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# Can Managerial Psychology Affect Investment Efficiency?

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## Abstract
This paper explores the impact of varying levels of CEO overconfidence on investment efficiency, focusing on overinvestment and underinvestment. Using a sample of 3,900 firm-year observations from 2012 to 2023, the study employs the Generalized Method of Moments (GMM) regression to examine the relationship between managerial overconfidence and investment efficiency. The findings suggest that increasing low levels of overconfidence in CEOs helps firms move closer to optimal investment efficiency by reducing underinvestment. However, firms that are over-invested and have CEOs with low overconfidence do not experience significant improvements in investment efficiency. This research contributes to the literature by refining measures of overconfidence to differentiate between low and high levels, offering valuable insights for academics, practitioners, and regulators focused on enhancing investment efficiency.

## Keywords
Investment Efficiency, Under-Investment, Over-Investment and Managerial Overconfidence

## 1. Introduction
Investment decisions are among the most significant, critical and crucial business decisions. The quality of those investment decisions is of considerable importance to the firm since it has a direct influence on its growth opportunities, thus, its value; indeed, an efficient investment decision should improve and enhance a firm's value (Ying et al. 2019; kim et al, 2019; Tan et al, 2024; Melina and Endri, 2025).

Making an efficient investment decision requires to undertake all projects with a positive net present value (Biddle and al, 2009). Therefore, if a firm does not take on all potential projects because of financial constraints for example, it may destroy its investment efficiency by under-investing. Likewise, if a firm invest beyond the optimum level, it may damage its investment efficiency by over-investing. To abate the extent of the over / under-investment problem, is to further improve a firm's investment efficiency.

Given the importance of this decision, it has been broadly studied for the last forty years. Indeed, both Jensen (1986) and Shleifer and Vishny (1989), reveal consecutively, the "agency cost" and the "managerial entrenchment" theories, and state that CEOs may invest in negative NPV projects because of self-intrest, resulting in overinvestment. If information cannot be communicated to the capital market, CEOs may avoid investing in positive NPV projects to prevent negatively impacting the firm's share value, leading to underinvestment (Myers and Majluf, 1984).

The aforementioned theories, if they explain the distortion of a firm's investment efficiency by the managerial attitude, they do not demonstrate whether a firm's investment policy is affected by the psychological preferences and the behavioral biases of its managers.

How the psychology of managers may affect the investment efficiency of firms has not been fully explored yet. Our study aims to fill this gap.

Indeed, beyond the aforesaid traditional financial theories ("agency cost", "managerial entrenchment" and "asymmetry of information"), which fail to fully explain why firm's investment inefficiency actually exists, behavioral finance suggests a plausible explanation for this finding, which derives mainly from the psychological and cognitive literature, where CEO's behavioral biases, play a fundamental role when explaining firm's abnormal and irregular investment behavior (Hung and Tsai, 2019; Danso et al., 2019).

Behavioral finance, which has reintroduced the human being to justify some deviant and uncommon investment behaviors, seems an attractive field for finding explanations for questions left unresolved by traditional financial theories.

In this study, we suggest a plausible explanation of firm's non-optimal investment behavior; however, instead of focusing on firm's characteristics, we will tie in corporate investment decisions with individual characteristics of decisions makers. Several psychological and academic, studies have shown that managers' behavior when making firms' major decisions is usually not perfectly rational. Indeed, CEOs will be influenced by their convictions, governed by their emotions and affected by their cognitive and psychological biases (Bertrand and Schoar, 2003, Baker and Wurgler, 2009, Malmendier, Tate and Yan, 2011; Rehman et al, 2024).

Looking in the behavioral finance realm, we found an excellent literature review of several behavioral biases that may have an influence on managers in the decision-making process (Hilary et al., 2016; Ying et al., 2019 etc.).

The choice of this behavioral bias is motivated, on the one hand, by the fact that it is well documented by anecdotal and academic evidence; indeed, overconfidence has been widely studied in the literature of Biais et al., (2005), Malmendier and Tate (2005), Glaser et al (2008) and Campbell and al (2011).

And, on the other hand, because is indicated in previous studies that overconfidence is a general phenomenon among leaders, CEOs and managers; indeed, most of them are likely to be too confident about their own abilities. A general phenomenon that will undoubtedly have an impact on the investment policy of their firms (Chen et al., 2018).

Therefore, it will be very significant to look into what impacts firm's investment inefficiency from a new perspective.

So to summarize, we found out that traditional financial theories have explained firm's investment inefficiency through "agency cost" and "asymmetry of information".

Indeed, since the interests of the different stakeholders of a firm are heterogeneous, so the CEO will rely on the most mastered information by him to make investments according to his own interest. He can also use the financing of a project to serve his personal concerns, which destroys the investment efficiency of the firm, shareholder value and that of the company, by overinvesting.

To those two recent theories, which have explained a significant part of the distortion of firm's investments, we can add a third plausible explanation, also stemming from the traditional financial theories, namely the "managerial entrechment", through excessive investments in specific and idiosyncratic assets and purchases of profitability.With the development of economy, firms may exhibit henceforth an unusual and deviant investment behavior that can not be explained simply by the vision of traditional financial theories. Indeed, researchers have shown that even without agency problems, for example, managers will always have an inefficient investment behavior.

Behavioral finance suggests a new plausible explanation for this finding, which derives mainly from the psychological and cognitive literature, where the behavioral biases of a manager are likely to explain the abnormal investment behavior of a firm. It remains to be mentioned that behavioral finance, which played a pivotal role in explaining the firm's investment activities, considering the managerial traits rather than the firm's characteristics, broadened research areas, however, it did not deny traditional interpretations and researches.

Indeed, even if behavioral finance has enriched the financial theory and shed new light on the investment problem, however, financial theories are perfectly complementary. In fact, when firms have problems of agency cost or information asymmetry, the presence of CEOs with overconfidence problems, will have a greater impact on the firm's investment efficiency.

On this basis, we anticipate four fundamental explanations for firm's investment inefficiency (see Figure 1).

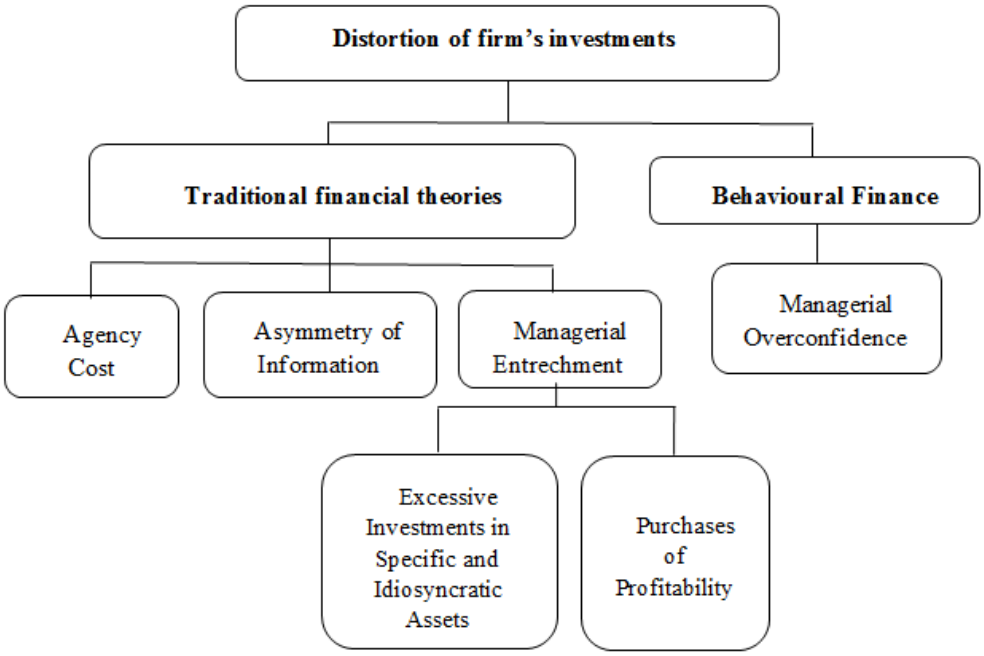


**Fig. 1** Firm's inefficient investment between traditional financial theories and behavioral finance

Our main concern is to put together a puzzle in corporate finance by answering the following question: "What is theimpact of the different levels of the managerial overconfidence on firm's investment efficiency? "

The paper is organized as follows: Section 1 covers the literature review and hypothesis development, Section 2 details the research design, including the sample, models, and variable measures, and section 4 presents the empirical results.

## 2. Background and Hypotheses Development

As mentioned above, managers should undertake all projects with a positive NPV (Biddle and al, 2009; Ying et al., 2019). Thus, cash flow forecast is the main input when making an investment decision. Overconfidence leads managers to make biased predictions (El Gaied and Zgarni, 2018; Karkin, et al 2024).

Indeed, many researches show up that overconfidence makes managers believe that their decisions are the best according to their own information and without any real justification; an illusion of knowledge that leads to overestimate the future prospective outcomes of their investment projects (Mahmoud and Shaban, 2016 ; Xiao and Zhou, 2017).

As a result of the future prospective outcomes' overestimation and the potential risks' underestimation, we expect that overconfident managers will invest beyond the optimal level, destroying therefore firm's investment efficiency by over investing. Unlike managers with a low level of overconfidence, who because of their more careful and safe investment policy, destroy firm's investment efficiency by underinvesting (Gervais et al., 2002; Wang et al., 2009; Ying et al., 2019). Hackbarth (2008) predicts the existence of an optimal internal level of managerial overconfidence that does not deteriorate a firm's investment policy and ensures its expansion.

Based on the above analyzes and on the classification of the managerial overconfidence in different levels: low, moderate and high, we suggest a concave function to explain the relationship between a firm's investment efficiency and the managerial overconfidence.

This function evinces the existence of a moderate level of overconfidence that leads managers to choose the best level of investment (top of the function). A level of managerial overconfidence lower (higher) than the optimal internal level, leads CEOs to under-invest (over-invest) and therefore to destroy a firm's investment efficiency.

We distinguish three parts in this function:

***Part A:*** When the managerial overconfidence level is moderate (the optimal level), firm's investment policy is efficient and firm's value is maximized.

***Part B:*** When the managerial overconfidence level is low (lower than the optimal level), managers destroy firm's investment efficiency by underinvesting.

The idea is to study, if this low level of managerial overconfidence increases, we move closer to the investment efficiency (less underinvestment), since we are approaching further more to the optimal level of managerial overconfidence.

***Part C:*** When the managerial overconfidence level is high (higher than the optimal level), managers destroy firm's investment efficiency by overinvesting.

We investigate, if this high level of managerial overconfidence decreases, we move closer to the investment efficiency (less overinvestment), since we are approaching further more to the optimal level of managerial overconfidence.

Thus, we propose our first set of hypotheses in table 1:

***$H_1$:*** When the manager's level of overconfidence is low, we estimate that increasing this level leads firms to move closer to investment efficiency (less underinvestment).

***$H_2$:*** When the manager's level of overconfidence is high, we estimate that decreasing this level leads firms to move closer to investment efficiency (less overinvestment).

**Table 1** The empirical predictions and the expected signs of our first set of hypotheses

| | Overinvestment | Underinvestment | Convergence Towards Efficiency |
|---|---|---|---|
| Low level of managerial overconfidence | - | + | - |
| Moderate level of managerial overconfidence | - | - | + |
| High level of managerial overconfidence | + | - | - |

If previous studies, including those of Malmendier and Tate (2005); Glaser et al. (2008) and Xiao and Zhou (2017), agreed that managerial overconfidence and optimism have negative effects on firm's investment efficiency, the theoretical and empirical results of Campbell and al (2011) found out that those negative effects come out only when managers are overly (hardly) confident.

The idea is to study if those extremely high (low) levels of managerial overconfidence may improve firm's investment efficiency under certain circumstances.

Indeed, an under-invested firm with a manager that has a high level of managerial overconfidence, who is therefore able to over-invest (Glaser et al, 2008; Wang et al., 2009; Ying et al. 2019), can improve the firm's investment efficiency by increasing its level of investment, ergo reducing the extent of underinvestment (less underinvestment).

Analogously, an over-invested firm with a manager that has a low level of managerial overconfidence, can improve the firm's investment efficiency by decreasing its level of investment, ergo reducing the extent of overinvestment (less overinvestment), given his careful and safe investment policy (Wang et al., 2009).

We build on the work of Campbell et al. (2011) to explore how varying levels of managerial overconfidence influence investment efficiency, particularly in firms prone to both over-investment and under-investment.

Thus, we propose our second set of hypotheses in table 2:

***$H_3$:*** A manager that has a low level of managerial overconfidence in an over-invested firm can improve its investment efficiency.

***$H_4$:*** A manager that has a high level of managerial overconfidence in an under-invested firm can improve its investment efficiency.

**Table 2** The empirical predictions and the expected signs of our second set of hypotheses

| | Under-invested Firms | Over-invested Firms | Improvement of firm's investment efficiency |
|---|---|---|---|
| Low level of managerial overconfidence | | X | + |
| High level of managerial overconfidence | X | | + |

## 3. Research Design

### 3.1 Sample and Data

The sample includes 390 firms spanning the period from 2012 to 2023 (Table 3). Firms in financial and highly regulated industries are excluded due to their distinct accounting practices.

**Table 3** Sample selection

| Sample | Number of firms |
|---|---|
| Initial sample | 390 |
| Financial firms | (108) |
| Final sample | 282 |
| Period N | 12 |
| Total obs | 3384 |

The final sample consists of 3384 firm-year observations after removing firms with missing data.

### 3.2 Dependent Variable

Investment efficiency means firms invest in all positive NPV projects and stick to expected investment levels. Deviations from this, like under- or over-investment, signal inefficiency. Biddle et al. (2009) and Gomariz et al. (2013) use a model linking investment to sales growth, with residuals showing deviations. These residuals help identify under- and over-investing firms, potentially influenced by CEO biases like overconfidence.

First, we estimate a firm-specific investment model as a function of growth opportunities, and we use the model residuals as a specific proxy of deviations from the expected investment, for each firm. The model is defined below:

$$Investment_{i,t+1} = \beta_0 + \beta_1 \, Sales\ Growth_{i,t} + \varepsilon_{i,t+1} \quad (1)$$

We define, $I_{i,\,t+1}$ as the net increase in tangible and intangible assets scaled by lagged total assets for firm (i) and in year (t).

As for the variable "Sales growth", it indicates the annual rate of sales change for the firm (i) between (t-1) and (t).

When we finish estimating this equation for all firms belonging to our sample, we then sort them based on residuals of equation (2), ie deviations from the expected investment, to distinguish firms that over-invest from those that under-invest. We propose the following summary table 4.

**Table 4** Sorting firms to distinguish those that have an efficient investment policy from those that have not (over or under- invest), according to residuals of equation (1)

| ε | ε<0 | ε=0 | ε>0 |
|---|---|---|---|
| **Investment** | Inefficient (Underinvestment) | Efficient | Inefficient (Overinvestment) |

We notice, that all the residual values are different from zero, therefore none of the firms belonging to our sample has an efficient investment policy. These firms can in turn be sorted according to the non-efficient investment policy adopted, using the sign of the corresponding residual value. Results are summarized in table 5.

**Table 5** Sorting Over-Invested From Under-Invested Firms

| | |
|---|---|
| Over-invested Firms (ε> 0) | N1= 3001 |
| Under-invested Firms (ε<0) | N2= 383 |

The importance of the regression model (1), lies in its ability to estimate the residual values (ε) which will serve as values for our dependent variable "Investment Inefficiency", denoted « INV_INEFF ».

### 3.3 Independent Variables

*CEO overconfidence*

Measuring **managerial overconfidence** is difficult because it is a key aspect of CEO behavior that cannot be observed directly. Recent studies have used various methods to assess it. In research by Hirshleifer et al. (2012), Chen et al. (2019), and Andreou et al. (2019), overconfidence is proxied by media coverage. A CEO is considered overconfident if the number of articles portraying them as **confident/optimistic** exceeds those describing them as **cautious/pessimistic**. The **Conf (Press)** variable captures this by comparing the frequency of confident versus cautious references.

Conf (Press) = [(Confident + Optimistic) – (Cautious + Not Confident)] /Sum Total

Confident, Optimistic, Cautious, Not Confident, and SumTotal are article counts for the entire sample period and, thus are CEO-specific. The measure ranges from -1 to 1.

We classify CEOs as: - High overconfidence if $0 \leq$ Conf (Press) $\leq 1$

- Low overconfidence if $-1 \leq$ Conf (Press) $< 0$

A second method for measuring CEO overconfidence, suggested by Hirshleifer et al. (2012) and Lee et al. (2019), is to assign a value of one if a CEO receives at least 67% of their total optional compensation in two or more years, and zero otherwise. Another approach, known as **Prior Performance** (used by Fama and French, 1997; Koellinger et al., 2007; Choi et al., 2018), measures overconfidence by the ratio of adjusted **OCFR** (operating cash flow returns) for a given year to the market value of assets from the previous year. A newer proxy from Hribar and Yang (2016) and Huang et al. (2019) defines overconfidence as when a CEO's profit predictions exceed actual profits for two or more consecutive years. We will classify managers into two groups: low and high overconfidence, using the median value as a threshold.

### 2.4 Control variable

In order to mitigate the effects that might confuse our conclusions, we introduce a set of control variables.

First, we include the size of the firm, the tangibility of its assets and its leverage ratio, in accordance with Biddle and al (2009).

Second, firm's investment policy is also influenced by its growth opportunities. According to Fazzari et al. (1988), we control the growth opportunities by Tobin's Q.

Finally, as already discussed by Dechow et al. (1998) and Dechow and Dichev (2002), firms in different phases of business cycle, have dissimilar investment decisions. We therefore introduce as a control variable a measure of firm age.

A detailed summary of all variables used in this study, is provided in Appendix 1.

### 2.5 Regression Models

This study examines the impact of managerial overconfidence on investment efficiency, with CEO overconfidence as the independent variable and investment efficiency as the dependent variable. Five control variables are included: firm size (SIZE), financial leverage (LEV), Tobin's Q, firm age (AGE), and tangibility (TANG), based on prior research. The models are outlined in Appendix I.

To investigate the relationship between the managerial overconfidence and firms' investment efficiency, we will estimate the following regression model:

$$INV\_EFF_{i,t+1} = \beta_0 + \beta_1 INV\_INEFF_{i,t-1} + \beta_2 Overconf_{i,t} + \beta_3 AGE_{i,t} + \beta_4 LEV_{i,t} + \beta_5 TOBIN'S\ Q_{i,t} + \beta_6 TANG_{i,t} + \beta_7 SIZE_{i,t} + \varepsilon_{i,t} \quad (2)$$

where i =; t =; INV_INEFF = investment efficiency; INV_INEFF i,t-1 = Lag Corporate investment efficiency; Overconf = CEO overconfidence.

## 3. Empirical Results

### 3.1 Summary Statistics

Table 6 displays the descriptive statistics (mean, min, median, max, and standard deviation) for the regression variables across the entire sample.

**Table 6** Summary statistics of the sample

| Variables | Mean | Min | Median | Max | SD | 25th Pr | 75thPr |
|---|---|---|---|---|---|---|---|
| INV_INEFF | 1.482 | -2.151 | 0.280 | 2.882 | 1.542 | 0.024 | 5.210 |
| OVERCONF1 | - 0.0221 | - 0.816 | - 0.035 | 0.989 | 0.180 | - 0.098 | 0.0001 |
| OVERCONF2 | 0.599 | 0.2 | 0.6 | 1 | .282 | 0.4 | 0.8 |
| OVERCONF3 | 9.740 | - 1.003 | - 0.009 | 7.511 | 2.101 | - 0.106 | 0.003 |
| TOBIN'S Q | 1.875 | -16.660 | 1.470 | 49.380 | 2.693 | 0.940 | 2.295 |
| TANG | 0.293 | -0.342 | 0.246 | 0.930 | 0.220 | 0.131 | 0.425 |
| AGE | 55.127 | 0 | 35 | 187 | 47.935 | 21 | 83 |
| SIZE | 15.669 | 8.770 | 15.592 | 19.745 | 1.556 | 14.714 | 16.864 |
| LEV | 0.253 | 0 | 0.244 | 0.860 | 0.140 | 0.161 | 0.342 |

***Notes:*** INV_INEFF = investment efficiency; Overconf1, Overconf2, Overconf3 = CEO overconfidence; AGE= natural logarithm of the firm's age; LEV = ratio of the long-term and short-term debt reported to the book value of total assets; TOBIN'S Q; TANG = ratio of tangible assets and equipment divided by total assets; SIZE =LN of the total asset.

Table 7 shows the correlations among the variables. A correlation above 0.70 could indicate multicollinearity. The highest correlation of 0.244 is between SIZE and LEV.

**Table 7** Pearson correlations for variables

| | INV-INEFF | Overconf1 | Overconf2 | Overconf3 | SIZE | LEV | AGE | Tang | Tobin's q |
|---|---|---|---|---|---|---|---|---|---|
| INV-INEFF | 1.000 | | | | | | | | |
| Overconf1 | 0.048 | 1.000 | | | | | | | |
| Overconf2 | -0.005 | 0.001 | 1.000 | | | | | | |
| Overconf3 | -0.004 | 0.005 | -0.010 | 1.000 | | | | | |
| SIZE | -0.061 | 0.012 | -0.0002 | -0.022 | 1.000 | | | | |
| LEV | -0.037 | 0.033 | -0.014 | -0.019 | 0.244 | 1.000 | | | |
| AGE | 0.014 | 0.0001 | -0.004 | 0.027 | 0.036 | -0.077 | 1.000 | | |
| TANG | 0.137 | -0.023 | 0.006 | 0.035 | 0.010 | -0.013 | -0.066 | 1.000 | |
| Tobin's Q | -0.0001 | -0.0003 | 0.045 | -0.007 | 0.020 | 0.031 | 0.008 | 0.032 | 1.000 |

***Notes:*** INV_INEFF = investment efficiency; Overconf 1, Overconf2, Overconf3= CEO overconfidence; AGE = natural logarithm of the firm's age; LEV = ratio of the long-term and short-term debt reported to the book value of total assets; TOBIN'S Q ; TANG = ratio of tangible assets and equipment divided by total assets; SIZE = ln of the total asset.

### 3.2 Regression Results

We further apply multiple panel regressions to test the relation between investment and the level of CEO overconfidence and through the generalization of the following equation:

$$INV\_EFF_{i,t+1} = \beta_0 + \beta_1 INV\_INEFF_{i,t-1} + \beta_2 Lowoverconf_{i,t} + \beta_3 AGE_{i,t} + \beta_4 LEV_{i,t} + \beta_5 TOBIN'S\ Q_{i,t} + \beta_6 TANG_{i,t} + \beta_7 SIZE_{i,t} + \varepsilon_{i,t} \quad \text{.....(3)}$$

$$INV\_EFF_{i,t+1} = \beta_0 + \beta_1 INV\_INEFF_{i,t-1} + \beta_2 Highoverconf_{i,t} + \beta_3 AGE_{i,t} + \beta_4 LEV_{i,t} + \beta_5 TOBIN'S\ Q_{i,t} + \beta_6 TANG_{i,t} + \beta_7 SIZE_{i,t} + \varepsilon_{i,t} \quad \text{.....(4)}$$

*where* i =; t =; INV_INEFF = investment efficiency; INV_INEFF i,t-1 = Lag Corporate investment efficiency; Highoverconf = High CEO overconfidence; Lowoverconf = Low CEO overconfidence; AGE = natural logarithm of the firm's age; LEV = ratio of the long-term and short-term debt reported to the book value of total assets; TOBIN'S Q = ratio of the market value of equity, plus the book value of the debt and divided by total asset; TANG = ratio of tangible assets and equipment divided by total assets; SIZE = natural logarithm of the total asset; Ɛ is an error term.

We use the Generalized Method of Moments (GMM) regression method to estimate Models (3) and (4). Table 8 reports the regression results of the association between the low level of overconfidence and the investment inefficiency. In order to test the hypothesis (H1) and check whether the increase in the low level of managerial overconfidence leads their firms to move closer to investment efficiency (less under-investment), we will estimate the regression equation parameters (3). By obtaining a negative and significant coefficient β2, this hypothesis will be validated. Although the observed sign of the β2 coefficient corresponds to the expected sign (β2 = - 4.882 p, β2 = - 1.142 and β2 = - 5.422) and statistically significant (p < 0.10 or better) for the three measures of overconfidence respectively, supporting our first hypothesis.

In line with our theoretical predictions, when the level of CEO overconfidence is low, which is often associated with a cautious investment policy and a tendency to under-invest, we postulate that an increase in this level, so that we get closer to the optimal overconfidence level, will be accompanied by an increase in the level of investment, which reduces the extent of underinvestment problem (less underinvestment), and helps the firm in question to move closer to the efficiency of its investments.

To test the hypothesis (H2) and check whether the decrease in the high level of CEO overconfidence leads their firms to move closer to investment efficiency (less over-investment), we will estimate the regression equation parameters (4). We are looking for β2 to be positive and significant; a condition if verified, we accept (H2). Table 8 report that the coefficients on High level of overconfidence CEO is not significant, lead to reject the hypothesis (H2).

**Table 8** Relationship between investment efficiency and different levels of CEO optimism

| Panel 1: investment efficiency | *Overconf1* | | *Overconf2* | | *Overconf3* | |
|---|---|---|---|---|---|---|
| | *Model1* | *Model2* | *Model3* | *Model4* | *Model4* | *Model6* |
| Constant | - 4.542***<br>(0.000) | -2.442***<br>(0.002) | 6.192<br>(0.192) | -1.812<br>(0.101) | - 8.282***<br>(0.000) | -2.001<br>(0.878) |
| Lag invest | 0.732***<br>(0.000) | 0.774***<br>(0.000) | 0.531***<br>(0.000) | 1.346***<br>(0.000) | 0.717***<br>(0.000) | 0.528***<br>(0.000) |
| Low-overconf | - 4.882***<br>(0.000) | | - 1.142*<br>(0.085) | | - 5.422***<br>(0.000) | |
| High-overconf | | 3.112<br>(0.378) | | - 4.312<br>(0.711) | | -4.292<br>(0.933) |
| TANG | 1.642***<br>(0.000) | 9.302***<br>(0.000) | 2.312***<br>(0.000) | -5.472***<br>(0.000) | 2.762**<br>(0.008) | 8.861***<br>(0.000) |
| AGE | 1.461*** | 8.662 | 1.102* | -5.642*** | -1.201*** | 1.980 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | (0.000) | (0.591) | (0.092) | (0.000) | (0.000) | (0.456) |
| LEV | -1.402<br>(0.861) | - 4.072<br>(0.629) | - 2.572<br>(0.408) | 1.242**<br>(0.003) | 2.212**<br>(0.032) | -5.621<br>(0.662) |
| Tobin's Q | 9.801*<br>(0.067) | 3.372<br>(0.651) | 1.272<br>(0.775) | 2.162<br>(0.704) | -6.631<br>(0.498) | -1.151<br>(0.137) |
| SIZE | -3.082***<br>(0.000) | -2.542<br>(0.584) | -1.142*<br>(0.085) | - 4.312<br>(0.711) | 1.202**<br>(0.048) | -1.211<br>(0.114) |
| AR(1) | -7.440 | - 6.800 | … | … | - 13.210 | … |
| AR(2) | -0.160 | 0.570 | … | … | - 0.610 | 3.680 |
| Sargan OIR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| (a)GMM<br>(null, H=exogenous) | 0.000<br>1.000 | 0.000<br>0.000 | 0.000<br>0.000 | 0.000<br>0.000 | 0.000<br>1.000 | 0.000<br>0.000 |
| (b)GMM instruments<br>for levels<br>H excluding group<br>DIF | 0.315<br>0.000 | 0.539<br>0.000 | 0.191<br>0.000 | 0.329<br>0.000 | 0.073<br>0.000 | 0.071<br>0.000 |
| (c)IV(VC, eq(diff)) | 0.000<br>1.000 | 0.000<br>1.000 | 0.000<br>1.000 | 0.000<br>1.000 | 0.000<br>1.000 | 0.000<br>1.000 |
| Fisher | 7920.85 | 3137.40 | 734.23 | 5728.70 | 22568.74 | 305.29 |
| Instruments | 50 | 45 | 41 | 40 | 40 | 58 |
| Observations | 2005 | 996 | 1408 | 1593 | 1803 | 1198 |

INV_INEFF = investment efficiency; Overconf 1, Overconf2, Overconf3= CEO overconfidence; t-Statistic values are in the parentheses. Statistical significance at the 10, 5 and 1% levels is indicated by *, ** and ***, respectively.

Table 9 report the results of testing whether the low level of CEO overconfidence in firms experiencing overinvestment problems, actually makes it possible to improve the efficiency of its investments. We estimate the parameters of the regression only for firms with a tendency to overinvest (INV_INEFF> 0). The results show a negative and significant coefficient β2 ($p < 0.10$ or better) for the three measures of overconfidence, nevertheless they lead us to reject the hypothesis (H3).

**Table 9** Relationship between overinvestment efficiency and low level of CEO overconfidence

| **Panel 3: investment efficiency** | **Subsample: over-invested firms** | | |
|---|---|---|---|
| | *Model1 overconf1* | *Model2 Overconf2* | *Model3 Overconf3* |
| Constant | -3.312***<br>(0. 000) | 9.002<br>(0.111) | -3.092***<br>(0.000) |
| Lag invest | 0.674***<br>(0.000) | 0.531***<br>(0.000) | 0.927***<br>(0.000) |
| Low-overconf | -5.472***<br>(0.000) | -1.812**<br>(0.039) | -1.822***<br>(0.000) |
| TANG | 1.252***<br>(0.000) | 2.262***<br>(0.000) | 4.142***<br>(0.000) |
| AGE | 1.331***<br>(0.000) | 1.182<br>(0.122) | -2.741<br>(0.117) |
| LEV | -7.402<br>(0.276) | -1.902<br>(0.632) | 1.172<br>(0.108) |
| Tobin's Q | 1.032**<br>(0.046) | -2.612<br>(0.974) | -9.441<br>(0.350) |
| SIZE | -3.302***<br>(0.000) | -3.832*<br>(0.093) | -1.071<br>(0.980) |
| AR(1) | -7.790 | ... | -17.010 |
| AR(2) | -0.510 | … | -0.550 |
| Sargan OIR | 0.000 | 0.000 | 0.000 |
| (a)GMM instruments for levels<br>H excluding group<br>DIF (null, H=exogenous) | 0.000<br>1.000 | 0.000<br>0.000 | 0.000<br>0.000 |
| (b)<br>null, H=exogenous) | 0.066<br>0.000 | 0.180<br>0.000 | 0.000<br>0.000 |
| (c)IV(VC, eq(diff))<br>H excluding group | 0.000<br>1.000 | 0.000<br>1.000 | 0.000<br>1.000 |
| Fisher | 11897.34 | 610.15 | 46669.89 |
| Instruments | 50 | 41 | 40 |
| Observations | 3001 | 1108 | 1748 |

INV_INEFF = investment efficiency; Overconf 1, Overconf2, Overconf3= CEO overconfidence; t-Statistic values are in the parentheses. Statistical significance at the 10, 5 and 1% levels is indicated by *, ** and ***, respectively.

The purpose of (H4), being to examine whether a high level of CEO overconfidence for firms tending to under-invest, contributes to improving the efficiency of the investments of these firms. Tests on a sub-sample, made only by firms experiencing under-investment problems (INV_INEFF <0), we obtain table 10. The table shows that the regression coefficient for high level of CEO overconfidence is positive for two measures of overconfidence (overconf2 and overconf3) and statistically significant ($p < 0.01$). This is contradicting with our hypothesis (H4).

**Table10** Relationship between underinvestment efficiency and high level of CEO overconfidence

| **Panel 2: investment efficiency** | **Subsample: under-invested firms** | | |
|---|---|---|---|
| | *Model1 overconf1* | *Model2 Overconf2* | *Model3 Overconf3* |
| Constant | 8.461* | | 7.651** |
| | (0. 091) | | (0.006) |
| Lag invest | 4.076*** | 2.831*** | 4.729*** |
| | (0.000) | (0.000) | (0.000) |
| High-overconf | 1.131 | 4.131*** | 9734.31*** |
| | (0.651) | (0.000) | (0.000) |
| TANG | 1.601*** | 3.621*** | 6.011** |
| | (0.000) | (0.000) | (0.028) |
| AGE | -4.660 | 2.440 | -7.090 |
| | (0.522) | (0.184) | (0.222) |
| LEV | -7.821** | 3.190 | -5.081** |
| | (0.028) | (0.254) | (0.037) |
| Tobin's Q | -1.870 | 1.272 | -4.190 |
| | (0.163) | (0.775) | (0.700) |
| SIZE | -6.250** | -2.780*** | - 4.312 |
| | (0.029) | (0.000) | (0.711) |
| AR(1) | -4.660 | -1.20 | -6.470 |
| AR(2) | 1.84 | … | 3.710 |
| Sargan OIR | 0.000 | 0.000 | 0.000 |
| Hansen OIR | ... | 0.000 | ... |
| (a)GMM instruments for levels | | | |
| H excluding group | 0.003 | 0.000 | 0.000 |
| DIF | 0.000 | 1.000 | 0.000 |
| (b)GMM instruments for levels | 0.008 | 0.603 | 0.010 |
| H | 0.000 | 0.000 | 0.000 |
| (c)IV(VC, eq(diff)) | 0.000 | 0.000 | 0.000 |
| H excluding group | 1.000 | 1.000 | 1.000 |
| Fisher | 308.49 | 5.4307 | 518.43 |
| Instruments | 28 | 33 | 28 |
| Observations | 338 | 156 | 254 |

INV_INEFF = investment efficiency; Overconf 1, Overconf 2, Overconf 3= CEO overconfidence; t-Statistic values are in the parentheses. Statistical significance at the 10, 5 and 1% levels is indicated by *, ** and ***, respectively.

The rejection of these hypotheses (H3 and H4) implies that a low level of CEO overconfidence (respectively, high) in a firm that tends to over-invest (respectively, to under-invest) does not help to improve the efficiency of these firms' investments. In fact, the presence of a manager with a low level of CEO overconfidence, even with his conservative and prudent investment policy, he cannot compensate the level of investment significantly higher than optimal, in a firm with a tendency to overinvest, which does not favor the improvement of the efficiency of its investments.

Thus, the presence of managers with an extremely high level of overconfidence, who are likely to invest more, does not compensate the level of investment significantly lower than the optimal in firms that tend to under-invest, but further amplifies the underinvestment problem, hence promoting the inefficiency of the investment policy of these firms.

## 4. Conclusion

We investigate the impact of CEO overconfidence on a firm's investment efficiency. Specifically, we suggest that moderating CEO overconfidence—shifting from low to moderate or high to moderate levels—can improve investment efficiency by reducing underinvestment or overinvestment, respectively. We further propose that high levels of overconfidence are beneficial for firms prone to under-investment, while low levels are more effective for firms prone to over-investment. To measure CEO overconfidence, we focus on identifying firms that are typically subject to under- or over-investment. Our results show that increasing low levels of overconfidence among CEOs helps firms reduce underinvestment, bringing them closer to optimal investment efficiency. However, we find that for firms with high levels of over-investment, increasing CEO overconfidence does not significantly improve efficiency, even when overconfidence is low.

This study underscores the significance of considering varying levels of CEO overconfidence in both theoretical and empirical research. We also contribute by refining existing measures of overconfidence to better distinguish between low and high levels.

The findings suggest that firms should incorporate psychological profiling into their CEO selection process. Assessing the level of overconfidence in potential candidates can help ensure a good match between the CEO's psychological traits and the firm's investment needs. For firms prone to underinvestment, hiring a CEO with moderate to high overconfidence may drive more proactive investment decisions. Conversely, firms with a history of overinvestment may benefit from selecting a CEO with a more balanced, grounded approach to prevent excess capital expenditure.

Companies should align their leadership selection with their specific investment strategies. A CEO with moderate overconfidence can be particularly effective in improving investment efficiency by addressing underinvestment. In contrast, for firms experiencing overinvestment, a CEO with lower levels of overconfidence may help reduce excessive risk-taking and prevent unnecessary expansion or spending.

CEOs with extreme levels of overconfidence may benefit from targeted training programs to balance their decision-making approach. High overconfidence might lead to overly optimistic projections and excessive risk-taking, so leaders could be trained to make data-driven, more conservative decisions. On the other hand, CEOs with low overconfidence might need support in building confidence and adopting a more assertive, growth-oriented investment strategy.

It is important for firms to establish a culture that balances risk-taking with prudent financial management. By understanding the psychological tendencies of CEOs, firms can implement internal checks and balances, encouraging a more measured and collaborative approach to investment decisions. This could be achieved by integrating risk management frameworks that account for the CEO's personality and psychological traits.

Firms should adopt flexible scenario planning to account for the varying effects of CEO overconfidence on investment efficiency. By preparing for different leadership traits and potential biases, companies can better navigate the challenges associated with underinvestment or overinvestment. This proactive approach can help mitigate the risks of ineffective investment decisions, regardless of the CEO's psychological profile.

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**Appendix I.** Variable definitions and measurement

| Variables | Definition and measurement |
|---|---|
| INV_INEFF | To estimate our dependent variable "Investment Inefficiency", we will predict « Investment » in terms of « Sales Growth », through the following equation: $Investment_{i,t+1} = \beta_0 + \beta_1 \text{ Sales Growth}_{i,t} + \varepsilon_{i,t+1}$ The investment is the net increase in tangible and intangible assets, scaled up by lagged total assets and multiplied by 100. Sales Growth, is the annual rate of sales change for the firm (i) between (t-1) and (t). |
| Over-investment | Positive residues from the investment model. |
| Under-investment | Negative residues from the investment model. |
| CEO Overconfidence | Equally weighted average of the environmental and the social score. |
| Firm Size | The natural logarithm of the total asset. |
| Firm Age | The natural logarithm of the firm's age. |
| Leverage | The ratio of the long-term and short-term debt reported to the book value of total assets. |
| Tangibility Ratio | The ratio of the market value of equity, plus the book value of the debt and divided by total asset. |
| Tobin's Q | Research and development expense ratio, measured as research and development expense scaled by lagged assets. Missing values for research and development expense are set to zero. |