Journal of Quantitative Finance and Economics
Volume 3; Number 1; 2021; pp : 79-98

ARF INDIA
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The Impact of R&D Investment on Firm Performance: through the Moderating Effect of Investor Sentiment

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Received: 29 March 2021; Revised: 31 March 2021;
Accepted: 12 April 2021; Publication: 3 May 2021

Abstract: An empirical research that underscores the interaction between corporate R&D investment and firm performance through the moderation of a behavioural variable (Investor Sentiment) is imperative in modern times. This study analyzes how investor sentiment serves as a moderator for the relation between R&D investment and firm performance. We argued with empirical basis that, investor sentiment moderates the said relation. We examined a nine-year panel data, from 2009 to 2017, consisting of 3500 Chinese listed firms. The empirical results revealed that, investor sentiment statistically moderates the relation between R&D investment and performance of firms. Results from the analysis also suggested a direct association between firm's R&D investment and performance, with investor sentiment as a moderator. A robustness checks on the findings was conducted and then discussed its contribution, theoretically and practically.

Keywords: Investor sentiment, R&D investment, firm performance, moderating effect.

1. Introduction

The concept of organizational investment in Research and Development (R&D) in modern corporate activities is indisputably a major determinant of corporate success. The term R&D has been defined as a means of increasing human, cultural and social knowledge and the creative implementation of this knowledge in real application (OECD, 2019). In the quest of firms to obtain and sustain a favourable position in the highly intensive technological market, especially regarding knowledge-centered economics, it is imperative to enhance their innovative capacity so as to improve quality service delivery and increase performance. Research works that capture the relation between R&D Investment and firm performance gained much attention after the seminar of Griliches in 1958. The R&D-

performance phenomenon has since then obtained much credence in inquiry and its research has now become necessary. R&D investment in corporate activities is geared towards ascertaining new strategies and ideas for enhancing business performance. Firms' ability to acquire competitive capacity through the desire for R&D determines their absolute existence in the market. China has consistently increased her investment in R&D so as to enhance productivity in the country. In the year 2009, the country invested 1.62 trillion-yuan in R&D. This increased to 1.71 trillion-yuan in 2010. In 2011, the country invested 1.78 trillion yuan in R&D in the quest to increasing productivity. The desire for R&D investment further increased as it was seen in its investment in the year 2012, as 1.91 trillion-yuan investment was made in R&D. The country spent 1.99 trillion-yuan into R&D investment in 2013. An increment occurred in 2014 by investing 2.02 trillion-yuan in R&D. This was increased to 2.07 in 2015. In the year 2016, China invested 2.11 trillion-yuan in R&D investment. The country increased her investment capacity to 2.13 trillion-yuan in 2017, followed by about 2.15 trillion-yuan investment in the year 2018. The country has consistently advanced its investment in R&D as it spent about 2.17 trillion yuan in R&D investment in the year 2019 (National Bureau of Statistics, 2019). R&D investments tend to be costly due to the level of uncertainty attached to its outcomes (Hall and Lerner, 2010). Managers may forgo R&D investment due to the high level of uncertainty attached to its outcomes (Dalziel, Gentry, & Bowerman, 2011). The intangibility of R&D investment outcomes act as an impediment in accessing funding for its implementation. Global R&D portfolios adds to the value of firms (Phene and Almeida, 2008; Lahiri, 2010; Piening *et al.*, 2016), however, they are accompanied with significant challenges (Alcácer and Zhao, 2012; Berry, 2014; Kim, 2016).

Several studies have acknowledged the role sentiment plays in organizational investment in R&D (Xu *et al.*, 2018; Wenping *et al.*, 2018). Sentiment is an important variable in corporate business activities (Joseph, 2017). Investor sentiment enhances corporate R&D investment (Shiller, 2002; Baker and Wurgler, 2007). Investor sentiment impacts on firm's innovation practices (Zheng and Zheng, 2014; Ernst and Brem, 2017). Sentiment also causes firms to make certain critical decisions (Kaplan and Haenlein, 2010). The opinions and actions of investors have the capacity to reshape business R&D investment strategy (Yan *et al.*, 2016; Smales, 2017).

Whereas there exists some research work on the R&D- performance relation, relatively less attention is given to how investor sentiment serves as a moderator. The study would seek to empirically ascertain the impact of corporate R&D Investment on performance, through the moderation of investor sentiment.

2. Review of Literature

In as much as there exist little or no disagreement on the theoretical aspect regarding the impact of corporate R&D investment on performance, the acceptance in the empirical literature has been disputed by some previous researchers. The often-lacking robustness of the estimates to support the findings also makes the conclusions on R&D investment and firm performance contestable, thereby requiring further inquiry.

2.1. Theoretical Perspectives on R&D Investment and Firm Performance

Firms' strategically invest in R&D in order to boost performance. A research by Koutroumpis, Leiponen and Thomas (2020) examined the impact of R&D investment on the productivity of large firms. The study revealed that, small firms benefit from the investment in R&D than large firms. The findings revealed that, R&D investment significantly affects the revenue levels of firms. Mario, Chengqi, Mavroudia, Junjie and Katsikeas (2018) revealed that, firm's geographic dispersion and co-location of R&D investments lead to different firm performance outcomes. David, Weihong, Zhua and Lan (2019) concluded that, firms R&D intensity has an asymmetric effect on their performance. The study also indicated that, inconsistent feedback slightly affects firm's R&D investments as compared to consistent feedback. A research by Elisabete (2019) showed that, R&D investment through government support programs, education and training and favourable entry regulations allow countries to derive benefits from the investment made in R&D, which may be effectively exploited by new and growing firms. Pegah and Teirlinck (2018) concluded that, R&D investment gives large firms a higher average scale efficiency and technical efficiency as compared to small firms.

Upon an analysis of 588 sampled Korean small and medium sized enterprises, Hyejin, Hwangb and Kim (2018) revealed that, the effect of R&D investment is not identical in all firms. They found that, R&D investment is shown to be a poor choice for general firms to survive; however, it is an effective strategy for innovative firms. Using a firm-level data from the period between 2004 to 2016, Alam, Atif, Chu and Soyta? (2019) found that, R&D investment improves the environmental performance of industries. Rupika and Sharma (2018) also found that, R&D and IT investments have effect on labour productivity. A research by Mingshan, Xiao, Chan and Fung (2019) argued that, there exist a negative association between pre-IPO performance pressure and an IPO applicant's research and development investments.

Yiqi and Oyakhilome (2019) also argued that, there exist threshold effects between R&D investment and firm performance, suggesting that R&D

investment has a nonlinear relationship with firm performance. According to Diéguez-Soto, Manzaneque, González-García and Galache-Laza (2019), R&D intensity reinforces the negative effect of family management on firm performance. They found R&D intensity as a moderator for those firms having large levels of R&D investment relative to their industry peers. Parcharidis and Varsakelis, (2016) found that, R&D Investment has negative impact on firm profitability for the year of the investment and can show strong positive relation after 2 years. Nina and Meluzín (2016) studied 103 firms in the electronic industry of Czech that invest in R&D between 2007 and 2013 and concluded that, firms utilize R&D investment in order to enhance their efficiency. After observing 401 panel datasets consisting of 110 multinational companies in the energy sector, Nuria, Alberto, and Natalia (2018) concluded that, firm's innovative performance has a U-shape which is inverted in either the degree or the geographic diversification of its R & D internationalization.

2.2. Moderating Effect of Investor Sentiment

There exist little or no credence to the role that investor sentiment plays on corporate R&D investment in classical finance theory (Morck *et al.*, 1990; Blanchard *et al.*,1993 ; Zhaohui Zhu & WenSheng Huang, 2014). However, recent studies tend to give different opinions and conclusions on the interplay between these variables. Ding and Hu (2019) showed that, an increase in market sentiment positively affects the investment and debt issuance of firms with lower credit ratings. Jiexiang, Roberts and Tan (2018) postulated that, there exist a positive association between media sentiment and firm's R&D expenditures. Qiulin and Sieracki (2019) explored sentiment-driven trading behaviour of various investor categories in the London office market and found a statistically significant relationship between investor sentiment and real estate activities. Axel & Ebner (2019) employed statistical language modelling techniques to construct directional sentiment metrics and linked to aggregate stock index returns. The findings showed a significant predictive gain over benchmark models in times of negative market returns.

Xiaohan (2018) concluded that, sentiment shock contributes to a greater portion of the variations that occur in firm's output as well as its investment in the short run. Junyan, Jianfeng and Zhao (2017) also concluded that, high-risk firms earn a larger income on investment as compared to firms with low risk during low-sentiment periods. A research by Bo, Sun and Fu (2019) postulated that, there exist a positive association between media sentiment stock returns in both the short and long runs. Cai, Xu and Zhang (2019) concluded that. investor sentiment and leverage effect have

significant effects on volatility forecasting. David and Zhang (2019) suggested that, price dynamics are influenced by social-media sentiment pricing factors, with different balances of importance for firm specific and the general market sentiment.

Tri and Xu (2016) postulated that, there exist a direct relationship between market-wide sentiment and firms' innovation activities. A research by Wenping, Kang, Jiang and Pei (2018) showed that, sentiment expressed via public opinions triggers firm strategic decisions regarding innovation investment. Mujtaba, Sharma and Ferdinand (2018) argued that, there exist a significant association between the sentiment of investors and the advertising expenditure of firms.

3. Empirical Strategy

This study emphasizes the impact that corporate R&D Investment has on firm performance by considering the moderating role of a behavioural variable (investor sentiment). A research of this kind is necessary in current times as far as the studies of corporate finance and behavioural economics are concerned. The study therefore seeks to critically investigate the interplay between these variables, empirically.

3.1. Data and Sample

Data was obtained from the Chinese enterprise annual report and the ifind database (a Chinese database). The hypotheses developed are empirically tested through the assessment of a nine-year firm-based panel data. The data covers the period of 2009 - 2017, it also consists of both private and state-owned firms. Data is collected on 3,500 Chinese listed firms for the study. The data consists of a multi-industry sample of firms for the empirical analysis.

3.2. Description of Variables

3.2.1. Key Variables

Firms' annual expenditure in research and development would be used as an indicator for measuring R&D investment and denoted as, (RDI_{it}). Firms' Return on Asset (ROA_{it}) would also be used as an indicator for measuring how firms perform in their operations. Firms' Return on Assets is a good measure of its performance. This is a widely used proxy for measuring firm performance (Mario *et al.*, 2018; J. Diéguez-Soto *et al.*, 2019). Firms' cumulative monthly stock returns for the previous year would be used as an indicator for measuring investor sentiment (Hua, Liu and Xu, 2011). This is denoted as $SENT_{it}$.

3.2.2. Control variables

Other relevant variables that have the potential to influence firm performance would also be considered in the model in order to minimize the threat of potential endogeneity (Wooldridge, 2010).

Operating Income (OPI_{it}): Firm's R&D investment would have the tendency to increase its income levels. Firms would therefore aspire to be innovative so as to acquire higher incomes in operations. This help firms to stay in business, for this reason, each firm's operating income would be controlled for.

Total Assets (TOA_{it}): Firms' asset base would determine its strength in business. Firms with an increased asset base largely tend to tolerate R&D investment than those with smaller asset base due to the uncertainty in R&D outcomes. This variable would be controlled for in the model.

Number of Employees (NOE_{it}): The categorization of firm size is determined by its number of employees. Comparatively, bigger firms may be tempted to tolerate R&D than smaller firms. This variable would therefore be considered in the models as a control variable.

Asset Liability Ratio (ALR_{it}): The ratio of firm's assets and liabilities is crucial to the rate at which it invest in R&D. Firms' with higher levels of assets than liabilities in their operations would have greater financial capacity to invest in research.

Cash Flow (CF_{it}): Firms' revenue and expenditure patterns can affect their desire for R&D investment. Firms with excess revenue over expenditure would have higher chances to invest in R&D. The degree at which cash moves in and out of an organization is an essential element for determining corporate R&D investment decisions. Firm's Cash Flow patterns would be controlled for, in the models.

Shareholder's Equity ($SHEQ_{it}$): The proportion of shareholder's equity in main business income can affect corporate R&D investment. Firms with higher proportion would increase investor optimism towards the entity, this increased optimism would generate innovation waves which will result in corporate innovation investment. This variable will also be considered in the model.

Earnings Per Share (EPS_{it}): This is a measure of firms' profitability levels. EPS is used to gauge a company's net income allotted to all the shares of its income. Firms' with high profitability levels would have a higher tendency to embrace R&D investment in their operations. This variable is included in the models as control variable.

Average rate of return (ARR_{it}): This refers to returns made on investment. Firms that gain increased returns on their investments would relatively tolerate R&D investment in their operational plan than those with low returns. This variable is therefore captured in the models as control variable.

Nature of Firm (NAF_i): The nature of business would determine firm's degree of R&D investment. Firms in high-technology domains such as biotechnology, pharmacology and IT would have greater capacity to spend more on R&D investment than those in different firm category. A categorical variable, NOF_i, would be constructed to control for variations in R&D investment across industries.

Year dummy ($YEAR_t$): Finally, the perception and attitude of investors towards an organization can change its R&D investment patterns over time. Year dummy variables are therefore included in the estimation models.

3.3. Statement of Hypotheses

Hypotheses are deduced based on a retrospection of previous research related to the study. Prior studies that emphasize the role of investor sentiment in enhancing the interaction between firms' R&D investment and performance are critically analyzed. Primarily, the study would aim at ascertaining how corporate R&D investment affects firm performance by considering the moderating factor of investor sentiment. The study would also lend credence to other variables that may have the propensity to foster firm performance.

3.3.1. Hypotheses

Hypothesis 1: *Investor sentiment moderates the impact of corporate R&D investment on firm performance.* This hypothesis is proposed on the grounds that, investor sentiment enhances the impact that R&D investment has on the performance of firms. Investor sentiment affects firms R&D decisions and that triggers financial performance (Cai, Xu, Zhang, 2019). Negative information tends to influence firm's decision than positive information (Yin *et al.*, 2014). Negative sentiment triggers 'positive anger' within firms and also enhances a free flow of information (Kimmel and Kitchen, 2014). In general, negative sentiment tends to have more constructive information for decision making such as, suggestions regarding product quality, strategy or firm's image. Negative sentiment pushes firms to increase their desire for innovation (Junyan *et al.*, 2017). Highly negative perceptions and opinions of investors cause firms to embrace innovation investment, in their quest to making changes so as to advance growth (Lele *et al.*, 2018).

Hypothesis 2: *R&D investment has positive association with firm performance.* This hypothesis is proposed, upon a retrospection of past research works that suggested an increase in firm growth as R&D investment increases. R&D investment has high propensity to increase the growth of firms (Berchicci, 2013). It increases firms' efficiency and reduces the cost they incur in their operations. It also gives firms comparative advantage. R&D investment plays a crucial role in improving a firm's performance by further enhancing technical understanding (Cantwell and Mudambi, 2005) and also help firms to identify new capabilities in international markets (Kotabe *et al.*, 2007; Lu and Beamish, 2004).

Hypothesis 3: *Investor sentiment affects R&D investment decisions of large firms.* This hypothesis is developed on the premise that, investor sentiment fosters higher R&D investment in large firms than smaller firms (Jiexiang *et al.*, 2018). R&D investment's impact on firm productivity is different at various levels of R&D intensity. R&D investment affects performance in larger firms than smaller firms (d'Artis and Siliverstovs, 2015). Large firms enjoy a higher average scale of technical efficiency through the investment in R&D (Pegah and Teirlinck, 2018).

3.4. Empirical Model

Econometric models would be employed in the quest to analyzing the data empirically. The returns that firms make on their assets (ROA) is set as dependent variable. All variables are transformed using logarithms, as a result of the variations in the sizes of firms. The study employs the AR (Autoregression) process with lagged variables in the attempt to empirically analyze the variables. The AR process reduces potential correlations of serial nature in the errors and also controls for possible endogeneity problems. The study would first examine the effect that investor sentiment has on corporate R&D investment. The study would further examine the impact that firm's R&D investment has on its performance whilst considering the moderating role of investor sentiment.

The study captures the long run effect of sentiment on firm performance. It gives the firm specific measures of the returns on assets and sentiment of firm (i) at a specific time (t), including other relevant control variables and an error term. This is estimated for the entire number of firms considered in the study. Investor sentiment's long run effect on firm performance is considered in equation 1. The equation is set as:

$$logROA_{it-1} = \alpha_0 + \alpha_1 log(SENT_{it-1}) + \beta Z + \mu_{it} \quad (1)$$

The impact that corporate R&D investment has on performance is also considered in equation (2). Firm's R&D investment is regressed on the return

on assets so as to ascertain the impact of the investment decisions on performance. Other relevant variables that have the propensity to foster firm performance are included, with an error term to cater for all other factors that are not considered. This is stated as:

$$logROA_{it} = \alpha_0 + \alpha_1 log(RDI_{it-1}) + \beta Z + \mu_{it} \quad (2)$$

Also, the study conducts an assessment on the interplay between corporate R&D investment and firm performance by lending credence to the moderating role of investor sentiment. The equation considers other relevant control variables that can affect firm performance and also included the error term. The equation is set as:

$$logROA_{it} = \alpha_0 + \alpha_1 \log(RDI_{it-1})) + \alpha_2 log(SENT_{it-1})) + \beta Z + \mu_{it} \quad (3)$$

Variable Z captures the extensive set of control variables included in the model in an attempt to reducing the threat of endogeneity (Wooldridge, 2010).

$$\begin{aligned} Z = {} & \beta_1 * OPI_{it} + \beta_2 * OPI_{it-1} + \beta_3 * TOA_{it-1} + \beta_4 * NOE_{it-1} + \beta_5 * ALR_{it-1} + \beta_6 * DPS_{it-1} \\ & + \beta_7 * SHEQ_{it-1} + \beta_8 * CF_{it-1} + \beta_9 * EPS_{it-1} + \beta_{10} * ARR_{it-1} + \beta_{11} * NOF_i \\ & + \beta_{12} * GRW_{it-1} + \beta_{13} * YEAR_t \end{aligned}$$

The subscripts captured in the specifications above denote measures across firms (i) and years (t). We lagged all independent and control variables by one year in order to mitigate the possibility of reverse causality μ_{it} denotes the error term.

4. Results

Table 1 summarizes the definition of variables and Table 2 also presents the descriptive statistics of the analysis. The descriptive statistics shown in Table 2 reports 1.970 mean value for firms ROA (proxy for measuring performance). It also reports 17.286 and 13.306 mean values for investor sentiment (the moderator) and firms' R&D expense, respectively. Table 3 reports correlation values between the studied variables. It indicates that, most of the variables have low bivariate correlations. The highest correlation recorded is between Number of Employees (NOE_{it}) and Total Assets (TOA_{it}), 0.798, signifying a strong positive correlation between the said variables. The table presents the correlation between Cash Flow ($CFit$) and Asset Liability Ratio (ALR_{it}), -0.438 as the weakest.

Autoregression models (fixed and random effect models) are employed in an attempt to examine the moderating role that investor sentiment plays on firm's R&D investment and performance relation. In order to empirically ascertain the said relation, investor sentiment (independent variable) was

first regressed on corporate R&D investment. This is presented in Table 4. The results showed that, investor sentiment is statistically significant to a firm's R&D investment decisions ($\beta = 0.744$, $p<0.001$ in model 1; $\beta = 0.848$, $p<0.001$ in model 2). The result means that, investor's optimism has influence on firm's R&D investment decisions. This is consistent with previous study (Zhai *et al.*, 2017; Huang, Roberts & Tan, 2018). This result strongly supports hypothesis 1. The results also indicated a statistically significant and direct relationship between firm's R&D investment and its performance ($\beta=0.186$, $p<0.001$ in model 3; $\beta=0.406$, $p<0.001$ in model 4). This agrees with previous study (Berchicci, 2013; Md. Chu *et al.*, 2019; David *et al.*, 2019; Yiqi, Oyakhilome, 2019). This also supports hypothesis 2. Results from the empirical analysis also revealed the moderating effect of the sentiment of investors in large firms as postulated in hypothesis 3 ($\beta=0.155$, $p<0.10$, in model 5; $\beta=0.972$, $p<0.05$ in model 6).

With respect to the control variables in models 1 and 2, it was revealed that, firm's operating income affects its R&D investment, with positive correlations. This means that, firms with higher income would make higher investment in R&D which would trigger in their performance, other things being equal. Firm's growth rate in assets was revealed to be statistically significant to their R&D investment. The results also postulated a statistically significant and direct relationship between firm size and R&D investment. This means that, larger firms would have greater tolerance for investment in R&D than smaller firms which would reflect in their performance. Firm's total asset base together with the ratio of their assets and liabilities is statistically significant with their R&D investment decisions. The pattern at which cash circulates in firm's operations (cash flow) affect its R&D investment. Shareholders equity and R&D investment relation was only significant in the fixed effect model. The results suggested that, corporate dividend per share as well as the earnings per share are statistically significant to firms' R&D investment decisions in the fixed effect model. The findings indicated no statistically significant relation between average rate of return and R&D investment. Most of the results for the controlled variables in model 3 and model 4 are statistically significant to the dependent variable (firm performance, ROA as a proxy). Firm's operating income suggested a statistically significant and direct association with its performance, indicating that, higher incomes boost firm's performance. The growth rate in firms' assets has significant relationship with their performance in both models 3 and 4. The size of firm is statistically significant with its performance in model 3. Firms total asset is also statistically significant with its performance. This means that, firm's with larger asset base enjoy higher performance than those with low asset base.

Table 1. Description of studied Variables

Variables	*Description*
Performance (ROA_{it})	A specific firm *i*'s return on assets in an accounting year *t*.
Innovation Investments (RDI_{it})	The innovation investments of firm *i* in a specific year *t*, which is measured by the R&D expenses of firms.
Stock Returns ($SENT_{it}$)	The cumulative monthly stock returns of firm *i* in a financial year *t*.
Operating Income (OPI_{it})	The income earned by firm *i* in financial year *t*.
Total Assets (TOA_{it})	The overall assets owned by a specific firm *i* in financial year *t*.
Number of Employees (NOE_{it})	The total number of people employed in a particular firm *i* in an accounting year *t*.
Firms' Growth Rate (GWR_{it})	The rate at which a specific firm *i* enjoyed growth in year *t*.
Asset Liability Ratio (ALR_{it})	This is a ratio of a specific firm *i*'s assets and liabilities in a financial year *t*.
Cash Flow (CF_{it})	The rate at which cash flows in a particular firm *i* in an accounting year *t*.
Shareholder's Equity ($SHEQ_{it}$)	The equity of shareholders in a particular firm *i* during an accounting year *t*.
Earnings Per Share (EPS_{it})	Firm *i*'s earnings on each share in an accounting period *t*.
Dividend per Share (DPS_{it})	The unit share of firm *i*'s dividend in an accounting year *t*.
Average Rate of Return (ARR_{it})	The rate of return on firm *i*'s investment in a specific financial year *t*.
Nature of Firm (NAF_i)	The industrial nature of a specific firm.
Year dummy ($YEAR_t$)	Year dummy variables.

Table 2
Descriptive Statistics. The table below describes the summary statistics for the sample (2009-2017)

Variable	*Obs.*	*Median*	*Mean*	*Std. Dev.*	*Min.*	*25th%*	*75th%*	*Max*
ROA_{it} (log transformed)	26,884	2.045	1.970	0.879	-9.210	1.456	2.566	7.696
RDI_{it} (log transformed)	21,192	17.270	17.286	1.541	6.685	16.441	18.172	23.646
$SENT_{it}$ (l0g transformed)	31,501	13.306	13.306	0.001	13.305	13.306	13.306	13.306
OPI_{it} (log transformed)	20,885	2.985	2.854	1.213	-5.240	2.276	3.583	10.512
TOA_{it} (log transformed)	29,232	21.494	21.672	1.620	11.348	20.606	21.511	30.892
NOE_{it} (log transformed)	28,304	7.341	7.389	1.386	1.099	6.506	8.214	13.223
GWR_{it} (log transformed)	23,489	2.898	2.842	1.341	-5.521	2.130	3.612	13.065
ALR_{it} (log transformed)	29,232	3.782	3.640	0.659	-1.757	3.311	4.101	9.535
CF_{it} (log transformed)	28,963	2.763	2.718	0.839	-5.150	2.250	3.286	4.605
$SHEQ_{it}$ (log transformed)	24,683	3.527	3.478	0.492	-1.238	3.159	3.849	4.605
DPS_{it} (log transformed)	16,495	-2.303	-2.322	1.044	-7.131	-2.996	-1.609	2.398
EPS_{it} (log transformed)	26,731	-0.907	-1.162	1.184	-8.112	-1.761	-0.355	4.357
ARR_{it} (log transformed)	3,008	1.324	1.110	1.154	-2.709	0.588	1.876	4.737
NOF_i	31,501	Category variable. State and Private- owned firms						
$YEAR_t$	31,501	Category variable (2009-2017, 9 years).						

Table 3
Correlation between variables

Variable	ROA_{it}	RDI_{it}	$SENT_{it}$	OPI_{it}	TOA_{it}	NOE_{it}	GWR_{it}	ALR_{it}	CF_{it}	$SHEQ_{it}$	DPS_{it}	EPS_{it}	ARR_{it}
ROA_{it}	1.000												
RDI_{it}	0.038	1.000											
$SENT_{it}$	0.048	-0.095	1.000										
OPI_{it}	0.172	0.021	0.075	1.000									
TOA_{it}	-0.074	0.538	-0.322	-0.015	1.000								
NOE_{it}	0.002	0.567	-0.276	-0.073	0.798	1.000							
GWR_{it}	0.286	0.004	0.106	0.329	-0.018	-0.077	1.000						
ALR_{it}	-0.238	0.241	-0.222	0.019	0.534	0.476	-0.000	1.000					
CF_{it}	0.170	-0.045	0.143	-0.298	-0.299	-0.260	0.154	-0.438	1.000				
$SHEQ_{it}$	0.052	0.008	-0.053	-0.066	0.144	0.136	-0.042	0.061	-0.011	1.000			
DPS_{it}	0.573	0.135	-0.029	0.014	0.100	0.144	0.113	-0.202	0.227	0.151	1.000		
ESP_{it}	0.751	0.198	0.020	0.149	0.753	0.157	0.290	-0.123	0.209	0.112	0.761	1.000	
ARR_{it}	0.016	-0.057	0.030	0.031	-0.085	-0.045	0.017	-0.006	0.014	0.025	-0.008	0.029	1.000

The results showed that, the ratio of firms' assets and liabilities has statistically significant impact with their performance, in model 3. It was also revealed that, the pattern at which cash flows in an organization has impact on its performance as shown in models 3 and 4. The results showed no significant association between the equity of shareholders and performance of firm. The results showed that, the share of firm's dividend together with its earnings per share have significant relationship with its performance. Finally, firm's rate of return on their investment (in average terms) is significant to their performance, as presented in model 3.

4.1. Robustness checks

Two samples were generated based on the size of firms which is measured by the number of employees, in an attempt to assess the robustness of the

Table 4
Regression results

	R&D Expense		*Firm Performance (ROA)*	
	Model 1 (Random-effect)	*Model 2 (Fixed-effect)*	*Model 3 (Random-effect)*	*Model 4 (Fixed-effect)*
Hypothesis 1:				
$SENT_{IT\text{-}1}$	0.744***(0.03)	0.848***(0.010)		
Hypothesis 2:				
$R\&D_{it\text{-}1}$			0.186*** (0.015)	0.406*** (0.025)
Control variables:				
$OPI_{it\text{-}1}$	0.024***(0.004)	0.027***(0.004)	0.023***(0.005)	0.015**(0.005)
$GRW_{it\text{-}1}$	-0.059*** (0.003)	-0.056***(0.003)	0.059***(0.004)	0.073***(0.005)
$NOE_{it\text{-}1}$	0.262***(0.100)	0.194***(0.013)	0.019†(0.011)	-0.019 (0.018)
$TOA_{it\text{-}1}$	0.698***(0.009)	0.707***(0.011)	-0.280*** (0.014)	-0.449***(0.023)
$ALR_{it\text{-}1}$	0.177*** (0.011)	0.153***(0.013)	-0.102***(0.013)	-0.029 (0.018)
$CF_{it\text{-}1}$	-0.019*(0.008)	-0.043***(0.009)	-0.081***(0.009)	-0.044***(0.012)
$SHEQ_{it\text{-}1}$	0.017 (0.017)	-0.040† (0.024)	-0.019 (0.017)	-0.047 (0.033)
$DPS_{it\text{-}1}$	0.019*(0.007)	0.017*(0.008)	-0.037***(0.009)	-0.060***(0.011)
$EPS_{it\text{-}1}$	0.075*** (0.008)	0.069***(0.009)	0.548***(0.010)	0.537***(0.012)
$ARR_{it\text{-}1}$	-0.005 (0.003)	-0.005 (0.003)	-0.009†(0.004)	-0.006 (0.004)
NOF_i	*Category variable*		*Category variable*	
$YEAR_t$	*Financial year of the variable (2009-2017)*		*Financial year of the variable (2009-2017)*	
Cons	-0.706	-8.364	5.733***(0.173)	5.676***(0.311)
R^2 : within	0.923	0.924	0.629	0.645
R^2 : between	0.891	0.853	0.641	0.555
R^2 : overall	0.910	0.862	0.621	0.550

†p < 0.10, *p < 0.05, **p < 0.01, ***p < 0.001. Standardized coefficients are showed and standard errors presented in parentheses.

findings (Pegah and Teirlinck, 2018). The top 20% and the bottom 20% of firms by size, consisting of 875 firms were sampled for the robustness checks. We used these newly generated samples to re-estimate the hypotheses. The results of the robustness checks are presented in Tables 5 and 6, models 5-12. Results from the large firms, shown in Table 5 confirmed the role of investor sentiment as the moderator in the R&D-performance relation. This means that, investor sentiment enhances the impact of R&D investment on firm performance in large firms, as suggested in the third hypothesis. Results from the robustness checks confirmed an existing significant interaction between the dependent variable (ROA) and some controlled variables such as firm's total asset and each shares' earnings, as presented in Table 5 below. Results from the small firms indicated a statistically significant relationship, with a positive coefficient between firm's R&D investment and its performance. This is consistent with previous study (Koutroumpis *et al.*, 2020).

Table 5
Regression results for top one-fifth largest firms

	R&D Expense		*Firm Performance (ROA)*	
	Model 5 *Random-effect*	*Model 6* *Fixed-effect*	*Model 7* *Random-effect*	*Model 8* *Fixed-effect*
Hypothesis 3:				
$SENT_{it-1}$	0.155†(0.084)	0.972 *(0.705)		
$R\&D_{it-1}$			0.094*(0.083)	0.382*(0.172)
Control variables:				
OPI_{it-1}	-0.109† (0.066)	-0.104†(0.062)	0.016 (0.027)	0.013 (0.028)
GRW_{it-1}	0.002 (0.070)	0.015 (0.067)	-0.011 (0.028)	0.001 (0.031)
NOE_{it-1}	0.142 (0.107)	-0.024 (0.105)	0.019 (0.042)	-0.026 (0.048)
TOA_{it-1}	0.917***(0.135)	1.327***(0.156)	-0.192*(0.086)	-0.444*(0.173)
ALR_{it-1}	-0.110 (0.255)	0.050 (0.253)	0.026 (0.102)	0.029 (0.132)
CF_{it-1}	0.226 (0.153)	0.074 (0.155)	-0.038 (0.056)	-0.039 (0.074)
$SHEQ_{it-1}$	0.461 (0.4130	0.715 (0.457)	0.030 (0.133)	-0.002 (0.218)
DPS_{it-1}	-0.212 (0.133)	-0.262†(0.130)	-0.117*(0.056)	-0.099 (0.066)
EPS_{it-1}	0.427 (0.136)	0.495***(0.134)	0.506***(0.061)	0.443***(0.074)
ARR_{it-1}	0.024 (0.043)	0.022 (0.040)	-0.002 (0.018)	-0.004 (0.018)
NOF_i	*Category variable*		*Category variable*	
$YEAR_t$	*Financial year of the variable (2009-2017)*		*Financial year of the variable (2009-2017)*	
Cons	-7.199	-24.595	4.578***(1.056)	5.707**(1.989)
R^2 : within	0.675	0.706	0.603	0.580
R^2 : between	0.350	0.297	0.204	0.374
R^2 : overall	0.458	0.399	0.233	0.388

† p < 0.10, *p < 0.05, **p < 0.01, ***p < 0.001. Standardized coefficients are shown and standard errors presented in parentheses.

Table 6
Regression results for the bottom one-fifth smallest firms.

	R&D Expense		*Firm Performance (ROA)*	
	Model 9 *Random-effect*	*Model 10* *Fixed-effect*	*Model 11* *Random-effect*	*Model 12* *Fixed-effect*
$SENT_{it-1}$	81.249 (122.640)	18.025 (61.635)		
$R\&D_{it-1}$			0.123* (0.060)	0.190† (0.129)
Control variables:				
OPI_{it-1}	0.002 (0.029)	0.032 (0.031)	0.098* (0.040)	0.084† (0.049)
GRW_{it-1}	-0.104***(0.025)	-0.079**(0.028)	0.043 (0.039)	0.031 (0.049)
NOE_{it-1}	-0.083 (0.137)	0.007 (0.198)	0.225 (0.154)	0.443 (0.276)
TOA_{it-1}	0.755***(0.062)	0.533***(0.112)	-0.497***(0.054)	-0.733***(0.134)
ALR_{it-1}	0.173** (0.063)	0.058 (0.082)	0.164* (0.082)	0.064 (0.117)
CF_{it-1}	0.051 (0.063)	0.218* (0.106)	0.150*(0.073)	0.213*(0.104)
$SHEQ_{it-1}$	0.585* (0.244)	0.354 (0.763)	-0.078 (0.133)	-0.518† (0.271)
DPS_{it-1}	0.024 (0.072)	-0.025 (0.078)	-0.005 (0.075)	0.619*** (0.101)
EPS_{it-1}	0.322***(0.056)	0.163*(0.073)	0.693*** (0.067)	0.678*** (0.022)
ARR_{it-1}	0.038 (0.226)	-0.441 (0.819)	-0.027 (0.033)	-0.058 (0.076)
NOF_i	*Category variable*		*Category variable*	
$YEAR_t$	*Financial year of the variable (2009-2017)*		*Financial year of the variable (2009-2017)*	
Cons	-1.065	-23.682	8.051	10.910
R^2 : within	0.760	0.808	0.593	0.633
R^2 : between	0.807	0.627	0.496	0.472
R^2 : overall	0.771	0.588	0.495	0.493

† p < 0.10, *p < 0.05, **p < 0.01, ***p < 0.001. Standardized coefficients are shown and standard errors presented in parentheses.

5. Discussion and Conclusion

The study delved into researching how a behavioral variable (investor sentiment) moderates the relationship between firm's R&D investment and its performance. Findings of the research affirm the position of previous researchers who argued that, investor sentiment moderates the impact of firm's R&D investment on its performance. The study identified a statistically significant association between the sentiment of investors and firm's R&D investment, which impacts on firm performance. This statistically significant relationship is affirmed in the large firms' categorization in the robustness checks, indicating that; investor sentiment moderates corporate R&D investment in large firms. The study contributes to the knowledge in literature on how investor sentiment enhances firm performance in the long run.

5.1. Theoretical contribution

A research that focuses on how a behavioral variable (sentiment) moderates the interaction between corporate R&D investment and performance is quite distinct from previous study. This study increases the knowledge in the few existing related literature that lends credence to how investor sentiment enhances the impact that corporate R&D investment has on organizational performance (Zhai *et al.*, 2017; Cai, Gong and Zhang, 2019). Findings of the study support the position of previous researchers who argued that, investor sentiment enhances firms' R&D investment (Junyan, Yu and Zhao, 2017). The study provides a contribution to the knowledge in literature on factors that can boost firm performance in the long run.

Results of the research provide an adequate information for firms in their R&D investment decisions, towards enhancing business performance (DiMassi *et al.*, 2012). Such information is vital to firms' strategic alignment as they resort to preemptively seeking new avenues in order to advance growth through the identification of fresh business opportunities. The study admonishes firms to fully regard the perception and attitude of their customers since investor sentiment has an impact on R&D investment and firm performance relation.

Results from the robustness checks would help large firms to fully regard the sentiment of their investors since investor sentiment has proved to be a positive moderator which enhances the impact that corporate R&D investment has on performance. This means that, investor sentiment has a long run effect on firm growth.

5.2. Limitations of the Study and Future Research

The inadequate data on some of the variables acted as a limitation to the study despite the attempt to empirically investigate the moderating role of investor sentiment, as far as the impact of firm's R&D investment on its performance is concerned. A research in the future should considerably endeavor to analyze all the dataset if available.

Although investor sentiment was found to statistically moderate the R&D investment and firm performance relation, however, other external variables such as government policy decisions or macroeconomic shocks in the country may also moderate the said relation. Future research is therefore admonished to consider other covariate variables such as economic shocks and policy effects.

The study's dataset consists of both private and state-owned firms in China. Future research should empirically assess private and state-owned firms separately, in order to ascertain how investor sentiment enhances the R&D investment- firm performance relation of each sector, distinctively.

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To cite this article:

Adubofour Isaac, Xiaoyang Xu, Tinashe Mangudhla and Dadzie Benjamin Mensah (2021). The Impact of R&D Investment on Firm Performance: through the Moderating Effect of Investor Sentiment. *Journal of Quantitative Finance and Economics*, Vol. 3, No. 1, pp. 79-98