other') focus on India, Ireland, and Ecuador.

Figure 6 Geographic distribution of studies included in the literature review



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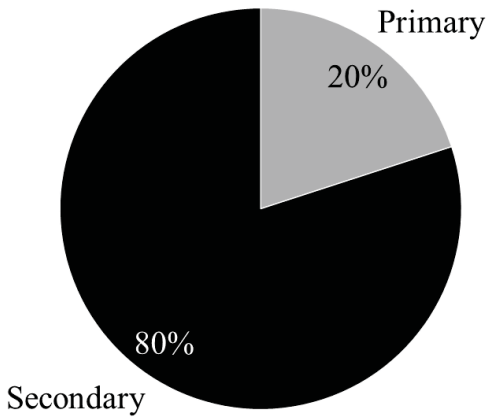
Further, most of the articles rely on secondary data, and only 20% of researchers constructed primary datasets (Figure 7). With US-based secondary data being easily available and offering the advantage of building and sustaining for instance frequently used environmental variables, primary data and non-US-samples are substantially under-represented.

Figure 7 Level of analysis of studies included in the literature review



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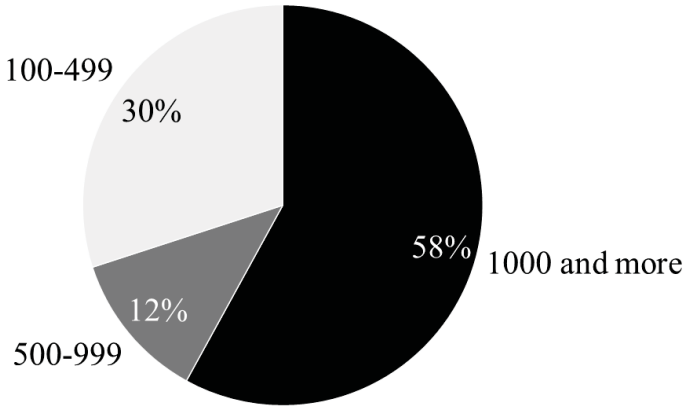
In line with the previous observation, the sample sizes of the literature included here are relatively large, likely driven by the large number of data points included in the frequently used datasets such as COMPUSTAT. 58% of the samples underlying the research included in

this literature review consist of more than 1000 firm-year observations, and only 30% consist of less than 500. None of the studies rely on a sample with less than 100 firm-year observations.

Figure 8 Sample size of studies included in the literature review



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The following sections review the bespoke literature in detail.

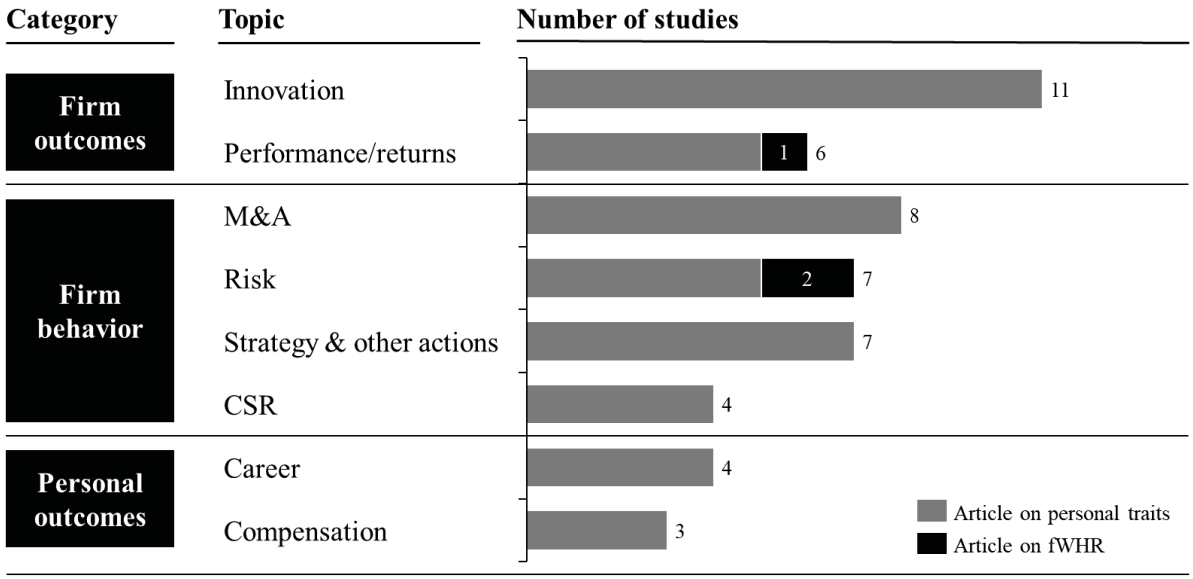
2.2 Review of the relevant literature

To illuminate the findings of previous researchers in a structured manner, this literature review is categorized based on the impact or consequence assessed in relation to CEO personality. The structure aims at determining and documenting all effects of CEO personality and facial masculinity that research has already examined. Accordingly, this structure enables me to draw conclusions about the consequences of CEO characteristics on firm and personal behavior and outcomes, as previously examined in different studies and research settings. Thus, the following section sheds light on the impact of specific CEO characteristics documented already, and especially on where additional assessment is interesting and required.

An initial review of the focal papers' dependent variables assessed in relation to CEO characteristics gives insight on the prevalent core topics. Accordingly, I determine eight topics around which the included 50 studies circulate: performance/returns, innovation, risk, mergers and acquisitions (M&A), corporate social responsibility (CSR), strategy and other actions,

compensation, and career. Subsequently, I group these topics into three overarching categories, namely firm outcomes, firm behavior, and personal outcomes. Firm outcomes is related to the companies' measurable results such as financial or innovative performance. Firm behavior includes the firms' actions, for instance regarding acquisitive activity, CSR, risk-taking behavior, or other strategies and actions. Personal outcomes refer to the compensation- and career-related consequences of CEO characteristics. Figure 9 illustrates the number of articles per category and topic.

Figure 9 Distribution by category/topic of articles included in the literature review



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The first category related to firm outcomes includes two topics: the largest topic of all, innovation, holds eleven articles that relate CEO characteristics to firm innovative performance, while financial performance is assessed by six studies. The latter includes the research of Wong et al. (2011) on the impact of CEO fWHR on financial return, contingent on the TMT's cognitive complexity.

In the category firm behavior, eight studies examine CEO personality related to M&A behavior, seven to risk-taking, seven to strategy and other actions, and four to CSR. Research included in the topic strategy and other actions determines for instance the impact of CEO

personality on international diversification (Zhu & Chen, 2015), stock repurchases (Banerjee et al., 2018), stakeholder commitment (Phua et al., 2018) or feedback responsiveness (Chen et al., 2015). Both fWHR-related articles included in this category address the topic of risk-taking. Jia et al. (2014) assess the relation of high CEO fWHR and financial misreporting, insider trading or option backdating. Ahmed et al. (2019) relate the fWHR of bank CEOs to the risk-taking and stock volatility of their firms.

The third category on personal outcomes includes four articles on career- and three articles on compensation-related findings. To this day, no research on the impact of fWHR on career or compensation of the CEO has been published.

The following sections explore the findings of extant research per category and topic, with each section including a table that lists the relevant articles.

2.2.1 Firm outcomes

This section analyzes previous literature on the relationship between CEO characteristics and the outcomes of their firms in terms of innovation and performance. Overall, it is evident that no CEO personality trait or characteristic is entirely beneficial or harmful under all circumstances for a particular outcome. Instead, for example in the case of narcissism, research distinguishes both the bright and the dark sides of it (O'Reilly et al., 2018). Self-confidence and effective leadership stand in contrast to underestimation of risks and poor teamplay, with the ultimate impact of narcissism much depending on environmental aspects.

CEO characteristics and innovation. This topic does not include any studies focusing on CEO testosterone. However, five articles link CEO overconfidence to firm innovation, pointing out that overconfident CEOs have a tendency to think they have more precise knowledge than they actually have, they trust they will experience favorable future outcomes and underestimate potential risks (Ho et al., 2016). Accordingly, overconfident CEOs may support the exploitation of innovative growth opportunities (Hirshleifer et al., 2012; Ho et al.,

2016). Hirshleifer et al. (2012) describe, for instance, that overconfident CEOs drive greater return volatility and invest more in innovation. Thus, they obtain more patents and patent citations, and achieve larger innovative success for a given research and development (R&D) expenditure. Similarly, Koh et al. (2018) explore how CEO personal traits influence their firms' R&D disclosure practices. Because R&D is a major, long-term investment for any firm, it involves substantial risk and uncertainty, and potentially influences the companies' competitive advantage. The article elaborates, that firms with confident CEOs are more probable to report their R&D expenditures than firms with cautious CEOs. Cautious CEOs, in contrast, are more likely to drive patent activities in a low R&D disclosure period. Based on the abovementioned circumstance that overconfident CEOs systematically overestimate the return to their investment projects, their financing preferences are influenced as well. According to Malmedier and Tate (2005), the investment behavior and activeness of overconfident CEOs is positively linked to cash flow, especially in equity-dependent firms. According to their research, overconfident CEOs are reluctant to issue new equity as they believe the stock of their company to be undervalued. Therefore, as soon as additional cash flows arise, they increase their investment. Also the results of Galasso and Simcoe (2011) suggest that overconfident CEOs bring their companies to a new technological level. They elaborate that overconfident CEOs, who underestimate the chance of failure, are more likely to boost and achieve innovation. This relation is larger in more competitive industries. Engelen et al. (2014) follow a similar line of argumentation: They argue, CEO overconfidence is positively related with entrepreneurial orientation, with decreasing marginal effects. According to their findings, overconfident CEOs are intrigued to engage in difficult tasks, especially in dynamic environments, and push entrepreneurial activities based in their profound self-esteem. However, with increasing overconfidence, employees' willingness to contribute to entrepreneurial behavior increases at a decreasing rate, as they are not confident anymore to meet the CEO's expectations (Engelen et al., 2014).

An additional facete to CEO personality is core self-evaluation, closely related to over-confidence. This line of research is extended by Simsek et al. (2010), who, because stronger core self-evaluation CEOs have greater self-esteem and confidence in their ability to shape the firm's future positively, argue that those CEOs have a stronger positive influence on their firms' entrepreneurial orientation, especially in dynamic environments.

Another personality trait highly represented in extant literature is CEO narcissism. Narcissism is described in research as an "exaggerated, yet fragile self-concept of one's importance and influence" (Resick et al., 2009). Accordingly, narcissistic CEOs are more likely to strive for bold, daring actions to draw attention and push themselves into the limelight (Judge et al., 2009). Further, narcissists are motivated by a strong desire to compete, which leads them and their organizations to take more aggressive strategic actions, including innovative moves. Extant research assesses narcissism in a variety of settings. Zhang et al. (2017) determine, for instance, that CEOs who have simultaneous humility and narcissism increase employee perceptions of socialized charisma and thus, effectively lead firm innovation. Building on the narcissists' strong desire for applause, Gerstner et al. (2013) argue that when audience engagement is high, narcissistic CEOs will undertake bold actions and invest especially aggressively in a discontinuous technology in anticipation of applause. Wales et al. (2013) use entrepreneurial orientation as explanatory factor for varying firm performance, describing that CEO narcissism drives more extreme firm performance, which is mediated by entrepreneurial orientation. Adding to the two-sidedness of every personality trait, Kashmiri et al. (2017) contribute that firms led by narcissistic CEOs are likely to exhibit more new product introductions and radical innovations, but also more product-harm crises.

Last, also CEO hubris, defined as the managers' extreme self-confidence, can affect all kinds of firm behavior and outcomes (Malmedier & Tate, 2005). Tang et al. (2015) find, that CEO hubris is positively related to firm innovation. However, environmental munificence and

complexity weaken this relation. A munificent environment provides a variety of opportunities to firms, meaning that executives must choose among a plethora of options and temptations, drawing their attention away from the focal area of innovation.

CEO characteristics and performance/returns. The topic around performance includes one article focused on CEO fWHR. Wong et al. (2011) identify that CEOs with high fWHRs achieve superior financial performances, which is moderated by characteristics of their leadership teams. The relationship between high CEO testosterone and firm profitability is stronger when the leadership team demonstrates a lower level of cognitive complexity.

Focusing on CEO overconfidence, Deshmukh et al. (2013) elaborate that the more overconfident a CEO is, the more he will invest. Accordingly, dividend payout is lower in firms headed by overconfident CEOs, particularly in firms with lower growth opportunities, lower cash flow, and greater information asymmetry. Similarly, Kim et al. (2016) describe that overconfident CEOs believe to be maximizing long-term value with their current, negative NPV projects. Accordingly, they are more likely to experience firm-specific stock price crashes in the future.

With regard to CEO narcissism and performance, Ham et al. (2018) describe a negative relationship between CEO narcissism and the firm's investment policies and performance. Because narcissistic CEOs pursue big-exposure investments to polish their reputation, they place a blind eye on routine capital expenditures required to maintain the firm's assets, leading to overall less productive and profitable investments.

Two articles assess the impact of the five-factor model traits on firm performance. Nadkarni and Herrmann (2010) find, that strategic flexibility generally mediates the relationships between CEO personality and firm performance. Their results suggest that the effectiveness of a CEO's FFM trait depends on whether it enhances or inhibits strategic flexibility. Accordingly, extraversion, emotional stability, and openness to experience heightened firm performance by

promoting strategic flexibility, whereas CEO conscientiousness weakened firm performance by hindering flexibility. Building on this, Herrmann and Nadkarni (2014) describe that different CEO FFM traits are needed to initiate versus to implement strategic change and achieve performance effects. Accordingly, extraversion and openness promote the initiation of strategic change while conscientiousness improves the performance effects of change implementation.

Table 1 CEO characteristics and firm outcomes

Topic	Author	Year	Sample characteristics	IVs (relevant)	DVs (relevant)	Moderators (relevant)	Findings (relevant)
Innovation	Hirshleifer, David; Low, Angie; Teoh, Siew Hong	2012	- US public firms - 1993-2003 - 1,771 firms - N=9,807	Overconfidence (+)	Project risk, innovation, patent activity	-	Overconfident CEOs cause higher return volatility, invest in innovation, secure more patents and patent citations, and achieve higher innovative success for given research and development (R&D) expenditure
Innovation	Koh, Ping-Sheng; Reeb, David M.; Zhao, Wanli	2018	- US public firms - 1992-2010 - N=18,407	Overconfidence (+|-)	Disclosure of R&D expensitures; patent activity	-	Firms with confident CEOs are likely to report their R&D expenditures relative to firms with cautious CEOs; Cautious CEOs rather have patent activities in a low R&D disclosure period
Innovation	Malmedier, Ulrike; Tate, Geoffrey	2005	- Public US firms - 1980-1994 - N=3,728	Overconfidence (+)	Corporate investment	Cash flow (+)	Investment behavior of overconfident CEOs is responsive to cash flow in equity-dependent firms

Topic	Author	Year	Sample characteristics	IVs (relevant)	DVs (relevant)	Moderators (relevant)	Findings (relevant)
Innovation	Galasso, Alberto; Simcoe, Timothy S.	2011	- Public US firms - 1980-1994 - 290 firms and 627 CEOs - N=3,648	Overconfidence (+)	Patents filed	Industry competitiveness (+)	Overconfident CEOs underestimate the risk of failur and are likely to drive innovation; especially in more competitive industries
Innovation	Engelen, Andreas; Neumann, Christoph; Schwens, Christian	2015	- High-tech S&P 500 firms - 2005-2007 - N=142	Overconfidence (+)	Entrepreneurial orientation	Industry dynamism (+)	CEO overconfidence is positively related with EO, with decreasing marginal effects as CEO overconfidence grows
Innovation	Simsek, Zeki; Heavey, Ciaran; Veiga, John (Jack) F.	2010	- CEOs of firms located in Ireland - Two-staged survey with follow-up after one year - N=129	Self-evaluation (+)	Entrepreneurial orientation	Industry dynamism (+)	CEOs with high self-evaluations positively influence the entrepreneurial orientation of their firms, especially in dynamic environments
Innovation	Zhang, Hongyu; Ou, Amy Y.; Tsui, Anne S.; Wang, Hui	2017	- Chinese firms - Survey conducted in year 2015 - responses from 194 CEOs, 143 TMT members	Narcissism & humility (+)	Innovative culture, innovative performance	Socialized charisma (+)	CEOs who have simultaneous humility and narcissism increase employee perceptions of socialized charisma and, thus, effectively lead firm innovation

Topic	Author	Year	Sample characteristics	IVs (relevant)	DVs (relevant)	Moderators (relevant)	Findings (relevant)
Innovation	Gerstner, Wolf-Christian; König, Andreas; Enders, Albrecht; Hambrick, Donald C.	2013	- US pharmaceutical firms - 1980-2008 - 72 CEOs, 33 firms - N=521	Narcissism (+)	New technology investments	Audience engagement (+)	When the attention of the audience is high, narcissistic CEOs anticipate applause for their bold actions and invest more aggressively in a discontinuous technology
Innovation	Wales, William J.; Patel, Pankaj C.; Lumpkin, G. T.	2013	- US high-tech manufacturing firms - Survey data of CEOs - N=173	Narcicissm (+)	Firm performance variance	Entrepreneurial orientation (+)	CEO narcissism drives more extreme firm performance, which is mediated by entrepreneurial orientation
Innovation	Kashmiri, Saim; Nicol, Cameron; Arora, Sandeep	2017	- US public firms - 2006-2010 - N=1,975	Narcicissm (+)	Product innovation, Product-harm crises	Competitive aggressiveness (+)	Narcissistic CEOs are drive a higher rate of new product introductions and innovations, but also more product-harm crises
Innovation	Tang, Yi; Li, Jiatao; Yang, Hongyan	2015	- Chinese manufacturing firms - Survey data collected in 2000 - N=5,075	Huris (+)	Firm innovation	Environmental munificence (-), environmental complexity (-)	CEO hubris is positively related to firm innovation; environmental munificence and complexity weaken this relation

Topic	Author	Year	Sample characteristics	IVs (relevant)	DVs (relevant)	Moderators (relevant)	Findings (relevant)
Performance/returns	Deshmukh, Sanjay; Goel, Anand M.; Howe, Keith M.	2013	- Public US firms - 1980-1994 - N=2,809	Overconfidence (-)	Dividend payout	Opportunities, cash flow, and information symmetry (+)	Dividend payout is lower in firms managed by overconfident CEOs, particularly in firms with lower growth opportunities, lower cash flow, and greater information asymmetry
Performance/returns	Kim, Jeong-Bon; Wang, Zheng; Zhang, Liandong	2016	- US S&P 1500 firms - 1993-2010 - N=16,229	Overconfidence (+)	Stock price crash risk	-	Overconfident CEOs are at more risk to experience firm-specific stock price crashes in the future
Performance/returns	Ham, Charles; Seybert, Nicholas; Wang, Sean	2018	- US public firms - 2011-2015 - N=6,361	Narcicissm (+;-)	R&D and M&A expenditures, Financial productivity	-	CEO narcissism is negatively linked to the firm's investment policies and performance
Performance/returns	Haselhuhn, Michael; Ormiston, Margaret	2011	- Fortune 500 companies - 1996-2002 - N=385	fWHR (+)	Financial performance (RoA)	TMT cognitive level of complexity (-)	CEOs with a higher fWHR achieve superior financial performance, espcially when TMT cognitive complexity is low

Topic	Author	Year	Sample characteristics	IVs (relevant)	DVs (relevant)	Moderators (relevant)	Findings (relevant)
Performance/returns	Nadkarni, Sucheta; Herrmann, Pol	2010	- Small and medium-sized firms from business process outsourcing industry - N=195	FFM traits (~)	Firm performance	Strategic flexibility (+)	Strategic flexibility mediates the relation between CEO personality and firm performance
Performance/returns	Herrmann, Pol; Nadkarni, Sucheta	2014	- SMEs in Ecuador - 2010 - N=120	FFM traits (~)	Stategic change initiation, Firm performance	Strategic change implementation (+)	Different CEO FFM traits are needed to initiate versus to implement strategic change and achieve performance effects

2.2.2 Firm behavior

This section analyzes previous literature on the relationship between CEO characteristics and the behavior of their firms, for instance in terms of M&As or CSR. Again, the personality of firm leadership has a great impact on its behavior – but extant research highlights the importance of environmental factors such as the independence of the board of directors as well.

CEO characteristics and M&A. This topic does not include any studies focusing on CEO testosterone. However, M&As have been thoroughly assessed by extant research in relation with different CEO personality traits, which impact for example the price paid or execution time immensely. In line with the abovementioned example for environmental factors, Kolasinski and Li (2013) point out that independent directors not only mitigate agency problems. In fact, powerful and independent boards restrain acquisitions driven by CEO overconfidence, and thus, help executives avoid honest mistakes which harm shareholder value. This finding delivers insight on how the negative sides of overconfidence can be mitigated. Ferris et al. (2013) add to this by confirming that overconfident CEOs not only make more acquisition offers, which are of diversifying nature, but they also prefer to use cash rather than equity as the primary financing vehicle. Specifically, they find this to be true for firms headquartered in Christian countries, whereas countries whose cultures are fond of a long-term orientation have less overconfident CEOs. Based on the notoriously high levels of confidence which overconfident CEOs inherit, they overestimate their ability to generate returns and underestimate the associated risks. As Malmedier and Tate (2008) confirm, overconfident CEOs are more likely to conduct mergers, especially when internal financing is available. However, their high M&A activeness is not necessarily rewarded, as they are more likely to undertake value-destroying mergers. On the other hand, Pavićević and Keil (2021) contribute to extant research by finding the overconfident CEOs' tendency to overpay for M&As decreases when the pre-deal processes are more lengthy.

Similarly, Aktas et al. (2016) find that narcissistic acquiring CEOs negotiate faster and are more likely to initiate deals. Consistent with empirical findings, narcissistic CEOs can be extremely productive and fast when they sense an opportunity for self-enhancement (Wallace & Baumeister, 2002). Additionally, Chatterjee and Hambrick (2007) argue that narcissism drives strategic dynamism and grandiosity, the number and size of acquisitions, and the fluctuation of organizational performance. Their study confirms the statement that narcissistic CEOs favor bold moves to attract attention and limelight.

CEO hubris is another personality trait, which hugely impacts a firm's M&A behavior. Hayward and Hambrick (1997) point out that CEO hubris drives the size of premiums paid, especially when board vigilance is lacking. Accordingly, massive premiums are paid by acquirers who are convinced they can turn toads into princes with a kiss (Berkshire Hathaway Annual Report, 1981).

The same is true for extraverted CEOs, who according to Malhotra et al. (2018) are more likely to engage in more and larger acquisitions, especially in less competitive industries. Extraverted CEOs possess a tendency to seek and enjoy large-scale projects and opportunities as they view them more positively.

CEO characteristics and risk. Risk-taking is a fundamental driver of firms' decision-making with a profound impact on their success and survival. This topic includes two studies which focus on firm risk-taking related to fWHR. Risk-seeking is one of the masculine behaviors associated with facial masculinity. Thus, it comes as no surprise, that Jia et al. (2014) confirm in their research how CEOs with more masculine faces have a higher incidence of financial misreporting. In line with this, Ahmed et al. (2019) add that banks led by CEOs with a high fWHR take more risks and show more volatile stock returns. According to their findings, these banks are also perceived as riskier by stock market participants.

Similarly, Ho et al. (2016) argue that banks led by overconfident CEOS have greater increases in leverage during noncrisis years as they overestimate the business, leading them to relax lending standards and incur additional debt. Unsurprisingly, they are confronted with the consequences frequently: Banerjee et al. (2018) determine that overconfident CEOs are more likely to engage in reckless or intentional actions and disclosures which lead to securities class actions. These often have significant implications for the firms and their CEOs.

Focusing on CEO narcissism, O'Reilly et al. (2018) contribute that narcissistic CEOs tend to approve actions that result in their firm being sued, and they are less likely to settle a lawsuit even when the probability of losing is high. Research suggests that narcissism is not associated with effective performance in the long term as the negative the negative consequences of narcissism can destroy value (Blair et al., 2008). In line with this, Buyl et al. (2019) confirm that narcissistic bank CEOs increase the riskiness of their policies, especially when compensation policies that promote risk-taking are in place. However, this relationship is weaker when the CEOs are more effectively monitored.

Finally, J. Li and Tang (2010) state that previous research has not paid adequate attention to risk-taking and CEO hubris, and argue that CEO hubris spurs firms to make more risky decisions, contingent on managerial discretion.

CEO characteristics and strategy and other actions. The topic strategy and other actions bundles a variety of different types of firm behaviors and actions. None of the studies included here focuses on CEO facial masculinity. Most of the papers included in this topic assess the relationship of CEO overconfidence and different firm actions. First, Phua et al. (2018), argue that overconfident CEOs strengthen stakeholder commitment towards greater relationship-specific investment and higher relationship durability through their leadership. Accordingly, overconfident CEOs possess the ability to influence stakeholders to contribute to the CEO's goals and vision. Additionally, Banerjee et al. (2018) describe how overconfident

CEOs are more likely to repurchase stock, even at a low level of cash holding, as they believe their shares to be undervalued. The excessive confidence of these CEOs places a blind spot on weaknesses and feedback. Chen et al. (2015) argue, that firms led by overconfident CEOs respond less to corrective feedback and attribute underperformance to external factors. Their unrealistically positive view of certain outcomes and underestimation of risks becomes evident in other areas as well: Rawson (2021) argues most recently, that firms with overconfident CEOs provide significantly more narrative R&D as the CEOs underestimate the risk of rivals using the information to their own advantage. Similarly, according to Andreou et al. (2019), overconfident CEOs are more likely to engage in value-destructive corporate diversification activities, which confirms the findings of researchers included in this literature review.

Narcissist CEOs, as described previously, emphasize their own opinion and experiences more than others'. In line with this, Zhu and Chen (2015) find narcissistic CEOs to be influenced by corporate behaviors or strategies which they witnessed at other firms and strongly refrain from the influence of other directors' prior experience. Adding to this, Patel and Cooper (2014) describe that narcissistic CEOs possess a stronger approach focus, equal to a high motivation towards desirable outcomes, and weaker avoidance focus. This behavior may leave their firms vulnerable against potential threats or when economic fortunes change rapidly.

CEO characteristics and CSR. Corporate social responsibility has been defined as "actions that appear to further some social good, beyond the interests of the firm and that which is required by law" (McWilliams & Siegel, 2001). The range of potential CSR activities is endless, such as using environmentally friendly materials working with community organizations, affecting both the firm and broader society. This topic does not include articles that focus on CEO fWHR.

Regarding overconfidence, McCarthy et al. (2017) find that CEO overconfidence is negatively related to the level of CSR, especially the institutional aspects of CSR like

community and workforce diversity. Similarly, Tang et al. (2015) argue that CEO hubris is negatively related to their firm's socially responsible and positively related to irresponsible activities, which is weakened by its dependence on stakeholders for resources. Narcissism, on the other hand, has positive effects on levels and profile of organizational CSR, but reduces the effect of CSR on performance, as argued by Petrenko et al. (2016). Tang et al. (2018) add another dimension to the above-mentioned findings by pointing out that the positive relationship between CEO narcissism and the negative one between CEO hubris and CSR is strengthened when peer firms invest less.

Table 2 CEO characteristics and firm behavior

Topic	Author	Year	Sample characteristics	IVs (relevant)	DVs (relevant)	Moderators (relevant)	Findings (relevant)
M&A	Kolasinski, Adam C.; Li, Xu	2013	- S&P 1500 firms - 1996-2006 - N=15,204	Overconfidence (+)	Acquisitiveness, diversifying acquisitiveness	Board independence (-)	More powerful, independent boards restrain acquisitions driven by CEO overconfidence, and thus, help managers avoid honest mistakes which create shareholder harm
M&A	Ferris, Stephen P.; Jayaraman, Narayanan; Sabherwal, Sanjiv	2013	- Fortune 500 firms - 2000-2006 - N=2,705	Overconfidence (+)	Merger activity, diversifying offers, use of cash	-	Overconfident CEOs make more acquisition offers, which are of diversifying nature, using cash rather than equity as the primary financing vehicle
M&A	Pavićević, Stevo; Keil, Thomas	2021	- Public US firms - 2001-2008 - N=349	Overconfidence (+)	Acquisition premium paid	Predeal process duration (-)	The tendency of overconfident CEOs to overpay for M&As decreases when the predeal processes take more time
M&A	Malmendier, Ulrike; Tate, Geoffrey	2008	- Forbes 500 companies - 1980-1994 - N=3,457	Overconfidence (+)	Merger activity	Availability of internal resources (+)	Overconfident CEOs are more likely to conduct mergers, especially when internal financing is available

Topic	Author	Year	Sample characteristics	IVs (relevant)	DVs (relevant)	Moderators (relevant)	Findings (relevant)
M&A	Aktas, Nihat; de Bodt, Eric; Bollaert, Helen; Roll, Richard	2016	- US mergers and acquisitions - 2002-2006 - N=135	Narcissism (+)	Acquisition initiation, negotiation speed	-	Narcissistic acquiring CEOs negotiate faster and initiate more deals
M&A	Chatterjee, Arijit; Hambrick, Donald C.	2007	- US high-tech firms - 1992-2004 - N=352	Narcissism (+)	Strategic dynamism, M&A activity, performance variance	-	Narcissism drives strategic dynamism and grandiosity, the size and number of M&As, and fluctuation of organizational performance
M&A	Hayward, Mathew L. A.; Hambrick, Donald C.	1997	- Public US firms - 1989-1992 - N=106	Hubris (+)	Acquisition premium paid	Board vigilance (-)	CEO hubris drives the size of premiums paid, especially when board vigilance is lacking
M&A	Malhotra, Shavin; Reus, Taco H.; Peng Cheng Zhu; Roelofsen, Erik M.	2018	- S&P 1500 firms - 2002-2012 - N=1,710	Extraversion (+)	M&A activity, M&A size	Competitive aggressiveness (-)	Extraverted CEOs engage in more and larger acquisitions, especially in less competitive industries

Topic	Author	Year	Sample characteristics	IVs (relevant)	DVs (relevant)	Moderators (relevant)	Findings (relevant)
Risk	Ho, Po-Hsin; Huang, Chia-Wei; Lin, Chih-Yung; Yen, Ju-Fang	2016	- Publicly listed US banks - 1994–2009 - N=1,643	Overconfidence (+)	Bank lending, leverage	Absence of crisis (+)	Overconfident bank CEOs allow a larger leverage increase in noncrisis years because they overestimate business opportunities, leading them to relax lending standards and incur debt
Risk	Banerjee, Suman; Humphery-Jenner, Mark; Nanda, Vikram; Tham, Mandy	2018	- Public US firms - 1996-2012 - N=194	Overconfidence (+)	Likelyhood of SCA	Governance (-)	Overconfident CEOs are probable to engage in reckless actions or disclosures, which cause securities class actions
Risk	O'Reilly, Charles A.; Doerr, Bernadette; Chatman, Jennifer A.	2018	- High-tech firms in Fortune 1000 - 2009 - 32 firms, 250 employees	Narcissism (+)	Number and average length of lawsuits	-	Narcissists are more likely to approve actions that result in their firm being sued, and they are less likely to settle a lawsuit even when the risk of losing is high

Topic	Author	Year	Sample characteristics	IVs (relevant)	DVs (relevant)	Moderators (relevant)	Findings (relevant)
Risk	Buyl, Tine; Boone, Christophe; Wade, James B.	2019	- US commercial banks - 2006-2014 - 92 CEOs - N=920	Narcissism (+)	Riskiness of bank policies	Corporate governance practices (-)	CEO narcissism increases the riskiness of banks policies, especially when compensation policies encourage risk-taking. This relationship is weaker when these CEOs were more effectively monitored
Risk	Li, Jiatao; Tang, Yi	2010	- Chinese manufacturing firms - Survey conducted in year 2000 - 2,075 responses	Hubris (+)	Risk taking	Managerial discretion (+)	CEO hubris spurs firms to make more risky decisions, contingent on managerial discretion
Risk	Jia, Yuping; Lent, Laurence van; Zeng, Yachang	2014	- S&P1500 firms - 1996–2010 - N=1,136	fWHR (+)	Financial misreporting, insider trading, option backdating	-	CEOs with more masculine faces have a higher incidence of misreporting
Risk	Ahmeda, Shaker; Sihvonenb, Jukka; Vähämaa, Sami	2019	- Public US banks - 2006–2014 - N=618	fWHR (+)	Bank risk taking	-	Banks led by CEOs with a high fWHR take more risks and show more volatile stock returns

Topic	Author	Year	Sample characteristics	IVs (relevant)	DVs (relevant)	Moderators (relevant)	Findings (relevant)
Strategy & other actions	Phua, Kenny; Tham, T. Mandy; Wei, Chishen	2018	- US public firms - 1993-2011 - 1,921 firms - N=14,745	Overconfidence (+)	Number of suppliers, number of dependent suppliers, supplier R&D intensity	-	Through their leadership, overconfident CEOs strengthen stakeholder commitment in terms of greater relationship-specific investment and higher relationship durability
Strategy & other actions	Banerjee, Suman; Humphery-Jenner, Mark; Nanda, Vikram	2018	- US public firms - 1992-2011 - N=20,000	Overconfidence (+)	Stock repurchases	Cash holdings (+)	Overconfident CEOs are more likely to repurchase stock, even at lower levels of cash holding
Strategy & other actions	Chen, Guoli; Crossland, Craig; Luo, Shuqing	2015	- US public firms - 1994-2008 - N=578	Overconfidence (-)	Feedback responsiveness (improvement of management forecast accuracy)	Managerial discretion (-)	Firms led by overconfident CEOs respond less to corrective feedback and attribute poor outcomes to external factors
Strategy & other actions	Rawson, Caleb	2021	- US public firms - 2001-2017 - N = 10,731	Overconfidence (+)	Narrative R&D disclosures	-	Firms with overconfident CEOs provide significantly more narrative R&D

Topic	Author	Year	Sample characteristics	IVs (relevant)	DVs (relevant)	Moderators (relevant)	Findings (relevant)
Strategy & other actions	Andreou, Panayiotis C.; Doukas, John A.; Koursaros, Demetris; Louca, Christodoulos	2019	- Public US firms - 1993-2010 - N=3,717	Overconfidence (+)	Value loss of diversified firms	-	Overconfident CEOs engage in more value-destructive corporate diversification activities
Strategy & other actions	Zhu, David H.; Chen, Guoli	2015	- Fortune 500 firms - 1997-2006 - N=591	Narcissism (+)	Acquisition emphasis, international diversification	Status of other firms tied to the CEO (+)	Narcissistic CEOs are influenced by corporate strategies which they experienced at other firms and strongly resist the impact of other directors' previous experience
Strategy & other actions	Patel, Pankaj C.; Cooper, Danielle	2014	- Public US firms - 2005-2010 - N=2,352	Narcissism (-/+)	Approach motivation, avoidance motivation	-	Narcissistic CEOs possess stronger approach focus (motivation towards desirable outcomes) and weaker avoidance focus (motivation away from undesirable outcomes)

Topic	Author	Year	Sample characteristics	IVs (relevant)	DVs (relevant)	Moderators (relevant)	Findings (relevant)
CSR	McCarthy, Scott; Oliver, Barry; Song, Sizhe	2017	- S&P 1500 US firms - 1992-2012 - N=15,379	Overconfidence (-)	CSR	-	CEO overconfidence is negatively linked to CSR activeness, especially in the institutional aspects such as community and workforce diversity
CSR	Petrenko, Oleg V.; Aime, Federico; Ridge, Jason; Hill, Aaron	2016	- Fortune 500 firms - 1997-2012 - N=1,051	Narcissism (+)	CSR	For CSR-> Performance: Narcissism (-)	CEO narcissism boosts the level and profile of organizational CSR, but reduces the impact of CSR on performance
CSR	Tang, Yi; Mack, Daniel Z.; Chen, Guoli	2018	- S&P 1500 firms - 2003-2010 - N=769	Narcissism (+)/hubris (-)	CSR	Peer influence (+)	The positive relationship between CEO narcissism and the negative relationship between CEO hubris and CSR is strengthened when peer firms invest less
CSR	Tang, Yi; Qian, Cuili; Chen, Guoli; Shen, Rui	2015	- S&P 1500 index firms - 2001-2010 - N=1,925	Hubris (-)	CSR	Dependence on stakeholders (+)	Hubris is negatively related to a firm's socially responsible activities and positively related to its irresponsible ones, which is weakened by its dependence on stakeholders for resources

2.2.3 Personal outcomes

This section analyzes previous literature on the relationship between CEO characteristics and their personal outcomes in terms of career and compensation achievements. Overall, the personality of a candidate has a great impact on his or her compensation preferences or their probability to be promoted to CEO. Interestingly, principals have come to understand some of these dynamics and might exploit them in their favor. This category does not include articles focused on CEO fWHR.

CEO characteristics and career. The personality of a CEO not only influences his or her chances to be promoted to CEO, but also the success within this role. CEO optimism, similar to overconfidence, can lead the risk-ignoring CEO to engage in value-destroying activities and must be closely monitored by the board of directors. Campbell et al. (2011) describe in their research, that CEOs with high optimism face significantly greater risks of forced turnover for overinvesting. Thus, directors who act in the interest of shareholders and monitor the CEO adequately, strengthen this relation.

Overconfidence is, at least initially, a career booster. According to Banerjee et al. (2020), overconfident candidates are more likely to be named CEO when firms hire internally. Especially when boards are busy and more insulated from the negative implications of their action, they are more receptive for the candidates' self-advertising. On the other hand, the negative consequences of overconfidence do not stay undetected. Kim (2013) argues, that CEOs with self-attribution-bias are more likely to be let go by the board due to low performance. Their self-attribution-bias causes them to attribute the firm's outperformance to their own doing while underperformance is caused by bad luck or other external factors.

Narcissism is another personality trait with significant influence on one's career prospects. Narcissists have been found to lead larger, more valuable firms (Olsen et al., 2012) and are even willing to commit crimes to enhance the appearance of their firm's performance

(Olsen & Stekelberg, 2016). Their ambitious nature, does help narcissistic candidates to advance faster to become CEO, regardless of whether the firm is a family business or not, as Rovelli and Curnis (2021) point out in their recent research.

CEO characteristics and compensation. The personality of a CEO influences for instance his or her preferences regarding level and structure of compensation. Humphery-Jenner et al. (2016) argue, that overconfident CEOs prefer incentive-heavy compensation contracts. Their firms, on the other hand, exploit the CEOs' positively biased views of their prospects. An overconfident CEO, who overestimates the probability of good outcomes and, thus, the value or the variable compensation package can be cheaply satisfied with option- and stock-heavy packages.

Given narcissists' inflated sense of self-worth and low empathy, they consider a large payment spread among TMT members to be justified and fair. According to O'Reilly et al. (2014), narcissistic CEOs with higher tenure have higher compensation packages, also in relation to other TMT members.

Psychology research describes extraversion as the trait most closely linked to leadership emergence (Green et al., 2019). Extraverted CEOs, as Green et al. (2019) find, earn higher salaries, are less probable to experience forced job turnover, achieve a longer job tenure, serve on more outside boards, and act as directors at larger firms.

Table 3 CEO characteristics and personal outcomes

Topic	Author	Year	Sample characteristics	IVs (relevant)	DVs (relevant)	Moderators (relevant)	Findings (relevant)
Career	Campbell, T. Colin; Gallmeyer, Michael; Johnson, Shane A.; Rutherford, Jessica; Stanley, Brooke W.	2011	- Public US firms - 1992-2005 - N=12,334	Optimism (+)	Risk of CEO turnover	Quality of governance (+)	CEOs with high optimism face significantly greater risks of forced turnover for overinvesting; Directors who act in the interest of shareholders strengthen this relation
Career	Banerjee, Suman; Dai, Lili; Humphery-Jenner, Mark; Nanda, Vikram	2020	- Public US firms - 1994-2016 - N=2,567	Overconfidence (+)	Promotion to CEO	Governance (-)	Overconfident candidates are more likely to be promoted to CEO when firms hire internally
Career	Kim, Y. Han (Andy)	2013	- CEO interviews on CNBC - 1997–2006 - N=6,931	Overconfidence (+)	CEO forced turnover	Firm performance (-)	CEOs with self-attribution-bias are more likely to be fired by the board due to low performance
Career	Rovelli, Paola; Curnis, Camilla	2021	- US public firms - N=172	Narcissism (+)	Promotion to CEO	Family business	Narcissistic managers advance faster to become CEO, regardless of whether the firm is a family business or not

Topic	Author	Year	Sample characteristics	IVs (relevant)	DVs (relevant)	Moderators (relevant)	Findings (relevant)
Compen-sation	Humphery-Jenner, Mark; Lisic, Ling Lei; Nanda, Vikram; Silveri, Sabatino Dino	2016	- Public US firms - 1992-2011 - N=12,810	Overconfidence (+)	Incentive-based compensation	CEO bargaining power (+)	Overconfident CEOs prefer incentive-heavy compensation contracts, while firms exploit the CEOs' positively biased views of their prospects
Compen-sation	O'Reilly, Charles A.; Doerr, Bernadette; Caldwell, David F.; Chatman, Jennifer A.	2014	- US high-technology firms - 2009 - 250 survey respondents of 32 firms	Narcicissm (+)	Compensation, CEO Pay Slice	CEO tenure (+)	Narcissistic CEOs with higher tenure have higher compensation packages, also in relation to other TMT members
Compen-sation	Green, T. Clifton; Jame, Russell; Lock, Brandon	2019	- S&P 1500 firms - 2006-2013 - N=4,500	Extraversion (+)	Compensation, career success	-	Extraverted CEOs earn higher salaries, are less probable to experience forced job turnover, achieve a longer job tenure, serve on more outside boards, and act as directors at larger firms

2.3 Derivation of research gaps and research questions

This section identifies gaps within extant research and derives the research questions that form the core of this dissertation.

Evidently, there is a growing interest in management research and how CEO personality influences firm outcomes. As seen in the literature review, the number of studies published in this field increases year by year and only four of the included 50 papers were published before 2010. This highlights the growing interest and attention regarding the impact of CEO personality on firm behavior as well as firm and personal outcomes.

However, as seen in the review of extant literature, most articles focus on distinct personality traits, such as overconfidence or narcissism. Despite the conclusion that physical attributes are highly relevant antecedents of firm outcomes and should be a focal point for extant researchers (Jia et al., 2014; Lefevre et al., 2013), very little research exists on any physical characteristics, such as facial masculinity, attractiveness, voice, height, and alike. Unsurprisingly, this has led me to the conclusion to contribute one piece of research to the most burning questions within each of the categories illustrated above (firm outcomes, firm behavior, personal outcomes).

Additionally, as Nofal et al. (2018) state, "[…] most managerial behavior is likely accounted for by the interaction of human biology and environmental factors, additional research should empirically investigate how environment and biology interplay to influence management" (p. 23). This is confirmed by Harrison et al. (2019), highlighting that every strategic action is an interplay of CEO characteristics and the situation. Evidently, the impact of a CEO's characteristics is contingent on environmental factors, leaning the overall impact more towards the dark or the bright side of each trait. Therefore, I make the choice to include the impact of the environmental setting into each of the three studies and the respective research questions.

The first research question stems from the category firm outcomes, which includes the topic innovation and performance. Within the literature review, I only identified one testosterone-related study in this category, which addresses the relation of CEO facial masculinity and firm financial performance. Although the innovation topic includes the most articles within this literature review, none of them are related to CEO testosterone. Thus, addressing not only firm innovation but also future firm value, I formulate the first research question accordingly:

Research question 1 (RQ 1): *Does male CEOs' facial masculinity impact firm performance in terms of creating product innovations and future business and how is this influenced by industry dynamism?*

Research question 1a (RQ 1a): *Do alpha CEOs increase firm innovation in terms of new product releases in undynamic industries?*

Research question 1b (RQ 1b): *Do alpha CEOs outperform in terms of firm value creation in undynamic industries?*

The second research question addresses the second category, firm behavior. Again, the topic strategy and other actions – despite being the second largest within this category – does not include a study related to CEO testosterone. I identified venture capital investments as a significant area of interest because of their long-term, strategic and high visibility nature. Surprisingly, however, not one of the studies included in this literature review focuses on corporate venture capital investing. Thus, addressing the gap around VC investing and testosterone-related research in terms of firm strategic actions, I formulate the second research question:

Research question 2 (RQ 2): *Does male CEOs' facial masculinity impact firm strategic investing moves and how is this influenced by industry dynamism?*

Research question 2a (RQ 2a): *Do alpha CEOs undertake fewer venture capital investments, especially in undynamic industries?*

Research question 2b (RQ 2b): *Do alpha CEOs prefer to undertake venture capital investments with fewer co-investors in undynamic industries?*

The third research question is directed at the third category, personal outcomes. This category does not include any research related to facial masculinity. Therefore, I make the choice to address the topic, which I consider most generally of interest: compensation. In a world that talks about fair compensation and for instance gender equality, it still seems to be an unwritten law that alpha males, who bang on their chests the loudest, receive the highest compensation. I aim to shed light on this myth by formulating the third research question:

Research question 3 (RQ 3): *Does male CEOs' facial masculinity impact their structure and level of compensation and how is this influenced by competitive intensity?*

Research question 3a (RQ 3a): *Do alpha CEOs secure compensation packages with a higher share of variable components when competitive intensity is low?*

Research question 3b (RQ 3b): *Do alpha CEOs secure a higher overall compensation when competitive intensity is low?*

Table 4 summarizes this dissertation's underlying research questions.

Table 4 Overview of research questions

Research question 1	**Does male CEOs' facial masculinity impact firm performance in terms of creating product innovations and future business and how is this influenced by industry dynamism?**	
RQ 1a	Do alpha CEOs increase firm innovation in terms of new product releases in undynamic industries?	Study I
RQ 1b	Do alpha CEOs outperform in terms of firm value creation in undynamic industries?	Study I
Research question 2	**Does male CEOs' facial masculinity impact firm strategic investing moves and how is this influenced by industry dynamism?**	
RQ 2a	Do alpha CEOs undertake fewer venture capital investments, especially in undynamic industries?	Study II
RQ 2b	Do alpha CEOs prefer to undertake venture capital investments with fewer co-investors in undynamic industries?	Study II
Research question 3	**Does male CEOs' facial masculinity impact their structure and level of compensation and how is this influenced by competitive intensity?**	
RQ 3 a	Do alpha CEOs secure compensation packages with a higher share of variable components when competitive intensity is low?	Study III
RQ 3b	Do alpha CEOs secure a higher overall compensation when competitive intensity is low?	Study III

3 Theoretical foundations

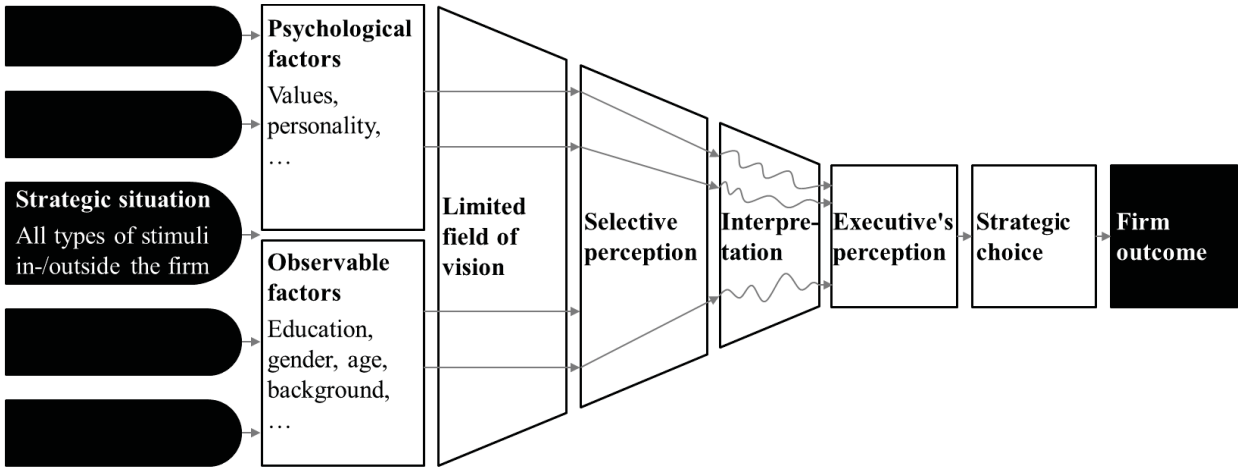
Section 3 outlines this dissertation's theoretical foundations and underlying theories, which the research questions described above are based on. This dissertation and its studies are based on upper echelons theory, facial masculinity and agency theory of compensation, as described in detail in the following sections.

3.1 Upper Echelons Theory

As initially set forth by Hambrick and Mason (1984), upper echelons theory realizes that top managers and leaders view and interpret situations through their highly individual, personalized lenses. This personalized understanding of strategic situations ascends because of the executives' differences in values, previous experiences, character traits and other human factors. Building on this perspective, scholars have studied the impact of TMT configuration and processes on firm behavior and performance, as well as the influence of CEO characteristics on strategy and performance. Today, innumerable articles and studies confirm the argumentation of upper echelons theory, leading to the simple conclusion that to understand strategy, we must understand the strategists first.

Decision-making is not entirely rational or depends on entirely objective factors with perfect information available but is influenced by an individual's background characteristics (Hambrick, 2007). However, individuals are subject to bounded rationality, a construct of the human decision-making process first described by Simon (1955). Bounded rationality suggests that humans have limited capacity to make rational decisions due to their limited cognitive ability, time constraints, or imperfect information. Hambrick and Mason (1984) and Finkelstein et al. (2009) build on this and depict a process of strategic decision-making of executives as illustrated in Figure 10.

Figure 10 Strategic decision-making according to the Upper Echelons Theory



Source: own illustration based on Hambrick and Mason (1984) and Finkelstein et al. (2009)

The strategic situation describes any stimuli influencing the executive or organization, such as events, trends, the external environment, or internal factors (Finkelstein et al., 2009). Thus, the strategic situation an executive faces is more complex and manifold than he or she could possibly comprehend (Hambrick & Mason, 1984). Accordingly, he or she must filter the incoming information to be able to make a strategic choice (Hambrick & Mason, 1984). This filtering and how the executive perceives the situation is, however, influenced by their psychological (e.g., values, cognition, personality) and demographic factors (e.g., age, prior education, work background) (Finkelstein et al., 2009). The information passes through three layers of unconscious filtering before being interpreted by the executive and leading to a decision which ultimately determines firm behavior or performance.

Before psychological constructs like personality traits came into play, Hambrick and Mason (1984) focus their analysis on the executives' observable background characteristics (e.g., age, tenure, education). This was driven primarily by the feasibility of the research, considering that those background characteristics were more easily accessible. In an updated review of their previous research, Hambrick (2007) points out that managers' interpretations are a "function of the executives' experiences, values, and personalities". Since then, management scholars

have widely used upper echelons theory as a fundament of their research for assessing how TMT members' personality affects firm behaviors and outcomes.

3.2 Facial masculinity

As Nofal et al. (2018) point out in their literature review, the scarcity of research at the just recently emerging interface of biology and management is surprising, considering that biology influences all aspects of human behaviors, including the ones of CEOs. Ignoring this factor as an explanation for executive behavior equals missing an important part of the puzzle (Nofal et al., 2018). Recently emerging research in the field linking management and biology has found a variety of physical characteristics which drive managerial decision making. In particular, facial structure or masculinity of male managers has been elevated to be such a decision-making antecedent (Jia et al., 2014). Facial masculinity is largely an outcome of craniofacial bone growth during the male pubertal stage, which is regulated by testosterone administration (Lefevre et al., 2013). This enables researchers to use the metric fWHR as a proxy for the individual's facial masculinity and testosterone level and assess its relation to firm behavior and outcomes.

The level of testosterone drives a complex of related behaviors and personality traits in males. And as to most personality traits or characteristics, there is a bright and a dark side related to high levels of testosterone. On the negative side, research links facial masculinity for instance to aggressiveness, risk taking, and egocentrism (Carré & McCormick, 2008; Wong et al., 2011), but also economic behaviors like financial misreporting (Jia et al., 2014). Alpha males possess a tendency to ignore the perspectives of others while overweighing their own (Galinsky et al., 2008). Accordingly, they view colleagues and subordinates merely as a tool for their own purpose (Gruenfeld et al., 2008). Because of this sense of objectification, colleagues and team members feel alienated so that collaborative benefits are diminished (Galinsky et al., 2008).

In contrast, research seems to focus less of the socially beneficial traits that are associated with high levels of testosterone. Wong et al. (2011) argue that testosterone-based behavior is associated with a psychological sense of power. This link between testosterone and power is fundamental, as powerful individuals view their situation, external environment, and challenges more optimistically, realizing opportunities, and focusing on the big picture rather than the details (Galinsky et al., 2008). Moreover, they are more likely to attend to task-relevant information (Overbeck & Park, 2001), and to engage in activities that are aligned with principal objectives (Galinsky et al., 2008). In summary, the positive consequences of testosterone by themselves are the core of effective leadership (Galinsky et al., 2008). A summarized overview of testosterone-related character traits is illustrated in Table 5.

In sum, by building on previous psychology and biology studies, researchers can derive insights about CEOs' behavior, and relate it to both firm and personal outcomes (Jia et al., 2014). Looking at the theoretical foundations, assessing the impact of testosterone in the field of company executives and top management teams seems extraordinarily relevant. Nevertheless, only recently have a handful of researchers started to conduct respective studies - but the trend is picking up noticeably.

Table 5 Positive and negative testosterone-related traits of CEOs

Positive testosterone-related traits	**Negative testosterone-related traits**
Optimistic behavior	***Diminished perspective-taking and over-confident judgment***
• Positive and convincing mindset, wording, and actions, causing others to trust and follow • Openness to opportunities, triggering new visions, and setting the course for future growth and success	• Overestimation of own perspective and ignorance of others • Restriction of information flow by nullifying others' contributions • Overvalued potential payoffs
Goal-directed behavior	***Objectification of other team members***
• Focus on global, not local stimuli • Management of gist of information	• Elimination of valuable ideas • Alienated team members

• Actions in line with currently held goals	• Hindered collaborative benefits
Effective leadership	***Risk-taking, unethical behavior***
• Ability to influence, motivate, and enable individuals to contribute to the success of a shared purpose • Ability to inspire and unite all stakeholders behind priorities, making them believe in new visions or projects	• Underestimation of risks and downsides • Tendency towards unethical dealings or questionable/illegal behavior and misreporting • Destruction of shareholder value, financial underperformance

3.3 Agency theory of compensation

A critical theory which study III touches on, but illuminates from a different perspective, is agency theory. In large companies, ownership and control are separated, meaning that shareholders (principals) employ a management team (agents) to run their company for them (Jensen & Meckling, 1976). Agency theory is the study of incentives provided to agents and forms the basis of many corporate governance studies which address the relationship between shareholders and executives (Mizik, 2010).

Agency theory of compensation addresses how compensation contracts or incentives of executives should be constructed in order to perfectly align their interests with the objectives of shareholders. One friction point, for example, could be differing attitudes about risk. Managers typically have a lower risk-tolerance than shareholder, who can diversify their risk by investing in multiple firms (Eisenhardt, 1989). Thus, principals must align their own with the agents' interests for instance by including compensation contract components that reward risk-taking (Eisenhardt, 1989). Failing to do so can lead to a deviation of the agents' actions from the principals' objectives and destroy shareholder value.

Traditionally, compensation related research is based on agency theory (Rekker et al., 2014). Despite – or maybe because of – the predominance of this theory, a growing stream of research focuses on the perspective of the CEO instead of the firm or its directors when

assessing the antecedents and determinants of CEO pay. Assuming that CEOs want to maximize their income, different personality traits would influence their strategy to achieve this. Study III of this dissertation addresses this question not based on agency theory but from the opposite, CEO-centered viewpoint.

4 Research design and empirical approach

The dissertation's research design is described in two sections. The first section illustrates the sample development (section 4.1), and the second section describes the methods of statistical analyses applied in our research studies (section 4.2).

4.1 Sample development

This dissertation relies on secondary data from commonly used databases providing firm-level information, described in detail in section 4.1.1, as well as primary data measured to determine the CEOs' levels of testosterone, described in section 4.1.3.

4.1.1 Data sources

This dissertations' sample consists of large, publicly traded companies, which were listed in the US S&P 500 index between 2010 and 2014. The fundament of all three studies includes the Compustat, ExecuComp and Boardex databases, three established and widely used databases in management research, as well as the fWHR measurements of the respective CEOs. Additionally, this basic framework is enriched with Ravenpack, Crunchbase and (more extensive) ExecuComp data for the first, second and third study, respectively.

Compustat, ExecuComp and Boardex databases are part of Wharton Research Data Services (WRDS). Compustat is a comprehensive collection of fundamental financial and market information on global companies, indices, and industries (Wharton Research Data Services, 2022). It was utilized to construct both dependent and control variables, as well as the environmental indicators used as moderators in all three studies.

Boardex provides access to the educational background, prior employment, and connections of directors and executives. It is very frequently used, like in our case, to construct CEO-level controls such as age, gender, and experience.

For the first study, information from the Ravenpack database was added to the sample. Ravenpack collects action-level data from a breadth of sources and newswires and classifies

news articles into categories of action for nearly 40,000 firms. The use of the dataset has notably increased in management research recently and claims to be "the most published alternative dataset out there" (Ravenpack News Analytics, 2022).

For the second study, we match our sample with the Crunchbase database, in which our focal companies are listed as investors. Crunchbase is the source for all data collected on startups, with a particular focus on funding rounds. The database is self-reported by thousands of participants and double checked with different online platforms such as VentureXpert before publishing. Crunchbase has become a frequently used source for empirical research (Homburg et al., 2014).

The ExecuComp database was used to construct control variables, and in particular in our third study, to assess compensation variables in relation to CEO testosterone. ExecuComp includes over 80 different compensation items on the top five executive officers per company (more than 12,500 executives in total), in firms included in the S&P 500, S&P 400 MidCap and S&P SmallCap 600 indexes (Wharton Research Data Services, 2022).

4.1.2 Measurement of CEO fWHR

As the CEO's level of testosterone is the backbone of this dissertation, this section ought to provide detailed insights on its measurement. In line with extant research, we measure the CEOs' propensity to masculine behavioral traits via "an unfakeable facial feature" (Jia et al., 2014). The measure facial width-height-ratio (fWHR) serves as a proxy for testosterone and has been increasingly adopted in management research, especially the analysis of firm CEOs (e.g., Wong et al., 2011, Kamiya et al., 2019, Jia et al., 2014). Lefevre et al. (2013) has particularly validated fWHR as an adequate proxy for testosterone, stating that fWHR has a significant positive correlation with saliva-assayed testosterone in men, and thus, is superior to further facial masculinity measures.

The relative width of the face, i.e., facial masculinity, is the outcome of a person's craniofacial bone growth driven by their testosterone level during adolescence (Verdonck et al., 1999). Therefore, a male's fWHR is not subject to change over his lifetime, making it unnecessary to consider the age of the photograph. Further, it is important to notice that it is common practice in extant fWHR research to exclude women from the sample, as in their case testosterone is less directly related to facial morphology, driven by confounding effects of other hormonal factors (Lefevre et al., 2013).

To construct the pictorial database of our sample CEOs, I searched each CEO on their company website or annual reports. If no picture could be obtained, I used the CEO's full name in combination with the company name to search for the best available portrait on Google Images. Among the available pictures, I then identified the best portrait in terms of resolution, and whether the CEO is forward-facing with a neutral or lightly smiling expression. Subsequently, I used the portraits to measure the bizygomatic width (distance between the two zygons or cheekbones), and the height of the upper face (distance between the highest point of the eyelid and the upper lip). The ratio of the respective width and height is the fWHR. The mean fWHR of the datasets of this dissertation is 1.98/1.99, depending on the sample subset used for the individual studies. This is well in line with the observed values of previous researchers such as Wong et al. (2011), with a mean of 1.96, or Jia et al. (2014), with a mean of 2.01. As clinical studies have revealed that testosterone in men decreases over time (Feldman et al., 2002), I have included age as control variable in all three studies.

4.1.3 Sample preparation

The construction of the sample follows five steps, with the first two being identical for all studies and the last three being individual for each study (Figure 11).

Figure 11 Overview of sample development

Equal for studies	**1. Sample basis**	**S&P 500 firms and CEOs from 2010-2014** (Compustat for firm-level, Boardex/Execucomp for executive-level data)		
	2. CEO fWHR	**fWHR measurement of male sample CEOs** (as proxy for level of testosterone)		
		Study I	**Study II**	**Study III**
Individual for studies	**3. Key variables**	Financial performance (Compustat) Product innovations (Ravenpack) Industry dynamism (Compustat)	Venture Capital investment behavior (Crunchbase) Industry dynamism (Compustat)	Compensation level and structure (ExecuComp) Competitive intensity (Compustat)
	4. Control variables	Firm-level (Compustat) Executive-level (ExecuComp/Boardex) Panel structure* (Compustat)	Firm-level (Compustat) Executive-level (ExecuComp/Boardex) Panel structure* (Compustat)	Firm-level (Compustat) Executive-level (ExecuComp/Boardex) Panel structure* (Compustat)
	5. Sample filter	Exclusion of female CEOs Exclusion of lines with missing values	Exclusion of female CEOs Exclusion of lines with missing values Exclusion of firms without VC investments	Exclusion of female CEOs Exclusion of lines with missing values
Final characteristics		Study period 2010-2014, 1676 firm-year observations with 352 companies and 484 male CEOs	Study period 2010-2014, 342 firm-year observations with 134 companies and 153 male CEOs	Study period 2010-2014, 4317 firm-year observations with 390 companies and 493 male CEOs

Note: Industry- and year-dummies included to control for panel structure of dataset

Source: own illustration

First, I used the Compustat database as fundament for my sample. I restricted the data to the years 2010 to 2014 and merged it with both the Boardex and ExecuComp database. I linked these databases on a yearly basis, based on the six-digit corporate identifier Global Company Key (gvkey) provided by WRDS. After having merged the three databases, I filtered it for only the relevant subset, i.e., only including S&P500 companies and male CEOs. This resulted in a starting point of 390 companies, for which all required firm- and executive-level information was available.

In the second step, I retrieved portraits of the respective sample CEOs and measured their facial proportions as a proxy for their level of testosterone (as described in section 4.1.2). To validate my approach further, I measured the first 100 CEOs from two portraits each, in order to detect a faulty measuring technique. However, after the measurements where identical to the second digit, I continued the measuring process based on one portrait. I included the fWHR values of 496 unique CEOs in the sample.

The third step varied for each study. In the first study, in which we assessed the relation between CEO fWHR and product innovation and future business, I merged the existing sample with the Ravenpack database to include the count of new product releases. Additionally, I created the variable Tobin's Q from Compustat data, to capture both immediate and future firm performance (Amit & Wernerfelt, 1990). For the second study, I merged the fundamental sample with the Crunchbase dataset. I generated the number of investments per firm and the average number of co-investors from applying a count function to the funding rounds, on which Crunchbase is based. For the third study, I utilized data from ExecuComp, which was already included in the original sample. ExecuComp includes a plethora of different payment variables – however, I selected the most commonly used variables for total and incentive compensation (M. Li et al., 2021). The moderating variables industry dynamism (used in study I and II) and competitive intensity (used in study III) where constructed from Compustat data. Industry dynamism was calculated as the standard deviation of sales in firms' primary industry across the prior five

years, divided by mean value of industry sales for those years (Fang et al., 2011). To determine the competitive intensity, I used the well-known Herfindahl index and squared the market shares of the top four firms in the same SIC code (Saboo et al., 2016).

Next, I added control variables for all three studies. Some of the firm- and executive-level variables were readily available in the original databases, such as firm EBIT, number of employees or CEO tenure. Other variables were ratios of existing variables and needed to be constructed, such as CEO pay slice, CEO stock ownership in percent, or firm leverage. The control variables were chosen based on what relevant, comparable articles with the same independent or dependent variables had used.

Finally, I cleansed each study's sample by removing lines with missing values or by winsorizing outliers in the dependent variables, leading me to consistent and complete sample subsets I could perform meaningful analysis with. The sample of study I includes 1676 firm-year observations with 352 companies and 484 male CEOs, study II is based on 342 firm-year observations with 134 companies and 153 male CEOs, and study III consists of 4317 firm-year observations with 390 companies and 493 male CEOs.

4.2 Method of statistical analyses

The choice of statistical methods must of course be tailored to the characteristics of the research questions, data structure and variables. In the case of this dissertation, the research questions are very similar in nature, addressing the impact of high CEO testosterone on different quantitative outcomes in the context of the industry environment. Additionally, the data structure is identical for our three sample subsets for the respective studies: All studies use unbalanced time-series cross-sectional datasets (i.e., unbalanced panel datasets), including all available observations per firm and CEO in the given time period to assess the impact of CEO testosterone on product innovation, venture capital behavior and compensation.

The three studies are based on regression analyses, calculating both a pooled ordinary least squares (OLS) regression and a generalized estimation equation (GEE) model, with the

alternate model yielding consistent results in terms of significance level, direction, and size, respectively. To accommodate our cross-sectional data set, I use generalized estimating equations (GEE). As stated by Ballinger (2004), "GEEs use the generalized linear model to estimate more efficient and unbiased regression parameters relative to ordinary least squares regression in part because they permit specification of a working correlation matrix that accounts for the form of within-subject correlation of responses on dependent variables of many different distributions, including normal, binomial, and Poisson". GEE models address the likelihood that multiple observations of the same company in different years will correlate with each other, and, thus, observations tend to be more similar to each other than to those of other firms. Therefore, a GEE model is suitable for the study's research purpose (Hardin & Hilbe, 2012).

Our alternative model, the linear OLS regression model, supposes that a continuous explanatory variable has a linear effect on a continuous dependent variable (Moutinho & Hutcheson, 2011). Accordingly, I used a pooled OLS regression to address the sample's panel structure as this model allows for consistent estimates when companies are observed multiple times (Wooldridge, 2010). Moreover, I account for the panel structure by including heteroskedasticity and serial correlation robust standard errors clustered at the firm and year level (Arellano, 1987).

In sum, the statistical methods applied in the three studies are well-tailored to the requirements of the data and variable structure. I used R, a widely applied, free software environment for statistical computing for the empirical work in all three research studies.

5 Research studies

The following chapter presents the core of this dissertation: three autonomous, scientific studies that answer our research questions and fill the respective gaps in the literature. First, section 5.1 provides a summary of the research studies. Subsequently, the sections 5.2, 5.3, and 5.4 provide studies I, II, and III in full length, including the corresponding figures, tables, and references.

5.1 Summary of research studies

The following sections offer a summary of each study's research question, methodology, findings, and contributions.

5.1.1 Summary of study I

The first research study is titled "A Moment to Shine for the Alpha Ego – How Testosterone-fueled CEOs Outperform in Creating Product Innovations and Future Business" and introduces a biological perspective on CEOs' physical characteristics driving their decision-making. Using facial width-height-ratio as a proxy for testosterone, we establish a theoretical model that illuminates the links between CEOs' testosterone levels and product introductions and firm value creation. Research on what drives the creation of innovations and new business has directed our attention to CEOs, especially pointing out that their demographic characteristics (e.g., Strohmeyer, Tonoyan, and Jennings, 2017) and personality (e.g., Kashmiri and Mahajan, 2017) are central antecedents (You, Srinivasan, Pauwels, and Joshi, 2020). Recently, studies in psychology, neuroscience and financial economics have used biological measures to help explain executive (economic) behavior like risk taking and financial decision making (Cesarini, Dawes, Johannesson, Lichtenstein, and Wallace, 2009; Cesarini, Johannesson, Lichtenstein, Sandewall, and Wallace, 2010; Kuhnen and Knutson, 2005; Jia, van Lent, and Zeng, 2014). To develop their studies, previous researchers built on extant biology and psychology studies documenting that the metric facial width-height-ratio, representing an individual's facial masculinity and testosterone level, predicts different types of behaviors across individuals. For instance, based on

this measure researchers describe that facial masculinity relates to general behaviors like aggressiveness, egocentrism and risk taking (Carré and McCormick, 2008; Haselhuhn and Wong, 2012; Stirrat and Perrett, 2010), but also CEOs' economic behaviors like financial decision making or misreporting (Jia et al., 2014). Accordingly, there are comprehensible reasons why a high testosterone level may be related to product introductions and the creation of future firm value.

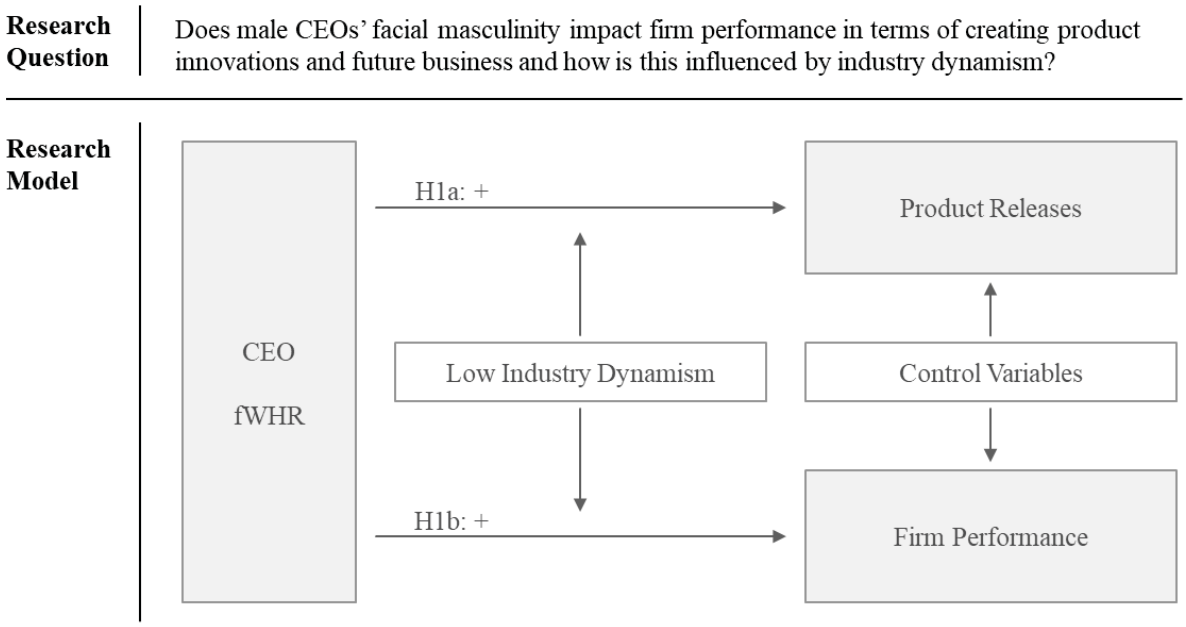
However, opposing character traits of high-testosterone executives highlight the need for investigation and the dependence on environmental factors. Earlier studies found facial masculinity to relate to risk taking, driving the creation of new opportunities and leading to increased innovation performance, for example concerning product innovation effectiveness (García-Granero, Llopis, Fernández-Mesa, and Alegre, 2015). Further, researchers found firms whose CEOs induce greater competitive aggressiveness to achieve more new product introductions, but also experience more product-harm crises (Kashmiri, Nicol, and Arora, 2017). Consequently, there might also be downsides of high-testosterone CEOs since their aggressive behavior may deter potential business partners, thereby diminishing future firm value creation. Given these mixed results and following up on this linkage of the biology and management literature streams, we further investigate the particular effects of CEOs' testosterone levels to shed light on this study's research question:

> ***Research question 1 (RQ 1):*** *Does male CEOs' facial masculinity impact firm performance in terms of creating product innovations and future business and how is this influenced by industry dynamism?*

To resolve the tensions in the literature around how male CEOs' testosterone levels work, we argue that the effects of CEO testosterone on product introductions and firm value are contingent on industry dynamism. We assume that the positive effects on these outcomes play out when dynamism is low, while there are no such effects when dynamism is high. We expect that a high-dynamism environment fuels the alpha CEO's weaknesses: disrupting collaboration and

information flow, not taking all opinions into account, and ignoring risks for rewards. In contrast, we expect, that a low-dynamism environment fuels his strengths: Unveiling opportunities while dealing with the gist of information, keeping an eye on balancing company goals, and executing effective leadership. The requirements of turbulent industries, namely the high complexity and information-processing needs, are not served by high-testosterone CEOs' strong suits. Therefore, we expect industry turbulence to be a crucial environmental factor determining whether high CEO testosterone has a positive or negative impact on firm innovative activeness and performance. The research question and our research model's predictions are shown in Figure 12.

Figure 12 Overview of the first research study's research question and model



Source: own illustration

To test our hypothesis, we conduct our study based on publicly traded US firms, listed in the S&P 500 index, between 2010 and 2014. Our sample includes 1676 firm-year observations with 352 companies and 484 male CEOs. The study combines company and financial data from the COMPUSTAT database with competitive moves from the Ravenpack News Analytics database. Portraits of the sample's CEOs were used to measure their fWHR scores.

Our study shows that the positive consequences of high CEO testosterone predominate in environments with a low degree of turbulence. We determine that high-testosterone CEOs drive a higher level of firm activity in terms of product releases and achieve superior financial value when industry dynamism is low, while this is not the case when industry dynamism is high.

This study contributes to upper echelons research in innovation management by considering the interface of management and biology and offering a novel CEO characteristic impacting innovation. Moreover, it contributes to research on testosterone in executives by adding a strategic perspective. Last, this study also contributes to contingent perspectives on the relation of CEO characteristics and firm outcomes by finding that a biological characteristic can be beneficial in one situation and detrimental in another. Thus, this study also answers the call for research at the interface of biology and management of Nofal et al. (2018).

5.1.2 Summary of study II

The title of our second research study is "Not in the Mood for a Unicorn – How Testosterone-fueled CEOs Pursue Less Venture Capital Investments in Undynamic Environments" and illuminates from a biological perspective how CEOs' physical characteristics drive their venture capital investment behavior. The body of research on the drivers of innovation, such as corporate venture capital, has grown tremendously over the last decades. However, the focus lies on whether strategic goals are achieved, how innovation programs should be run, or under which conditions the corporate and venture collaborate most fruitfully (Dushnitsky & Lenox, 2005). Venture capital investments represent a significant commitment of resources in terms of financials and time (Freese et al., 2007). Nevertheless, research on the antecedents of CVC investments, i.e., what drives the CVC commitment and scale, is vastly limited. In more general terms, extant research lists CEOs' demographic characteristics (e.g., Strohmeyer et al., 2017) and personality (e.g., Kashmiri & Mahajan, 2017) as important antecedents for innovation and new business (You et al., 2020), leading us to address this call for research (Anokhin et al., 2016).

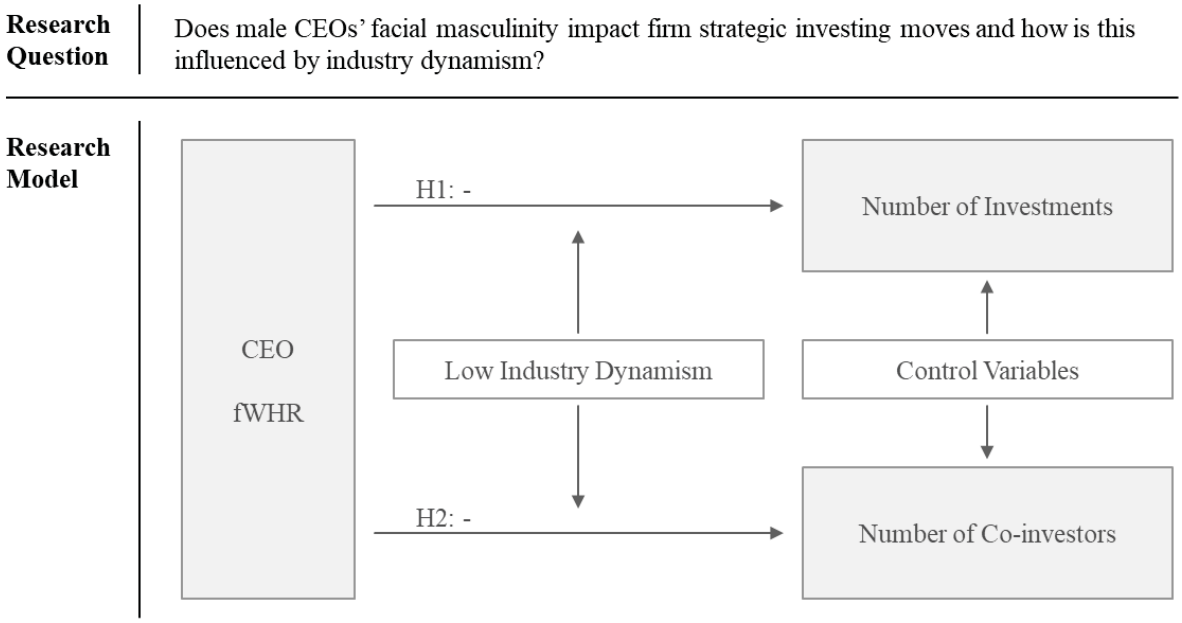
At the recently emerging link of management and biology, extant research shows that executives' facial structure and the level of testosterone this reflects, is a driver of their managerial behavior. Researchers use the metric facial width-height-ratio, a proxy for facial masculinity and testosterone, to derive insights about their behavior (Jia et al., 2014). Based on this, they describe facial masculinity-related behaviors like aggressiveness, risk taking, and egocentrism (Carré & McCormick, 2008; Haselhuhn & Wong, 2012; Stirrat & Perrett, 2010), but also managerial behaviors like financial decision making or misreporting (Jia et al., 2014) – relevant traits which impact one's investment behavior. Combining the above-mentioned research streams, we ask the question how male CEOs' facial masculinity is associated with their firms' strategic moves like venture capital investments.

Research question 2 (RQ 2): *Does male CEOs' facial masculinity impact firm strategic investing moves and how is this influenced by industry dynamism?*

Our research illuminates the link between CEOs' testosterone levels and their investment behavior in terms of number of investments and co-investors. On the one hand, alpha CEOs are highly optimistic opportunity-seekers who dare to make bold and fast decisions (Wallace & Baumeister, 2002) – the perfect prerequisite for making many and large VC investments. But on the other hand, high-testosterone CEOs tend to nullify the opinions of others (Diesing, 1962), potentially diminishing the buy-in of their fund managers, all other employees, and TMT members. We argue that the weight of these counter-acting characteristics depends on whether VC investments offer the opportunity to draw enough of the public attention and applause that alpha CEOs seek. Therefore, we reason that the effects of their testosterone levels on firm VC activeness are reliant on industry dynamism. Specifically, we expect that in low-dynamism environments, the VC investment interest of alpha CEOs is not triggered while they are drawn towards more predictable, quicker wins, which also offer a spot in the limelight. Accordingly, we assume that the negative effects of testosterone play out when industry dynamism is low,

whereas this is not the case when dynamism is high. Figure 13 depicts the research question and our research model's predictions.

Figure 13 Overview of the second research study's research question and model



Source: own illustration

To test our hypothesis, we construct a sample of publicly traded US firms in the S&P 500 index, between 2010 and 2014. The sample includes 342 firm-year observations with 134 companies and 153 male CEOs. Our article's sample unites company data from the COMPUSTAT database, pictures of the sample CEOs, and CVC investment data from the Crunchbase database. The methodology of measuring the CEOs' fWHR is described in detail in the research design section.

Our research study shows that the high level of testosterone of CEOs can negatively relate to the company's VC investment activeness in settings where industry dynamism is low. Our findings suggest that the negative relationship is not universally valid but, instead, highly depends on environmental aspects. Specifically, we find that in undynamic environments, alpha CEOs undertake fewer investments alongside fewer co-investors than their low-testosterone peers, which is not the case when industry turbulence is high. Thus, this article identifies low

industry turbulence to be the 'lazy spot' for alpha CEOs, where venture capital investments do not offer sufficient predictable returns or a spot in the limelight to trigger their interest.

This study makes three primary contributions: First, we contribute to upper echelons research in open innovation management by offering a novel CEO characteristic as antecedent of corporate venture capital commitment and scope. Second, we contribute to the emerging body of research on testosterone in executives. Specifically, we add a strategic perspective to the currently rather operational-focused effects of CEOs' level of testosterone and facial structure. Finally, we extend existing leadership research by accounting for the environment or broader context in which leaders make decisions on behalf of their companies. Thus, the integration of industry dynamism as a moderator answers Nofal et al.'s (2018) call for research on how environment and biology interplay to influence management.

5.1.3 Summary of study III

The title of our second research study is "The Great Gamble of Alpha CEOs – How Testosterone-fueled CEOs Negotiate Higher Incentive Payment Components and offers a biological perspective on how CEOs' physical characteristics drive their level and structure of compensation. With a typical CEO making 361 times the salary of his or her average employee in 2018 (Hembree 2018), management compensation has long triggered the attention of media, practitioners, and researchers: Researchers and practitioners alike are questioning whether CEO compensation is still justified, equitable, and even moral (Li et al. 2021). The majority of extant research in compensation theory takes the perspective of an agency theory model (Bebchuk and Fried 2004), exploring how compensation systems can be designed to incentivize CEOs and align the respective interests. However, a growing stream of research declares that CEOs possess a significant impact on the level and structure of their compensation and setting the CEO's income is not an entirely rational or objective process (O'Reilly et al. 2014). Instead, CEOs can negotiate it most favorably based on their risk preferences beyond what is objectively justified. Additionally, directors are subject to several biases. Research describes, for instance, the

significant positive impact of biological signals, such as attractiveness, level of voice, or height (Li et al. 2021).

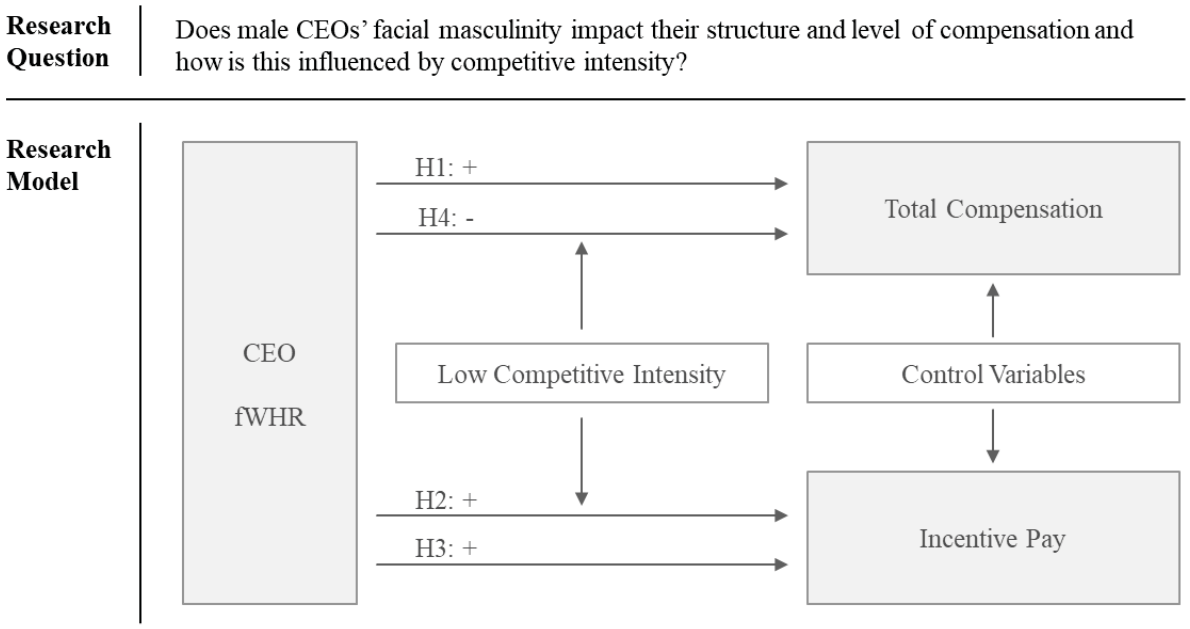
At the recently emerging intersection of management and biology, extant researchers describe that executives' facial structure and the level of testosterone it mirrors, is a driver of their managerial behavior. Researchers use the facial width-height-ratio, a proxy for facial masculinity and testosterone, to derive insights about the individual's behavior (Jia et al., 2014). Specifically, they describe facial masculinity-related behaviors like aggressiveness, risk taking, and egocentrism (Carré & McCormick, 2008; Haselhuhn & Wong, 2012; Stirrat & Perrett, 2010), but also managerial behaviors such as financial decision making or misreporting (Jia et al., 2014) – relevant traits which impact one's compensation preferences. We link the above-mentioned streams, to shed light on this study's research question:

Research question 3 (RQ 3): *Does male CEOs' facial masculinity impact their structure and level of compensation and how is this influenced by competitive intensity?*

On one side, alpha CEOs are extremely result-seeking individuals, who with their natural leadership and goal-directed behavior have the ability to accomplish an overall higher compensation package. As Li et al. (2021) elaborate, executives who show a higher level of confidence, elicit more respect, have great communication skills, and immediately build interpersonal relationships, are the ones who accomplish to increase their compensation. But on the other hand, high-testosterone CEOs' risk-seeking behavior drives their compensation packages to be structurally different, due to their stronger preference for performance-based pay components. But while they are fond of risky incentive pay components, they underestimate the sheer possibility of not meeting one of the associated targets. However, extant research finds this behavior to be disadvantageous for overly optimistic CEOs, as by accepting risky compensation packages they may end up with lower total compensation due to the overestimation of their incentive claims (Otto 2014). We expect that the industry the firm operates in plays a significant role in this relation: In industries with lower competitive intensity, CEO compensation is generally higher

(Jung and Subramanian 2017) which leaves CEOs with more flexibility to negotiate compensation packages to their preferences. Thus, we predict that alpha CEOs with their result-seeking behavior possess the ability to generally negotiate a slightly higher total compensation. In less competitive environments, however, their risk-seeking behavior diminishes this effect as the higher incentive pay they negotiate does not lead to a higher total compensation. The research question and our research model's predictions are shown in Figure 14.

Figure 14 Overview of the third research study's research question and model



Source: own illustration

To confirm our hypotheses, we construct a sample based on publicly traded US firms listed in the S&P 500 index, between 2010 and 2014. The sample consists of 4,317 firm-year observations with 390 companies and 493 male CEOs and combines company data from the COMPUSTAT database, portraits of the sample, and CEO compensation data from the ExecuComp database.

Our analysis confirms that high levels of testosterone can influence the level and structure of CEO compensation. However, our findings suggest that this very much depends on environmental factors such as their industry's competitive intensity. Specifically, we find that high-testosterone CEOs generally achieve a higher overall compensation related to their low-

testosterone peers. In less competitive environments, however, their preference for performance-based pay component secures them more incentive pay without leading to a higher total compensation.

This study contributes to extant research in three major ways: First, our study contributes to the CEO compensation literature and offers a biological perspective as determinant of CEO compensation, particularly contributing to the emerging stream of research which illuminates compensation research from the CEO perspective instead of based on agency theory. Secondly, this study contributes to the emerging body of research on testosterone in executives and its consequences. Finally, this article confirms the importance of contextual factors by linking physical characteristics to the process of determining CEO pay, while showing that it is closely related to the competitiveness of the firm's industry.

5.2 Research study I

A MOMENT TO SHINE FOR THE ALPHA EGO - HOW TESTOSTERONE-FUELED CEOS OUTPERFORM IN CREATING PRODUCT INNOVATIONS AND FUTURE BUSINESS

ABSTRACT

This article introduces a biological perspective on CEOs' physical characteristics driving their decision-making. Using facial width-height-ratio (fWHR) as a proxy for testosterone, we establish a theoretical model that illuminates the links between CEOs' testosterone levels and product introductions and value creation. We argue that the effects of CEOs' testosterone levels on product introductions and firm value are contingent on industry dynamism. We assume that the positive effects play out when dynamism is low, while there are no such effects when dynamism is high. To validate the arguments empirically, we conduct our study based on public US firms of the S&P 500 index, between 2010 and 2014. Our sample includes 1676 firm-year observations with 352 companies and 484 male CEOs, showing that the positive consequences of high testosterone predominate in environments with low turbulence. We found that high-testosterone CEOs drive higher firm activity in terms of product releases and achieve superior financial value when industry dynamism is low. This study contributes to upper echelons research in innovation management by considering the interface of management and biology and offering a novel CEO characteristic being important for innovation. In addition, this study contributes to research on testosterone in executives by showing that high testosterone also feeds into strategic outcomes, thereby, adding a strategic perspective on the effects of executives' testosterone levels. This study contributes to contingent perspectives at the interface of CEOs' characteristics and firm outcomes by finding that a biological characteristic can be beneficial in one situation and detrimental in another.

INTRODUCTION

Research on what drives the creation of innovations and new business has directed our attention to CEOs, especially pointing out that their demographic characteristics (e.g., Strohmeyer, Tonoyan, and Jennings, 2017) and personality (e.g., Kashmiri and Mahajan, 2017) are important antecedents (You, Srinivasan, Pauwels, and Joshi, 2020). Recently, studies in psychology, neuroscience and financial economics have used biological measures to help explain (economic) behavior like risk taking and financial decision making (Cesarini, Dawes, Johannesson, Lichtenstein, and Wallace, 2009; Cesarini, Johannesson, Lichtenstein, Sandewall, and Wallace, 2010; Kuhnen and Knutson, 2005; Jia, van Lent, and Zeng, 2014). In particular, at the recently developing interface of biology and management, researchers have also shown that facial structure and the testosterone level it reflects drive executive behavior. To develop their study, Jia et al. (2014) built on previous biology and psychology studies documenting that the metric facial width-height-ratio (henceforth fWHR), representing an individual's facial masculinity and testosterone level, predicts variation in behaviors across individuals. Based on this measure, researchers found that facial masculinity relates to general behaviors like aggressiveness, egocentrism and risk taking (Carré and McCormick, 2008; Haselhuhn and Wong, 2012; Stirrat and Perrett, 2010), but also CEOs' economic behaviors like financial decision making or misreporting (Jia et al., 2014).

These results regarding the link between facial structure and executive behavior show how interdisciplinary collaborations between social scientists and biologists can open up fruitful novel research avenues. Following up on this linkage of literature streams, we now ask the question how male CEOs' facial masculinity is related to strategic outcome variables like new product introductions and future firm value creation. While it is not obvious why individuals' physical traits should be associated with their (economic) behavior and the effects of facial structure on innovation and future business creation are far from being evident, one approach for explaining the underlying mechanisms is that testosterone affects both the development of

individuals' facial structure and behavior (Jia et al., 2014). For our study, there are comprehensible reasons why a high testosterone level may be related to product introductions and the creation of future firm value. Since earlier studies found facial masculinity to relate to risk taking, the latter in turn creates new opportunities and leads to increased innovation performance, for example concerning product innovation effectiveness (García-Granero, Llopis, Fernández-Mesa, and Alegre, 2015). Further, researchers likewise found firms whose CEOs induce greater competitive aggressiveness to achieve more new product introductions, but also experience more product-harm crises (Kashmiri, Nicol, and Arora, 2017). Accordingly, there might also be downsides of CEOs with too high testosterone levels since their aggressive behavior may deter potential business partners, thereby diminishing future firm value creation. Given these mixed results, it surprises that studies have not yet investigated the particular effects of CEOs' testosterone level, measured via fWHR, on new product introductions and firm value.

To address this dearth of research, we develop a research model based on upper echelons and extant research on CEO characteristics as antecedents of firm-level outcomes that links testosterone level and facial structure to new product introductions and future value creation. Our theorizing accounts for the heterogeneous set of possible effects of high testosterone in CEOs. It presents the arguments for positive and negative associations between CEOs' testosterone level and our dependent variables. To resolve the tensions around how CEOs' testosterone level works, we integrate industry dynamism as a moderator in our research model. We argue that the effect of CEOs' facial masculinity on firm value and product introductions is contingent on the dynamism of the industry the firm operates in. More specifically, we assume that the positive effects of CEOs' testosterone level on these outcomes play out when dynamism is low, while the negative effects are relevant when dynamism is high.

To validate the arguments empirically, we conduct our study based on publicly traded US firms, listed in the S&P 500 index, between 2010 and 2014. Our sample includes 1676 firm-year observations with 352 companies and 484 male CEOs. The study combines company and

financial data from the COMPUSTAT database with competitive moves from the Ravenpack News Analytics database and pictures for the fWHR score of the sample's CEOs.

This study enriches the literature in three major ways: First, we contribute to upper echelons research in innovation management that, for example, related CEO personality to firm-level outcomes. By integrating insights from recent research at the interface of management and biology, we offer a novel CEO characteristic that might play an important role in determining innovation and future business creation-related activities. Thereby, we introduce a biological perspective on CEOs' influential physical characteristics driving their organizational decision-making and add facial masculinity as a novel characteristic reflected in facial structure that drives strategic outcome variables and requires our attention. Specifically, we inform the literature at the interface of upper echelons and innovation management by introducing CEOs' facial masculinity as a driver of firm-level innovation in the form of new product introductions. In doing so, we answer the call of Kashmiri et al. (2017) for exploring the innovation implications of CEO characteristics other than narcissism.

Second, since researchers frequently use the fWHR ratio as a proxy for the testosterone level of CEOs, we contribute to research on testosterone in executives. So far, this literature has been dominated by research that relates testosterone to rather operative activities, like attending to task-relevant information (Overbeck and Park, 2001) and engaging in activities and behaviors that are consistent with principal goals (Galinsky, Jordan, and Sivanathan, 2008a). We extend this line of research by arguing and showing that the trait of a high testosterone level feeds into strategic outcomes like new product introductions and firm performance. Thereby, we add a strategic perspective on the effects of executives' testosterone level and facial structure.

Third, we contribute to contingent perspectives in research at the interface of CEOs' characteristics and firm outcomes. We develop arguments and empirically find that a given biological characteristic can be beneficial in one specific situation and detrimental in another, emphasizing the strong need to contextualize associations between important CEO

characteristics and strategic outcome variables. This also answers the call for research at the interface of biology and management of Nofal, Nicolaou, Symeonidou, and Shane (2018) who state that since "[…] most managerial behavior is likely accounted for by the interaction of human biology and environmental factors, additional research should empirically investigate how environment and biology interplay to influence management" (p. 23).

THEORETICAL FRAMEWORK AND HYPOTHESIS

Upper echelons theory, introduced by Hambrick and Mason (1984), deals with executives' meaningful impact on organizational decision-making and related strategic firm-level outcomes. Thereby, the theory's central premise is that executives' personalities, values, experiences and, thus, their characteristics strongly affect their personalized interpretations of the faced situations which, in turn, influence their decisions. This premise is also reflected in the concept of bounded rationality which implies that uncertain situations with complex information overloads are rather subjectively interpretable by individuals through their cognitive bases than objectively knowable (Carpenter, Geletkanycz, and Sanders, 2004; Hambrick, 2007).

In terms of personality investigations, several upper echelons-based studies have already found associations between personality traits and firm-level outcomes, especially those that relate to the creation of new business (e.g., new products/services and firm value). While Kashmiri and Mahajan (2017) showed that CEOs' political ideology influences new product introductions, Tobin's q and stock market volatility (Kashmiri and Mahajan, 2017), the latter has also been found to be affected by CEOs' conscientiousness, neuroticism and extraversion (Harrison, Thurgood, and Boivie, 2020). Further investigating the Big Five personality traits, Harrison, Thurgood, Boivie, and Pfarrer (2019) documented CEOs' openness and agreeableness to relate to strategic change, inter alia with regard to R&D intensity (Harrison et al., 2019).

Besides the effects of personality, extant upper echelons research has shown that particularly executives' observable characteristics, such as demographic ones like gender or education are valid proxies for their underlying values, cognitions and perceptions of situations which ultimately affect their strategic firm-level decisions (Carpenter et al., 2004; Hambrick, 2007). Noting that nonetheless demographics should be treated with care due to the black box problem (Hambrick, 2007), Bertrand and Schoar (2003) for instance found CEOs' education to be associated with their responsiveness to firms' future growth opportunities as embodied in Tobin's q, whereas Strohmeyer et al. (2017) found gender to be influential for the introduction of new or substantially improved products or services.

Facial Structure and Testosterone

As Nofal et al. (2018) stated in their literature review, the dearth of research at the only recently developing interface of biology and management surprises given that biology influences all aspects of human behaviors, also the ones of CEOs, being biological entities. If we ignore this aspect as an explanation for managerial behavior, we miss an important part of the puzzle (Nofal et al., 2018). Recent research at the interface of management and biology has found different physical characteristics to drive managerial decision making. In particular, researchers found facial structure or masculinity of male managers to be such a decision making driving characteristic (Jia et al., 2014). The latter is largely an outcome of craniofacial bone growth during the pubertal stage which, in turn, is regulated by testosterone administration (Lefevre, Lewis, Perrett, and Penke, 2013). While this enables researchers to investigate individuals' testosterone levels via facial structure, however, little is known about the socially beneficial traits that come with high testosterone that must have driven the evolutionary selection of it. Wong et al. (2011), for instance, reason that testosterone-based aggressive behavior aimed at dominating other individuals or obtaining a resource is often associated with a psychological sense of power. This link between testosterone and power is central, as powerful people tend to view their external

environment and challenges more optimistically, noting opportunities, and focusing on the big picture rather than the details (Galinsky et al., 2008a). They are also more likely to attend to task-relevant information (Overbeck and Park, 2001), and to engage in activities and behaviors that are consistent with principal goals (Galinsky et al., 2008a). In summary, the positive consequences of testosterone are part and parcel of effective leadership (Galinsky et al., 2008a). Accordingly, assessing the impact of testosterone is particularly relevant in the field of company executives and top management teams.

Nevertheless, only recently have researchers started to conduct studies at the interface of biology and management, for instance in research streams of psychological and accounting research. However, in these few examples, particularly facial structure and the underlying testosterone level were identified as a driving force of managerial behavior and financial performance (Jia et al., 2014; Wong et al., 2011), therefore also being of relevance for our study's purpose.

RESEARCH MODEL

Recent advances of research on biology and management indicate that CEOs' physical characteristics, and in particular their testosterone level reflected in facial structure, drives their managerial decision making (Jia et al., 2014). Yet, there are mixed results in the literature indicating that there may be upsides and downsides of CEOs' testosterone level, for example showing that firms whose CEOs induce greater competitive aggressiveness achieve more new product introductions, but also experience more product-harm crises (Kashmiri et al., 2017). Given such ambivalent results, in our study we would like to resolve the tensions around how CEOs' testosterone level works and, thus, investigate the particular effects of CEOs' testosterone level, measured via fWHR, on new product introductions and firm value. To do so, in the following we initially discuss the positive and negative effects of testosterone on new product

introductions and firm value creation, in order to respectively illuminate their particular role in low or high industry dynamism afterwards.

Positive Effects of Testosterone on New Product Introductions and Firm Value Creation

When examining the relation of testosterone and executive behavior, a wealth of extant research initially describes the significant impact of CEOs on their firm's strategy, activities and, ultimately, their performance. For example in the field of psychology, researchers document a clear relationship between individuals' characteristics and their thinking, feelings and behavior (Colbert, Barrick, and Bradley, 2014; Costa, McCrae, and Kay, 1995; McCrae and Costa, 1987; Judge, Bono, Ilies, and Gerhardt, 2002; Peterson, Smith, Martorana, and Owens, 2003). Comparable to our study, most of these scholars also build their contributions on the upper echelons theory.

Further, leadership research has theorized that innate characteristics distinguish successful leaders from unsuccessful ones (Wong et al., 2011). Following the argumentation of Wong et al. (2011), high testosterone has a positive impact on company returns, proving the superior leadership performance of testosterone-fueled managers. As described above, high-testosterone managers feel a greater sense of power, triggering a certain kind of behavior. Kipnis (1976) was one of the first empirical social psychologists to describe the metamorphic consequences of possessing power. Evidence suggests that individuals are transformed by the experience of power and, thus, power and its effects come to reside psychologically within the individual (e.g., Bargh, Raymond, Pryor, and Strack, 1995, Chen, Lee-Chai, and Bargh, 2001, Galinsky, Gruenfeld, and Magee, 2003, Galinsky, Magee, Gruenfeld, Whitson, and Liljenquist, 2008b).

In what follows, building on the metamorphic effect of testosterone-induced power, we link testosterone with firms' level of activeness and financial performance. First, to investigate a CEO's level of activeness in terms of creating and realizing opportunities, we can understand the number of product releases as a proxy (Guo, Sengul, and Yu, 2020). Evidently, an above-

average number of new products foots on a distinct mindset of decision makers within a firm. To generate and realize new product ideas, it is a sine qua non for leaders to identify new opportunities such as white spots in the industry, unmet customer demands or any kind of beneficial addition to their firm's product portfolio. Moreover, launching new products fast requires the power and willingness to remove manifold obstacles and pass quickly through the many layers of governance and decision-making processes – i.e. not to get stuck in extensive calculations, discussions, or market research. Lastly, launching high numbers of new products and experimenting early for instance with minimum viable products (MVP) requires inspirational leadership for employees to get excited instead of exhausted about the plethora of new product adventures. But while high company activeness requires an extra mile of leaders and employees, it is an underlying component of company success: As Connelly, Tihanyi, Ketchen, Carnes, and Ferrier (2017) describe, competitive actions including product releases are linked to firm success as "[…] engaging rivals with a complex set of actions allows a firm to respond better to changing environmental conditions, take advantage of emerging opportunities, defy imitation by rivals, and keep opponents off guard" (p. 1152). Accordingly, a high level of activeness and variety of competitive actions, such as new product releases, empowers the firm to grow and transform with a changing competitive environment.

Second, we predict an impact of CEO behavior on the long-term company performance and value. The CEO's actions of today manifest and are reflected in investors' valuation of the company – their expectation for the company's future development. Hence, a firm's value increases when its market value rises disproportionately to its book value because of investors' growth opportunity projections (Li and Chi, 2013). Such a focus on the future can be driven by a range of growth-oriented initiatives, like allocations to new plant and equipment (Finkelstein and Hambrick, 1990, Haynes and Hillman, 2010, Jiang, Xia, Devers, and Shen, 2020), which are considered 'major expenditures' and require the board's approval (American Bar Association, 2007). Such growth initiatives at the strategic level indicate that the company is on a

mission to generate future value, opportunities, and competitiveness (Liao, Lin, and Lin, 2016). We argue that CEOs, in their role as pilots of their company's strategic actions, today set the course for tomorrow's company value.

Based on the previously established link between high testosterone and its positive consequences, we predict that firms headed by 'alpha CEOs' with greater fWHRs have the potential to perform superior in terms of company activeness and performance as their strengths substantially address the requirements we see. There are three main underlying drivers for this assumption:

"Optimistic behavior." First, high-testosterone CEOs are optimists in action: Their testosterone-induced sense of power directly translates into action (Galinsky et al., 2008a), positively influencing both of company activeness and performance. Alpha CEOs are more likely to react in an actionist way in day-to-day situations like an emergency. They spring to action to help others in distress (Galinsky et al., 2008b) while their low-testosterone peers sit back, lacking a sense of responsibility and looking to other non-responders to confirm their own behavior. This tendency to 'spring to action' is a universal trait – not only in emergencies but also in case of opportunities (like market white spots). The alpha CEOs will snap at the chance while low-testosterone CEOs are likely to miss out, seeing more potential hazards and interpreting the world as a threatening place (Anderson and Galinsky, 2006). Furthermore, alpha CEOs tackle not only short-term benefits but also long-term opportunities for future growth and success (Galinsky et al., 2008a). Staying ahead of the competition requires actions or investments today. Low-testosterone CEOs, with their inferior sense of power, will show a tendency to sit back motionlessly and leave difficult decisions to their successors (Galinsky et al., 2008b). In contrast, the alpha CEO's positive, actionist, and convincing reactions, mindset and wording are transparent to outside stakeholders and will likely sway investors towards a more positive valuation. In sum, alpha CEOs with their senses wide awake for opportunities and willing to take

action, will on the one hand trigger new visions or prototypes, and on the other hand, set the course for future growth and success.

"Goal-directed behavior." Second, high-testosterone CEOs show more goal-directed behavior: The testosterone-induced sense of power channels a person's thoughts and behavior towards accomplishing one's goal in a wide variety of situations, including short-term product releases or long-term firm value (Bargh et al., 1995, Chen et al., 2001, Galinsky et al., 2003). This, moreover, triggers a focus on the global rather than the local features of stimuli (Guinote, 2007). The alpha executives process information at higher levels of abstraction, they focus less on the details and more on the big picture (Smith and Trope, 2006). Accordingly, they can perceive patterns better and capture the gist of information. Moreover, with their own financial benefit in mind, investors will likely prefer a CEO who is prone to act in line with currently held goals - which they will recompense with a positive valuation. In sum, their effective goal focus allows high-testosterone CEOs to drive above-average product release numbers and to both generate success today and tomorrow.

"Effective leadership." Finally, high-testosterone CEOs are more effective leaders: Testosterone-fueled CEOs tend to be uninfluenced by others (Galinsky et al., 2008b). In contrast, being (or feeling) powerless - when one's outcomes are determined by others – means being constrained. A powerful CEO possesses the ability to influence, motivate, and enable a group of individuals to contribute to the success of a shared purpose (Wilderom et al., 1999), which is fundamental to his positive influence both on company activeness and performance. The alpha CEOs are able to see, create, and articulate a broad vision of the world — one that could potentially inspire others (Galinsky et al., 2008a). This is key to above-average product release numbers: Instead of finding the optimistic CEO's vast number of ideas irritating, employees and other leaders place trust in the idea, put in the extra work and agree to launch for instance early MVPs. A less trusted CEO is more likely to find his idea stuck in the layers of governance and decision-making. Moreover, extant research has shown that over 80 percent of

companies decrease discretionary expenses to meet short-term capital market expectations, abandoning growth opportunities and long-term potential for short-term profitability (Hendricks, Howell, and Bingham, 2019). Arguably, it requires an inspirational 'influencer' – the essence of effective leadership – to not only balance short-term and long-term priorities but also to unite all stakeholders behind these priorities and the associated requirements. Therefore, we expect the alpha CEOs to succeed in inspiring and joining others behind their visions and, on the one hand, believe into new product ideas, turning them into reality faster, and, on the other hand, gain investors' trust and maximize their perception of the company's future worth.

Negative Effects of Testosterone on New Product Introductions and Firm Value Creation

Since testosterone drives a complex of related masculine behaviors, negative consequences are just as likely to manifest. Psychological consequences for testosterone-fueled managers, which can turn out to be barriers for new product introductions and firm value creation, are diminished perspective-taking and overconfidence as well as the tendency to objectify others by perceiving them through a lens of self-interest (Galinsky et al., 2008a).

"Diminished perspective-taking and overconfident judgment." With particular regard to strategic firm-level outcomes, first, these consequences can lead high-testosterone CEOs to ignore others' perspectives while overweighing their own, potentially hindering both the launch of new products and future firm value. Their testosterone-induced sense of power tends to reduce social attentiveness, placing a blind spot on the unique vantage points of others (Galinsky et al., 2008a). Consequently, it seems to almost impair the CEO's ability to see things from another person's point of view. In fact, they are not only less accurate in judging others' facial expressions of emotions, but also less influenced by them (van Kleef, Dreu, Pietroni, and Manstead, 2006). Furthermore, dominant CEOs tend to restrict the flow of information to nullify the contribution of a colleague (Diesing, 1962). Unsurprisingly, they are highly overconfident in their judgments and decisions (Fast, Sivanathan, Mayer, and Galinsky, 2012), making

it obsolete for them to calibrate with their team members. Yet, focusing on results rather than risks, when presented with a risky course of action, this can lead to overvaluing the potential payoffs (Galinsky et al. 2008a).

"Objectification of other team members." Second, high-testosterone CEOs tend to view team members merely as a tool for one's own purpose (Gruenfeld, Inesi, Magee, and Galinsky, 2008) and, thus, prefer to surround themselves with likeminded people who will support their opinion. This results in the elimination of critical and often valuable ideas and insights and can harm the identification of actions for future success or beneficial products. In this regard, researchers even found firms whose CEOs induce greater competitive aggressiveness to experience more product-harm crises regarding newly introduced products (Kashmiri et al., 2017). Also, due to the mentioned objectification team members feel alienated (Galinsky et al. 2008a), and collaborative benefits cannot be realized. Accordingly, there might also be downsides of CEOs with too high testosterone levels for firms since their aggressive behavior may diminish successful new product introductions and, thus, related future firm value creation.

We summarize and contrast the previously illustrated positive and negative effects of CEOs' testosterone-related drivers and barriers on new product introductions and firm value creation in Table 1, before illuminating the effects' particular role in low or high industry dynamism in the following.

TABLE 1 Positive and Negative Effects of High CEO Testosterone

CEOs' Testosterone-Related Drivers Causing Positive Effects	CEOs' Testosterone-Related Barriers Causing Negative Effects
Optimistic behavior • Positive and convincing mindset, wording, actions and reactions leading investors towards more positive valuations • Openness to opportunities triggering new visions or prototypes and setting the course for future growth and success	***Diminished perspective-taking and overconfident judgment*** • Overestimation of own perspective and ignorance of others • Restriction of information flow by nullifying others' contributions • Overvalued potential payoffs ➔ Hindering both the launch of new products and future firm value
Goal-directed behavior • Focus on global, not local stimuli • Management of gist of information • Actions in line with currently held goals ➔ Leading investors to positive valuations, driving above-average product release numbers and generating success today and tomorrow	***Objectification of other team members*** • Elimination of valuable ideas • Alienated team members • Hindered collaborative benefits ➔ Harming the identification of actions for future success or beneficial products
Effective leadership • Ability to influence, motivate, and enable individuals to contribute to the success of a shared purpose, being fundamental to a positive influence on company activeness and performance • Ability to inspire and unite all stakeholders behind priorities, making them believe in new product ideas, gaining investors' trust and maximizing their perception of the company's future worth	

The Moderating Role of Industry Dynamism

Given the mixed results and arguments regarding the positive and negative effects of testosterone on our dependent variables, we choose industry dynamism as a moderating variable to resolve the tensions around how CEOs' testosterone level works, depending on the individually evaluated situation. Since it is unlikely that we can explain managerial behavior only through biological factors like testosterone and most managerial behavior is probably accounted for by the interaction of biological and environmental factors, in this way we investigate how these factors interact to influence management. So far, there is little empirical evidence of such interactions in the literature (Nofal et al., 2018).

Research has previously described different environmental setups, which come with unique requirements and impact the expected performance of certain managerial types. One of these environmental variables is industry dynamism, characterized by frequent, difficult-to-predict changes in customer needs and technologies (Fang, Palmatier, and Grewal, 2011). Said environments can vary in their degree of turbulence or stability (Dess and Beard, 1984), as well as the degree of managerial discretion they permit (Hambrick and Finkelstein, 1987). Dynamic environments increase both the firm's external linkages and the rate of change in those linkages (Freeman and Aldrich, 1981). Stable environments, in contrast, are more predictable with a more established set of relatively unchanging actors (Haleblian and Finkelstein, 1993). Hence, the degree of environmental dynamism or stability greatly impacts the information-processing requirements and the complexity of managerial work for the leadership of a firm. This confirms the elaboration of Mintzberg (1973), stating that the more turbulent the environment, the more varied and fragmented the nature of managerial work and the greater the information-processing demands on the CEOs and their teams. Dynamic environments create new opportunities and crises that often necessitate strategic and structural adaptations (Galbraith, 1973).

Evidently, the surpassing complexity of turbulent environments makes the steering of the firm a team sport. We predict that turbulent environments carry a level of complexity that

exceeds the CEO's processing capabilities – he needs a collaborative, equitable team to form a functional information-processing center and to realize the firm's performance potential. In this study, we examine the performance of high-testosterone CEOs in turbulent environments, which are characterized by their high complexity, volatility, an overflow of information, and the necessity to prioritize. Maneuvering in turbulent industries is not a one-man-show but a team sport – hence, we want to assess whether high industry turbulence would be the tipping point, at which testosterone-fueled CEOs start to stand in the way of higher firm performance with their potentially destructive behaviors. We discuss the impact of industry turbulence along the previously illustrated testosterone-related drivers and barriers of CEOs influencing both company activeness and value.

First, alpha CEOs being optimists in action see more opportunities and turn them into reality faster. Yet, Eisenhardt and Bourgeois (1988) state that top teams with dominant CEOs achieved inferior firm performance in a turbulent, high-velocity environment. According to their findings, dominant CEOs tend to restrict the flow of information in such environments. Such a restriction can be driven by the CEO nullifying the contribution of a colleague (Diesing, 1962) or by others being afraid to contribute ideas that run counter to those preferred by the alpha CEO (Hambrick and D'Aveni, 1992). The CEO's ignorant behavior would lead to suboptimal, less effective decisions or more discussions and disagreement in the process. In contrast, according to Kotter (1982), information and decision-making requirements in stable environments are more standardized, systematic, and routine. Therefore, only when information-processing requirements are low – as generally true in low dynamism environments – the actionist CEOs are more likely to have sufficient information to make high-quality decisions by themselves, launch the right products fast and pave the way for future success.

Second, high-testosterone CEOs show more goal-directed behavior. As previously seen, alpha CEOs keep their goals in mind at all times. However, in turbulent environments, the overall company goals are more likely to change or rather the entire industry is disrupted by

new trends or technologies. Clearly, such industries require a team of alert minds to stay ahead of the game. However, high-testosterone CEOs tend to objectify others for their own agenda and prefer to surround themselves with people supporting their opinion (Galinsky et al., 2008a). This eliminates critical insights and can harm the identification of beneficial products or actions for future success in high dynamism industries. Moreover, high-testosterone CEOs ignore risks when rewards are in sight: Testosterone increases people's proclivity for risk (Anderson and Galinsky, 2006). In fact, they focus on results rather than risks, so when presented with a risky course of action they will overvalue the potential payoffs (Galinsky et al. 2008a). These positive illusions can also lead people to achieve unlikely accomplishments, to make the impossible possible when embarking on low-probability journeys (Taylor and Brown, 1988). On the other hand, disregarding risks and other opinions, especially under the overwhelming amount of information and choices in a turbulent environment, can directly contribute to poor decision making and inferior performance. In sum, in a volatile world in which directional changes happen more frequently and decisions are more difficult to make, alpha CEOs find themselves surrounded by yeasayers while missing out on a trend and sticking to outdated goals. In contrast, in undynamic environments with more stability, alpha CEOs are in their sweet spot, outperforming in terms of above-average product release numbers and company performance.

Third, high-testosterone CEOs are more effective leaders. The nature of a top team's information-processing capabilities is determined by balanced power distribution, open-mindedness, flexibility, and functioning communication, i.e. information sharing and idea exchange. Interaction and trust in cross-functional collaboration, for instance, boost product innovativeness (Clercq, Thongpapanl, and Dimov, 2011). However, how alpha CEOs objectify their peers proves to be a great source of conflict and can stand in the way of firm activeness and value especially in a turbulent environment. Team members feel alienated (Galinsky et al. 2008a), honest communication is disrupted, and collaborative benefits, such as the synergies that cross-functional collaboration offers (Jassawalla and Sashittal, 1998), cannot be realized. Thus, team

members who are not feeling valued may sabotage the CEO's endeavors and harm the decision making and execution power of the company as a result. We have seen above that firm leadership in turbulent environments is a team sport and, generally, it is a widely accepted view that a good leader is foremost a team player (Bolton, Bunnermeier, and Veldkamp, 2010) – however, great teaming is not on the high-testosterone CEOs' list of strengths. In fact, testosterone disrupts human collaboration by increasing egocentric choices (Wright et al., 2012). The increased status-seeking of high-testosterone CEOs goes hand in hand with decreased collaboration as they are less inclined to take account of the opinions of others – although human collaboration is fundamental to successful innovation (Stock, Totzauer, and Zacharias, 2014). We find this behavior to be the opposite of effective leadership and hindering a firm in a dynamic environment from realizing collaboration-driven benefits.

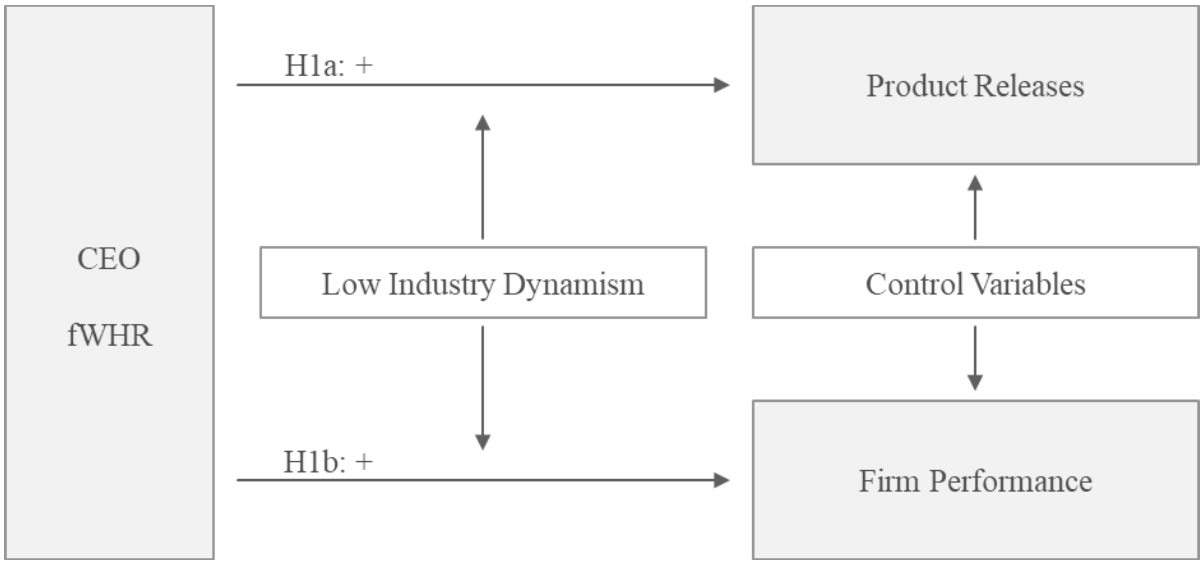
In summary, the requirements of turbulent industries, namely the high complexity and information-processing needs, which require all hands on deck, are not served by high-testosterone CEOs. We predict that a high-dynamism environment fuels the alpha CEO's weaknesses: disrupting collaboration and information flow, not taking all opinions into account and ignoring risks for rewards. On the other hand, we predict, that a low-dynamism environment fuels his strengths: Unveiling opportunities while dealing with the gist of information, keeping an eye on balancing company goals, and executing effective leadership. Therefore, we expect industry turbulence to be a crucial environmental factor with the power to flip the medal – with only undynamic environments being the alpha CEO's moment to shine.

Accordingly, we propose higher firm activeness and performance related to high fWHR in undynamic environments by hypothesizing:

Hypothesis 1 (H1): The relationships between fWHR and both (a) the number of product releases and (b) firm performance are positive when industry dynamism is low, while there are no such effects when industry dynamism is high.

Figure 1 depicts our research model.

FIGURE 1 Overview of Research Model



METHODOLOGY

Sample and Data Sources

To explore our hypotheses, we constructed a sample of publicly traded US firms, listed in the S&P 500 index, between 2010 and 2014. We focus on large, public companies to ensure high data availability and accuracy, and chose the respective timespan for its absence of major financial crises or other altering environmental circumstances. We collected all company data and financial indicators for our target firms from the COMPUSTAT database. Additionally, we matched the company data with executive-level information from the ExecuComp and Boardex databases, which were required to construct some of the control variables. Lastly, we constructed the pictorial database and determined the fWHR score for the male CEOs in our sample. We identified high-quality pictures of the CEOs preferably on the company website, former annual reports or, if otherwise not found, via Google Image Search.

To test our hypothesis, we extracted data on competitive moves of our sample firms from the Ravenpack News Analytics database. This database collects press releases and further media sources to provide action-level information and has been increasingly used in management and finance research (Guo et al., 2020). To minimize extreme observations' influence, our

dependent variables product releases and Tobin's q were winsorized at a 1% and 99% level. After excluding all entries with missing data, our sample includes 1676 firm-year observations with 352 companies and 484 male CEOs. The sample size was initially limited by the data availability of Boardex: When filtering for the S&P 500 index in our given timeframe, we received 392 unique companies. 24 of these could not be met with ExecuComp data, leaving us with a list of 368 companies. After excluding female CEOs from the sample, we arrived at 360 companies and 496 male CEOs. Finally, the remaining observations were lost due to winsorizing outliers and excluding entries with missing data, resulting in our 1676 firm-year observations.

Measures

Independent variable. We measure a male CEO's propensity to the masculine behavioral traits described above via "an unfakeable facial feature" (Jia et al., 2014). The facial width-height-ratio (fWHR), a proxy for testosterone, has been increasingly adopted in management research, such as in the analysis of firm CEOs by Wong et al. (2011), Jia et al. (2014) and Kamiya et al. (2019). FWHR has been particularly validated as an adequate proxy for testosterone by Lefevre et al. (2013), according to whom fWHR has a significant positive correlation with saliva-assayed testosterone in men, and is, thus, superior to alternative facial masculinity measures.

To construct our pictorial database, we searched each CEO from our sample on the company website or previous annual reports. If no picture could be found, we used the executive's full name and the company name to search for the best available portrait on Google Images.

Facial masculinity, i.e. relative width of the face, is the result of a person's craniofacial bone growth driven by the testosterone level during adolescence (Verdonck, Gaethofs, Carels, and Zegher, 1999). Therefore, a subject's fWHR is not subject to change over a lifetime, which makes it irrelevant whether an obtained photograph is rather recent or older. Additionally, it is

common practice in fWHR research to exclude women from the sample, as for them testosterone is less directly related to facial morphology due to confounding effects of other hormonal factors (Lefevre et al., 2013).

We identified the best portrait in terms of resolution, and whether the executive is forward-facing with a neutral/lightly smiling expression. Subsequently, we measured the distance between the two zygons (bizygomatic width), i.e. the cheekbones, and the distance between the highest point of the eyelid and the upper lip (height of upper face). The resulting ratio of width and height is the fWHR. The mean fWHR of our sample CEOs is 1.99, which is well in line with the observed values of other researchers such as Wong et al. (2011) with a mean of 1.96 or Jia et al. (2014) with a mean of 2.01. Lastly, as clinical studies have discovered that testosterone levels in men decrease over time (Feldman et al., 2002), we have included age as control variable.

Dependent variables. To measure a CEO's level of activity in terms of viewing the external factors optimistically, creating and realizing opportunities, and engaging in behaviors that are in line with economic goals, we measured the number of product releases - a tactical action that does not involve significant resource commitments or long lead times (Guo et al., 2020). We measured the number of product releases as total annual product releases per firm from the Ravenpack dataset. Ravenpack collects action-level data from a variety of newswires and sources and classifies news articles into categories of action, like product releases, for nearly 40,000 firms. The use of the dataset has notably increased in management research recently (Connelly, Lee, Tihanyi, Certo, and Johnson, 2019, Hayward and Fitza, 2017). To increase our measurement precision and avoid double-counting, we added additional filters to the dataset. Firstly, we included only new stories with a relevance score of at least 90 to guarantee that all counted activities are central to our sample firms. The relevance score indicates how central the focal entity is to the news article or press release (Bonsall, Green, and Muller, 2020).

To avoid double-counting strategic moves, we only include the first mentions of each move (Connelly et al., 2019).

A depth of previous research have explored both the short- and long-term performance implications of the CEO (Mackey, 2008). Accordingly, to test our second hypothesis, we require a performance indicator for our model which is both forward-looking and cumulative. Additionally, given the heterogeneity of our sample firms, our dependent variable must be generalizable and comparable across different industries and performance objectives. In line with Germann et al. (2015), we chose Tobin's q as a capital market-based measure to fulfil the following purpose: to capture both immediate and future firm performance, to be organizational goal agnostic, to permit performance comparison across firms that pursue different performance goals, and to be less affected by accounting conventions (Amit and Wernerfelt, 1990). Accordingly, we employ Tobin's q as our focal performance indicator, defined as the ratio of a firm's market value to the current replacement cost of its assets (Tobin, 1969) – a forward-looking, capital market–based measure of the value of a company. Tobin's q provides a measure of the premium or discount that the market is willing to pay above or below the replacement costs of a firm's assets, thus capturing any above-normal returns expected from a firm's collection of assets (Amit and Wernerfelt, 1990). Moreover, because Tobin's q combines capital market data with accounting data, it minimizes distortion by implicitly using the correct risk-adjusted discount rate (Amit and Wernerfelt, 1990). However, as the CEO's actions may take time to manifest and be reflected in shareholders' valuations of the respective firm, we lag our Tobin's q by one year.

Moderator. Because dynamic environments may require a different management style than less dynamic and relatively stable environments, and different CEO character traits might affect performance accordingly, we chose industry dynamism as our focal moderator. It serves to capture the effects of the environmental changes by indicating to which extent industry demand is rapidly and unpredictably changing (Kohli and Jaworski, 1990). Industry dynamism

was operationalized as the standard deviation of sales in firms' primary industry across the prior five years, divided by mean value of industry sales for those years (Fang et al., 2011). Values range from 0 to 1.

Control variables. In line with prior top management team (TMT) research, we included CEO-, firm-, and industry-specific control variables that might impact our dependent variable. In terms of CEO characteristics, we controlled for the natural logarithm CEO age to account for the diminishing levels of testosterone over lifetime (Feldman et al., 2002). For a proxy of CEO dominance, we constructed the variable CEO pay slice, a measure of relative CEO compensation versus full TMT compensation, as widely used in TMT research (Zagonov and Salganik-Shoshan, 2018). We control for CEO duality as a dummy variable equal to 1 if the CEO is also the chairman of the board, and 0 if otherwise. Lastly, we included a dummy variable equal to 1 to indicate CEO turnover within the respective year.

In terms of company-specific variables, we control for firm size as the natural logarithm of total assets and the natural logarithm of employees. Moreover, we included return on assets as an indicator for firm profitability (Germann et al., 2015), the natural logarithm of leverage, calculated as total long term debt plus debt in current liabilities over stockholders' equity, and EBIT. Finally, we control for stock ownership to account for the CEO's ability or motivation to demonstrate influence (Daily and Johnson, 1997), differentiating five types of ownership: Publicly traded company, subsidiary of a publicly traded company, subsidiary of a company that is not publicly traded, company that is publicly traded but not on a major exchange, or company that has undergone a leveraged buyout.

Lastly, since our sample is structured as an unbalanced panel dataset, we include year dummies with 2010 as the base year to account for environmental influences or external shocks affecting all firms in a specific year (Jing, Keasey, Lim, and Xu, 2019). We include industry dummies based on 1-digit SIC codes to capture industry-specific effects that are not covered by our control variables.

Method of Analysis

We use generalized estimating equations (GEE) to accommodate our cross-sectional dataset and evaluate whether CEO fWHR affects the number of product releases or firm performance, especially given different degrees of industry dynamism. As described by Ballinger (2004), "GEEs use the generalized linear model to estimate more efficient and unbiased regression parameters relative to ordinary least squares regression in part because they permit specification of a working correlation matrix that accounts for the form of within-subject correlation of responses on dependent variables of many different distributions, including normal, binomial, and Poisson". For our dependent variable product releases, a counted event happening independently and randomly over time, we apply the Gaussian family and identity link after taking the natural logarithm of our variable. As our second dependent variable Tobin's q is normally distributed, we also specify a Gaussian family and identity link. Further, we estimate robust standard errors to account for heteroscedasticity and run the model with all potential correlation structures (independent, exchangeable, ar1, unstructured). To examine which structure is the best fit, we calculate the quasi-likelihood under the independence model criterion, QIC (Ballinger, 2004).

RESULTS

Descriptive Statistics

Table 2 shows the descriptive statistics (mean and standard deviation) and bivariate correlations. Correlations among the control variables are weak to moderate (Ratner, 2009). FWHR, our independent variable, correlates only insignificantly or very slightly with the other variables. The number of product releases is positively correlated with EBIT and the number of employees. Moreover, we see a positive relation between Tobin's q and profitability as well firm size. Some of our firm-describing variables have correlation coefficients above |0.03|, meaning they do not meet the evaluation criteria proposed by (Kalnins, 2018). However, we

decided to include these control variables to address the frequently asked question if profitable firms chose high-fWHR managers or, vice versa, the high-fWHR managers increase their firms' profitability. Excluding profitability (ROA) and EBIT from our regressions, though, left results unchanged. Moreover, the upper moderate correlation coefficients pose no threat of multicollinearity as we saw by analyzing the variance inflation factors.

Table 2 Descriptive statistics and bivariate correlations

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 fWHR	1,99	0,13	1,00	0,04	0,05	0,02	0,00	0,01	0,01	-0,05	0,00	-0,07	-0,06	0,06	0,04	0,01
2 Product Releases	1,83	1,33		1,00	0,07	-0,07	0,16	0,05	-0,06	-0,03	-0,02	-0,05	-0,07	0,36	0,24	0,00
3 Tobin's q t+1	1,31	0,84			1,00	-0,09	-0,53	0,66	0,11	0,05	-0,04	0,05	-0,02	0,05	-0,15	-0,05
4 Industry Dynamism	0,12	0,08				1,00	0,06	-0,05	-0,01	0,00	-0,04	0,03	-0,05	-0,15	0,06	-0,04
5 Firm Size	9,73	1,18					1,00	-0,46	-0,07	-0,05	0,02	-0,10	0,05	0,23	0,64	-0,02
6 Profitability	0,06	0,05						1,00	-0,10	0,03	-0,05	0,00	-0,01	0,11	-0,06	-0,07
7 Leverage	0,35	0,34							1,00	0,07	0,02	-0,05	-0,05	-0,11	-0,02	0,08
8 CEO Pay Slice	0,38	0,17								1,00	-0,10	0,01	-0,04	0,03	-0,07	0,04
9 CEO Turnover	0,08	0,27									1,00	0,03	-0,17	-0,01	0,00	-0,02
10 CEO Duality	0,48	0,50										1,00	0,17	0,00	-0,06	-0,05
11 Age	57,00	5,90											1,00	0,06	0,04	-0,04
12 Employees	2,89	63,20												1,00	0,33	-0,05
13 EBIT	2075	3401													1,00	-0,03
14 Ownership Structure	0,02	0,19														1,00

Note: correlations larger or equal to |0,06| are significant at the 0,05 level

Table 3 GEE and Pooled OLS models testing H1a and H1b

	GEE Models						*Pooled OLS Models*					
	Model 1			**Model 2**			**Model 3**			**Model 4**		
	b	SE	p-value	b	SE	p-value	b	SE	p-value	b	SE	p-value
Intercept	1.52e+00	1.57e+00	0.33344	3.55e+00	7.58e-01	2.8e-06	1.60e+00	1.65e+00	0.33228	5.93e+00	1.43e+00	3.7e-05
fWHR	7.99e-01	4.05e-01	0.04839	6.38e-01	1.80e-01	0.00038	7.99e-01	4.10e-01	0.05145.	6.47e-01	3.80e-01	0.0893.
Industry Dynamism (5 Years)	1.22e+01	5.46e+00	0.02553	7.77e+00	2.20e+00	0.00042	1.23e+01	5.61e+00	0.02803	8.70e+00	4.06e+00	0.0322
Firm Size	1.57e-01	5.00e-02	0.00175	-2.46e-01	2.39e-02	<2e-16	1.48e-01	5.02e-02	0.00321	-4.46e-01	5.64e-02	4.6e-15
Profitability	1.31e+00	8.20e-01	0.11011	8.64e+00	6.47e-01	<2e-16	1.31e+00	8.52e-01	0.12468	7.98e-01	5.32e-01	0.1341
Leverage	-3.03e-03	4.20e-02	0.94260	1.16e-01	2.53e-02	4.7e-06	-2.33e-03	4.46e-02	0.95833	4.86e-02	5.06e-02	0.3370
CEO Pay Slice	-1.91e-01	1.77e-01	0.28150	2.91e-02	7.72e-02	0.70612	-2.03e-01	1.86e-01	0.27575	7.46e-02	1.13e-01	0.5089
CEO Turnover	-2.10e-01	1.12e-01	0.06056.	-6.09e-02	4.55e-02	0.18095	-2.10e-01	1.10e-01	0.05734.	-1.00e-01	5.35e-02	0.0613.
CEO Duality	-4.19e-03	6.02e-02	0.94454	5.69e-02	2.81e-02	0.04271	-2.49e-03	5.73e-02	0.96535	8.22e-03	6.06e-02	0.8921
Age	-1.10e+00	2.87e-01	0.00014	-2.28e-01	1.52e-01	0.13233	-1.10e+00	2.99e-01	0.00024	-2.34e-01	2.74e-01	0.3922
Employees	2.31e-01	3.13e-02	1.5e-13	2.31e-02	1.69e-02	0.17117	2.32e-01	3.10e-02	1.1e-13	4.72e-02	3.62e-02	0.1934
EBIT	4.32e-05	9.75e-06	9.3e-06	2.69e-05	6.29e-06	1.9e-05	4.56e-05	1.09e-05	2.9e-05	6.60e-05	2.54e-05	0.0095
Ownership Structure	2.27e-01	1.07e-01	0.03415	-9.21e-02	3.21e-02	0.00413	2.24e-01	1.06e-01	0.03494	-2.09e-01	7.37e-02	0.0047
Product Releases*Industry Dynamism	-5.98e+00	2.70e+00	0.02703	-	-	-	-6.03e+00	2.77e+00	0.02980	-	-	-
Tobin's q t+1*Industry Dynamism	-	-	-	-3.93e+00	1.09e+00	0.00032	-	-	-	-4.45e+00	2.04e+00	0.0290
Industry dummies		Included			Included			Included			Included	
Year dummies		Included			Included			Included			Included	
Number of observations		1676			1676			1676			1676	

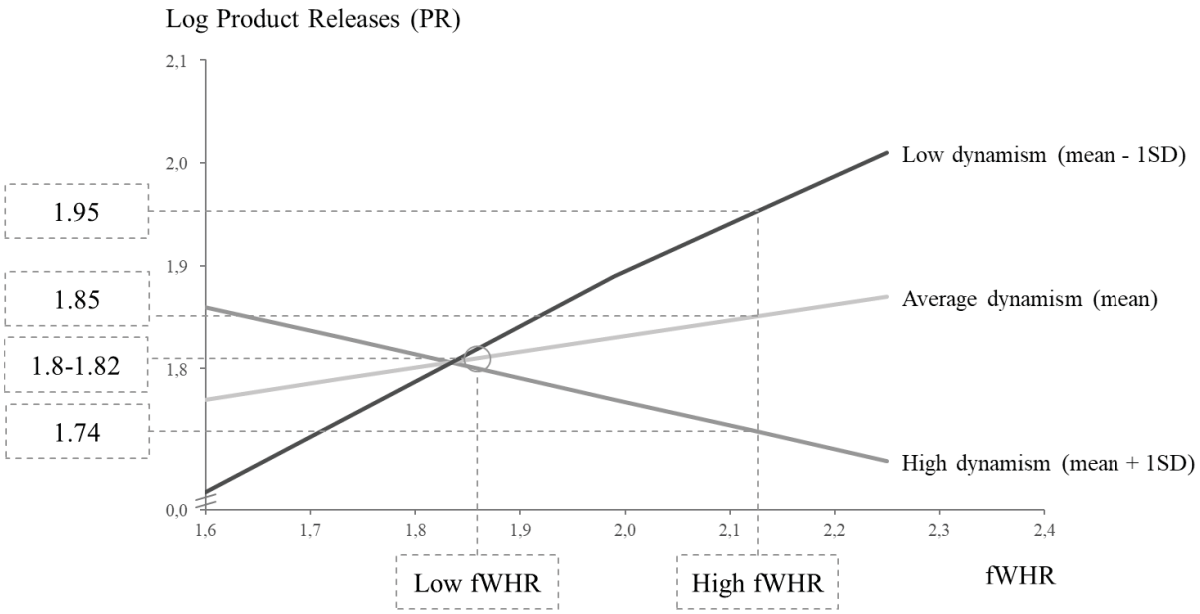
$p < 0.001$ $p < 0.01$ $p < 0.05$

Main Findings

In table 3, model 1 and 2 illustrate the GEE results of H1a and H1b: model 1 refers to the number of product releases and model 2 to Tobin's q, both moderated by industry dynamism. Model 3 and 4 show the pooled OLS results for H1a and H1b, as described in the following robustness section.

Model 1 and 2 present the results for the moderating role of industry dynamism on the relation between fWHR and both company activeness and value. Industry dynamism negatively moderates the relationship between fWHR and the number of product releases (-5.98e+00, p= 0.02703*), plotted in figure 2.

FIGURE 2 Moderating effect of industry dynamism on the number of product releases (H1a)

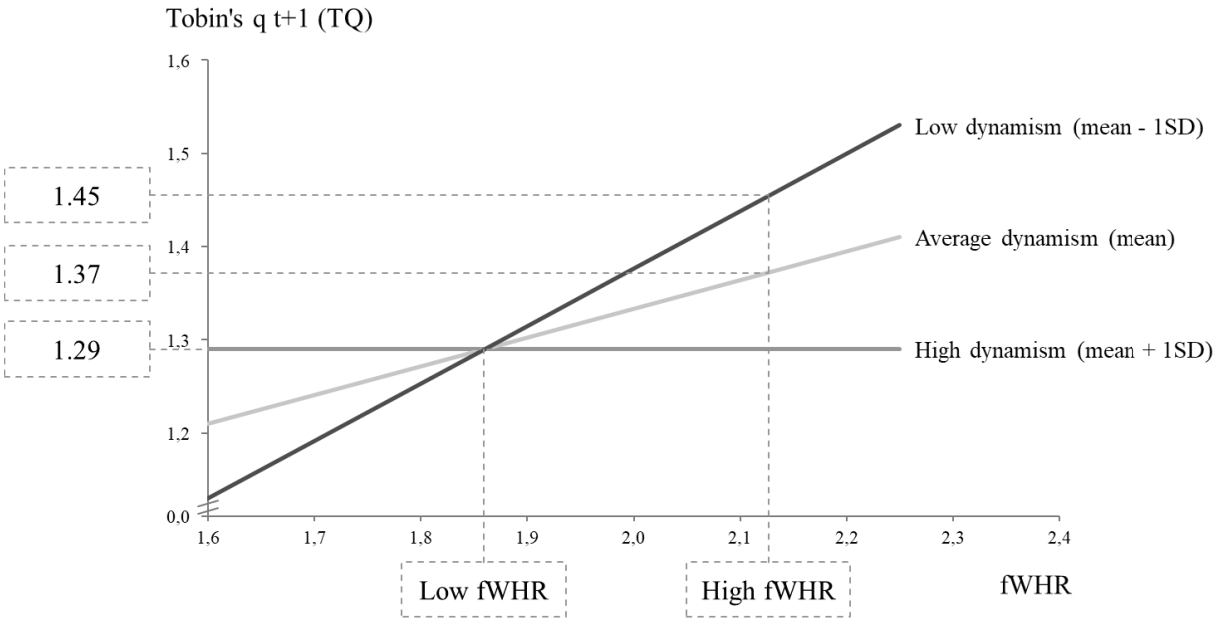


We can derive 3 main insights from the chart: Firstly, in average- and low-turbulence environments, the level of testosterone positively relates to firm activeness in terms of product releases. Further, we see that high-testosterone managers perform significantly better in low than in average dynamism environments (product releases (log) of 1.95 vs. 1.85, 1SD above the mean vs. mean). In undynamic settings, high-testosterone CEOs will be 5.4% more active than in average environments. The simple slope test confirms the significance of two of the plotted lines (mean dynamism and - 1SD). The line illustrating high dynamism has been proven

insignificant by the simple slope test. Finally, in contrast to their alpha peers, CEOs with a very low fWHR (even below mean - 1SD) are more active in average than in low-turbulence environments – never, however, above high-testosterone CEOs. In summary, we find that in low-turbulence environments, fWHR is a decisive predictor of company activeness in terms of product releases. In such settings, testosterone-fueled CEOs release 7.1% more products than their low-testosterone peers (product releases (log) of 1.95 vs. 1.82, 1SD above and below the mean).

Likewise, industry dynamism negatively moderates the relationship between fWHR and company performance (-3.93e+00, p=0.00032***), plotted in figure 3.

FIGURE 3 Moderating effect of industry dynamism on Tobin's q t+1 (H1b)



Again, we can derive 3 main insights from the graph: Firstly, in turbulent environments, the level of testosterone has no impact on firm performance in terms of Tobin's q of the following year (Tobin's q t+1 flat at 1.29). In contrast, we find that in undynamic industries, the higher the CEO's fWHR, the higher the subsequent year's company value. Further, we see that high-testosterone managers perform significantly better in low than in high dynamism environments (Tobin's q t+1 of 1.45 vs. 1.29, 1SD below and above the mean). In undynamic settings, high-testosterone CEOs will perform 5.8% better than in average, and 12.4% better than in dynamic environments. Lastly, opposite to their alpha peers, CEOs with a very low fWHR

(even below mean – 1SD) perform better in dynamic environments – never, however, better than high-testosterone CEOs. This finding is well in line with extant research, for instance with Wong et al. (2011) who relate high fWHR to a higher return on assets. The simple slope test confirms the significance of the three plotted lines (mean dynamism and +/- 1SD). In summary, we find that in low-turbulence environments, fWHR is a decisive predictor of company performance. In such settings, testosterone-fueled CEOs perform 12.4% better than their low-testosterone peers (Tobin's q t+1 of 1.45 vs. 1.29, 1SD above and below the mean).

These results support our H1a and H1b that low industry dynamism increases the positive relationship between fWHR and both the number of product releases and long-term firm value.

Robustness Tests

To guarantee the robustness of our findings, we perform several additional analyses and run alternative models.

Multicollinearity. On the one hand, we examine potential multicollinearity issues by analyzing the variance inflation factors (VIFs). Our VIFs range from 1.02 to 3.44 with an average of 1.67. All of our values lie, accordingly, well below the accepted threshold of 10 (Cohen, Cohen, West, and Aiken, 2003). Despite the positive outcome of this test, we continue to test the stability and plausibility of our coefficients further. Following (Echambadi, Arroniz, Reinartz, and Lee, 2006), we repeat our regression analyses with subsets of the full sample. We draw ten random subsets with 90% of the sample and repeat the regression analyses for our hypotheses. The outcomes with the sample subsets are highly consistent with our previous findings in terms of significance levels, direction, and size. Thus, as our results do not vary, the problem of multicollinearity does not distort the results of our study and can be disregarded (Echambadi et al., 2006).

Endogeneity. Endogeneity problems are caused by omitted variable bias if a variable has not been included in the model although it affects both the explanatory and dependent variables (Wooldridge, 2010). To address this concern, we follow Frank (2000) to calculate the impact threshold of a confounding variable (ITCV). This analysis illustrates how strong an omitted variable would have to be to overturn our results. We utilized the konfound package in R to evaluate our finding that a high fWHR positively affects product releases and Tobin's q. The analysis shows that to invalidate our result, 12.2% (for product releases) and 45.6% (for Tobin's q) of the estimate would have to be due to bias – meaning a substantial number of the observations would have to be replaced with cases for which the effect is 0. Therefore, we derive that omitted variable bias is unlikely to distort our results.

Alternative regression models. As robustness check, we repeat our analyses on fWHR in relation with product releases and Tobin's q with a pooled ordinary least squares regression model (pooled OLS) with heteroskedasticity and serial correlation robust standard errors clustered at the firm- and year-level (Arellano, 1987) – see table 3 model 3 and 4. We find that the results for our hypotheses are consistent in significance level, direction, and size compared to our GEE model. Thus, our previous findings can be confirmed.

DISCUSSION

The present research theoretically develops and empirically validates that CEOs' higher testosterone level can positively relate to new product introductions and firm value. The findings further suggest that the relationships between such testosterone levels and these strategic outcomes are not universally valid, but determined by industry dynamism. In more detail, the study establishes a positive significant impact when moderated by low industry dynamism: For H1a and H1b, we find high-testosterone CEOs to be 7.1% more active and 12.4% more successful than their low-testosterone peers in an undynamic environment. Yet, we do not find such significant effects for high-testosterone CEOs when industry dynamism is high. Accordingly, this

study finds below-average turbulence to be the sweet spot of alpha CEOs, in which they perform at their best. In summary, this study provides new evidence on the impact of CEOs' fWHR and testosterone level on the firm's activeness and value. We discuss our findings' implications for theory and practice in the following.

Theoretical and Research-Related Implications

This study contributes to extant literature in a multitude of ways: First, we contribute to upper echelons research in innovation management which, for instance, related CEO personality to firm-level outcomes. By integrating insights from recent research at the interface of management and biology, we provide a novel CEO characteristic that might play an important role in determining future business creation-related activities and innovation. A CEO's fWHR predicts a complex of masculine behaviors, which - as suggested by upper echelons theory - are reflected in company outcomes. We contribute to this theoretical stance by conceptually deriving and empirically confirming the relationship between facial masculinity and company activeness and value. Thereby, we introduce a biological perspective on CEOs' influential physical characteristics driving their organizational decision-making. We add facial masculinity as a novel characteristic reflected in facial structure that drives strategic outcome variables and, thus, requires our attention. Specifically, we inform the literature at the interface of upper echelons and innovation management by introducing CEOs' facial masculinity as a driver of firm-level innovation in the form of new product introductions. In doing so, we answer the call of Kashmiri et al. (2017) for exploring the innovation implications of CEO characteristics other than narcissism.

Second, since researchers frequently use the fWHR ratio as a proxy for the testosterone level of CEOs, we contribute to research on testosterone in executives. So far, this literature has been dominated by research that relates testosterone to rather operative activities, like attending to task-relevant information (Overbeck and Park, 2001) and engaging in activities and

behaviors that are consistent with principal goals (Galinsky et al., 2008a). The further growing body of research found for instance that high-fWHR CEOs deliver higher return on assets (Wong et al., 2011). Our results echo those of Wong et al. (2011), showing that alpha CEOs outperform their low-testosterone peers, which is particularly boosted by certain external factors. Wong et al. (2011) argued that the relationship between CEOs' facial measurements and their firms' financial performance is stronger in firms with cognitively simple leadership teams. We extend this line of research by theoretically arguing and empirically showing that the novel CEO characteristic of a high testosterone level feeds into strategic outcomes like new product introductions and firm performance, particularly in undynamic organizational environments. Thereby, we add a strategic perspective on the effects of CEOs' testosterone level and facial structure.

Third, we contribute to contingent perspectives in research at the interface of CEOs' characteristics and firm outcomes. Our study links physical characteristics to organizational outcomes and advances leadership research by showing that objective facial metrics of male CEOs in combination with the dynamism of their industry are closely related to organizational performance. Specifically, we develop arguments and empirically find that a given biological characteristic can be beneficial in one specific situation and disadvantageous in another, emphasizing the strong need to contextualize links between important CEO characteristics and strategic outcome variables. A large body of literature has previously associated masculine facial features to high testosterone levels and masculine behavioral traits such as increased aggression, risk-seeking, and egocentrism (e.g., Apicella et al., 2008, Lefevre et al., 2013, Wright et al., 2012). Our study shows that in low-turbulence environments, the level of testosterone positively relates to firm activeness in terms of product releases and company value. Accordingly, high-testosterone managers perform significantly better in low than in high dynamism environments. Thus, by integrating the contingency of the respective industry's low dynamism level, our study also contributes to the smaller body of research that illustrates the positive sides

of testosterone and the associated masculine facial characteristic. Likewise, the integration of industry dynamism as a moderator also answers Nofal et al.'s (2018) call for research concerning the interface of biology and management, who state that since "[…] most managerial behavior is likely accounted for by the interaction of human biology and environmental factors, additional research should empirically investigate how environment and biology interplay to influence management" (p. 23).

Practical Implications

From a practical viewpoint, our findings underscore the impact of CEO characteristics on organizational decision-making and how much it varies in different environments. To become a true leader and realize one's full potential no matter the environmental factors, individuals will need to fully harness the positive consequences of testosterone we describe in this study, while mitigating the negative ones. Being aware for instance of one's tendency to nullify others' opinions and, thus, not operating at one's maximum performance in turbulent industries, is the first step for alpha CEOs towards more collaborative and equitable behavior. On the other hand, it can be helpful for team members to be aware of testosterone-related behavioral traits of their colleagues, superiors, or subordinates to encourage or incentivize a beneficial team spirit. Likewise, for executive recruiters and decision boards, it can be fruitful to keep these considerations in mind and create a balance of TMT members' different characteristics and testosterone levels, also with a focus on increasingly hiring female executives, particularly in high dynamism organizational environments.

Limitations and Avenues for Future Research

Our study has several limitations and offers additional opportunities for future research. Firstly, we do not have a measure of CEO testosterone exposure, but only a measure of facial structure that predicts a variety of masculine traits. However, one would ideally draw saliva and serum

samples from CEOs to examine the biochemical composition and (base) testosterone content. Unfortunately, it is unlikely for a vast number of CEOs to participate in this endeavor. Moreover, it must be noted that detecting the effects between leader appearance (and underlying hormone levels) and performance may require different methodological paradigms and even more complex study designs. In this study, we aimed to disentangle the relationship of the level of testosterone and managerial performance, which might, however, be more complex than previously envisioned. For instance, if CEOs with a higher fWHR are generally assumed to be better CEOs (regardless of their actual performance), they might be more likely to be hired by better-performing companies. Being considered as more effective leaders by their employees may allow them to, indeed, lead their firms to greater success. Hence, the 'looks of success' may act as a self-fulfilling prophecy. Lastly, it should be noted that the sample CEOs were mostly Caucasian, meaning this study's findings might not be applicable across all ethnicities. Thus, future studies could also extend this study's scope to other cultural contexts.

Testosterone-related management research is not only highly thought-provoking but offers countless further opportunities for future research. Building on this study, it may be of interest to examine further measures of company performance and behavior. Especially interesting would be the further assessment of environmental moderators and their impact on the fWHR-performance link, for instance along the lines of Wong et al. (2011) who analyzed the effects of CEOs' facial measurements on their firms' financial performance, moderated by the cognitive capacity of their leadership team. Another field of future interest are additional performance-harming factors. As elaborated in this study, high-testosterone CEOs have a tendency towards unethical personal dealings or questionable behavior, one example being financial misreporting (Jia et al., 2014). Future research could examine whether this behavior is triggered or fostered by an externally increased sense of power, for instance CEO duality or a very high CEO pay slice. Like turbulent environments, such power-increasing external factors might hinder alpha CEOs to operate at their full performance potential. Finally, future scholars could

consider assessing the most fruitful combinations of high vs. low testosterone CEOs with other high vs. low testosterone TMT members. Based on literature on homophily, the CEO would prefer other TMT members to be of the same kind (Kamiya et al., 2019). On the other hand, based on the negative testosterone-associated traits described in this study, a more diversified set of characters in the team, also particularly including female members, could be most productive for firm performance. We leave this as a future research agenda.

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5.3 Research study II

NOT IN THE MOOD FOR A UNICORN – HOW TESTOSTERONE-FUELED CEOS PURSUE LESS VENTURE CAPITAL INVESTMENTS IN UNDYNAMIC ENVIRONMENTS

ABSTRACT

This study illustrates from a biological perspective how CEOs' physical characteristics drive their venture capital investment behavior. Applying facial width-height-ratio (fWHR) as a proxy for testosterone, we offer a theoretical model that illuminates the link between CEOs' testosterone levels and their investment behavior in terms of number of investments and co-investors. To address both the ambiguity in extant research around how CEOs' testosterone levels work, as well as the vastly limited literature on the antecedents of corporate venture capital (CVC) commitment, we argue that the effects of their testosterone levels on firm VC activeness are reliant on industry dynamism. We assume that the negative effects of testosterone play out when dynamism is low, whereas there are no such effects when dynamism is high. To confirm our arguments empirically, we conduct our study based on publicly traded S&P 500 US companies between 2010 and 2014. Our sample consists of 342 firm-year observations with 134 companies and 153 male CEOs and validates the assumed low corporate VC activeness and egocentric behavior of alpha CEO-led firms in undynamic industries. We find that when industry dynamism is low, testosterone-fueled CEOs undertake fewer investments – but when they do, they do so with fewer co-investors. This article contributes to upper echelons research in open innovation by offering a novel CEO characteristic as antecedent of CVC investing commitment and scope, as well as by considering the interface of management and biology. Additionally, this study contributes to extant research on testosterone in executives by linking it to CVC investing as long-term, strategic innovation and, thus, adding that strategic perspective.

Further, this study contributes to contingent perspectives at the interface of firm behavior and CEOs' characteristics by showing that a biological characteristic can be beneficial in one setting and detrimental in another.

INTRODUCTION

The body of research on the drivers of innovation, especially new practices of open innovations like corporate venture capital, has grown tremendously over the last decades. However, focus has fallen on whether or not strategic goals are achieved, how innovation programs should be run, or under which conditions the arrangement between corporate and venture is most fruitful (Dushnitsky & Lenox, 2005). These investments represent a significant commitment of the corporates' resources in terms of financials and time (Freese et al., 2007). Nevertheless, the antecedents of CVC investments, i.e., what drives the CVC commitment and scale, is met by a startling lack of attention. On a more general note, extant research lists CEOs' demographic characteristics (e.g., Strohmeyer et al., 2017) and personality (e.g., Kashmiri & Mahajan, 2017) as important antecedents for innovation and new business (You et al., 2020), guiding our attention to address this call for research (Anokhin et al., 2016).

At the recently emerging interface of management and biology, researchers have shown that executives' facial structure and the level of testosterone this reflects, is a driver of their managerial behavior. Building on previous psychology and biology studies, researchers use the metric facial width-height-ratio (henceforth fWHR), a proxy for the individual's facial masculinity and testosterone level, to derive insights about their behavior (Jia et al., 2014). Based on this measure, they describe facial masculinity-related behaviors like aggressiveness, risk taking, and egocentrism (Carré & McCormick, 2008; Haselhuhn & Wong, 2012; Stirrat & Perrett, 2010), but also economic behaviors like financial decision making or misreporting (Jia et al., 2014). Following up on the novel and fruitful research avenue at the linkage the above-mentioned streams, we ask the question how male CEOs' facial masculinity is associated with their

firms' strategic moves like venture capital investments. So, on the one hand, high-testosterone 'alpha CEOs' are highly optimistic opportunity-seekers who dare to make bold and fast decisions (Wallace & Baumeister, 2002) – ideal prerequisites for making many and large VC investments. But on the other hand, alpha CEOs tend to nullify the opinions of others (Diesing, 1962), potentially diminishing the motivation of their fund managers and the buy-in of all employees and TMT members. And most interestingly: Do VC investments offer the opportunity to draw enough of the public attention and applause that alpha CEOs seek?

To address the mentioned research gap, we offer a research model based on both upper echelons and extant research on CEO characteristics, and in particular testosterone, as drivers of firm behavior. The theory we derive takes positive and negative consequences of testosterone into account and assesses the heterogeneous set of possible effects on our dependent variables. Considering this two-sided view, we select industry dynamism as suitable moderating variable to resolve the tensions around the impact of CEO testosterone levels, depending on the individual situation or circumstances they are in. We argue that the effect of the CEOs' fWHR on firm VC investment behavior is related to the dynamism of the industry they operate in. Specifically, we predict that in low-dynamism environments, the VC investment interest of alpha CEOs is not triggered while additionally the negative associations of testosterone are more prevalent, whereas this effect is not observable in turbulent environments.

To validate our assumptions empirically, we construct a sample of publicly traded US firms, listed in the S&P 500 index, between 2010 and 2014. Our sample includes 342 firm-year observations with 134 companies and 153 male CEOs. Our study combines company data from the COMPUSTAT database, pictures of the sample CEOs for the fWHR score, and CVC investment data from the Crunchbase database.

This article contributes to extant literature in three major ways: First, we contribute to upper echelons research in open innovation management by offering a new perspective on the antecedents of corporate venture capital commitment and scope. This article provides a novel

CEO characteristic that may play a decisive role in determining future VC investing activeness by integrating findings from recent research at the interface of biology and management. The CEOs' fWHR predicts a set of masculine behaviors, which – as upper echelons theory suggests – influence company behavior and outcomes. We provide facial masculinity as novel characteristic and by doing so, we answer the call of Anokhin et al. (2016) pointing out the lack of research in the field of CVC antecedents. Moreover, we reply to the call of Kashmiri et al. (2017) for exploring the innovation implications of CEO characteristics apart from narcissism.

Second, we contribute to the growing body of research on testosterone in executives, in which researchers frequently use fWHR as a proxy for testosterone. Overall, extant research using fWHR focuses mostly on either operational tasks or on financial outcomes, showing for instance, that alpha executives attend to task-relevant information (Overbeck & Park, 2001a) or engaging in activities that are in line with principal goals (Galinsky, Jordan, & Sivanathan, 2008b). We extend this research by theoretically arguing and empirically presenting that the novel CEO characteristic of a high level of testosterone hinders strategic actions like venture capital investments, particularly in undynamic organizational environments. Thereby, we add a strategic perspective on the effects of CEOs' level of testosterone and facial structure.

Last, we extend existing leadership research by accounting for the broader context or environment in which leaders make decisions on behalf of their companies. Our study links physical characteristics to organizational behavior and has advanced leadership research by showing that objective facial metrics of male CEOs in combination with the dynamism of their industry are closely related to firms' venture capital activeness. Accordingly, the integration of industry dynamism as a moderating variable also answers Nofal et al.'s (2018) call for research on how environment and biology interplay to influence management.

THEORETICAL BACKGROUND AND HYPOTHESES

Corporate Venture Capital Investing

Corporate venturing is on the rise and the increasing intensity of CVC activities over the last decade has even been described as 'golden age' (Battistini et al., 2013). Dushnitsky and Lenox (2005) decipher corporate venture capital as "equity investments in entrepreneurial ventures by incumbent firms". Venture capital can be provided at different stages of the startup's evolution and is raised in subsequent funding rounds. It often involves early and seed round funding to secure high-growth opportunities in early-stage firms. Unlike the more typical or standard types of investment, however, financial gain is not the sole purpose of CVC investing (Anokhin et al., 2016). Instead, venture capital literature lists a plethora of strategic benefits which corporates seek to realize, including accessing a window on technology, strengthening innovation with existing business units, corporate diversification, leveraging internal technological developments, tapping into foreign markets or searching acquisition targets (Chesbrough, 2006). The venture capital investment process is part of what extant research describes as "venture capital cycle", which has not changed significantly after its first appearance in academic studies in the 1970s (Gompers & Lerner, 1999). Tyebjee and Bruno (1984) conceptualized the process with five steps: the discovery of promising investment opportunities (deal origination), the reduction of the many opportunities to a manageable quantity (deal screening), the careful analysis of the potential portfolio companies (deal evaluation), the clarification of the deal's terms (deal structuring), and last, the continuous support of the investee and preparation for future divestment (post-investment activities). The investing corporates can, by leveraging their extensive industry and technology expertise, gain direct benefits through the superior selection of their targets (Dushnitsky & Lenox, 2006). Established firms are well positioned to realize benefits through CVC as they often possess expert personnel to select valuable ventures, perform superior due-diligence, or provide complementary contacts, capabilities and resources (Gompers & Lerner, 1998). However, the benefits and insights hoped for are frequently eroded by the investors'

internal conflicts, weak incentives or rampant information asymmetries (Dushnitsky & Lenox, 2006). Accordingly, corporate venture capital is mostly viewed as a vehicle for exploration and passes through the corporate governance layers of investment decision-making with difficulty (Liu et al., 2019). The future payoffs of these investments are noisier than short-term oriented investments which have been tried and trusted by the company (Anokhin et al., 2016). Thus, to make valuable investments and add beneficial ventures to the company's portfolio, it is a sine qua non for leaders to inspire and convince hesitant stakeholders by identifying new opportunities such as white spots in the industry, newly emerging technologies or potential disruptors, unmet customer demands or any kind of beneficial addition to their current portfolio (Galinsky, Jordan, & Sivanathan, 2008b). Making the obligatory fast, bold investment decisions requires the power and willingness to remove manifold obstacles or doubts, and pass quickly through the decision-making processes – i.e., not to get stuck in extensive calculations, discussions, or market research. Usually, corporates do not make one-time venture capital investments on the fly – instead, it is required to set up a CVC program which is equipped with sufficient funds and talent to execute worthwhile investments and support the portfolio ventures subsequently (Dushnitsky & Lenox, 2006). Therefore, it necessitates committed and invested leaders to make such a program work.

As mentioned above, funding rounds usually consist of more than one investor. Often, investors even act as a formal group called 'syndicate' to share the risk and combine their financial power (Hopp & Rieder, 2011). The benefits of collaborating with co-investors are manifold. Apart from risk-sharing and reducing the financial burden for each investor, each party contributes their unique knowledge, network and resources to the incumbent and potentially increases its likelihood of success (Dushnitsky & Lenox, 2006). Across funding rounds, a corporate VC unit can build a network of trusted co-investors via active and stable involvement (Battistini et al., 2013). Consequently, co-investors share more information, trends, and opportunities with each other, enabling the CVC unit further to become a respected corporate

navigator for corporate innovation. On the other hand, a high number of co-investors per funding round decreases the individual's influence on the venture and the potential return, while intensifying the need for collaboration. The individual investor's opportunity to win the laurels for the incumbent's success is, of course, diminished.

In sum, leaders are generally confronted with two questions regarding their VC investing strategy: They must define both the scope and the type of investments they want to pursue. First, a firm's leadership must define whether or not they want to actively pursue venture capital investments and, if so, decide on the level of effort and resources their CVC unit shall be equipped with (Anokhin et al., 2016). This unit's manpower and financial resources ultimately drive the number of CVC investments a company can undertake (Dushnitsky & Lenox, 2006). Secondly, leaders must decide, whether they prefer to invest in smaller, potentially earlier, funding rounds to be able to exercise more power towards the incumbent without having to share the laurels, or whether they want to serial-fund alongside a network of trusted co-investors (Hopp & Rieder, 2011).

Upper Echelons Theory and VC Investment Behavior

Upper echelons theory, first introduced by Hambrick and Mason (1984), describes the meaningful impact of executives on their organizations' decision-making and related strategic firm-level outcomes. Thus, the theory's central premise is that executives' personalities, values, experiences, and their characteristics strongly affect how they interpret and react to the situations they face and which decisions they will derive consequently. Likewise, this premise is reflected in the concept of bounded rationality, implying that complex information overloads in uncertain situations are not objectively knowable but rather subjectively interpretable by individuals through their cognitive bases (Carpenter et al., 2004; Hambrick, 2007).

A variety of upper echelons-based studies have described links between personality traits and firm-level outcomes, in particular those that relate to the creation of new business (e.g., through

venture capital investments). The characteristics associated with a CEO's level of testosterone are, while of course inheriting situational elements, stable personality traits (Malmendier & Tate, 2005). They play a role in how external information or stimuli are filtered, interpreted, and brought to a decision. Thus, they determine how open a CEO is to novel solutions, how they embrace change and whether they allocate firm resources accordingly (Engelen et al., 2013).

Apart from the effects of personality traits, extant research has described that executives' observable characteristics, such as gender or education are particularly valid proxies for their underlying perceptions, values, and cognitions of situations, which consequently determine their strategic firm-level decisions (Carpenter et al., 2004; Hambrick, 2007). Nevertheless, these demographics should be treated carefully due to the black box problem (Hambrick, 2007). Bertrand and Schoar (2003), for instance, found CEOs' education to be associated with their responsiveness to future growth opportunities, which could be represented in a firm's venture capital investment behavior.

Facial Structure and Testosterone

As stated by Nofal et al. (2018), the very limited research at the just recently developing interface of biology and management is surprising. After all, biology impacts all aspects of human behaviors including - being biological entities - the ones of CEOs. Ignoring this aspect as a driver and explanation for managerial behavior equals missing an important piece of the puzzle (Nofal et al., 2018). In their recent studies at the interface of management and biology, researchers have described different physical characteristics to drive managerial decision-making. In particular, they identified facial structure or masculinity of male executives to be such a decision making driving characteristic (Jia et al., 2014). Facial masculinity, or the relative width of the face, is largely an outcome of craniofacial bone growth during the pubertal stage, driven by the males' level of testosterone (Lefevre et al., 2013). While this enables researchers to

investigate individuals' testosterone levels via facial structure, it appears that research has had a primary focus on socially undesirable correlates of high testosterone. Less is reported on the socially beneficial traits that come with high testosterone, which must have driven the evolutionary selection of it. First and foremost, Wong et al. (2011) in their study on the superior financial performance of high-testosterone CEOs, reason that "testosterone-based aggressive behavior aimed at dominating other individuals or obtaining a resource is often associated with a psychological sense of power". This link between testosterone and power is a central premise, as people with an inherent sense of power tend to view their external environment and challenges more optimistically, embrace opportunities, and focus on the big picture rather than smaller details (Galinsky, Jordan, & Sivanathan, 2008a). Moreover, they are also more likely to incorporate task-relevant information (Overbeck & Park, 2001b), and to promote activities and behaviors that are in line with principal goals (Galinsky, Jordan, & Sivanathan, 2008a). In sum, the positive traits linked to testosterone are part and parcel of effective leadership (Galinsky, Jordan, & Sivanathan, 2008a). Hence, assessing the influence of the level of testosterone is particularly interesting and relevant in the field of company executives and top management teams.

Nonetheless, researchers have started only recently to explore the interface of biology and management and conduct studies in this field, for instance linked to psychology and accounting research streams. These studies identify and describe the managers' facial structure and underlying testosterone level as a driving force of managerial behavior and financial performance (Jia et al., 2014; Wong et al., 2011), therefore also being relevant for the purpose of our study.

RESEARCH MODEL

As recent studies at the link of management and biology describe, the physical characteristics of CEOs, and in particular their level of testosterone reflected by their facial structure,

determine their managerial decision making and outcomes (Jia et al., 2014). However, there is a great variety in observed outcomes, for instance depending on environmental factors, pointing towards the existence of both upsides and downsides of high testosterone. Whereas Wong et al. (2011) describe higher company returns for alpha CEOs, Lu and Teo (2018) observed lower investment returns for alpha hedge fund managers. In the light of such undecisive results, in our study we aim to create more clarity on the impact of CEO testosterone levels, measured via fWHR, and investigate the respective influence on firms' CVC investment behavior. Therefore, initially we discuss both the positive and negative effects of testosterone on CVC investment activity in the following section, to illuminate their respective magnitude in low or high dynamism industries.

Positive Effects of Testosterone on Corporate Venture Capital Activeness

A wealth of extant research documents the strong impact of CEOs on their companies' activities, strategies, and success, which is highly relevant for examining the relation of testosterone and executive behavior. For instance, researchers in the field of psychology describe a clear relationship between individuals' characteristics and their thinking, feelings and behavior (Colbert et al., 2014; Costa et al., 1995; Judge et al., 2002; McCrae & Costa, 1987; Peterson et al., 2003). Most of these scholars build their contributions on the upper echelons theory, like we do in this study.

Moreover, extant leadership research has elaborated that innate character traits distinguish successful leaders from unsuccessful ones (Wong et al., 2011). Following their argumentation, the superior leadership performance of high-testosterone managers proves the positive impact of high testosterone on company returns. As mentioned previously, testosterone-fueled managers feel a greater sense of power, stimulating a specific kind of behavior. Kipnis (1976) was among the first empirical social psychologists to have theorized the metamorphic consequences of possessing power. As evidence suggests, power and its effects come to reside

psychologically within the individual as they are transformed by the experience of it (e.g., Bargh et al., 1995, Chen et al., 2001, Galinsky et al., 2003, Galinsky, Magee et al., 2008).

In what follows, building on the metamorphic effect of testosterone-induced power, we link the CEO's level of testosterone with firms' CVC activeness and behavior. First, to investigate a CEO's readiness or willingness to create and realize these risky but potentially highly beneficial opportunities (Dushnitsky & Lenox, 2006), we observe the number of annual venture capital investments. Second, to understand the collaborative behavior as an investor, we measure the average number of co-investors (Hopp & Rieder, 2011). To truly harvest the strategic and financial benefits of venture capital investments, a significant amount of care, effort and resources is required to reach a mutually satisfying agreement between the incumbent and the startup (Anokhin et al., 2016). Evidently, an above-average number of venture capital investments and a strong tie with numerous co-investors foots on a distinct mindset of decision makers within a firm.

For undertaking frequent startup investments, inspirational leadership towards employees is essential for various reasons. On the one hand, all employees should get excited instead of frustrated about the plethora of new adventures their employer gets engaged in (Dushnitsky & Lenox, 2006). For employees it can be difficult to understand why there is no budget for colored printouts while the firm decides to back pre-seed ventures with large sums. On the other hand, leaders must motivate their CVC fund managers, who typically receive a larger portion of their compensation in fixed salary than independent venture capital fund managers (Birkinshaw et al., 2002). For their lack of powerful incentives, fund managers are at danger to either lose motivation or wander off to an independent VC (Chesbrough, 2000). Strong leadership is required to unite employees behind the process, manage internal politics as business units may compete for scarce resources, and convince stakeholders that such investments are worthwhile although the return will not be realized immediately – and sometimes never at all (Gans & Stern, 2003). Likewise, maintaining a strong network of co-investors requires a collaborative

effort, to invest and manage jointly, to share ideas and opportunities, and to receive the same in return (Battistini et al., 2013). But while high company venture capital activeness requires an extra mile from leaders and employees, it can be a driver company success: Successful venture capital investing, like any kind of entrepreneurially oriented behavior, empowers pioneering firms to set industry standards (Covin & Slevin, 1991), exploit market opportunities ahead of competitors, establish brand recognition and speed up market penetration as well as associated cash flows (Lumpkin & Dess, 1996). Such growth and innovation initiatives at the strategic level indicate that the company is on a mission to generate future value, opportunities, and competitiveness (Liao et al., 2016).

Building on the previously established association between high testosterone and its positive consequences, we predict that companies headed by 'alpha CEOs' with greater fWHRs have the potential to behave more actively in terms of CVC investments and form strong co-investor alliances as their strengths substantially address the requirements we see. There are three main underlying drivers for this assumption:

"Optimistic behavior." First, alpha CEOs are optimists in action: Their testosterone-induced sense of power translates straight into action (Galinsky, Jordan, & Sivanathan, 2008a), positively influencing company activeness and behavior as an investor. High-testosterone CEOs have a stronger tendency to react in an actionist way in day-to-day situations such as an emergency. They jump to action to help others in distress (Galinsky, Magee et al., 2008) while low-testosterone individuals tend to sit back, lacking a sense of responsibility and looking to other non-responders for confirmation of their own behavior. This tendency to 'jump to action' is a universal characteristic – not just in emergencies but also in case of opportunities such as strategic venture capital investments. The alpha CEOs take the chance while their low-testosterone peers are likely to miss out, impaired by potential hazards and threats they see (Anderson & Galinsky, 2006). Furthermore, alpha CEOs keep not only short-term benefits in mind but especially tackle long-term opportunities for future growth and success (Galinsky, Jordan, &

Sivanathan, 2008a). With their inferior sense of power, low-testosterone CEOs tend to sit back motionlessly and leave difficult decisions to their successors (Galinsky, Magee et al., 2008). In contrast, the alpha CEO's actionist, convincing, and positive nature drives him to pursue investments without immediate return, having future benefits in mind, while inspiring other co-investors with their optimism to invest alongside them. In sum, alpha CEOs with their senses wide awake for opportunities and willing to take action, will take a leap of faith for those hardly predictable venture capital investments (Liu et al., 2019).

"Goal-directed behavior." Second, alpha CEOs show more goal-directed behavior: Their testosterone-induced sense of power channels the individual's behavior and thoughts towards achieving one's goal independent of external factors or situations (Bargh et al., 1995, Chen et al., 2001, Galinsky et al., 2003). They possess a strong focus on the global rather than the local features of stimuli (Guinote, 2007). The testosterone-fueled managers process information at higher levels of abstraction and concentrate on the big picture instead of getting lost in the details (Smith & Trope, 2006). Accordingly, they can handle the gist of information and perceive patterns better. Therefore, they succeed in identifying ventures, which could give them for instance access to new technologies, markets or cashflows and take the chance accordingly. Moreover, they recognize the evident benefits of forming strong partnerships with co-investors which are crucial for the success of their own CVC program (Battistini et al., 2013). In sum, their effective goal focus enables high-testosterone CEOs to drive a high number of valuable venture capital investments to secure financial and strategic benefits for their company.

"Effective leadership." Finally, alpha CEOs are more effective leaders: High-testosterone executives tend to be uninfluenced by others (Galinsky, Magee et al., 2008). In contrast, feeling or being powerless – i.e., when one's outcomes are determined by others – equals being constrained. A powerful CEO is able to motivate, influence, and enable a group of subordinates or peers to contribute to the success of a shared purpose (Wilderom et al., 1999), which is fundamental for his ability to drive venture capital investments by first creating a venture capital

program and subsequently allocating the required resources to the respective structures. The alpha CEOs are able to see, create, and articulate a broad vision of the world, which allows them to inspire and unite others (Galinsky, Jordan, & Sivanathan, 2008a). This is key to motivate both talented CVC fund managers, who would be able to find better conditions working for an independent VC, and other employees who may struggle to support high venture capital investment activity while their own business unit is financially constrained (Dushnitsky & Lenox, 2006). Thus, employees and other leaders place trust in these ideas and strategies, put in the extra work and agree to make for example risky but potentially worthwhile venture investments. Moreover, he succeeds to inspire his network of co-investors to follow his lead or ideas. A less trusted CEO, on the other hand, is more likely to find his ideas stuck in the layers of decision-making or discredited by shareholders and investors. Moreover, extant research states that more than 80 percent of companies decrease discretionary expenses to meet short-term capital market expectations, abandoning long-term growth opportunities to improve short-term profitability (Hendricks et al., 2019). Arguably, it requires an inspirational 'influencer' – part and parcel of effective leadership – to balance short-term and long-term priorities and to unite all stakeholders behind a highly debated venture capital strategy and the associated requirements. Therefore, we expect high-testosterone CEOs to succeed in inspiring and joining others behind their visions and, thus, support the firm's potentially adventurous investment strategies alongside a loyal network of co-investors.

Negative Effects of Testosterone on Corporate Venture Capital Activeness

The level of testosterone drives a complex of related behaviors in males, meaning that of course negative consequences are just as likely to manifest. Again, building on the previously established association between high testosterone and its negative consequences, we predict that companies headed by 'alpha CEOs' with greater fWHRs have the potential to stand in the way of CVC investments and strong co-investor alliances: Psychological consequences for high-

testosterone managers are diminished perspective-taking and overconfidence as well as the tendency to objectify others by perceiving them through a lens of self-interest (Galinsky, Jordan, & Sivanathan, 2008a), which can be a barrier for a company's venture capital activeness and influence overall investment behavior.

"Diminished perspective-taking and overconfident judgment." One consequence of high testosterone with a particular impact on strategic firm-level outcomes is the alpha CEOs' tendency to ignore others' perspectives while overweighing their own, potentially hindering the placement of venture capital investments or the collaboration with co-investors. Their testosterone-induced sense of power harms social attentiveness by placing a blind spot on the unique vantage points of others (Galinsky et al., 2008a). This, consequently, weakens the CEO's ability to see things from another person's point of view significantly. As extant research describes, alpha CEOs are not only less able to interpret others' facial expressions of emotions, but also less influenced by them (van Kleef et al., 2006). Moreover, dominant CEOs tend to nullify the contribution of their colleagues and to restrict the flow of information (Diesing, 1962). Unsurprisingly, they are extremely confident regarding their own judgments and decisions (Fast et al., 2012), not seeing the necessity to calibrate with their team members such as the CVC fund managers. Not only will this lead to missing out great opportunities but also, especially when presented with a risky course of action, to overvaluing the potential payoffs and ignoring downsides (Galinsky et al. 2008a). Moreover, this trait clearly diminishes the collaborative benefits of a co-investor network, which requires respectful partnership both pre and post investment. Especially post-investment, co-investors want to jointly influence and determine the incumbents way forward without one party enforcing their will (Battistini et al., 2013). This, in sum, negatively influences the firms CVC activeness and behavior.

"Objectification of other team members." Second, testosterone-fueled CEOs tend to view peers and colleagues merely as a tool for their own purpose (Gruenfeld et al., 2008) and, thus, prefer to surround themselves with likeminded 'followers' who will support their every

opinion. This leads to the elimination of critical and often valuable insights and ideas and can impair the identification of relevant technological trends or valuable investment opportunities. Evidently, due to the mentioned objectification, colleagues and team members feel alienated so that collaborative benefits cannot be realized (Galinsky et al. 2008a). Especially the fund managers, who are indispensable to the success of the corporate VC program, must be treated respectfully for them to not follow the higher remuneration prospects at independent VCs (Chesbrough, 2000). Likewise, co-investors and partners need to be met at eye-level for them to share valuable investment opportunities and to be willing, for instance, to share the financial burden and risk together as a formal group of co-investors (Hopp & Rieder, 2011). Thus, there are also evident downsides of CEOs with a high level of testosterone as their aggressive behavior may diminish the employees' and partners' motivation to bring forward their ideas and observations, harming the activeness and success of the corporate venture capital program.

One distinct characteristic, however, is difficult to declare as either beneficial or harmful just yet. Rooted in the alpha CEOs' sense of power, self-admiration and desire for superiority lies a strong need for constant applause and a longing for public limelight. So while on the one hand, this drives their goal orientation and bold, speedy decisions (Wallace & Baumeister, 2002), it may on the other hand also lead to the abortion of potentially valuable opportunities for the mere lack of publicity (Covin et al., 2006). Similarly, Hayward, Shepherd and Griffin (2006) describe how overconfidence manifests in "decisions about which opportunities to pursue".

We illuminate the role of positive and negative effects of CEOs' testosterone-related drivers and barriers on CVC activeness in low versus high industry dynamism in the following.

The Moderating Role of Industry Dynamism

Considering the two-sided view of both positive and negative effects of testosterone on our dependent variables, we select industry dynamism as suitable moderating variable to resolve

the tensions around the impact of CEO testosterone levels, depending on the individual situation or circumstances they are in. It is of course questionable that we can explain managerial behavior only through biological factors like the level of testosterone and most managerial behavior is likely accounted for by the interaction of biological and environmental factors. Therefore, we investigate how these factors interact with each other to influence management. Thus far, there is very little empirical evidence of such interactions in the literature (Nofal et al., 2018).

Extant research describes diverse environmental setups, which are associated with unique requirements and influence the expected behavior and performance of certain managerial types. One of those common environmental variables is industry dynamism, which is characterized by frequent, difficult-to-predict changes in customer needs and technologies (Fang et al., 2011). These environments differ in their degree of stability or turbulence (Dess & Beard, 1984), as well as the degree of managerial discretion they permit (Hambrick & Finkelstein, 1987). In dynamic environments, both the firm's external linkages and the rate of change in those linkages are higher (Freeman & Aldrich, 1981). Undynamic environments, in contrast, are more foreseeable with a more established set of relatively stable actors (Haleblian & Finkelstein, 1993). Accordingly, the extent of an industry's dynamism or stability greatly influences the information-processing requirements and the complexity of managerial tasks for the leadership of a company. Turbulent environments drive a more varied and fragmented nature of managerial work, as well as greater information-processing demands on the CEOs and their teams (Mintzberg, 1973), and create new opportunities and crises that frequently require strategic and structural adaptations (Galbraith, 1973).

Evidently, the exceptional complexity of dynamic environments makes the steering of the firm a team effort. We predict that turbulent environments carry a level of complexity that triggers the alpha CEOs' interest and 'miracle worker' attitude (Engelen et al., 2013). Turbulent environments are characterized by their high volatility, complexity, an overflow of information, and the necessity to prioritize. Thus, the great challenge of maneuvering successfully in

turbulent industries poses a particular opportunity for applause – hence, we want to examine whether low industry turbulence would be the tipping point, at which testosterone-fueled CEOs start to stand in the way of higher venture capital activeness with their lack of interest and potentially destructive behaviors. We discuss the impact of industry dynamism along the previously illustrated testosterone-related drivers and barriers of CEOs influencing their company's VC investment behavior.

First, alpha CEOs - being optimists in action - see more opportunities, embrace them fearlessly and turn them into reality faster. Especially in venture capital, where firms face great information asymmetries as ventures fear their expropriation, investors do require a fair share of optimism (Dushnitsky & Lenox, 2006). And as mentioned previously, they see themselves as 'miracle workers' who succeed at fulfilling tasks better than others (Engelen et al., 2013). This, however, often goes hand in hand with a restriction of information, driven by the CEO by nullifying the contribution of a colleague (Diesing, 1962) or by others being afraid to share ideas and suggestions that are not congruent with those of the alpha CEO (Hambrick & D'Aveni, 1992). Especially in stable environments, according to Kotter (1982), information and decision-making requirements are more standardized, systematic, and routine. This leaves testosterone-fueled CEOs with more capacity to control their team members and employees, who, as a result, refrain from sharing ideas or taking responsibility (Engelen et al., 2013). Such a hostile environment can be incredibly harmful for any kind of entrepreneurial or innovative advancements since these heavily depend on nonmanagerial employees and their willingness to make a contribution (Engelen et al., 2014). Moreover, the fund managers, not finding their opinions and suggestions respected - additional to their less attractive incentive pay - might transfer to an independent VC, leaving the corporate VC program in less capable hands (Chesbrough, 2000). Likewise, co-investors will refrain from entering a collaborative partnership, the more capacity alpha CEOs have, in order to force their views onto the post investment venture. Therefore, especially in undynamic environments, where alpha CEOs have more capacity to control their

employees and partners, and nullify their contributions, their dominant behavior and failure to stimulate followers intellectually would reduce the number of valuable investment opportunities identified and executed by the firm. Additionally, this behavior will lead alpha CEOs to underestimate the benefit of allied co-investors – their perception of simply being better off by themselves will steer them towards smaller funding rounds with fewer co-investors.

Second, testosterone-fueled CEOs show more goal-directed behavior. As previously seen, high-testosterone CEOs always keep their goals in mind. And apart from their company's performance targets, we have seen earlier that external affirmation, limelight, and applause are on top of the alpha CEOs' personal agenda (Engelen et al., 2013). However, in dynamic environments, overall company goals tend to change more quickly, or even the entire industry is disrupted by new technologies or trends. In contrast, when information-processing requirements are low – as generally true in less dynamic environments – the alpha CEOs are more likely to have sufficient information at hand to make high-quality decisions that will grant them the publicity they seek, such as launching new products fast or entering new markets. Following Wallace and Baumeister (2002), for instance, narcissistic CEOs perform better and work harder when they see an opportunity for self-enhancement towards an audience of observers. This lust for attention drives the CEOs' actionist behavior particularly in challenging environments and is, as Campbell and Campbell (2009) elaborate, beneficial in chaotic "emerging zones" and harmful in stable "enduring zones". In sum, when there is not much to win and no fun to have, alpha CEOs will stick to the safer choice. Therefore, it is likely that in undynamic environments alpha CEOs will focus on tried and trusted investment opportunities for which the outcome is more predictable, than aiming for the insecure and long-term benefits venture capital investments offer (Anokhin et al., 2016). Accordingly, we expect that in undynamic environments, in which other forms of investments or activities offer alpha CEOs faster and easier applause, they show less interest in making venture capital investments, and especially not in a larger alliance of co-investors.

Third, alpha CEOs are more effective leaders. In their sense of seeing themselves as miracle workers, they make bold, speedy decisions (Engelen et al., 2013), create a vision, and unite their employees behind them (Galinsky et al. 2008a). However, how alpha CEOs tend to objectify their colleagues is a great source of conflict and can stand in the way of venture capital activeness especially in a low dynamism environment. On the one hand, creating a vision for employees in undynamic environments is not equally important as in turbulent settings, in which the future is unforeseeable, and employees tend to need more guidance. On the other hand, the increased status-seeking of alpha CEOs harms collaboration, for instance with other TMT members or within their network of co-investors, as the CEOs show less interest in the opinion of others. In particular when setting up a CVC program, which binds a significant amount of resources, internal conflicts can arise, especially when other executives feel undermined or left out in the discussion (Dushnitsky & Lenox, 2006). The same is true for the collaborative identification of opportunities, as well as the venture steering post-investment alongside their co-investors. Their peers feel alienated (Galinsky et al. 2008a), effective communication is disrupted, and collaborative benefits are diminished. In turbulent industries, this behavior may get tolerated as the speedy decisions of the CEO can save the company from missing out on a time sensitive opportunity. In undynamic environments, however, the alpha CEOs' ignorant behavior would lead to suboptimal, less effective decisions or more discussions and disagreement in the process, impairing the ability to set up a successful VC program and realize valuable opportunities.

In summary, with their fearless and optimistic nature, their laser focus on company goals even in the long-term and their ability to motivate and inspire employees to share their ideas, one would expect alpha CEOs to drive above average venture capital investments in all settings. However, we predict low-dynamism environments to fuel the alpha CEOs' weaknesses, and not trigger their interest respectively. The controlling, hostile environments they tend to create harm the entrepreneurial behavior of nonmanagerial employees - who are crucial in the process

of identifying trends and sharing ideas - and the motivation of the equally indispensable fund managers. By executing decisions over their heads, the alpha CEO stirs internal conflicts among his team members and disrupts collaboration especially in undynamic environments, where speedy decisions are required to a lesser extent. His controlling and overconfident behavior will cause co-investors to refrain from sharing opportunities and jointly undertake investments. And most importantly, his eagerness to gain others' attention and applause drives him away from venture capital investments and towards more predictable, quicker wins. Accordingly, we propose lower corporate venture capital activeness related to high fWHR in undynamic environments by hypothesizing:

Hypothesis 1 (H1): The relationship between fWHR and the number of venture capital investments is negative when industry dynamism is low, while there are no such effects when industry dynamism is high.

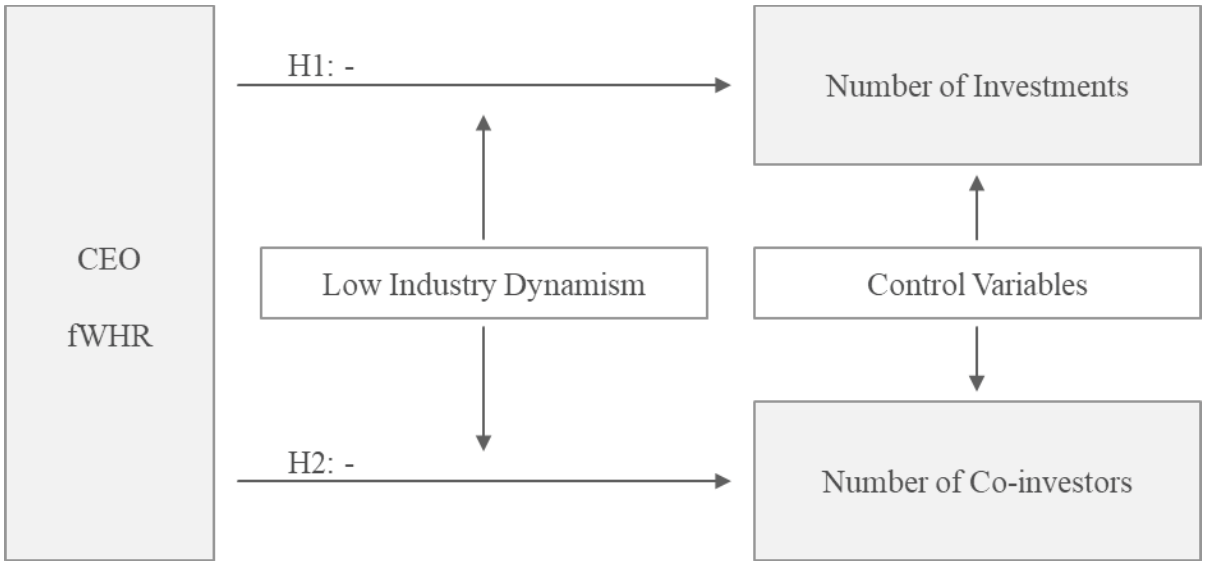
The reasoning above paints a specific picture of how alpha CEOs behave as investors and what motivation drives them to make such an investment. An as described above, venture capital investing can be seen as a team sport, since in each funding round there are typically several investors. A stable and trusted network of co-investors to undertake repeated investments with, is helpful for getting access to great opportunities and for easier collaboration to successfully support incumbents. Allied co-investors share great investment opportunities with each other and fruitfully steer the venture post-investment together (Hopp & Rieder, 2011). However, great teaming skills are not on the alpha CEOs' list of strengths. Evidently, as seen above, testosterone disrupts human collaboration by increasing egocentric choices (Wright et al., 2012) and leads them to the conclusion that they are better off by themselves. Therefore, co-investors will refrain from building lasting partnerships with someone who doesn't play the team sport. Moreover, we predict that a CEO who is seeking the limelight will not be willing to share it. Therefore, we expect alpha CEOs in undynamic industries not only to undertake fewer venture capital investments but when they do, they take action in smaller funding rounds with fewer co-

investors. The alpha CEO wants to be the one, and the only one, who found the next unicorn. Accordingly, we propose a lower number of co-investors per venture capital funding round related to high fWHR in undynamic environments by hypothesizing:

Hypothesis 2 (H2): The relationship between fWHR and the number of co-investors in venture capital funding rounds is negative when industry dynamism is low, while there are no such effects when industry dynamism is high.

Figure 1 depicts our research model.

FIGURE 1 Overview of Research Model



METHODOLOGY

Sample and data sources

To explore our hypotheses, we construct a sample of publicly traded S&P 500 listed firms between the years 2010 and 2014. We choose the respective timespan for its absence of major financial crises or other altering environmental circumstances and focus on large, public companies to ensure high data transparency and accuracy. We collect all relevant financial indicators and data for our sample firms from the COMPUSTAT database. To construct our dependent variables, we match our sample with the Crunchbase database, in which our focal companies are listed as investors. Crunchbase is a source of information for all data collected on startup

companies, with a particular focus on funding rounds. The database is self-reported by thousands of participants and double checked with other online platforms such as VentureXpert before publishing and has become a frequently used source for empirical research (Homburg et al., 2014). Additionally, we match the company data with executive-level information from the ExecuComp database, which was required to construct the related control variables CEO age, pay slice and duality. Lastly, we compile the pictorial database to determine the fWHR score of the male CEOs in our sample. We identified high quality portraits of the CEOs preferably on former annual reports, the company website, or, if otherwise not found, via Google Image Search.

After merging the different sources of data and excluding all entries with missing data, our sample includes 342 firm-year observations with 134 companies and 153 male CEOs. Initially, the sample size was slightly limited by the data availability of ExecuComp: When filtering for the S&P 500 listed companies in our given timeframe from 2010 to 2014 and matching it with the ExecuComp data for male CEOs only, we received 442 unique companies. A large number of observations was lost as there were no records of investor activities for some of our sample companies, either in all or at least in some of the years observed. This resulted in 346 firm-year observations. Finally, 4 entries were lost due to excluding entries with missing data, resulting in our 342 firm-year observations with 134 companies and 153 male CEOs.

Measures

Independent variable We measure our male sample CEO's tendency towards masculine behavioral traits described above via their facial proportions, "an unfakeable facial feature" (Jia et al., 2014). As a proxy for testosterone – and, thus, masculine behavior –, the facial width-height-ratio (fWHR) has been increasingly applied in management research, such as in the analysis of firm CEOs by Wong et al. (2011), Jia et al. (2014) and Kamiya et al. (2019). Lefevre et al. (2013) have validated fWHR in particular as an adequate proxy for testosterone, pointing

out that fWHR has a significant positive correlation with saliva-assayed testosterone in men, qualifying the measure as superior to alternative facial masculinity measures.

To construct the pictorial database for our sample CEOs, we searched each individual in annual reports or on the company website. In case no picture was available, we used the executive's full name plus company name to find the most suitable portrait on Google Images. Facial masculinity, i.e. relative width of the face, is the outcome of a male's craniofacial bone growth directed by the level of testosterone during adolescence (Verdonck et al., 1999). Therefore, a male's fWHR will not change over his life, which makes the age of the obtained image irrelevant. It shall be pointed out, that in fWHR research it is common practice to exclude female CEOs from the sample, as due to confounding effects of other hormonal factors, testosterone is less directly related to facial morphology for them (Lefevre et al., 2013).

We select the best portraits in terms of resolution, and whether the CEO is looking straight at the camera with a neutral or lightly smiling expression. In the following, we measure the distance between their two zygons (bizygomatic width), i.e., the cheekbones, and the distance between the highest point of the eyelid and the upper lip (height of upper face). The resulting ratio of width and height the so-called fWHR. The mean fWHR of our sample CEOs is 1.98, which is well in line with the observed values in extant research such as Jia et al. (2014) with a mean of 2.01 or Wong et al. (2011) with a mean of 1.96. Lastly, we follow previous researchers to include age as control variable, as clinical studies have discovered that testosterone levels in males decrease over their lifetime (Feldman et al., 2002).

Dependent variables To measure the alpha CEOs' level of activity in terms of evaluating unpredictable opportunities optimistically, identifying and executing valuable investments, motivating, and uniting all stakeholders and engaging in line with company goals, we measure the number of CVC investments per year. While there is a plethora of extant research on the matter of venture capital in general, hardly any previous researchers have focused their attention on CVC commitment and scale (Anokhin et al., 2016). The majority of scholarly investigations

focuses on the strategic or economic benefits of CVC investing, the conditions of mutually satisfying arrangements, or the comparison with other forms of open innovation programs (Dushnitsky & Lenox, 2005). Driving venture capital investments, often by setting up a functional CVC program, is a major commitment in terms of upper echelon's time and budget (Freese et al., 2007). Therefore, it is of utmost interest to us to understand what drives firms or executives to undertake this investment adventure. Among the first movers in assessing the antecedents of CVC commitments and scale are Anokhin et al. (2016), describing for instance that CEO duality has a negative relationship with the company's CVC activeness. Following their approach, we measure the number of corporate venture capital investments, both directly or via a CVC program, by counting the participations in funding rounds documented in the Crunchbase database.

Further, to test our second hypothesis, we extract the number of co-investors for each funding round our respective sample firms were active in. We predict that the size of funding rounds is linked to the CEO's level of testosterone. Assessing not only how often but also how these CEOs invest is a proxy for the manifestation of the different psychological consequences of testosterone, like for instance their egocentric decision-making (Wright et al., 2012) and their hunger for applause (Engelen et al., 2013). The number of co-investors per funding round plays a role in extant research from the angle of venture capital syndication, i.e., the collaborative investing of independent VCs in a formal partnership. We follow Hopp and Rieder (2011) in their approach to counting the number of co-investors, calculated as the average across all funding rounds each firm participated in within each year. Again, the number of co-investors was available in the funding round documentation in the Crunchbase database.

Moderator Dynamic environments may trigger a different management style or behavior than less dynamic and relatively stable environments, and a variety of CEO character traits might come into play differently. Because firm investment preferences might be altered accordingly, we choose industry dynamism as our focal moderator. By indicating to which extent

industry demand is rapidly and unpredictably changing, it serves to capture the effects of the environmental changes (Kohli and Jaworski 1990). Industry dynamism was operationalized as the standard deviation of sales in firm's primary industry across the prior four years, divided by mean value of industry sales for those years (Fang et al. 2011). Values range from 0 to 1.

Control variables In line with previous TMT researchers, we include CEO-, firm-, and industry-specific control variables that might impact the effect on our dependent variables. For CEO-specific characteristics, we include CEO age to control for the diminishing levels of testosterone over time (Feldman et al., 2002). To account for CEO power, we include CEO duality as a dummy variable equal to 1 if the CEO is simultaneously the chairman of the board, and 0 if otherwise. As a proxy for CEO dominance, we created the variable CEO pay slice, an indicator of relative CEO compensation against the total TMT compensation, as frequently used in extant TMT research (Zagonov & Salganik-Shoshan, 2018).

Regarding company-specific control variables, we represent firm size as the natural logarithms of total assets and the number of employees. Additionally, we account for return on assets as a measure of firm profitability (Germann et al., 2015), the natural logarithm of leverage, calculated as debt in current liabilities plus total long term debt over stockholders' equity as described in the majority of corporate risk literature (Aabo et al., 2021), and the natural log of EBIT.

Finally, our sample is structured as an unbalanced panel dataset. Therefore, we include year dummies with 2010 as the base year to account for environmental influences or external shocks affecting all firms in a specific year (Jing et al., 2019). Likewise, we include 1-digit SIC code industry dummies to capture industry-specific effects that are not covered by the included control variables.

METHOD OF ANALYSIS

To accommodate our cross-sectional data set, we use generalized estimating equations (GEE) to evaluate whether CEO fWHR affects the investment activity of a firm, especially given different degrees of industry dynamism. As descried by Ballinger (2004), "GEEs use the generalized linear model to estimate more efficient and unbiased regression parameters relative to ordinary least squares regression in part because they permit specification of a working correlation matrix that accounts for the form of within-subject correlation of responses on dependent variables of many different distributions, including normal, binomial, and Poisson". For our dependent variables number of investments and co-investors per funding round, we apply the Gaussian family and identity link after taking the natural logarithm of these variables. Moreover, we estimate robust standard errors to account for heteroscedasticity and calculate the model with all four potential correlation structures (independent, exchangeable, ar1, unstructured). Additionally, we calculate the quasi-likelihood (QIC) under the independence model criterion to determine the best fit (Ballinger, 2004).

RESULTS

Descriptive Statistics

Table 1 illustrates the descriptive statistics (mean and standard deviation) and bivariate correlations of our variables. Correlations among the control variables are mostly weak, with a few moderate exceptions (Ratner, 2009). Our independent variable, the CEOs' fWHR, correlates mostly insignificantly or very slightly with the other variables. One of our firm-describing control variables, firm size, correlates negatively with profitability and positively with EBIT and the number of employees. Firm size has correlation coefficients above |0.03|, meaning they are not in accordance with the evaluation criteria proposed by Kalnins (2018). Nevertheless, we decided to include this control variable to address the frequently asked question whether larger firms chose high-fWHR managers or, vice versa, the high-fWHR managers increase their firms'

size. Excluding firm size from our regressions, though, left our results unchanged. Additionally, as we see by analyzing the variance inflation factors, the upper moderate correlation coefficients are not causing multicollinearity.

TABLE 1 Descriptive Statistics and Bivariate Correlations

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
1 fWHR	1,98	0,12	1,00	0,05	0,01	0,09	0,06	0,01	-0,04	-0,20	-0,19	-0,07	0,11	-0,06
2 Number of Investments	1,13	0,57		1,00	0,14	-0,10	0,20	-0,12	-0,06	-0,21	0,07	0,02	0,15	0,12
3 Number of Co-investors	1,43	0,48			1,00	-0,02	0,13	0,00	-0,01	0,06	-0,07	0,08	0,14	-0,04
4 Industry Dynamism (4 Years)	0,09	0,06				1,00	0,13	0,03	-0,06	0,07	-0,09	-0,03	0,07	0,08
5 Firm Size	10,13	1,51					1,00	-0,51	-0,12	-0,18	-0,02	0,41	0,85	0,00
6 Profitability	0,06	0,06						1,00	-0,02	0,12	0,00	-0,02	-0,26	-0,09
7 CEO Pay Slice	0,37	0,17							1,00	0,07	-0,02	0,01	0,00	0,16
8 CEO Duality	0,50	0,50								1,00	0,13	-0,08	-0,17	0,04
9 CEO Age	57,60	6,43									1,00	-0,02	-0,03	-0,02
10 Employees	3,10	1,25										1,00	0,60	-0,10
11 EBIT	7,49	1,12											1,00	0,03
12 Leverage	0,22	0,13												1,00

Note: correlations larger or equal to |0,06| are significant at the 0,05 level

TABLE 2 GEE and Pooled OLS models testing H1 and H2

	GEE Models						*Pooled OLS Models*					
	Model 1			**Model 2**			**Model 3**			**Model 4**		
	b	SE	p-value	b	SE	p-value	b	SE	p-value	b	SE	p-value
Intercept	0,78	1,30	0,55	2,04	1,05	0,051.	0,78	1,35	0,56	2,04	1,08	0,06.
fWHR	-0,81	0,49	0,10	-0,64	0,47	0,17	-0,81	0,51	0,11	-0,64	0,48	0,19
Industry Dynamism (4 Years)	-19,90	6,74	0,003	-14,37	6,55	0,03	-19,90	6,99	0,005	-14,37	6,79	0,04
Firm Size	0,17	0,07	0,016	0,08	0,05	0,13	0,17	0,07	0,02	0,08	0,05	0,15
Profitability	1,06	0,42	0,011	0,70	0,39	0,07.	1,06	0,43	0,015	0,70	0,41	0,09.
CEO Pay Slice	-0,04	0,22	0,84	-0,07	0,15	0,65	-0,04	-0,04	0,85	-0,07	0,16	0,66
CEO Duality	-0,28	0,08	0,0002	0,11	0,06	0,08.	-0,28	0,08	0,0005	0,11	0,06	0,10.
CEO Age	0,01	0,00	0,04	0,00	0,00	0,34	0,01	0,00	0,05.	0,00	0,01	0,36
Employees	-0,13	0,05	0,004	0,01	0,05	0,88	-0,13	0,05	0,006	0,01	0,05	0,88
EBIT	0,00	0,09	0,99	0,00	0,06	0,97	0,00	0,09	0,99	0,00	0,06	0,97
Leverage	0,63	0,40	0,11	-0,28	0,21	0,19	0,63	0,41	0,13	-0,28	0,22	0,20
Investments * Industry Dynamism	9,44	3,25	0,004	-	-	-	9,44	3,37	0,005	-	-	-
Co-investors * Industry Dynamism	-	-	-	6,87	3,17	0,03	-	-	-	6,87	3,29	0,04
Industry dummies	Included			Included			Included			Included		
Year dummies	Included			Included			Included			Included		
Number of observations	342			342			342			342		

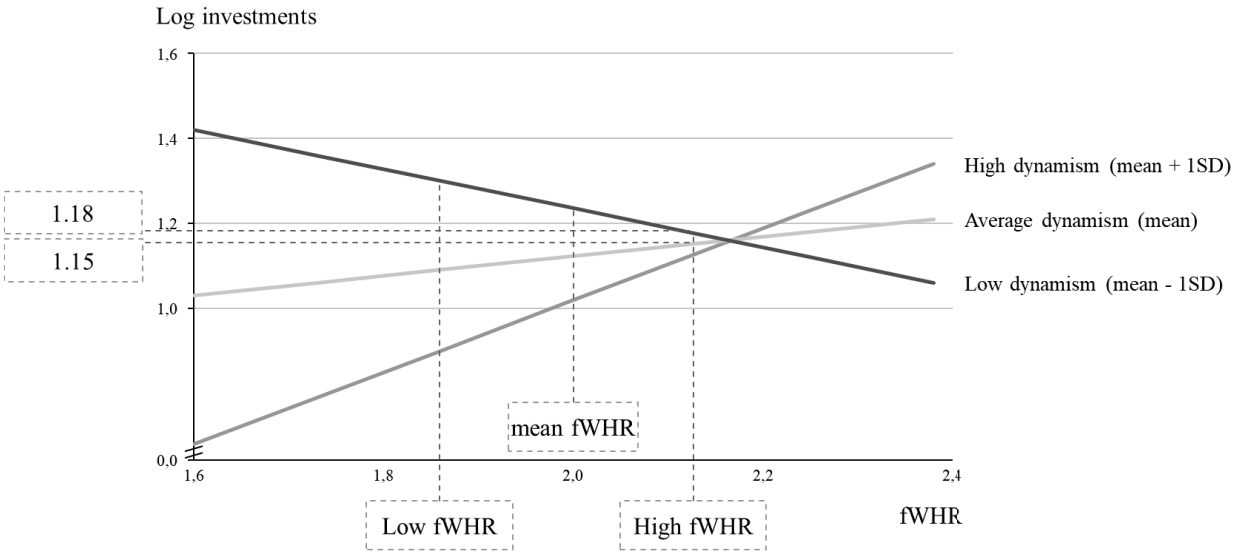
***** p < 0.001 ** p < 0.01 * p < 0.05**

Main Findings

In table 2, model 1 and 2 display the GEE results of H1 and H2: model 1 refers to the number of VC investments and model 2 to the number of co-investors, both moderated by industry dynamism. Model 3 and 4 illustrate the pooled OLS results for H1 and H2, as described in the following robustness section.

Model 1 and 2 illustrate the results for the moderating role of industry dynamism on the relation between fWHR and both number of investments and co-investors. Industry dynamism positively moderates the relationship between fWHR and the number of investments (9.44, p=0.004**), plotted in figure 2.

FIGURE 2 Moderating effect of industry dynamism on number of investments (H1)

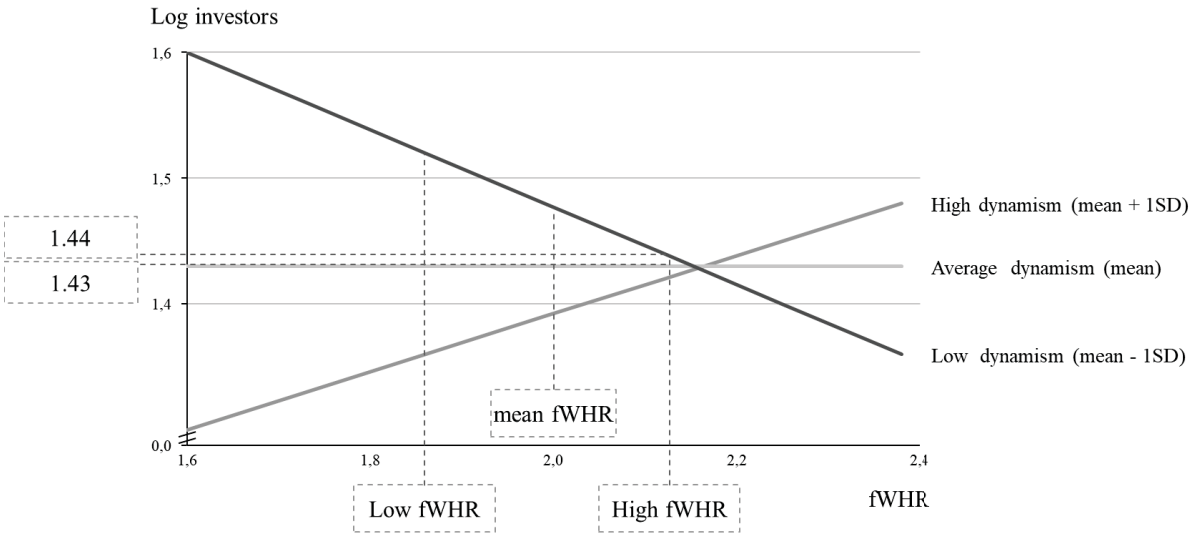


We can interpret two main insights from the graph: Firstly, in low-turbulence environments, the level of testosterone negatively relates to CVC activeness in terms of number of investments. Specifically, we see that in such environments, high-testosterone managers perform significantly less actively than their low-testosterone peers. Alpha CEOs undertake 9% less VC investments in undynamic settings (number of investments (log) of 1.18 vs. 1.30, 1SD above the mean vs. 1SD below the mean). The simple slope test confirms the significance of two out of three plotted lines (mean dynamism and - 1SD). The line representing high dynamism has been determined insignificant by the simple slope test. Interestingly, in contrast to

their alpha peers, CEOs with a low fWHR are much more active in low-turbulence than in average environments – which is not the case for high-testosterone CEOs. In summary, we find that in low-turbulence environments, fWHR is a decisive driver and predictor of firm activeness in terms of VC investments. In such settings, testosterone-fueled CEOs undertake 9% fewer investments than their low-testosterone peers.

Likewise, industry dynamism positively moderates the relationship between fWHR and the number of co-investors (6.87, p=0.03*), plotted in figure 3.

FIGURE 3 Moderating effect of industry dynamism on number of co-investors (H2)



The second graph very much mirrors the findings of above. Again, we can interpret two main insights from the chart: Firstly, in low-turbulence environments, the level of testosterone negatively relates to the average number of co-investors per funding round. We see that in such environments, high-testosterone executives participate in smaller funding rounds with fewer co-investors than their low-testosterone peers. Precisely, alpha CEOs invest alongside 5% fewer co-investors in undynamic settings (number of co-investors (log) of 1.44 vs. 1.52, 1SD above the mean vs. 1SD below the mean). The simple slope test confirms the significance of two out of three plotted lines (mean dynamism and - 1SD), whereas the line representing high dynamism has again been determined insignificant. In summary, we find that in low-dynamism environments, fWHR is a predictor of firm investment behavior in terms of number of co-

investors. In such settings, testosterone-fueled CEOs invest in 5% smaller funding rounds than their low-testosterone peers.

These results support our H1 and H2, stating that low industry dynamism drives a negative relationship between fWHR and both the number of VC investments and co-investors.

Robustness Tests

To guarantee the robustness of our findings, we perform an array of additional analyses and calculate alternative regression models.

Multicollinearity First of all, we prevent potential multicollinearity issues by assessing the variance inflation factors (VIFs). Our VIFs, in this case, range from 1.1 to 6.2 with an average of 2.6. Thus, our values lie well below the accepted threshold of 10 as described by Cohen et al. (2003). Further, we test the stability and plausibility of our coefficients by repeating our regression analyses with subsets of the full sample, following Echambadi et al. (2006). We repeat the regression analyses for our hypotheses ten times with randomly drawn 90% subsets of the sample. The repeated results with our reduced sample excerpts are highly consistent with our previous findings in terms of significance levels, direction, and size. Accordingly, as the results of our regressions remain consistent, the problem of multicollinearity does not alter the results of our study and can be disregarded (Echambadi et al., 2006).

Endogeneity Issues with endogeneity are the result of omitted variable bias, meaning that a variable has not been part of the model although it affects both the explanatory and dependent variables (Wooldridge, 2010). Following Frank (2000), we determine the impact threshold of a confounding variable (ITCV) to address the concern. The analysis illustrates how strong an omitted variable would have to be to invalidate our results. We used the konfound package in R to evaluate our identified link between CEO fWHR and firm investment activity. The result shows that 32.3% (for number of investments) and 9.2% (for number of co-investors) of the estimate would have to be due to bias to overturn our findings – in other words, a considerable

part of our observations would have to be substituted with cases for which the effect is 0. Accordingly, we conclude that omitted variable bias is unlikely to alter our described findings.

Alternative regression models To test our models' robustness, we repeat our analyses on fWHR in relation to the firms' investment activity with a pooled ordinary least squares regression model (pooled OLS) with heteroskedasticity and serial correlation robust standard errors clustered at the year- and firm-level (Arellano, 1987) – see table 2 model 3 and 4. In line with our GEE model, we find that the results are highly consistent in direction, significance level and size. As a result, the previous findings can be confirmed.

DISCUSSION

This study theoretically develops and empirically confirms that the high level of testosterone of CEOs can negatively relate to the company's VC investment activeness in settings where industry dynamism is low. These findings suggest that the negative relationship is not universally valid but, instead, much depends on environmental factors. Specifically, we find that alpha CEOs undertake 9% fewer investments alongside 5% fewer co-investors than their low-testosterone peers in undynamic environments. Yet, we do not find similar significant effects for high-testosterone CEOs when industry turbulence is high. Accordingly, this study identifies below-average turbulence to be the 'lazy spot' for alpha CEOs, where VC investments do not offer enough predictable return or a spot in the limelight to trigger their interest. In sum, the present research provides new evidence on the impact of CEOs' fWHR and testosterone level on the firm's VC investment behavior. We discuss the implications of our findings for theory and practice in the following.

Theoretical and Research-Related Implications

This study makes a contribution to extant research in multiple ways: First of all, we contribute to upper echelons research in open innovation management by offering additional insights on

the antecedents of CVC commitment and scope. This article provides a novel CEO characteristic that may play a decisive role on determining future VC investing activeness by integrating findings from recent research at the interface of biology and management. The CEOs' fWHR predicts a set of masculine behaviors, which – as upper echelons theory suggests – influence company behavior and outcomes. By conceptually deriving and empirically validating the link between facial masculinity and corporate VC investment behavior, we contribute to this theoretical perspective. In a broader sense, we echo the findings of Engelen et. al (2013, 2014), who describe how narcissistic or overconfident CEOs can be harmful for firm innovation or entrepreneurial orientation in specific settings for the same underlying traits we describe here. We provide facial masculinity as novel characteristic and by doing so, we answer the call of Anokhin et al. (2016) pointing out the lack of research in the field of CVC antecedents. Moreover, we reply to the call of Kashmiri et al. (2017) for exploring the innovation implications of CEO characteristics apart from narcissism.

Secondly, we contribute to the growing body of research on testosterone in executives, in which researchers frequently use fWHR as a proxy for testosterone. This emerging literature has focused predominantly on public CEOs: It finds that high-fWHR CEOs deliver higher return on assets (Wong et al., 2011), take on more risk (Kamiya et al., 2019), and are more likely to engage in financial misreporting (Jia et al., 2014). Further research on non-CEO executives describes, for instance, the underperformance of hedge fund managers (Lu & Teo, 2018). Overall, extant research using fWHR focuses mostly on either operational tasks or on financial outcomes. We extend this research by theoretically arguing and empirically presenting that the novel CEO characteristic of a high level of testosterone hinders strategic actions like venture capital investments and impacts collaborative behavior, particularly in undynamic organizational environments. Thereby, we add a strategic perspective on the effects of CEOs' level of testosterone and facial structure.

Last, we extend existing leadership research by accounting for the broader context or environment in which leaders make decisions on behalf of their companies. Our study links physical characteristics to organizational behavior and has advanced leadership research by showing that objective facial metrics of male CEOs in combination with the dynamism of their industry are closely related to firms' venture capital activeness. As this study shows, alpha CEOs undertake significantly fewer investments alongside fewer co-investors than their low-testosterone peers in undynamic settings. Accordingly, the integration of industry dynamism as a moderating variable also answers Nofal et al.'s (2018) call for research on the interface of biology and management, who state that since "[…] most managerial behavior is likely accounted for by the interaction of human biology and environmental factors, additional research should empirically investigate how environment and biology interplay to influence management" (p. 23).

Practical Implications

From the practitioners' viewpoint, this study underscores the influence of CEO characteristics on organizational behavior or decision-making, and how much it varies in different settings. To become a successful leader and realize one's full potential no matter the external setting, high-testosterone individuals must be aware of the consequences of testosterone and harness the positive while mitigating the negative ones. As elaborated above, motivating both fund managers as well as all other employees and stakeholders is crucial for running a successful and valuable VC investment program. Thus, being aware for example of one's tendency to nullify others' opinions is the first step for alpha CEOs towards more employee satisfaction, collaboration, and idea sharing. Likewise, it can be beneficial for team members to be aware of typical testosterone-related behaviors of their peers, subordinates, or superiors to better understand their motivations and incentivize or encourage more team-oriented behavior. Finally, also for executive recruiters or decision boards it is beneficial to be aware of testosterone-related traits

to balance out TMT members' different characteristics, as well with a focus on increasing diversity among leadership teams.

Limitations and Avenues for Future Research

This article has multiple limitations and offers further opportunities for future research. First, there is no measure of CEO testosterone exposure available, but only a measure of facial proportions to predict the variety of masculine traits. Ideally, one would draw saliva and serum samples from the respective CEOs to assess the biochemical composition and (base) testosterone content. Unfortunately, it is unlikely that this data will ever be available to us or other researchers. Additionally, it must be pointed out that detecting the effects between investment behavior and executive appearance (and underlying hormone composition) may require even more complex study designs and different methodological paradigms. In this article, we aimed to illuminate the relationship of CEO testosterone and corporate VC investment behavior – however, this may be more complex than initially envisioned. Thus, if CEOs with a high fWHR are generally assumed to be 'bolder executers', they might be more likely to be hired by companies with higher budgets for less predictable investments. The way the CEO looks could indeed be a self-fulfilling prophecy. Finally, we would like to note that the sample CEOs were mostly Caucasian, meaning this study's findings might not be generally applicable to all ethnicities. Therefore, future researchers could extend this study's scope to other cultural contexts.

Testosterone-related management research is not only a highly thought-provoking topic that matches currently discussed topics around the 'new normal' of executives, diversity and feminism – it also offers indefinite opportunities for future research. Building on this study, it would be of particular interest to assess further influencing factors on the antecedents of firm investing behavior. Wong et al. (2011), for instance, analyzed the effects of CEOs fWHR on their firms' financial performance, moderated by the cognitive capacity of their leadership team. Team-related aspects such as testosterone-diversity of the team are highly relevant research

opportunities to address. By doing so, future scholars could illuminate the most fruitful combinations of high vs. low-testosterone CEOs with the other high vs. low-testosterone TMT members. According to the literature on homophily, the CEO would prefer his TMT members to be of the same kind (Kamiya et al., 2019). However, based on the negative testosterone-associated traits mentioned in this article, a rather diversified set of characters in the team, also including different genders, could be the most productive mix. Moreover, while this study focuses entirely on high-testosterone CEOs and their related behavior, another interesting angle is of course the low-testosterone counterpart. As can be derived from our model, low-testosterone CEOs undertake significantly more VC investments in undynamic than in average environments. To develop an understanding for the associated character traits which drive this observation would be a very interesting additional angle. We leave this as a future research agenda.

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5.4 Research study III

THE GREAT GAMBLE OF ALPHA CEOS - HOW TESTOSTERONE-FUELED CEOS NEGOTIATE HIGHER INCENTIVE PAYMENT COMPONENTS

ABSTRACT

This article offers a biological perspective on how CEOs' physical characteristics drive their level and structure of compensation. Utilizing the facial width-height-ratio (fWHR) as a proxy for testosterone, we introduce a theoretical model that illuminates the relation between CEOs' testosterone levels and their level of compensation in terms of both total and incentive compensation. Due to several biases, determining a CEO's income is not an entirely rational process. Instead, CEOs possess a significant impact on their compensation and can negotiate it favorably. This study addresses both the ambiguity of previous research on how CEOs' levels of testosterone work and the growing body of research on determinants of CEO pay, other than quality. We propose that the effect of CEO testosterone depends on their flexibility to tailor their compensation package. We assume that in more flexible industries with low industry competitiveness, their risk-seeking behavior leads them to negotiate convex contracts while overestimating the value of their incentive claims. This, we predict, arbitrages the effect of their result-seeking behavior to secure higher total compensation. To confirm the arguments empirically, we conduct our study based on publicly traded US S&P 500 firms between 2010 and 2014. Our sample includes 4,317 firm-year observations with 390 companies and 493 male CEOs. This study contributes to compensation theory by adding a biological perspective to the CEO-driven determinants of compensation, while further illuminating the contextual factors which affect CEO compensation design. In addition, this article contributes to research on testosterone in executives by showing that a high testosterone level affects directors' decision-making, thereby, adding a governance perspective to the effects of executives' testosterone.

INTRODUCTION

A typical CEO used to make 20 times the salary of his or her average employee in the 1950s – this number increased to 361 times in 2018 (Hembree 2018). Therefore, executive compensation has long triggered the attention of media, practitioners, and researchers. It has become a topic of heated debates (Bebchuk and Fried 2004), with researchers and practitioners alike questioning whether CEO compensation is still justified, equitable, and even moral (Li et al. 2021). And although CEO compensation and incentivization decisions are subject to careful assessment of his or her quality and contributions to firm success, a growing stream of research declares that setting the CEO's income is not an entirely rational or objective process (O'Reilly et al. 2014). Instead, CEOs possess a significant impact on the level and structure of their compensation and can negotiate it most favorably based on their risk preferences beyond what is objectively justified. Additionally, decision makers are prone to a number of biases: In particular, research describes the significant positive impact of biological signals, such as attractiveness, level of voice or height (Li et al. 2021).

At the recently emerging link of management and biology research, executives' facial structure and the level of testosterone it reflects, has been shown to be a driver of their (managerial) behavior. Thus, building on extant biology and psychology studies, researchers use the facial width-height-ratio (henceforth fWHR), which is a proxy for the individual's facial masculinity and level of testosterone, to derive insights about their behavior (Jia et al., 2014). Based on this metric, researchers describe fWHR/facial masculinity-related behaviors such as aggressiveness, risk taking, and egocentrism (Carré and McCormick 2008; Haselhuhn and Wong 2012; Stirrat and Perrett 2010), but also task-related behaviors like financial decision making or misreporting (Jia et al., 2014). Contributing to this novel and fruitful research avenue at the linkage the above-mentioned streams, we ask the question how male CEOs' facial masculinity is associated with the level and structure of their compensation. On the one hand, high-testosterone 'alpha CEOs' are highly result-seeking individuals, who with their natural leadership

and goal-directed behavior succeed to accomplish an overall higher compensation package. As Li et al. (2021) confirm, individuals who show a higher level of confidence, elicit more respect, have great social and communication skills, and immediately start building interpersonal relationships, are the ones who accomplish to increase their compensation. But on the other hand, alpha CEOs risk-seeking behavior drives the alpha CEOs' compensation packages to be structurally different, due to their stronger preference for incentive pay components. Their optimistic behavior and overconfident judgement contribute to their fondness of performance-based compensation components, while they underestimate the sheer possibility of not meeting one of those targets. Interestingly, however, research finds this behavior to be disadvantageous, as overly optimistic CEOs who accept risky compensation packages may end up with lower total compensation due to the overestimation of their incentive claims (Otto 2014). Further, an additional structural factor that influences the compensation of CEOs and the impact of different determinants is the environment the company operates in (Malul and Shoham 2013).

In industries with low competitive intensity, CEO salaries are generally higher (Jung and Subramanian 2017) and leave CEOs with more flexibility to negotiate and tailor their compensation packages to their preferences. Therefore, we assess the impact of the CEOs level of testosterone on the level and structure of his compensation, and specifically determine the role of industry competitiveness to resolve tensions around the significance of result- versus risk-seeking behavior, depending on the negotiation flexibility for compensation contracts.

Specifically, we predict that alpha CEOs with their result-seeking behavior possess the ability to generally negotiate a slightly higher total compensation. In less competitive environments, however, their risk-seeking behavior diminishes this effect as the higher incentive pay does not lead to a higher total compensation.

To confirm our arguments empirically, we construct a sample based on publicly traded US firms listed in the S&P 500 index, between 2010 and 2014. Our sample includes 4,317 firm-year observations with 390 companies and 493 male CEOs. Our study combines company data

from the COMPUSTAT database, pictures of the sample CEOs to determine their fWHR score, and CEO compensation data from the ExecuComp database.

This article contributes to extant research in three major ways. First, our study contributes to the CEO compensation literature and offers a biological perspective as determinant of CEO compensation. Traditionally, CEO compensation is examined in the context of agency theory (Rekker et al. 2014), where the incentives of the CEO are aligned in order to serve the interests of the shareholders. We contribute to the growing body of research which takes the opposite perspective and assesses antecedents or determinants of compensation from a CEO view. We add facial masculinity, reflected in facial structure, with the associated result- and risk-seeking behavior as novel characteristic driving CEO compensation. In doing so, we answer the call of Devers et al. (2007) to examine alternative theoretical perspectives of determinants of CEO pay.

Secondly, this article contributes to the emerging body of research on testosterone in executives and its consequences. This emerging stream of literature has focused largely on public CEOs and their impact on firm behavior and performance: Researchers find for instance that high-fWHR CEOs achieve a higher return on assets (Wong et al., 2011), take on higher risk (Kamiya et al., 2019), and are more likely to engage in financial misreporting (Jia et al., 2014). We extend the more "inward-facing" perspective of this research, such as governance-related aspects, by theoretically arguing and empirically presenting that the novel CEO characteristic of a high level of testosterone influences the level and structure of compensation, particularly in organizational environments with low competitiveness.

Finally, extant literature has emphasized the importance of illuminating the contextual factors which affect CEO compensation design, such as the industry the firm operates in (Devers et al. 2007). Our study links physical characteristics to the process of determining CEO pay, showing that it is closely related to the competitiveness of the firm's industry. Thus, this

study not only contributes to the general determinants of CEO pay but also confirms the importance of the environmental setup, in which respective character traits play out differently.

THEORETICAL BACKGROUND AND HYPOTHESES

Drivers of CEO Compensation

> Too often, executive compensation in the U.S. is ridiculously out of line with performance. (Buffet 2015)

What determines the level of CEO compensation and the structure of the package? According to economic models, CEO renumeration should reflect their marginal product, i.e., the sum of 1) the performance benefit the company gains from being led by this CEO rather than the best alternative candidate, plus 2) how much it would cost the company to hire this alternative candidate (Gomez-Mejia et al. 1987). In simple terms, the CEO's compensation should reflect an evaluation of his or her quality (Nair et al. 2021). Extant corporate governance literature, however, has always acknowledged the prevailing information asymmetry regarding CEO quality, while assuming that the board of directors succeeds to close this information gap with its vigilant observation and monitoring of the CEO (Fama and Jensen 1983). Yet, more recent research has pointed out the difficulties directors face, hindering them to effectively assess the true quality of a CEO (Boivie et al. 2016):

First, although company performance is a widely used metric to determine CEO quality (Finkelstein and Boyd 1998), it is challenging to assess whether it was truly driven by the CEO's own actions and decisions. Instead of the CEO's own contributions, firm performance could be driven by industry fluctuations (Holmstrom 1982), actions of the previous CEO (Graffin et al. 2013), contributions of other executives (Boeker 1992), and even sheer luck (Fitza 2017).

Second, while one may expect directors to monitor every step of the CEO, they only spend a very limited amount of time on this highly complex task (Nair et al. 2021). Serving as

director on the board of a public company is not a full-time position. Evidently, many directors are committed to another full-time job or serve on several boards simultaneously (Boivie et al. 2016). The resulting overflow of information which directors are required to process can result in stress, cognitive overload, and reduced performance (Oldroyd and Morris 2012). Extant research confirms the diminished effectiveness of directors driven by their straining professional lives (Fich and Shivdasani 2006).

Third, numerous researchers have pointed towards the cognitive biases, which directors are subject to. The most prevalent ones include social comparison (O'Reilly et al. 1988), pluralistic ignorance (Westphal and Bednar 2005), ingroup favoritism (Zhu and Westphal 2014), group polarization (Zhu 2013), and the contrast heuristic (Graffin et al. 2013). Both cognitive overload and evaluative uncertainty, combined with little or limited information initially available about the CEO's performance, drive a higher vulnerability to biases (Boivie et al. 2016), potentially influencing the directors' decision on CEO compensation significantly. Additionally, a recent stream of research identified biological signals such as beauty or voice as drivers of CEO compensation. Accordingly, instead of determining the compensation package rationally, boards are in favor of attractive individuals (Li et al. 2021) with a masculine voice (Nair et al. 2021).

All of the above poses a sweet spot for incoming CEOs who are eager to present themselves in a positive light and negotiate their compensation most favorably. And based on the observations above, a wealth of extant research describes that CEOs can influence the board to develop policies to his or her advantage (O'Reilly et al. 2014). Accordingly, CEOs often have a significant impact on his or her level and structure of compensation (Bebchuk and Fried 2004). For example, numerous studies have shown how CEO can increase their compensation beyond what would be objectively justified by integrating themselves with the directors or providing rewards to them (Belliveau et al. 1996). O'Reilly and Main (2010), for instance, show that CEOs who had more opportunities to influence the board achieved a higher level of

compensation. Other CEOs, though, are especially intrinsically motivated and prepared to trade a share of their income for a higher budget for CSR activities (Rekker et al. 2014). In sum, it is evident, that CEO compensation is not an entirely rational process and CEOs are able and willing to use their positional power with their company's board to shape their most desirable outcome - mostly to secure outstanding compensation packages (Shin 2016).

Facial Structure and Testosterone

As Nofal et al. (2018) stated in their recent literature review, the role of biology in management is still new and fragmented. Nevertheless, the past decade has seen a significant increase along the developing interface of biology and management, given that biology impacts all aspects of human behaviors, such as the ones of CEOs. Therefore, this aspect as an explanation for managerial behavior is a central piece of the puzzle (Nofal et al. 2018). Recent research linking management and biology has found a variety of physical characteristics to drive managerial decision-making and behavior. Precisely, extant research finds facial structure or masculinity of males to be a driver of a specific set of character traits (Jia et al. 2014). Facial masculinity is the result of craniofacial bone growth during the pubertal stage, which is driven by testosterone administration (Lefevre et al. 2013). This enables researchers to investigate individuals' testosterone levels via facial structure, gaining an understanding of the positive and negative related character traits. Evidence from both laboratory and naturalistic settings demonstrates that high testosterone levels predict aggressiveness (Christiansen and Winkler 1992), risk-seeking (Apicella et al. 2008), egocentrism (Wright et al. 2012) and untrustworthiness (Wong et al. 2011). Further psychological consequences of testosterone-fueled managers are diminished perspective-taking, overconfidence, and the tendency to objectify others by perceiving them through a lens of self-interest (Galinsky et al. 2008a). However, it appears that research has had a primary focus on socially undesirable correlates of high testosterone. Less is known about its socially beneficial consequences which must have driven the evolutionary selection of high

testosterone. Wong et al. (2011), for instance, reason that aggressive behavior intended to dominate other individuals or obtain a resource is often associated with a psychological sense of power. This linkage between power and testosterone is essential, as powerful people incline to view their environment and challenges more optimistically, apprehend opportunities, and focus on the big picture rather than the details (Galinsky et al. 2008a) Individuals with a high sense of power are also more likely to attend to task-relevant information (Overbeck and Park 2001), and to tackle activities and behaviors that are in line with primary goals (Galinsky et al. 2008a). The research at the interface of biology and management, including the measurement of facial masculinity, is relatively recent. Nevertheless, in these examples, facial structure and the underlying testosterone level were identified as a driving force of personal and managerial behaviors that can be expected to have a significant impact on the level and structure of CEO compensation, therefore also being of relevance for our study's purpose.

RESEARCH MODEL

Most extant research in the field of compensation theory takes the perspective of an agency theory model (Bebchuk and Fried 2004), exploring how compensation systems can be designed by its owners, i.e., the board of directors, to incentivize CEOs and align the respective interests. On the other hand, an emerging body of research adds to compensation theory from the perspective of the CEO instead of the directors, describing that also CEOs can influence the board to their advantage through a number of mechanisms. Yet, research on whether personality is a factor in the amount and structure of the compensation package of the CEO is still limited. To add to the work of Li et. al (2021), who describe how CEO narcissism impacts the structure of compensation, and answer their call for further research in terms of CEO characteristics, we contribute a biological perspective. Recent advances of research on biology and management describe that CEOs' physical characteristics, specifically the testosterone level reflected in their facial structure, drives a plethora of related character traits and their managerial decision

making (Jia et al. 2014). We want to determine the impact of testosterone-related traits on the level and structure of CEO compensation. To do so, we initially discuss the respective consequences of testosterone and illuminate their particular role in industries with low competitive intensity, in which CEOs find even more room for flexibly negotiating their compensation package (Jung and Subramanian 2017).

Impact of Testosterone on CEO Compensation

A wealth of research has demonstrated that the CEO often has a significant ability to impact his or her level and structure of compensation (Bebchuk and Fried 2004). The directors' limited time to process information, a variety of potential biases and their weakness towards biological signals gives CEOs room for negotiation. Narcissist CEOs, for instance, are likely to be evaluated benevolently as they initially present themselves as the prototypical stereotype of a leader – dynamic, self-confident, and visionary (O'Reilly et al. 2014). As research suggests, narcissist CEOs have a strong sense of entitlement and are willing to aggressively take what they believe is owed to them (Bogart et al. 2004). Their assured body movements and noticeable confidence create a strong, positive impression on those who meet them for the first time. In addition, they use their ability to sell their ideas to others to influence the directors' compensation decision (O'Reilly et al. 2014).

Extant leadership research describes that innate characteristics separate successful leaders from unsuccessful ones (Wong et al. 2011) – this is not only the case in terms of company goals but also personal ones. As elaborated above, testosterone-fueled executives feel a greater sense of power, stimulating a certain kind of behavior. Kipnis (1976) theorized the metamorphic consequences of possessing power as one of the first empirical social psychologists. Research suggests, that the effects of power come to reside psychologically within a person as they are transformed by the experience of it (e.g., Bargh et al. 1995, Chen et al. 2001, Galinsky et al. 2003, Galinsky et al. 2008b).

In what follows, based on the metamorphic effect of the testosterone-induced sense of power, we link the CEO's level of testosterone with their level and structure of compensation. First, to investigate a CEO's ability to negotiate or achieve higher total compensation, we assess the most frequently used measure for total compensation TDC1 (Li et al. 2021). As seen above, CEO compensation is not an entirely rational process and, instead, depends greatly on the self-portrait the CEO succeeds to illustrate. We summarize these traits as result-seeking behavior: Individuals who show a higher level of confidence, elicit more respect, have great social and communication skills and immediately start building interpersonal relationships, are the ones who accomplish to increase their compensation (Li et al. 2021). Second, to understand whether the compensation package of alpha CEOs is structurally different to others', we assess their level of incentive pay (Aabo et al. 2021). Research suggests that managers who are extremely overconfident, accept highly convex contracts with high performance-based compensation components (Gervais et al. 2011). An increasingly prominent stream of research describes that these CEOs are more likely to accept very option-heavy compensation packages (Cooper et al. 2011). The performance components are overvalued by the overconfident CEO, who believes excessively that his decisions will lead to extraordinary outcomes. We group these traits as risk-seeking behavior: Both overconfidence and optimism are strong drivers of a preference for incentive pay (Gervais et al. 2011).

Building on the previously established association between high testosterone and its consequences in terms of result-seeking and risk-seeking behavior, we predict that alpha CEOs possess traits and behaviors that empower them to achieve larger total compensations than their low-testosterone peers and have a stronger preference for incentive pay components. There are four main underlying drivers for this assumption:

"Natural leadership." First, alpha CEOs make the impression of natural leaders: High-testosterone managers tend to be uninfluenced by others (Galinsky et al. 2008b). In contrast, feeling powerless – i.e., when the own outcomes are determined by others – means being or

feeling constrained. A powerful CEO is capable of motivating and influencing a group of subordinates or peers to contribute to the success of a shared purpose (Wilderom et al. 1999), which is fundamental for his ability to nudge directors in favor of his compensation package. According to Galinsky et al. (2008a), the alpha CEOs are able to see, create, and articulate a vision of the world, which inspires and unites others. This vision can be, for instance, the image of themselves as capable leader worthy of an above-average compensation. Presenting themselves self-confidently allows them to have more influence over others, elicit more respect and increase the level of performance others expect them to have (Guillén et al. 2018). Their words and body language transmit a level of self-assurance, that leaves a positive impression with those who meet them (O'Reilly et al. 2014). Entirely detached from their actual quality, alpha CEOs successfully convince directors or other decision-makers of their capability which is key to increase their compensation beyond what is justified (Belliveau et al. 1996). Therefore, we expect high-testosterone CEOs to succeed in influencing directors in their favor and securing an above-average total compensation.

"Goal-directed behavior." Second, alpha CEOs show more goal-directed behavior: The testosterone-induced sense of power they possess channels the individual's behavior and thoughts towards achieving their goal – such as an above-average compensation – independent of external factors or situations (Bargh et al. 1995, Chen et al. 2001, Galinsky et al. 2003). Additionally, they have a strong focus on global rather than local features of stimuli (Guinote 2007). The testosterone-driven managers concentrate on the bigger picture as they are able to process information at higher levels of abstraction (Smith and Trope 2006). Accordingly, they can handle a flood of information and perceive patterns better. Thus, we posit, the alpha CEO will not sit back and naively wait for his package served on a silver plate. As described above, the personal exchanges between the CEO and other firm stakeholders determine the level of compensation. With his goal of personal enrichment in mind, he precisely understands the importance and ties between different stakeholders, how to integrate himself with the board and

what to offer, in order to maximize his target (O'Reilly and Main 2010). In sum, their effective goal focus enables the high-testosterone CEOs to perfect their influential networking game to maximize their compensation package.

In summary, the kind of result-seeking behavior in high-testosterone CEOs enables them to express a higher level of confidence, elicit more respect, have great social and communication skills, and understand the invisible social ties and the power of networking. Accordingly, we propose that alpha CEOs succeed to accomplish an overall higher compensation package by hypothesizing:

Hypothesis 1 (H1): CEO fWHR is positively related to total CEO compensation.

Additionally, we assess whether the testosterone-related risk-seeking behavior drives the alpha CEOs' compensation packages to be structurally different, due to their stronger preference for incentive pay components.

"Optimistic behavior." Third, alpha CEOs are risk-tolerant optimists: The alpha males' testosterone-induced sense of power translates straight into action (Galinsky et al. 2008c), often without considering potential downsides (Aabo et al. 2021). High-testosterone executives have a higher tendency to react in an actionist way in everyday situations like an emergency. As research suggest, they jump to action to help others in distress (Galinsky et al. 2008b) while low-testosterone peers rather sit and wait, looking to other non-responders to confirm their own behavior and lacking a sense of responsibility. This tendency to 'jump to action' regardless of downsides or risks is a universal characteristic – not just in emergencies but also in case of compensation opportunities such as performance components, which may or may not pay off. The alpha CEOs are willing to take the chance, even at a risk, while their low-testosterone peers are likely to miss out as they fear potential hazards and threats they see (Anderson and Galinsky 2006). A wealth of extant research, for instance, determines overconfident CEOs, driven by their optimism and risk-ignorance, to undertake activities such as value-destroying merger and

acquisitions, overinvestments or empire building, which all lead to shareholder wealth loss (Cooper et al. 2011). In accordance with this, Aabo et al. (2021) describe that overconfident CEOs who receive high incentive compensation are associated with an increase in corporate risk of roughly 5.4%. Furthermore, alpha CEOs do not only have short-term benefits in mind but specifically tackle long-term opportunities for future growth and success (Galinsky et al. 2008c). While low-testosterone CEOs, with their inferior sense of power, tend to sit back unresponsively and leave difficult decisions to their successors (Galinsky et al. 2008b), alpha CEOs tackle opportunities actively, with their positive and actionist nature convincing others to join the ride. In sum, optimistic alpha CEOs with their senses wide awake for opportunities and willing to take risks, will have a preference for highly convex compensation contracts with a great potential incentive pay.

"Overconfident judgment and diminished perspective-taking." Finally, alpha CEOs tend to confidently overvalue their own contribution to successful outcomes. One consequence of a high level of testosterone is the alpha CEOs' tendency to ignore others' perspectives while overweighing their own, driving them even more toward incentive pay components within their overall package. Their testosterone-induced sense of power troubles their social attentiveness and places a blind spot on the contributions of others (Galinsky et al., 2008a). Consequently, the CEO's ability to see things from another person's point of view is weakened significantly. As extant research elaborates, alpha CEOs are not only less able to interpret their peers' facial expression of emotions, but are also less influenced by them (van Kleef et al. 2006). Likewise, dominant CEOs are likely to nullify the contribution of colleagues and to restrict the flow of information (Diesing 1962). Unsurprisingly, they are on the other hand extremely confident in terms of their own judgments and decisions (Fast et al. 2012). This kind of behavior translates into the devaluation of the contribution of others while overvaluing own contributions and claiming the performance-based compensation for it. Similarly, O'Reilly et al. (2014) describe narcissistic CEOs, with their comparable sense of superiority, are less concerned with

maintaining fair and equitable compensation schemes but truly believe the reward is theirs. This, in sum, contributes to the alpha CEOs' preference and even entitlement to high incentive pay components.

In conclusion, next to the tendency of diminishing the contribution of their peers, alpha CEOs have an imperturbable sense of optimism, underestimating the sheer possibility of not meeting a performance target - rather a bird in the hand than two in the bush is just not for them. Accordingly, we propose that alpha CEOs succeed to negotiate and accomplish a higher incentive pay by hypothesizing:

Hypothesis 2 (H2): CEO fWHR is positively related to CEO incentive pay.

The Moderating Role of Industry Competitiveness

As elaborated above, CEO talent is not the only determining factor for their compensation. An additional structural factor that influences the compensation of CEOs is the environment their company operates in (Malul and Shoham 2013). According to extant research, a company in an industry with low competitive intensity has the potential to generate higher profits than in a competitive market. Oligopolists have sufficient scale to create strategic options of their own and are less dependent on powerful buyers or suppliers (Finkelstein and Boyd 1998b). Typically, CEOs are then compensated for the abnormal profits resulting from the oligopolistic market structure (Malul and Shoham 2013). As a consequence, firms in less competitive environments tend to pay higher CEO wages (Jung and Subramanian 2017). Kedia (2006) confirms that in industries of strategic complements, CEOs earn significantly higher incentive pay, whereas the opposite is true for industries of strategic substitutes. In fact, research demonstrates that companies may change the structure of the incentives depending on the market competition (Raith 2003). Beiner et al. (2011) describe, for instance, that competition promotes a culture of good corporate governance. Accordingly, competition increases accountability and transparency, leading to better corporate governance and flatter incentive schemes.

Building on the previously described result-seeking and risk-seeking behaviors in association with high testosterone, we predict that alpha CEOs' particular behaviors and preferences will lead them to negotiate higher incentive pay components – however, without achieving larger total compensations than their low-testosterone peers in less competitive industries. These assumptions are based on the previously described behaviors:

"Optimistic behavior & overconfident judgment and diminished perspective-taking."

As elaborated earlier, high-testosterone CEOs possess a strong tendency to 'jump to action' regardless of downsides or risks. Optimistic alpha CEOs with their senses wide awake for opportunities and willing to take risks, will prefer highly convex compensation contracts with a great potential incentive pay. This effect will come into play more strongly, the more flexibly the compensation can be negotiated. Moreover, alpha CEOs confidently overvalue their own contribution to successful outcomes while devaluating the contribution of others. Again, the overvaluation of own contributions and boldly claiming the performance-based compensation for it can manifest more strongly in less competitive industries with more negotiation flexibility. In sum, we expect less competitive industries to leave CEOs with more room for negotiation and allow them to shape their payment components more flexibly according to their preferences. We propose that alpha CEOs with their risk-seeking behavior will successfully negotiate a higher level of incentive pay, especially in less competitive industries, by hypothesizing:

Hypothesis 3 (H3): CEO fWHR is positively related to CEO incentive pay when industry competitiveness is low, while there are no such effects when industry competitiveness is high.

"Natural leadership & goal-directed behavior." Again, high-testosterone CEOs possess the ability to nudge directors in favor of their compensation package driven by their result-seeking behavior. Presenting themselves self-confidently allows them to have more influence over others. Accordingly, alpha CEOs successfully convince directors or other decision-makers

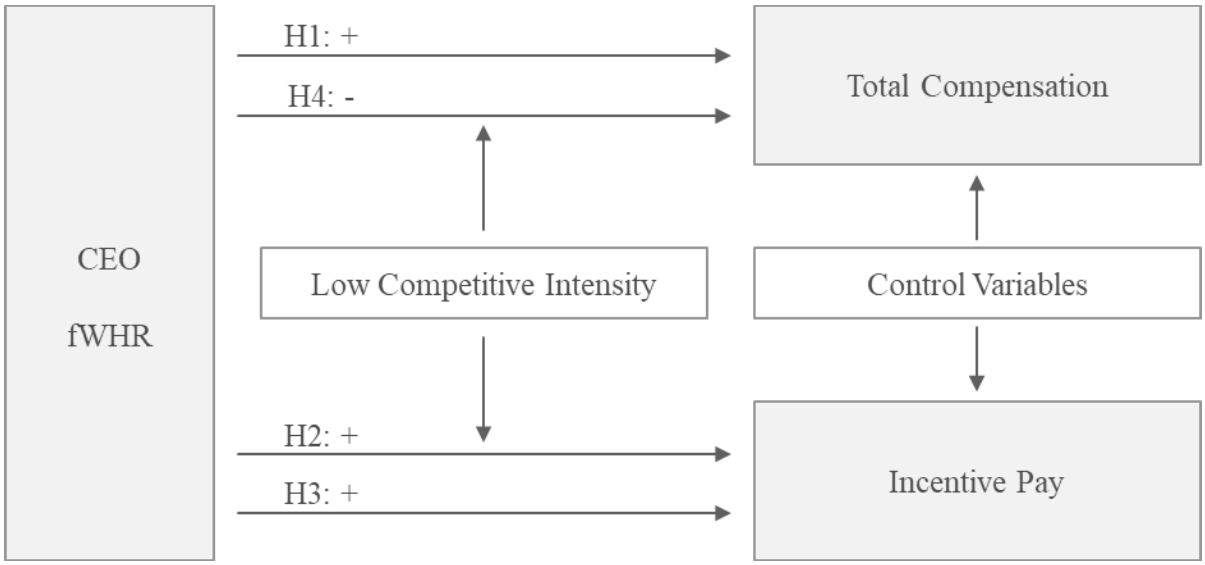
of their capability, which is key to increase their compensation beyond what is justified (Belliveau et al. 1996). They precisely understand the importance networking and the ties between different stakeholders, and will integrate themselves with the board accordingly, in order to maximize their target. Interestingly, however, extant research finds that the positive effect of this kind of behavior can be demolished or overthrown by the risk-friendliness of optimistic CEOs. As described above, optimistic alpha CEOs tend to believe that good outcomes are more likely than they really are, overestimating the probability of the firm's and their own success. Accordingly, they overestimate the value of their compensation claims by overestimating the probability that these outcomes will be realized – and, thus, accept highly convex compensation packages (Otto 2014). Otto (2014) describes that optimistic CEOs receive lower total compensation as sophisticated principals take advantage of their behavior and adjust the compensation contracts accordingly. Thus, too much overconfidence is detrimental to the alpha CEO, who is exposed to excessive risk by accepting such packages (Gervais et al. 2011). Heaton (2002) confirms this assessment by stating "the interests of principals may be served best by the design of mechanisms that exploit managerial irrationality rather than squash it. For example, principals may design incentive mechanisms that underpay irrational agents by exploiting the agents' incorrect assessments of their ability or the firm's risk". In sum, this stream of research shows how an unbiased principal can compensate an optimistic agent 'cheaply' and arbitrage the convex contract, as the optimist overestimates the claims' future payoffs. Firms can take advantage of the CEO's irrational behavior and construct a compensation package with which both parties believe to be better off – but of course only one really is (Gervais et al. 2011). Accordingly, we find that the result- and risk-seeking traits of alpha CEOs do work perfectly in the same direction, as they succeed to secure a very high potential compensation – as anticipated by the alpha CEO –, inflated by unrealistic performance-based components. But the total compensation they end up realizing is a different story, showing that a bird in the hand rather than two in the bush might have been a better deal after all. Accordingly, we expect that especially in less

competitive industries, in which alpha CEOs are more flexible to tailor highly risky compensation packages based on their preferences, they fail to earn an overall higher total compensation, by hypothesizing:

Hypothesis 4 (H4): CEO fWHR is negatively related to total CEO compensation when industry competitiveness is low, while there are no such effects when industry competitiveness is high.

Figure 1 depicts our research model.

FIGURE 1 Overview of Research Model



METHODOLOGY

Sample and data sources

To explore our hypotheses, we constructed a sample of publicly traded US firms, listed in the S&P 500 index, between 2010 and 2014. We chose the respective timespan for its absence of major financial crises or other altering environmental circumstances and focus on large, public companies to ensure high data availability and accuracy. We collected all financial indicators and company data for our sample firms from the COMPUSTAT database. Additionally, we matched the company data with executive-level compensation and tenure information from the ExecuComp database, which was required to construct the dependent variables as well as some

of the control variables. Lastly, we constructed the pictorial database to determine the fWHR score for the male CEOs in our sample. We identified high quality pictures of the CEOs preferably on former annual reports, the company website, or, if otherwise not found, via Google Image Search.

After excluding all entries with missing data, our sample includes 4,317 firm-year observations with 390 companies and 493 male CEOs. The sample size was slightly limited by the data availability of ExecuComp: When filtering for the S&P 500 index in our given timeframe and matching it with the ExecuComp data for male CEOs only, we received 442 unique companies. For 4 of these, industry information (competitive intensity) could not be determined, leaving us with a list of 438 companies. Finally, the remaining observations were lost due to excluding entries with missing data, resulting in our 4,317 firm-year observations with 390 companies and 493 male CEOs.

Measures

Independent variable. We measure our sample CEO's tendency towards masculine behavioral traits described above via their facial proportions, "an unfakeable facial feature" (Jia et al. 2014). As a proxy for testosterone, the facial width-height-ratio (fWHR) has been increasingly applied in management research, such as in the analysis of firm CEOs by Wong et al. (2011), Jia et al. (2014) and Kamiya et al. (2019). Lefevre et al. (2013) have particularly validated fWHR as an adequate proxy for testosterone, stating that fWHR has a significant positive correlation with saliva-assayed testosterone in men, and is, thus, superior to alternative facial masculinity measures.

To construct the pictorial database for our sample CEOs, we searched each CEO in previous annual reports or on the company website. In case no picture could be found, we used the executive's full name plus company name to find the best available portrait on Google Images.

Facial masculinity, i.e. relative width of the face, is the outcome of a male's craniofacial bone growth driven by his testosterone level during adolescence (Verdonck et al. 1999). Therefore, a person's fWHR will not change over a lifetime, which makes it irrelevant whether the obtained picture is fairly recent or older. Moreover, in fWHR research it is common to exclude women from the sample, as due to confounding effects of other hormonal factors, for them testosterone is less directly related to facial morphology (Lefevre et al. 2013).

We identified the best photographs in terms of resolution, and whether the CEO is forward facing with a lightly smiling or neutral expression. Subsequently, we determined the distance between the two zygons (bizygomatic width), i.e., the cheekbones, and the distance between the upper lip and the highest point of the eyelid (height of upper face). The resulting ratio of height and width is the fWHR. The mean fWHR of our sample executives is 1.99, which is in accordance with the observed values in extant research such as Wong et al. (2011) with a mean of 1.96 or Jia et al. (2014) with a mean of 2.01. Lastly, we have included age as control variable, as clinical studies have discovered that testosterone levels in males decrease over time (Feldman et al. 2002).

Dependent variables We assess the CEOs' total compensation as dependent variable to not only understand whether high-testosterone CEOs earn more than their low-testosterone peers, but especially to determine whether higher incentive pay will in fact lead to higher total compensation. For the CEOs' level of total compensation, we utilized the variable TDC1 from the ExecuComp database as seen in the vast majority of extant research (Li et al. 2021). TDC1, i.e., total compensation as calculated under the 1992 reporting format, includes the executive's salary, bonus, and long-term compensation. The latter is calculated as the value of restricted stocks granted, the value of stock options granted, payouts from long-term incentive plans, and all other compensation such as contributions to benefit plans or severance payments (Rekker et al. 2014). ExecuComp is a frequently used database including a battery of different compensation items on more than 12,500 executives (top five executive officers per company) in

companies included in the conventional indexes like S&P 500. Since wage distribution is heavily skewed (Gerhart et al. 2009), in accordance with previous researchers, we use the natural logarithm of total compensation (Brick et al. 2006).

CEO incentive compensation has grown both in absolute value and in percentage of the overall CEO compensation during the last decades (Murphy 2013). Moreover, as elaborated above, research describes high-testosterone individuals as optimistic, risk-taking and overconfident. This brings up the question, whether high-testosterone CEOs would generally be fonder of variable payment components, with their hopes high to exceed agreed performance targets. We used incentive compensation data from ExecuComp, which includes bonus, restricted stock grants and value of option grants (Aabo et al. 2021). In line with previous researchers, we use the natural logarithm of incentive compensation (Brick et al. 2006).

Moderator One structural factor that influences the compensation of CEOs is the environment their company operates in (Malul and Shoham 2013). According to extant research, a company in an industry with low competitive intensity has the potential to generate higher profits than in a competitive market. And since less competitive environments tend to pay higher CEO wages (Jung and Subramanian 2017), we expect these industries to leave CEOs with more room for negotiation and allow them to shape their payment components more flexibly according to their preferences. We therefore chose competitive intensity as our focal moderator. To determine the competitive intensity of an industry, we use the well-known Herfindahl index and square the market shares of the top four firms in the same SIC code (Saboo et al. 2016). Values range from 0 to 1.

Control Variables In accordance with extant TMT research, we included CEO-, firm-, and industry-specific control variables that might impact our dependent variables. In terms of CEO-specific characteristics, we include CEO age to control for the diminishing levels of testosterone over lifetime (Feldman et al. 2002). In terms of CEO power, we account for CEO duality as a dummy variable equal to 1 if the CEO is also the chairman of the board, and 0 if

otherwise. As a proxy of CEO dominance, we constructed the variable CEO pay slice, a measure of relative CEO compensation against full TMT compensation, as commonly used in TMT research (Zagonov and Salganik-Shoshan 2018). Additionally, we control for the CEO having entered the company from another firm in the respective year as a dummy variable equal to 1 for the year in which the CEO has entered his company, and 0 in all other years. Lastly, we control for CEO stock ownership as the fraction of CEO holdings to total outstanding shares (Aabo et al. 2021).

In terms of company-specific control variables, we account for firm size as the natural logarithms of total assets and employees. Moreover, we included return on assets as an indicator for firm profitability (Germann et al. 2015), the natural logarithm of leverage, calculated as total long term debt plus debt in current liabilities over stockholders' equity as used in the majority of corporate risk literature (Aabo et al. 2021), and the natural log of EBIT. Lastly, we include the stock ownership code to account for the CEO's ability or motivation to demonstrate influence (Daily and Johnson 1997), differentiating five types of ownership: Publicly traded company, subsidiary of a publicly traded company, subsidiary of a company that is not publicly traded, company that is publicly traded but not on a major exchange, or company that has undergone a leveraged buyout.

Finally, since our sample is structured as an unbalanced panel dataset, to account for environmental influences or external shocks affecting all firms in a specific year we include year dummies with 2010 as the base year (Jing et al. 2019). We include industry dummies based on 1-digit SIC codes to capture industry-specific effects that are not covered by our control variables.

METHOD OF ANALYSIS

To accommodate our cross-sectional data set we use generalized estimating equations (GEE) to evaluate whether CEO fWHR affects the overall compensation and the level of incentive

pay, especially given different degrees of competitive intensity. As stated by Ballinger (2004), "GEEs use the generalized linear model to estimate more efficient and unbiased regression parameters relative to ordinary least squares regression in part because they permit specification of a working correlation matrix that accounts for the form of within-subject correlation of responses on dependent variables of many different distributions, including normal, binomial, and Poisson". For our dependent variables total compensation and incentive pay, we apply the Gaussian family and identity link after taking the natural logarithm of each variable. Additionally, we estimate robust standard errors to account for heteroscedasticity and run the model with the four potential correlation structures (independent, exchangeable, ar1, unstructured). We calculate the quasi-likelihood (QIC) under the independence model criterion to determine the best fit (Ballinger 2004).

RESULTS

Descriptive Statistics

Table 1 shows the descriptive statistics (mean and standard deviation) and bivariate correlations of the variables included in our model. Correlations among our control variables are generally weak, with a few moderate exceptions (Ratner, 2009). CEO fWHR, the independent variable, correlates generally insignificantly or very slightly with the other dependent or control variables. None if our variables show a strong relationship (Ratner, 2009), apart from firm size, which correlates positively with EBIT. Nevertheless, we decided to keep this control variable included in order to address the frequently asked question whether large firms prefer high-fWHR managers or, vice versa, the high-fWHR managers grow their firms' size. Excluding the variable from our regressions, though, left the results unchanged. Additionally, by analyzing the variance inflation factors, we see that the upper moderate correlation coefficients are not causing multicollinearity.

TABLE 1 Descriptive Statistics and Bivariate Correlations

		Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	fWHR	1,99	0,13	1	0.06	-0.01	0.14	0.03	0.03	0.06	0.00	0.00	0.01	0.04	0.08	-0.07	-0.05	-0.02	0.00
2	Total Compensation	8,96	0,77	-	1	0.42	0.01	0.34	0.44	0.00	0.01	0.52	0.02	0.04	0.28	-0.03	0.12	-0.07	0.02
3	Incentive Pay	7,21	2,86	-	-	1	-0.06	0.17	0.16	-0.01	0.05	0.26	0.01	-0.03	0.03	0.01	0.03	-0.18	-0.07
4	Competitive Intensity	0,04	0,00	-	-	-	1	-0.02	0.05	0.05	0.01	-0.04	-0.01	0.05	0.27	-0.05	0.00	0.06	0.07
5	Firm Size	9,56	1,29	-	-	-	-	1	0.77	0.03	-0.05	-0.07	-0.02	-0.07	0.30	-0.04	0.14	-0.12	-0.35
6	EBIT	6,99	1,06	-	-	-	-	-	1	0.1	-0.01	0.01	-0.04	-0.01	0.46	-0.06	0.13	-0.12	0.06
7	CEO Tenure	13,60	4,03	-	-	-	-	-	-	1	-0.07	-0.01	-0.16	0.05	0.18	-0.08	0.07	0.21	0.07
8	Leverage	0,23	0,14	-	-	-	-	-	-	-	1	0.09	0.01	-0.03	-0.1	0.13	-0.05	-0.05	-0.16
9	CEO Pay Slice	0,40	0,11	-	-	-	-	-	-	-	-	1	0.02	0.04	0.01	0.02	0.02	-0.08	0.05
10	External CEO	0,01	0,10	-	-	-	-	-	-	-	-	-	1	-0.02	-0.01	0.01	-0.04	-0.04	-0.06
11	CEO Duality	0,94	0,24	-	-	-	-	-	-	-	-	-	-	1	0.08	-0.03	-0.14	-0.01	0.05
12	Employees	2,89	1,24	-	-	-	-	-	-	-	-	-	-	-	1	-0.02	0.06	-0.02	0.01
13	Ownership Structure	0,03	0,25	-	-	-	-	-	-	-	-	-	-	-	-	1	-0.07	0.01	-0.06
14	CEO Age	56,10	6,25	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.27	0.01
15	Shares Owned	0,24	0,53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04
16	Return on Assets	0,06	0,07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1

Note: correlations larger or equal to |0,06| are significant at the 0,05 level

TABLE 2 GEE and Pooled OLS models testing H1- H4

	GEE Models (direct)						*GEE Models (moderated)*		
	Model 1			**Model 2**			**Model 3**		
	b	SE	p-value	b	SE	p-value	b	SE	p-value
Intercept	4.59176	0.20204	< 2e-16	2.25995	0.94145	0.01637	1.26e-01	1.18e+00	0.91498
fWHR	0.20174	0.06350	0.00149	-0.13635	0.32193	0.67190	9.29e-01	4.71e-01	0.04836
Competitive Intensity	-	-	-	-	-	-	4.83e+02	1.67e+02	0.00388
Firm Size	0.07113	0.02235	0.00146	0.25101	0.07610	0.00097	2.52e-01	7.61e-02	0.00090
EBIT	0.18810	0.02314	4.4e-16	0.17246	0.07767	0.02639	1.73e-01	7.75e-02	0.02555
CEO Tenure	-0.00767	0.00239	0.00133	-0.00209	0.01006	0.83528	-1.88e-03	1.00e-02	0.85190
Leverage	0.05064	0.08751	0.56282	0.39145	0.36011	0.27703	4.50e-01	3.61e-01	0.21285
CEO Pay Slice	3.61064	0.15699	< 2e-16	6.54306	0.42157	< 2e-16	6.54e+00	4.22e-01	< 2e-16
External CEO	0.18663	0.09564	0.05101.	0.46152	0.46145	0.31723	4.87e-01	4.63e-01	0.29328
CEO Duality	0.08216	0.03104	0.00813	-0.48065	0.13325	0.00031	-4.64e-01	1.33e-01	0.00049
Employees	0.08196	0.00988	< 2e-16	0.02093	0.05270	0.69123	2.14e-02	5.49e-02	0.69674
Ownership Structure	-0.02749	0.04379	0.53017	0.04934	0.13712	0.71899	6.08e-02	1.39e-01	0.66222
CEO Age	0.00287	0.00179	0.10927	0.01729	0.00749	0.02096	1.73e-02	7.48e-03	0.02090
Shares Owned	-0.00334	0.02856	0.90688	-0.51286	0.10291	6.2e-07	-5.28e-01	1.03e-01	2.8e-07
Return on Assets	0.10425	0.24201	0.66663	-0.61406	0.76159	0.42008	-6.32e-01	7.61e-01	0.40605
Total Compensation*	-	-	-	-	-	-	-	-	-
Competitive Intensity Incentive Pay*	-	-	-	-	-	-	-2.47e+02	8.25e+01	0.00273
Competitive Intensity Industry dummies		Included			Included			Included	
Year dummies		Included			Included			Included	
Number of observations		342			342			342	

p < 0.001 p < 0.01 p < 0.05

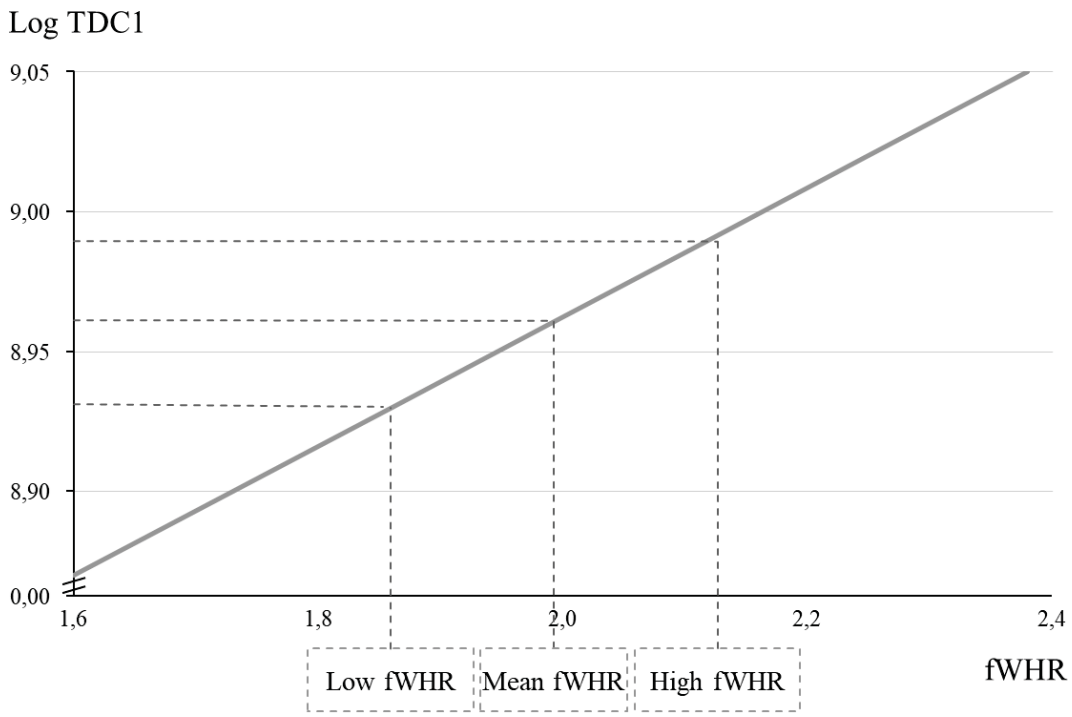
	Pooled OLS Models (direct)									*Pooled OLS Models (moderated)*					
	Model 4			**Model 5**			**Model 6**			**Model 7**			**Model 8**		
	b	SE	p-value	b	SE	p-value	b	SE	p-value	b	SE	p-value	b	SE	p-value
	4.85019	0.23493	< 2e-16	4.59176	0.19245	< 2e-16	2.25995	0.92755	0.01487	1.26e-01	1.15e+00	0.9132	4.85019	0.23029	< 2e-16
	0.09750	0.08406	0.24612	0.20174	0.06389	0.00160	-0.13635	0.30790	0.65791	9.29e-01	4.51e-01	0.0393	0.09750	0.07947	0.21995
	-74.16987	27.64362	0.00729	-	-	-	-	-	-	4.83e+02	1.66e+02	0.0037	-74.16987	24.93671	0.00295
	0.06966	0.02238	0.00185	0.07113	0.01609	1.0e-05	0.25101	0.07753	0.00122	2.52e-01	7.75e-02	0.0011	0.06966	0.02338	0.00291
	0.18749	0.02308	4.4e-16	0.18810	0.01689	< 2e-16	0.17246	0.08143	0.03424	1.73e-01	8.13e-02	0.0335	0.18749	0.02388	5.2e-15
	-0.00794	0.00239	0.00090	-0.00767	0.00221	0.00052	-0.00209	0.01064	0.84412	-1.88e-03	1.06e-02	0.8600	-0.00794	0.00242	0.00105
	0.06763	0.08612	0.43228	0.05064	0.06766	0.45421	0.39145	0.32609	0.23004	4.50e-01	3.27e-01	0.1688	0.06763	0.08734	0.43880
	3.60241	0.15708	< 2e-16	3.61064	0.07823	< 2e-16	6.54306	0.37702	< 2e-16	6.54e+00	3.77e-01	< 2e-16	3.60241	0.15834	< 2e-16
	0.18225	0.09579	0.05708 .	0.18663	0.08867	0.03537	0.46152	0.42737	0.28024	4.87e-01	4.27e-01	0.2540	0.18225	0.10427	0.08056 .
	0.08143	0.03135	0.00940	0.08216	0.03572	0.02149	-0.48065	0.17216	0.00526	-4.64e-01	1.72e-01	0.0070	0.08143	0.03252	0.01232
	0.08917	0.01022	< 2e-16	0.08196	0.00996	2.6e-16	0.02093	0.04802	0.66294	2.14e-02	4.89e-02	0.6619	0.08917	0.01079	< 2e-16
	-0.03277	0.04347	0.45104	-0.02749	0.03443	0.42466	0.04934	0.16592	0.76622	6.08e-02	1.66e-01	0.7142	-0.03277	0.04407	0.45725
	0.00288	0.00178	0.10635	0.00287	0.00148	0.05308 .	0.01729	0.00714	0.01545	1.73e-02	7.13e-03	0.0155	0.00288	0.00176	0.10135
	-0.00188	0.02862	0.94774	-0.00334	0.01790	0.85197	-0.51286	0.08627	3.0e-09	-5.28e-01	8.63e-02	1.0e-09	-0.00188	0.02647	0.94351
	0.12176	0.24218	0.61511	0.10425	0.17314	0.54713	-0.61406	0.83448	0.46186	-6.32e-01	8.34e-01	0.4482	0.12176	0.23115	0.59838
	31.72734	13.19778	0.01622	-	-	-	-	-	-	-	-	-	31.72734	11.94002	0.00791
	-	-	-	-	-	-	-	-	-	- 2.47e+02	8.08e+01	0.0022	-	-	-
		Included			In-cluded			Included			Included			Included	
		Included			In-cluded			Included			Included			Included	
		342			342			342			342			342	

Main Findings

In table 2, models 1 to 4 illustrate the GEE results of our hypotheses H1-H4: model 1 and 2 refer to the level of total compensation (1) and incentive pay (2), both in direct relationship with fWHR, and model 3 and 4 to incentive pay (3) and total compensation (4), both moderated by competitive intensity. Models 5-8 show the pooled OLS results for H1-H4, as described in the following robustness section.

Model 1 presents the results for the direct relation of fWHR and the CEOs' level of total compensation. This relationship shows to be positive and significant (0.20174, p= 0.00149 **). Accordingly, we can derive that alpha CEOs earn 0.7% more total compensation than their low-testosterone peers, as plotted in figure 2. We can confirm Hypothesis 1.

FIGURE 2 Direct effect of fWHR on total compensation (H1)

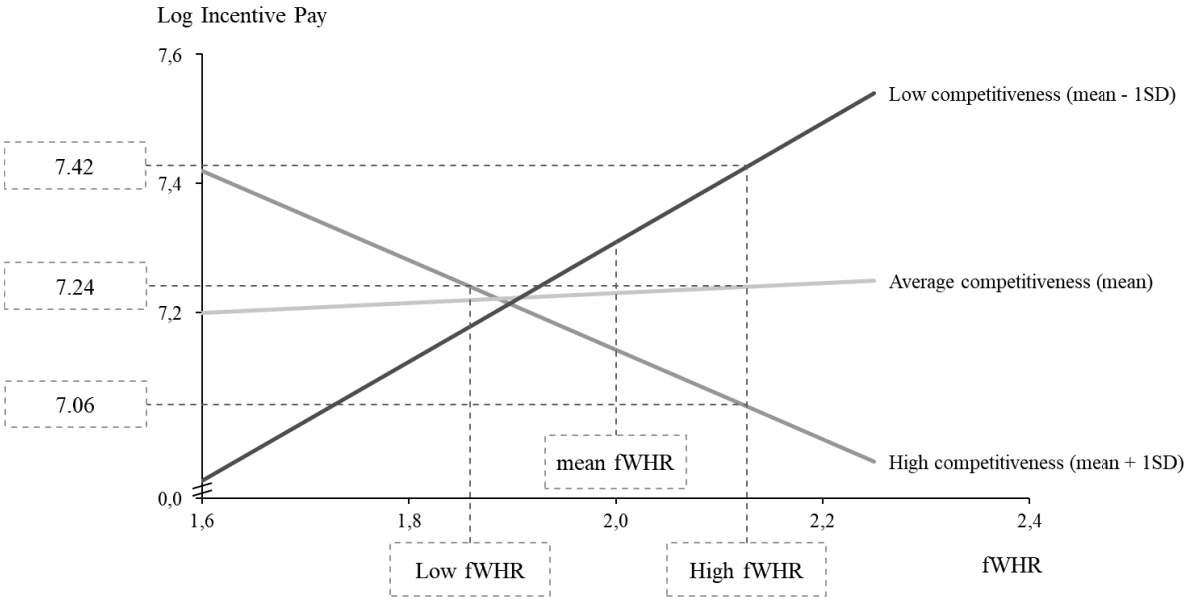


Model 2 illustrates the results for the direct relation of fWHR and the CEOs' level of incentive pay. As the model is not statistically significant, we reject Hypothesis 2.

Model 3 presents the results for the moderating role of competitive intensity on the relation between fWHR and incentive pay. The model confirms the relation to be significant (-2.47e+02, p= 0.00273 **) and allows us to derive the following insights from the chart plotted

in figure 3: First, we can interpret that in average competitive intensity, alpha CEOs only achieve a 0.3% higher level of incentive pay (incentive pay (log) of 7.23 vs. 7.21, 1SD above and below the mean). The simple slope test confirms the significance of two of the plotted lines (mean competitive intensity and - 1SD). For industries with above-average competitive intensity, the simple slope test determines the relation as insignificant. However, for industries with below-average competitive intensity – the relationship that interests us the most –, alpha CEOs achieve 3.3% higher incentive pay than low-testosterone CEOs (incentive pay (log) of 7.42 vs. 7.24, 1SD above and below the mean). Further, the chart shows that alpha CEOs earn 2.6% more incentive pay in industries with high vs. with average competitive intensity. In sum, we confirm our Hypothesis 3 by finding that indeed, in industries with low competitive intensity, high CEO fWHR drives higher levels of incentive pay.

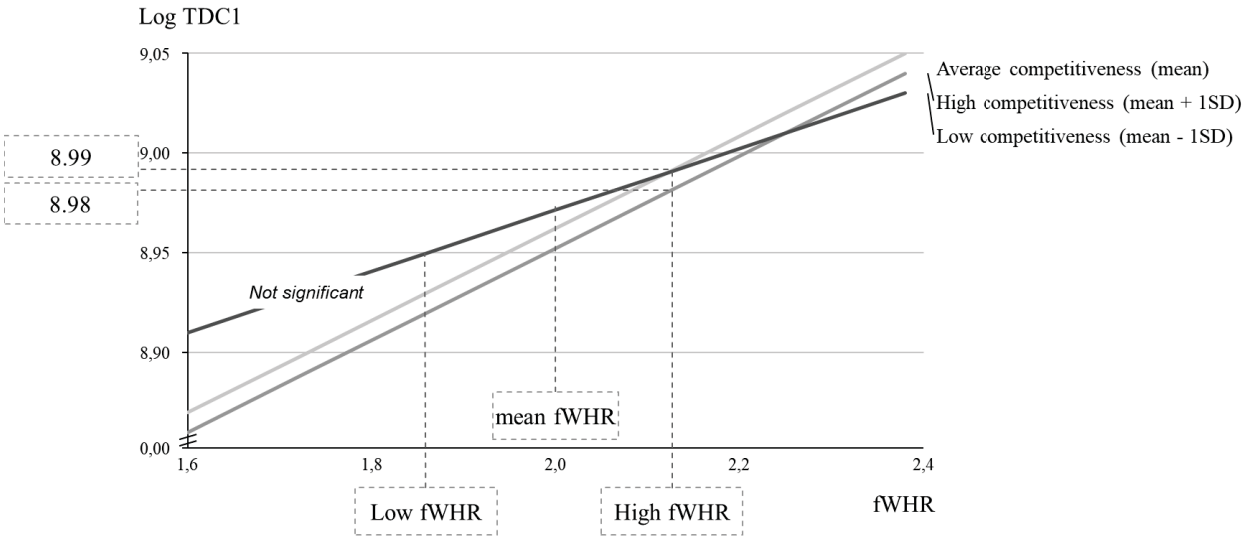
FIGURE 3 Moderating effect of competitive intensity on incentive pay (H3)



Model 4 presents the results for the moderating role of competitive intensity on the relation between fWHR and total compensation. The model confirms the relation to be significant (31.72734, p= 0.01622 *). However, the simple slope test confirms the significance of only two of the plotted lines (mean competitive intensity and + 1SD). For industries with below-average

competitive intensity, which interest us the most, the simple slope test determines the relation as insignificant. While this does not truly confirm our Hypothesis 4, which would have required a lower total compensation, it still interestingly illustrates how the alpha CEOs' 3.3% higher incentive pay does not translate into higher total compensation in industries with low competitive intensity. Further, we can interpret that in average competitive intensity, alpha CEOs achieve a 0.7% higher level of total compensation (TDC1 (log) of 8.99 vs. 8.93, 1SD above and below the mean), while only achieving a 0.3% higher level of incentive pay, as described above.

FIGURE 4 Moderating effect of competitive intensity on total compensation (H4)



In sum, we confirm H1 and H3, reject H2, and, while certainly also rejecting it, making interesting observations on H4.

Robustness Tests

To validate the robustness of our findings, we perform a multitude of additional analyses and run alternative regression models.

Multicollinearity Firstly, we rule out potential multicollinearity issues by analyzing the variance inflation factors (VIFs). Our VIFs range from 1.03 to 4.36 with an average of 1.76. Accordingly, all of these values lie well below the accepted threshold of 10 (Cohen et al. 2003). We continue to test the stability and plausibility of our coefficients further and repeat our

regression analyses with subsets of the full sample, following (Echambadi et al. 2006). We repeat the regression analyses for our hypotheses with ten randomly drawn subsets with 90% of the sample. The repeated results with the 90% sample subsets are highly consistent with our previous findings in terms of significance levels, direction, and size. Thus, as the results of our regressions remain consistent, the problem of multicollinearity does not distort the results of our study and can be disregarded (Echambadi et al. 2006).

Endogeneity Endogeneity problems are the result of omitted variable bias if a variable has not been included in the model although it affects both the explanatory and dependent variables (Wooldridge 2010). Following Frank (2000), we calculate the impact threshold of a confounding variable (ITCV) to address this concern. This analysis demonstrates how strong an omitted variable would have to be in order to overturn our results. We used the konfound package in R to evaluate our finding that a high fWHR positively affects the level of a CEO's incentive pay. This analysis shows that 18.4% (for total compensation) and 21.9% (for incentive pay) of the estimate would have to be due to bias to invalidate our results – in other words, a substantial number of our observations would have to be replaced with cases for which the effect is 0. Thus, we conclude that omitted variable bias is unlikely to distort our results.

Alternative regression models As robustness check, we repeat our analyses on fWHR in relation with total compensation and incentive pay with a pooled ordinary least squares regression model (pooled OLS) with heteroskedasticity and serial correlation robust standard errors clustered at the year- and firm-level (Arellano 1987) – see table 2 models 5 to 8. In comparison with our GEE model, we find that the results for our hypotheses are consistent in significance level, direction, and, thus, the previous findings can be confirmed.

DISCUSSION AND CONCLUSION

This study theoretically develops and empirically confirms that high levels of testosterone can influence the level and structure of CEO compensation. Our findings suggest that this is not

universally true, but, instead, much depends on environmental factors such as their industry's competitive intensity. Specifically, we find that alpha CEOs generally achieve a 0.7% higher overall salary compared to their low-testosterone peers. In little competitive environments, however, their preference for performance-based salary components generates 3.3% more incentive pay without leading to a higher total compensation. Accordingly, this research confirms the findings of previous researchers describing the impact of personal attributes on the setting of CEO compensation packages. On the other hand, our findings echo extant research stating that optimistic or overly confident CEOs do not end up with a higher total compensation after overestimating the value of their claims in performance-based components. In sum, the present research provides new evidence on the impact of CEOs' fWHR and testosterone level on their level and structure of compensation. We discuss the implications of these findings for theory and practice in the following.

Theoretical and Research-Related Implications

This article contributes to extant research in three major ways. First, our study contributes to the CEO compensation literature and, in particular, offers a biological perspective as determinant of CEO compensation. We add facial masculinity, reflected in facial structure, with the associated result- and risk-seeking behavior as novel characteristic driving CEO compensation. In doing so, we answer the call of Devers et al. (2007) to examine alternative theoretical perspectives of determinants of CEO pay. Traditionally, CEO compensation is examined in the context of agency theory (Rekker et al. 2014), where the incentives of the CEO are aligned in order to serve the interests of the shareholders. By generating insights on the relation between pay and behavior, with the underlying assumption that CEOs seek to maximize their compensation, we contribute to the growing body of research on the antecedents or determinants of compensation. This respective field of research focuses on the perspective of the CEO instead

of the directors or firm itself in terms of influencing and setting the level and structure of a compensation contract.

Secondly, this article contributes to the emerging body of research on testosterone in executives, in which researchers commonly use fWHR as a proxy for testosterone. This emerging stream of literature has focused largely on public CEOs and their impact on firm behavior and performance: Researchers find for instance that high-fWHR CEOs achieve a higher return on assets (Wong et al., 2011), take on higher risk (Kamiya et al., 2019), and are more likely to engage in financial misreporting (Jia et al., 2014). Overall, extant research using fWHR focuses mostly on "outward-facing" behaviors of the firm, or its respective performance and success. We extend the more "inward-facing" perspective of this research, such as governance-related aspects, by theoretically arguing and empirically presenting that the novel CEO characteristic of a high level of testosterone influences the level and structure of compensation, particularly in organizational environments with low competitiveness. Thereby, we add a more governance-oriented perspective on the effects of CEOs' level of testosterone and facial structure.

Finally, extant literature has emphasized the importance of illuminating the contextual factors which affect CEO compensation design, such as the industry the firm operates in (Devers et al. 2007). Our study links physical characteristics to the process of determining CEO pay, showing that it is closely related to the competitiveness of the firm's industry. As this study shows, while alpha CEOs may generally earn slightly higher total compensation, this effect diminishes in less competitive industries where they negotiate higher incentive pay. Thus, this study not only contributes to the general determinants of CEO pay but also confirms the importance of the environmental setup, in which respective character traits play out differently.

Practical Implications

From a practitioners' viewpoint, this article underscores the impact of the CEO's level of testosterone on his level and structure of compensation, and how much it depends on the

environmental setting. Our findings show that alpha CEOs with their result-seeking behavior possess the ability to generally negotiate a slightly higher total compensation. In less competitive environments, which offer them more room to tailor their compensation packages to their preferences, their risk-seeking behavior diminishes this effect, as the higher incentive pay does not lead to a higher total compensation.

Our study confirms extant research by suggesting that compensation setting is not a fully fair or rational process based on objective criteria such as CEO quality. Instead, decision makers are subject to a number of biases, reacting to preferred characteristics or even biological factors such as beauty or voice (Li et al. 2021). Accordingly, CEOs are able to influence directors successfully and lead them to set their compensation benevolently.

Therefore, our study offers practical implications to both CEOs – or any person in the situation of negotiating their salary -, and firms and their respective decision makers. First, for CEOs it may prove to be beneficial to be aware of their own level of testosterone and the behavior that is associated with it. High-testosterone individuals, who are aware of their high risk-affinity, are less likely to make the same mistake of accepting highly convex contracts and ending up worse off by overestimating the value of their incentive claims. Low-testosterone CEOs, on the other hand, can keep in mind that the level of compensation is not a given fact and, instead, may want to actively seek out networking opportunities and negotiate more boldly for a higher salary. For companies it proves equally important to be aware of the compensation preferences of the person they would like to hire. With talent being in high demand, they may be competing for the most sought-after CEOs. By being aware of the respective preferences, they can immediately make a well-targeted offer with well-fitted level of incentive pay to make a better impression than competing firms. Additionally, firms who want to abuse the risk-affinity of alpha CEOs may achieve cheaper contracts by trading fixed compensation with as much incentive components as possible – whether this is recommendable in terms of a long-term relationship and motivation is another matter, though. In sum, this study delivers a lot of

practical relevance and offers insights to only to CEOs but to any person negotiating an individualized compensation contract.

Limitations and Avenues for Future Research

This study has a number of limitations and offers additional paths for future research. First, while we can only use a measure of facial proportions to derive a variety of masculine traits, there is no measure of CEO testosterone exposure available. In an ideal world, one would use saliva and serum samples of the respective CEOs to identify their biochemical composition and base testosterone content. However, it is very unlikely that these samples will become available to us or other researchers. Additionally, we acknowledge that detecting the relationship between (the underlying hormone levels of) CEO appearance and their compensation may require even more complex study designs and methodology. This relationship might be more complex than envision by the authors. For instance, if high-fWHR CEOs were generally believed to be better CEOs regardless of their actual performance, they may be more likely to be employed by better-performing firms. Being considered as superior leaders by employees may enable them to, indeed, lead their firm more successfully which has a direct effect on their compensation. Therefore, the "look of success" might act as a self-fulfilling prophecy. Lastly, we would like to point out that most of the CEOs of our sample were Caucasian. Therefore, the results of this study may not generally be applicable across ethnicities. Thus, one of the avenues for future research would be to extend this work's scope to other cultural contexts.

Testosterone-related research is not only thought-provoking and contemporary, but it also offers numerous opportunities for further research. Of particular interest would be to deepen the biological perspective we offer and include further biological aspects as precedents of CEO compensation. For example, one could combine our findings on fWHR with extant research on voice (Nair et al. 2021) or beauty (Li et al. 2021). Would our finding still hold, if the alpha CEO did not fulfil the respective definition of beauty or had a very high voice? Moreover, research

has proven the existence of a height premium (Li et al. 2021), showing that very tall individuals earn a pay premium. It would be of highest interest, whether height influences CEO compensation and moderates the relationship of CEO fWHR and compensation. We leave this for the future research agenda.

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6 Conclusion

The final chapter of this dissertation summarizes the empirical research findings and how these address the previously identified research questions. Subsequently, I illustrate the dissertation's theoretical (6.2.1) and practical contributions (6.2.2) Finally, I point out the limitations of this research, as well as the resulting avenues for future research.

6.1 Summary of findings

This section summarizes the findings of the three research studies, which are the heart of this dissertation. The dissertation is guided by three overarching research questions, which are broken down into six specific questions (two each) directly allocated to the three studies. A tabular overview of questions and findings is provided at the end of this section (Table 6).

The first overarching research question is centered around firm performance and innovation:

Research question 1 (RQ 1): *Does male CEOs' facial masculinity impact firm performance in terms of creating product innovations and future business and how is this influenced by industry dynamism?*

Study I addresses RQ 1 by illuminating the links between CEOs' testosterone levels and both product introductions and value creation, and how they depend on industry dynamism. The underlying questions are addressed in study I, accordingly.

Research question 1a (RQ 1a): *Do alpha CEOs increase firm innovation in terms of new product releases in undynamic industries?*

Research question 1b (RQ 1b): *Do alpha CEOs outperform in terms of firm value creation in undynamic industries?*

Study I argues that CEOs' higher testosterone level can positively relate to innovation in terms of new product introductions, and firm value. The findings suggest that the relation between the CEO's testosterone levels and strategic outcomes like innovation and performance

are not universally valid but contingent on industry dynamism. Specifically, study I establishes a positive significant impact when industry dynamism is low: High-testosterone CEOs are 7.1% more active in terms of new product launches and 12.4% more successful than their low-testosterone peers in an undynamic environment. Yet, there is no such effect for high-testosterone CEOs when industry dynamism is high. The study confirms the previous prediction that high-dynamism environment fuels the alpha CEO's weaknesses: disrupting collaboration and information flow, diminishing the opinion of others, and ignoring risks for rewards. On the other hand, low-dynamism environment fuels the alpha CEO's strengths: Unveiling opportunities while dealing with a gist of information, aligning activities with overarching company goals, and executing effective leadership. Thus, study I identifies below-average turbulence to be the sweet spot of alpha CEOs, in which they perform the best as the positive effects of testosterone play out while the negative ones are less relevant.

The second overarching research question addresses the relation of CEO facial masculinity and long-term, strategic moves in terms of corporate venture capital investments:

Research question 2 (RQ 2): *Does male CEOs' facial masculinity impact firm strategic investing moves and how is this influenced by industry dynamism?*

Study II addresses RQ 2 by assessing the relationship between CEOs' testosterone levels and venture capital activeness, and how this relates to industry dynamism. The underlying questions are addressed in study II, accordingly.

Research question 2a (RQ 2a): *Do alpha CEOs undertake fewer venture capital investments, especially in undynamic industries?*

Research question 2b (RQ 2b): *Do alpha CEOs prefer to undertake venture capital investments with fewer co-investors in undynamic industries?*

Study II confirms that the high level of testosterone of CEOs can negatively influence the company's VC investment activeness when industry dynamism is low. Again, the findings confirm that the negative relationship is not universally valid but depends on the environmental setting.

Specifically, study II illustrates that alpha CEOs undertake 9% fewer venture capital investments alongside 5% fewer co-investors than low-testosterone CEOs in undynamic environments. Again, these findings are not valid when industry turbulence is high. In undynamic, stable industries, the eagerness to gain others' attention and applause drives the alpha CEO away from venture capital investments and more towards more predictable, quicker wins. Moreover, his controlling and over-confident behavior causes potential co-investors to refrain from sharing investment opportunities which could be undertaken jointly. Thus, study II identifies below-average dynamism to be the 'lazy spot' for alpha CEOs, where VC investments do not offer enough predictable return or a spot in the limelight to trigger their interest.

The third and last research question addresses the CEOs' personal outcomes in terms of compensation:

Research question 3 (RQ 3): *Does male CEOs' facial masculinity impact their structure and level of compensation and how is this influenced by competitive intensity?*

Study III addresses RQ 3 by assessing the link between facial masculinity and the structure and level of compensation of the CEO. The following more granular research questions are, thus, addressed in study III.

Research question 3a (RQ 3a): *Do alpha CEOs secure compensation packages with a higher share of variable components when competitive intensity is low?*

Research question 3b (RQ 3b): *Do alpha CEOs secure a higher overall compensation when competitive intensity is low?*

Study III argues that the high level of testosterone of a CEO can influence his level and structure of compensation. Also in this study, the findings suggest that this relationship is not universally valid but depends on environmental factors – in this case their industry's competitive intensity. Specifically, alpha CEOs generally achieve a 0.7% higher overall salary than their low-testosterone peers. However, in less competitive environments with more negotiation flexibility, their preference for variable pay components generates 3.3% more incentive pay

without converting into a higher total compensation. In other terms, the more flexibility high-testosterone CEOs have to tailor their packages to their own preference, the more negative is the impact on their total compensation. Optimistic alpha CEOs tend to believe that good outcomes are more likely than they really are and vastly overestimate the likelihood of the firm's and their own success. Their strong preference for a high potential compensation based on variable payment components does not translate into real dollars in the end. Thus, study III confirms the findings of previous researchers stating that optimistic or overly confident CEOs do not secure a higher total compensation as they overestimate the value of their claims in performance-based components.

Table 6 Overview of the studies' research questions and hypotheses

Research question		Study	Hypothesis (H)	Results
RQ 1	**Does male CEOs' facial masculinity impact firm performance in terms of creating product innovations and future business and how is this influenced by industry dynamism?**			
RQ 1 a	Do alpha CEOs increase firm innovation in terms of new product releases in undynamic industries?	I	H1a: The relationships between fWHR and the number of product releases is positive when industry dynamism is low, while there are no such effects when industry dynamism is high.	Supported
RQ 1b	Do alpha CEOs outperform in terms of firm value creation in undynamic industries?	I	H1b: The relationships between fWHR and firm performance positive when industry dynamism is low, while there are no such effects when industry dynamism is high.	Supported
RQ 2	**Does male CEOs' facial masculinity impact firm strategic investing moves and how is this influenced by industry dynamism?**			
RQ 2a	Do alpha CEOs undertake fewer venture capital investments, especially in undynamic industries?	II	H1: The relationship between fWHR and the number of venture capital investments is negative when industry dynamism is low, while there are no such effects when industry dynamism is high.	Supported
RQ 2b	Do alpha CEOs prefer to undertake venture capital investments with fewer co-investors in undynamic industries?	II	H2: The relationship between fWHR and the number of co-investors in venture capital funding rounds is negative when industry dynamism is low, while there are no such effects when industry dynamism is high.	Supported
RQ 3	**Does male CEOs' facial masculinity impact their structure and level of compensation and how is this influenced by competitive intensity?**			
RQ 3 a	Do alpha CEOs secure compensation packages with a higher share of variable components when competitive intensity is low?	III	H2: CEO fWHR is positively related to CEO incentive pay. H3: CEO fWHR is positively related to CEO incentive pay when industry competitiveness is low, while there are no such effects when industry competitiveness is high.	H2 not supported; H3 supported
RQ 3b	Do alpha CEOs secure a higher overall compensation when competitive intensity is low?	III	H1: CEO fWHR is positively related to total CEO compensation. H4: CEO fWHR is negatively related to total CEO compensation when industry competitiveness is low, while there are no such effects when industry competitiveness is high.	H1 supported; H4 not supported

6.2 Contributions

This dissertation makes a critical theoretical contribution to the extremely limited amount of testosterone-related upper echelons research. As seen in the literature review (section 2), extant research holds only three articles on CEO facial masculinity, and just one when strictly considering only A+/A journals. Moreover, it is equally valuable from a practical viewpoint, illuminating the two sides of the medal of alpha leaders related to different company and personal outcomes.

6.2.1 Theoretical contributions

This dissertation contributes substantially to extant research in all three categories mentioned above: firm outcomes (study I), firm behavior (study II), and personal outcomes (study III). The CEO's fWHR, as a proxy for his level of testosterone, predicts a complex of personality traits and behaviors, evidently translating into company and personal results. This dissertation's studies integrate recent research at the interface of management and biology and contribute a novel CEO characteristic, which may play an important role in determining both firm-level and personal outcomes.

First, study I and II contribute to upper echelons research in innovation management by conceptually deriving and empirically confirming the relationship between CEO facial masculinity and firm innovation performance and behavior. Study I links CEO fWHR to company activeness and value, and specifically informs the literature at the intersection of upper echelons and innovation management research by introducing CEO facial masculinity as determinator of firm-level innovations in the form of new product introductions. Thus, Study I answers the call of Kashmiri et al. (2017) to explore the innovation implications of characteristics other than narcissism. Study II offers additional insights on the antecedents of CVC commitment and scope. We thereby echo the findings of Engelen et al. (2013, 2014), who determine the potentially harmful effect of CEO narcissism and overconfidence on firm innovations in specific settings, while adding facial masculinity as novel perspective. Thus, we answer the call for

research of Anokhin et al. (2016) by addressing the lack of research in the field of CVC antecedents. In conclusion, study I and II contribute CEO fWHR as novel predictor of a set of masculine behaviors, which – as upper echelons theory suggests – determine company behavior and outcomes.

Secondly, since previous researchers have used the CEO fWHR as a proxy for their level of testosterone, study I, II and III contribute to the (still) very limited research on testosterone in executives. Up to now, this stream of literature has predominantly linked testosterone to rather operative activities or financial performance: It describes how high-fWHR CEOs deliver higher a return on assets (Wong et al., 2011), take on more risk (Kamiya et al., 2019), more likely to engage in financial misreporting (Jia et al., 2014), or underperform as hedge fund managers (Lu & Teo, 2018). Thus, the results of study I echo these findings of Wong et al. (2011), showing that alpha CEOs outperform their low-testosterone peers, which is positively linked to specific external factors. This dissertation extends this line of extant research by offering the characteristic of high testosterone as crucial determining factor for strategic outcomes like new product introductions and firm performance (study I), venture capital investment behavior (study II), and personal outcomes in terms of level and structure of compensation (study III). Thereby, this dissertation adds both a strategic, but also a personal outcome-related perspective regarding the effects of CEOs' testosterone level and facial structure.

Third, we extend extant leadership research by accounting for the broader context and environment, which impacts leaders' decision-making and behavior. The three studies included in this dissertation link CEOs' physical characteristics to organizational and personal behavior and have advanced leadership research accordingly. Study I and II show that objective facial metrics of male CEOs in combination with their industry's dynamism are closely linked to firm activeness in terms of product releases and company value, and to venture capital activeness, respectively. Study III illustrates that the CEOs' level of testosterone influences the level and structure of their compensation, particularly in organizational environments with low

competitiveness. Thus, this dissertation brings to light that a given biological characteristic can be beneficial in one specific situation and disadvantageous in another, emphasizing the strong necessity to contextualize links between CEO characteristics and strategic or personal outcome variables. The integration of industry dynamism and competitive intensity as moderating variables also answers the call of Nofal et al. (2018) for research on the interface of biology and management, stating that since "[…] most managerial behavior is likely accounted for by the interaction of human biology and environmental factors, additional research should empirically investigate how environment and biology interplay to influence management" (p. 23).

Finally, study III of this dissertation contributes to the CEO compensation literature and offers a biological perspective as determining factor of CEO compensation. Thus, we answer the call of Devers et al. (2007) to examine alternative theoretical perspectives of determinants of CEO pay by presenting CEO facial masculinity as different characteristic driving CEO compensation. Predominantly, CEO compensation is studied in the context of agency theory (Rekker et al., 2014), describing how to align the incentives of the CEO best with the interests of the shareholders. A growing body of research, however, takes the opposite perspective and assesses determinants of compensation from a CEO view, instead of the directors or firm itself. Study III contributes to this line of research and contributes insights on the relation between pay and behavior.

6.2.2 Practical contributions

From a practical viewpoint, the findings of this dissertation emphasize the impact of CEO characteristics on both organizational and personal decision-making, and how much this depends on the respective setting or environment. The findings at hand are relevant for CEOs themselves, but also for their employees and the extended firm leadership such as directors and other TMT members.

To achieve the best possible organizational and personal outcomes, individuals need to fully harness the positive consequences of testosterone while mitigating the negative ones – and

awareness of these is the first step. For instance, acknowledging one's tendency to nullify others' opinions and, thus, not realizing one's optimal performance in turbulent industries, is a crucial step for alpha CEOs towards more collaborative and equitable behavior. Similarly, being aware of their high risk-affinity and tendency to overestimate the value of their incentive claims, alpha CEOs can avoid accepting highly convex contracts and ending up worse off.

For team members, on the other hand, it can be helpful to be aware of testosterone-related behavioral traits of their peers, superiors, or subordinates to inspire or incentivize a beneficial team spirit. Likewise, for executive recruiters and decision boards, it can be beneficial to consider these insights and create a balance of TMT members' different characteristics and testosterone levels, also with a focus on increasingly hiring more diverse and female teams.

Finally, for companies it is fundamentally important to be aware of the compensation preferences of the person they seek to hire. By keeping the respective preferences in mind, they can make well-targeted offers to the most sought-after CEOs in the market.

6.2.3 Limitations and avenues for future research

As goes for all empirical research, this dissertation is not free from limitations. The studies included here have several limitations but also offer many additional opportunities for future research. Firstly, and relevant for all three studies, we do not have a laboratory measure of the CEOs' testosterone exposure, but only a representative measure of facial structure which predicts a complex of masculine traits. However, in an ideal world, one would draw saliva and serum samples from CEOs to examine the underlying biochemical composition and (base) testosterone content. Unfortunately, it is improbable that a large enough sample size of CEOs will participate in this endeavor.

Additionally, this research is based on samples of large, public US companies, which may limit broad generalizations to other firms, TMT members, or cultural contexts. Further, it is noteworthy that the sample CEOs were mostly Caucasian, limiting the findings' applicability in terms of other ethnicities. While there is no prevalent reason for the results not to hold for

other types of companies, ethnicities, or locations, it remains for future researchers to demonstrate whether this dissertation's findings are entirely replicable in other settings.

Further, it must be considered that assessing the effects between CEO appearance, the respective underlying hormone levels, and firm or personal outcomes may necessitate different methodological paradigms or even more complex study designs. This research aims to disentangle the relation of the testosterone level and firm or personal outcomes, which might, however, be more multifaceted than previously envisioned. For example, if CEOs with a higher fWHR are generally presumed to be more successful CEOs (notwithstanding their actual performance), they may be more likely to be appointed by better-performing companies. Thus, being considered a better leader by their subordinates and peers may enable them to, indeed, lead their companies to greater success: The 'looks of success' may act as a self-fulfilling prophecy. The same may be true regarding the CEO's compensation. Alpha CEOs, having a reputation of being gamblers or dare devils, might be offered higher shares of variable pay without having asked for it.

Any gender-related and especially testosterone-related management research is not only highly in vogue and thought-provoking but offers innumerable opportunities for future research. Building on the findings of this dissertation, it may be of interest to examine any other measures of company performance or behavior, such as M&A, CSR, or diversification, as seen in the literature review in combination with other personal characteristics. Especially interesting would be the further research of team-focused moderators and their impact on the fWHR-outcome link, along the lines of Wong et al. (2011) who examined the effects of CEOs' facial masculinity on their firms' financial performance, moderated by the cognitive capacity of their leadership team. In terms of company behavior and outcomes, future scholars could assess not only the relation of CEO fWHR and different firm variables but illuminate the impact of the team set up. This way, they could determine the most fruitful combinations of high vs. low testosterone CEOs with other high vs. low testosterone TMT members. According to the extant

literature on homophily, the CEO would prefer other TMT members to be of a similar nature (Kamiya et al., 2019). In contrast, based on the negative testosterone-driven traits described in this dissertation, a more diversified set of characters, skills, and backgrounds in the TMT, including female members, could be most productive. In terms of compensation, it would be extraordinarily interesting to identify, whether the alpha CEOs' preference for variable pay components changes with the TMT setup, for instance decreases when further alpha males are around.

Another field of interest would be additional performance-harming factors. As elaborated in the studies at hand, high-testosterone CEOs have a tendency towards unethical personal dealings or dubious behavior, such as financial misreporting (Jia et al., 2014). Future scholars could assess whether this behavior is triggered or enhanced by an externally reinforced sense of power, for instance CEO duality or a remarkable CEO pay slice. Such power-aggravating external factors might hinder alpha CEOs to operate at their full performance potential.

I leave this as a future research agenda.

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