R&D Expense Stickiness in Chinese Listed Firms

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Abstract

In 2021, the Chinese government announced China's objective to increase spending on research and development (hereafter R&D) by more than 7% per annum between 2021 and 2025, making China the world's second largest spender on R&D. Out of China's total R&D spending of RMB 2.39 trillion in 2022companies accounted for 77.6 percent (globaltimes, 2023). While companies make significant contributions to R&D they are faced with declining sales revenue in China and increasing competition internationally, thus, remaining profitable is a challenge for businesses. On the one hand R&D is a source of competitiveness and long-term profitability, on the other hand the combination of sales decline and more intense competition makes one question the prudence of increasing R&D investment. Therefore, the empirical, and timely question remains: How do firms adjust their R&D spending in response to changes in sales or to changes of other internal and external firm factors.

Drawing on research into cost stickiness, this thesis addresses three research questions, on how firms' spending on R&D changes in response in fluctuations in sales, and how this relationship is affected by: (1) management's motivation for earnings management and management's ability; (2) concentrated ownership in conjunction with management ability, and (3) intensity of product market competition in conjunction with management ability.

To address these questions, data is drawn from firms listed at the Shanghai and Shenzhen Stock Exchanges. A panel data is constructed and we explored the change of R&D expenses in response to the changes in sales revenue. We allow the changes to be different in sales increases and decreases using interaction variables – we interacted the growth of sales revenue with a dummy variable that indicates whether the sales had increased (growth positive) or decreased (growth negative). This modelling structure follows the customary setup used by the empirical literature on cost-stickiness. Instead of studying the overall costs, we focus on R&D spending. Although there are subtle differences in motives for controlling the expenses related to sales, general and administrations compared to those for controlling R&D, the incentive structure for the managers is similar, as is the principal-agent relationship between the managers and the shareholders.

Managers, as agents, act on behalf of shareholders. Yet, managers' and shareholders' interests might diverge, as shareholders are interested in the long-term performance of their shares while managers seek to maximise their (short-term) utility. At the same time, managers are not homogenous, some possess higher others lower abilities to understand the business environment and to make best use of firm's capabilities. Such management ability can be used to in times for sales decline to retain R&D investments to reap future benefits while low ability managers might engage in earnings management activities either to protect their short term interest or to compensate for their relatively low ability compared to firms in the same industry.

In the first paper we find that when sales revenues fall, managers who are motivated to avoid loss or profit decreases will aggressively cut R&D costs. When managers need to manipulate earnings, more capable managers will increase R&D more slowly when sales increase and reduce R&D more quickly when sales decline. China's investor landscape is increasingly dominated by institutional investors and particularly state ownership. Research found that large blockholders are often more long-term oriented, give that they cannot quickly sell off their shares without causing a decline in the firm's share price. This increases the motivation for blockholders to supervise management to secure their interest, which is to overcome the free rider issue faced by divergent shareholding (who can diversify their shareholding and to whom it is relatively costly while less beneficial to supervise management -providing benefits to other shareholders). At the same time blockholders have access to private information through direct interaction with management and the board. Blockholders could also have representatives on the board to exercise more supervision over management and to secure their long-term interests, which might include to remain R&D activities when firm's sales decline.

The findings of the second paper suggest that highly capable management, in the presence of high ownership concentration, strengthens R&D expense stickiness. This underpins long-term focused blockholders encourage R&D and are more 'forgiving' when sales and profits decline. Concentrated ownership also means that the shareholders monitor the management better, making it harder for the management to extract wealth for themselves through earnings management.

Another important aspect to shape firm's R&D investment is market competition. Firms do not operate in a vacuum but compete at least with firms in the same industry. Consequently, management cannot afford to 'fall behind' and might have the motivation to retain R&D despite sales declines.

Empirical results for the third paper indicate that managerial ability is positively associated with R&D stickiness. Furthermore, this association is driven by market competition for the product. At the same time, management ability cannot be neglected, which shaded additional light on the effect of competition on R&D stickiness.

The above findings were subject to further scrutiny through a battery of tests, including mechanism tests commonly used in research.

To summarize, these findings have extended our knowledge on how principal-agent conflicts between management and shareholders may play out with regards to R&D expenditure under different scenarios. The findings of the thesis provide insights into the role of concentrated ownership and principal-principal conflicts suggested by agency theory. The research also extends the resources-based view on the interaction between resources: managerial ability and R&D under product market competition. Implications of these findings are discussed.

Acknowledgements

My long period of pupillage during which I have immersed myself in the area of knowledge about which I am passionate, is drawing to a close. Life at the University of Nottingham Ningbo China has given me glimpses of a future that I never seriously considered before. It has kindled my passion for life and renewed my social network, for which I am immensely grateful.

As I now reach the completion of my dissertation, I want to express my deepest gratitude to Dr Ada Ma, Dr Shuai Yuan, and Dr Juergen Seufert. Their rigorous scholarship, and meticulous attention to detail have stimulated my mind and inspired me to pursue truth and confront unpleasant facts in my field of work. Their continual encouragement, unwavering support, and boundless patience have been the cornerstone of my academic progress. I would also like to extend my appreciation to Dr Qing-Ping Ma and Dr De Zoysa Anura, for their exceptional and indispensable guidance and recommendations throughout the entirety of my research journey. Under their mentorship, my horizons have expanded, and my passion for research has been invigorated. I am truly humbled and privileged to have had the opportunity to work under their tutelage, and I will forever be indebted to them for their unwavering commitment to my academic achievement.

It has been a blissful experience to be surrounded by teachers and students who passionately love their studies, family, and life at UNNC, particularly during the spread of the pandemic when we all worried about the future and faced difficulties such as restricted lockdown. With their assistance, I understood the value of slowing down, appreciating my surroundings, and cherishing the people who love and support me. It was through these bonds, networks, and love that I gained the courage to overcome setbacks. Also, instead of piling ephemeral achievements to fill the inner void, I learned from them to embrace something I really feel passionate about.

Although receiving education and acquiring knowledge are paramount in my doctoral student's life, the most significant lesson I have learned is the importance of person-to-person connection and the resulting intimacy. Before starting my doctoral journey at UNNC, I considered myself better at reading books than reading people. I had dedicated excessive time to the solitary activity of studying. Throughout my live I had never learned how to navigate the depths and complexities of intimate connections. Now I believe that life presents fewer opportunities to demonstrate our intelligence, but it provides countless occasions for us to fully immerse ourselves in the lives of others. And I hope I have made some improvements here.

Looking back on those days, there are countless unforgettable moments that I will cherish for a lifetime. I have no regrets about embarking on this journey and I am indebted to the people who shared their values and helped me become a better person.

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List of Abbreviations

CEO	Chief Executive Officer
EBIT	Earnings before interest and taxes
EPS	Earnings Per Share
EU	European Union
FASB	Financial Accounting Standards Board
FE	Fixed Effect
FY	Financial year
GDP	Gross domestic product
IASB	International Accounting Standards Board
IMF	International Monetary Fund
Ltd	Limited company
Obs.	Observations
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
PMC	Product market competition
POE	Private-owned enterprises
R&D	Research and development
R^2	R-square
RBV	Resource-based view
RMB	Renminbi (currency of People's Republic of China, Yuan)
RQ	Research Question
SG&A cost	Selling, General, and Administrative cost
SOEs	State-owned enterprises
UK	United Kingdom
US	United States
USD	US Dollar
WTO	World Trade Organization

Statement

The thesis has six chapters: the introduction (Chapter 1), a review of influencing factors on R&D investment decisions (Chapter 2), three empirical chapters (Chapter 3, Chapter 4 and Chapter 5) and the conclusion (Chapter 6). The thesis is my solo work, done under the guidance of supervisors.

The three papers that constitute the three pieces of investigations are all still in preparation stage. To be more specific, the papers will be written under these titles, within brackets are the authorship as it currently stands:

1) R&D stickiness, earnings management and managerial ability: Evidence from China (Guanzhong Zuo; Juergen Seufert; Ada Ma; Shuai Yuan)

2) Ownership concentration, managerial ability and the asymmetrical behaviour of R&D expenses: Evidence from China (Guanzhong Zuo; Juergen Seufert; Ada Ma; Shuai Yuan)

3) Managerial ability, market competition and R&D resource allocation: Evidence from China (Guanzhong Zuo; Juergen Seufert; Ada Ma; Shuai Yuan)

1 Introduction

This thesis consists of three independent but related papers. Before embarking on the major content of this thesis, the following terms need to be clarified. For this thesis the term 'sales revenue' refers to revenue from sales of products or services, thus sales activities related to the core business of a firm. Consequently, revenue related to other income, which is not part of the core business such as interest on savings or received cash dividends are excluded. The term 'sales revenue' is equivalent to 'operating revenues', which is another term used to describe revenue that a firm generates from its primary business activities.

The term 'R&D expense' and 'R&D cost' are used interchangeably, while acknowledging that R&D expenses are derived from financial accounting, here specifically 'other operating expenses', while R&D cost is a term associated with managerial or (more traditionally) cost accounting. In practice, the measurement of expense (e.g., following IFRS) or cost is likely to be different, given the cost definition is more flexible and cost can be defined firm-internally; for this dissertation 'R&D expense' is the proxy for 'R&D cost' and thus these terms are used interchangeably. Due to the lack of data on 'development cost' (see: IAS 38 Intangible Assets) the terms 'R&D expenses' and 'R&D investments' are also used interchangeably. It is acknowledged that 'expense' and 'investment', again, depart in their very definition with overlapping but also mutually exclusive components, however, due to the lack of available data these terms are used interchangeably.

1.1 Background

China has declared innovation to be one of its top national priorities and the Chinese government is encouraging firms to invest in innovation (Fu & Mu, 2014). In 2021, China's Premier Li Keqiang announced a countrywide objective to increase China's research and development spending between 2021 and 2025 by more than 7% per annum. Consequently, R&D spending will make up a higher percentage of gross domestic product (GDP) than in the previous five years. This spending is directed at the development of technology innovation areas such as semiconductors, health care, quantum computing and cloud computing (Kharpal, 2021). China's R&D spending increased from USD13.1 billion in 1991 to USD462.6 billion in 2018, a magnitude of more than 35-fold. The amount China spent in 2018 was equivalent to the sum for the next four countries (Japan, Germany, South Korea, and France) combined, or nearly 25% of the world's spend on R&D. It still lags about USD89 billion behind USA, although the gap is rapidly narrowing. In 2018, China's R&D spend was 76.6% (USD354.4 billion) financed by business, a significant increase from 32.4% in 1994. This increase is partly due to the growing number of Chinese listed enterprises; in 2000 there were 1,086 firms compared to 3,777 in 2019. This trend does not, however, reveal the importance of state-owned enterprises (SOEs) in the Chinese economy. SOEs receive orders from government officials which makes R&D projects financed by SOEs akin to government

funding. SOEs also get preferential access to bank lending from Chinese state-owned banks, which makes borrowing less costly and provides SOEs with stronger financial backing compared to private firms. In contrast to private firms in the US and Europe, which commonly draw on venture capital to finance R&D, Chinese private firms often finance their R&D by themselves.

The Chinese Government's contribution to research spending declined from 33.4% (2000) to 20.2% (2018) which is comparable to the United States (23%) and South Korea (20.5%). However, the "Made in China 2025" plan to increase technological innovation and manufacturing capability in key industries aimed at increasing government-led innovation. As part of this policy package, '901 government guidance funds' raised USD347 billion to help Chinese firms finance R&D while tax breaks further encourage R&D spending(OECD, 2022). In China, domestic restrictions limit inbound investment flows from overseas firms to finance R&D, resulting in a very small fraction of 0.36% (2018) of overall R&D spending in China; R&D centres operated by multinational corporations do not appear in this figure. While foreign entities do not play a significant role in terms of R&D spending, SOEs and companies with mixed, government, and private ownership made up 67.6% of firms' R&D expenditure in 2019; leaving 32.3% of R&D spending to private firms (ChinaStatisticsPress, 2020). Another feature of R&D spending in China is that in 1991 only 39.8% of all R&D activities were undertaken by firms. This increased to 77.4% (2018), beyond the level of the US (72.6%) and the average for the OECD (70.6%). Therefore, private firms have become increasingly important as providers of innovation and R&D; relative to SOEs, they devote more of their revenues to R&D and often achieve higher returns on investment (ChinaPowerProject, 2022).

Despite the impact of private firms on China's R&D spending, there are also challenges for these firms. The financing of private firms is limited and, while there was a prolonged period of economic growth allowing for internal financing through retained earnings, this growth is slowing down. The economic growth in China slowed in 2017 from 6.8% to 6.6% in 2017 and further reduced to 6.3% in 2019 and 6.1% in 2020 (AsianDevelopmentBankInstitute, 2019).

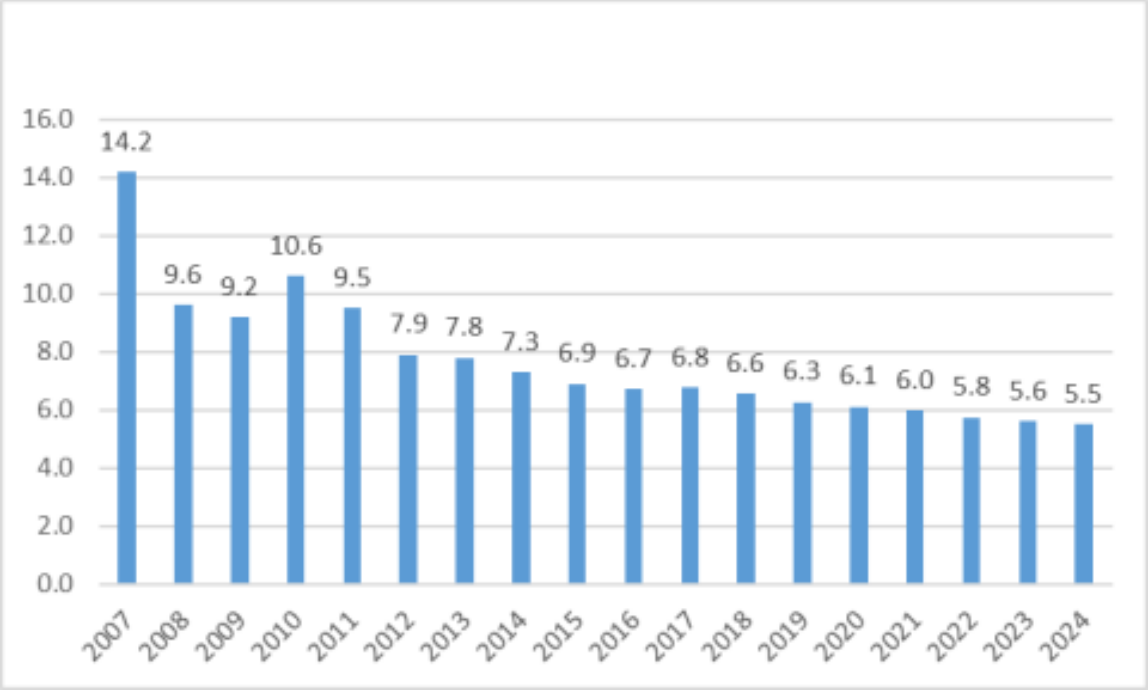

Figure 1– Economic growth in China 2007-2024 (forecasted)

Source: IMF, World Economic Outlook Database, April 2019,

Declining growth rates, diminishing productivity growth and lower profit margins pose challenges for firms to finance their ongoing and new R&D projects.

In summary, China's Government placed emphasis on R&D activities as part of the macro-economic political measures of the "Made in China 2025" plan. In line with these policies the government provides financial support through easier access to loans and lucrative tax treatments. A feature unique to China, compared to the US and Europe, is the important role of SOEs or partial government ownership. This government involvement further strengthens the drive for firms to engage in R&D activities. However, the macroeconomic indicators of economic growth, productivity and profitability are less favourable.

1.2 Motivations and objectives of the study

Schumpeter (1942) found a positive relationship between technological innovation and economic growth rate and productivity. Innovation brings 50% of a country's total gross domestic product (GDP)growth (OECD, 2015), and one standard deviation increase in patent stock per capita leads to a 0.85% increase in GDP (He & Tian, 2018). Besides the macroeconomic benefits there are firm implications. While R&D investment is important for a firm's long term development because R&D investment decisions are closely related to the firm's innovation, sustainable development and competitive advantage (Schuster et al., 2018), existing research shows that financial slack positively influences R&D investment (Carnes et al., 2019). However, there is a lack of research assessing whether firms will continue to invest

in R&D when sales revenue decreases. Ibrahim et al.'s (2022) systematic review of cost stickiness research in the 27 years from 1994 to 2020 finds that most of the existing cost stickiness studies (85%) focus on the behaviour of five cost categories (Selling, General, and Administrative (SG&A), operating costs, Cost of Goods Sold, total cost, and labour costs). In this research, we focus on R&D expenses to investigate firm resource allocation decisions on R&D when facing sales revenue declines.

Anderson et al. (2003) state that, contrary to the traditional symmetric relationship cost model, SG&A costs respond differently to upward or downward changes of sales units. They find that SG&A costs increased 0.55% per 1% increase in sales revenue but fell only 0.35% per 1% decrease in sales revenue. They named the asymmetric cost behaviour as “sticky”. Cost stickiness relates to both the level of unit change and the direction change (increase or decrease) brought about by a decline in sales revenue which results in a less proportional decline in costs. The Chinese context provides a unique setting with an economy-wide push for more R&D activities and innovation, the contradictory role of SOEs in bolstering R&D, as well as the weakening of macroeconomic indicators. Private firms mostly finance their R&D by themselves, in the absence of private equity, which makes access to the capital market even more important. China’s capital market is characterized by weak investor protection which bears the risk of principal-agent, and principal-principal conflicts. Principal-agent conflicts refer to the agent (management) acting in their own, rather than the principal’s, best interest; principal-principal conflicts refer to blockholders of firm’s shares expropriating resources and bonding with management to advance their interests over those of minority-shareholders. These potential agency issues could be mitigated by managers.

Therefore, do capable managers retain research and development (R&D) investments when sales decrease? This research examines the influence of managerial ability on the decision to allocate resources to R&D when sales decrease. More specifically, this research first investigates the effect of managerial ability on R&D stickiness and further investigates the moderating effect of managerial ability on the relationship between ownership structure and R&D stickiness. In doing so, agency theory is extended by examining the effect of capable managers on agent-principal and principal-principal conflicts of interests (type two agency problems). This research responds to Banker et al.’s (2017) statement of whether cost stickiness is “good” (rational) or “bad” (agency problem) and in doing so expands existing accounting research (Yang, 2019).

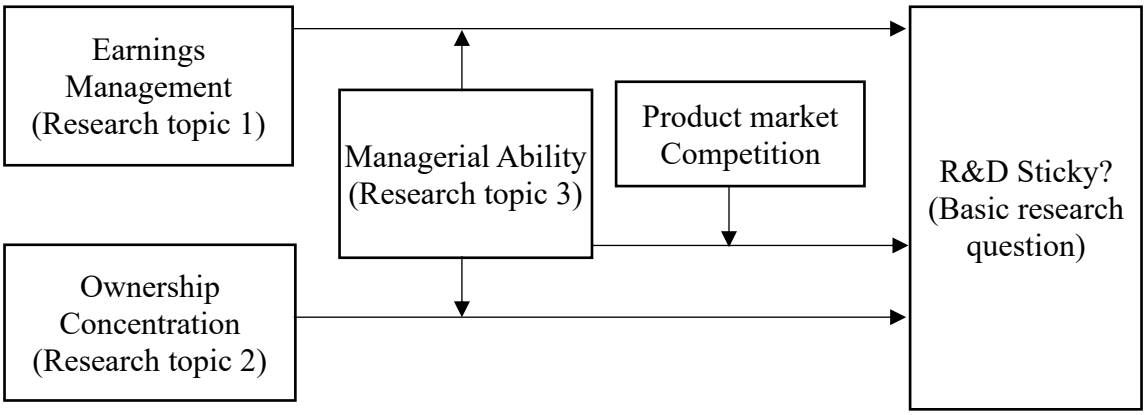

Figure 2– Overview of the research topics

In this paper, we explore how both type one (principal-agent) agency problems and type two (principal-principal) agency problems could influence firms' R&D investment decisions when sales decrease. Furthermore, this research also argues managerial ability plays a role in influencing agency problems to motivate managers to make "rational" R&D investment decisions when sales decrease. R&D is crucial for the long term and sustainable development of business. Therefore, this research provides important insights for governments, shareholders and regulators to understand managers' R&D decisions when sales decrease.

A firm's research and development (R&D) investment is the key driver for innovation, which could influence the firm's sustainable development and value creation (Lee & O'Neill, 2003). R&D investments have a key impact on innovation; this research helps the government, shareholders and regulators to identify the factors motivating managers' R&D investment decisions when a firm is experiencing a downturn. Therefore, the importance of this research is to help stakeholders better understand the effects of agency problems (both type one and type two agency problems) on firm R&D investment decisions when sales decrease.

The importance of this research not only stems from the Chinese economic conditions and its significance on the global R&D landscape. In a systematic review of cost stickiness research over the last 27years from 1994 to 2020, Ibrahim et al. (2022) find that 74% of existing cost stickiness research examines developed countries (249 times out of 327 times in total). Considering the economic size of developing countries, Ibrahim et al. call for research to examine cost stickiness in developing countries, which could enrich the cost stickiness literature.

Cost stickiness in China reflects research from other countries; companies listed on the Shanghai and Shenzhen Stock Exchange markets exhibit cost stickiness (Xu & Sim, 2017). Furthermore, Xue and Hong (2016) find that good corporate governance can reduce stickiness, while Chinese non-earnings-management companies significantly exhibit expense stickiness compared to earnings-managing firms. Bu et al. (2015a) find that ownership structure has an impact on cost stickiness as SOEs and companies with executive shareholding exhibit more

cost stickiness than their counterparts.

R&D Investment decisions are closely related to innovation, sustainable development and the competitive advantages of a company (Schuster et al., 2018). However, there is a lack of research looking at R&D investment decisions when a company is facing a decline in sales revenue. Managers must make a rational choice weighing short-term costs and long-term benefits. This gap is filled through investigating how motivation for earnings management, ownership structure (blockholding and institutional investors), managerial ability and product market competition impact on the stickiness of Chinese firms' R&D.

1.3 Research content

In contrast with previous research which only focuses on five cost categories (SG&A, operating costs, Cost of Goods Sold, total cost, and labour costs) (Ibrahim et al., 2022), this research investigates firms' allocation of resources to R&D when sales revenue decreases. More specifically, this research investigates the influence of agency problems (principal-agent and principal-principal) on R&D stickiness based on agency theory. This research further investigates the effect of managerial ability on R&D stickiness and the moderating effect of managerial ability on the relationship between agency problems and R&D stickiness. Three research questions will be addressed as follows:

Are R&D expenses sticky? This question is the starting point of this research. Managers are not motivated to retain R&D expenses when their firm suffers sales revenue declines. This is because of the associated risk of continuing R&D as that investment may not yield any profits if the R&D activity fails, or they may take a very long time to translate into profits. Based on the US data from 1980 through 2014, Cook et al. (2019) find that R&D is not sticky. However, rational managers will continue to invest in R&D even when sales revenues decrease, because the adjustment cost to cut R&D is higher than to maintain it (Venieris et al., 2015). Whether R&D is sticky is arguable and forms the basis for all three research questions.

The first of the three research papers considers *Earnings Management, Managerial Ability and the Asymmetrical Behaviour of R&D Expenses in China*. Due to the separation of ownership and control and information asymmetry between agents and principals, agency theory argues that principals and agents have conflicting goals. In this sense agents are likely to be self-serving, instead of focusing on maximizing shareholder value (Jensen & Meckling, 1976). Following this viewpoint, managers are motivated by self-interest to cut R&D expenses to manipulate earnings upwards and to avoid profit decline or small losses. However, existing research shows mixed results about whether managers would cut R&D expenses when motivated to manipulate earnings upwards. Roychowdhury (2006b) find that managers are motivated by self-interest to cut R&D and other costs to manipulate earnings upwards, so managers would cut R&D expenses when sales revenue decreases. However, R&D expenses have a positive signalling effect to investors because R&D potentially enhances shareholder value (Chan et al., 2001). In line with this argument, Sun (2020) finds that SG&A and R&D

play different roles in real earnings management. Sun (2020)further finds that companies will keep R&D and cut SG&A costs to manipulate earnings upwards. Whether R&D investment should be retired or retained when a company is experiencing a downturn is arguable. The first research question within the first research paper is:

To what extent does earnings management motivation influence R&D stickiness?

Constructing a manager-firm matched panel data set, Bertrand and Schoar (2003) found that manager fixed effects impact on corporate practices and managers behave differently when making corporate decisions even under similar economic environments. However, whether managerial ability could improve firm performance is still being debated. Some research finds that managerial ability could improve firm performance (Cornaggia et al., 2017; Demerjian et al., 2013; Wang et al., 2017). Other research finds that, in seeking to maximize self-interest, able managers are motivated to manipulate earnings (Gul et al., 2018; Handfield-Jones et al., 1999). The second research question within the first research paper is:

To what extent could managerial ability influence the relationship between earnings management motivation and R&D stickiness?

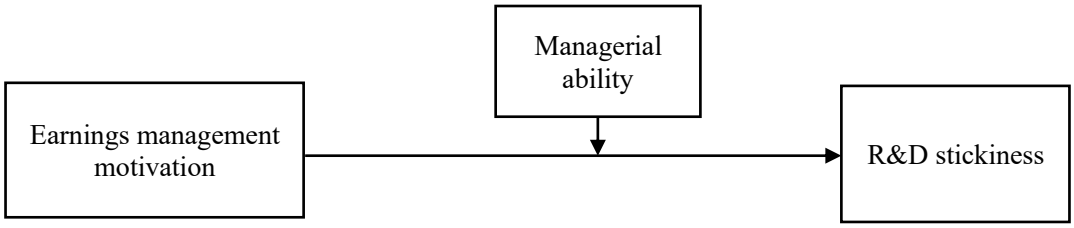

Figure 3 - Framework Research Paper 1

The second of the three research papers investigates *Ownership Concentration, Managerial Ability and the Asymmetrical Behaviour of R&D Expenses in China*. Due to the separation of ownership and control and information asymmetry between controlling shareholders and minority shareholders, agency theory in regard to type two agency problems argues that controlling shareholders are likely to be self-serving at the expense of minority shareholder interests (Jensen & Meckling, 1976). Following agency theory, the attention of researchers is drawn to the question of whether ownership concentration leads to greater risk-taking activities when allocating resources to R&D. However, existing research shows mixed results about the relationship between ownership concentration and R&D investment. Compared to minority shareholders, controlling shareholders face higher risk when management invests in R&D, so controlling shareholders are not motivated to allocate resources to R&D. Vito et al. (2010) and Minetti et al. (2015b) find a negative relationship between ownership concentration and R&D investment. From this perspective controlling shareholders will likely support management to reduce R&D investment when sales decrease. However, controlling shareholders are looking at a company's long-term development (Lee & O'Neill, 2003), so there is a positive relationship between ownership concentration and R&D

investment (Baysinger et al., 1991; Lee & O'Neill, 2003; Yafeh & Yosha, 2003). From this alternative perspective, we expect controlling shareholders will encourage management to keep on investing in R&D even when sales decrease. Whether controlling shareholders retain R&D investment when sales decrease is debatable. The first research question within the second research paper is:

To what extent does ownership concentration impact on R&D investment when the company is experiencing a downturn?

Given it is arguable whether capable managers could improve company performance, research shows that managerial ability could align the interests of agents and principals (Demerjian et al., 2013); however, other research shows the opposite results (Gul et al., 2018). The second research question within the second research paper is:

To what extent does managerial ability influence the relationship between ownership concentration and R&D stickiness?

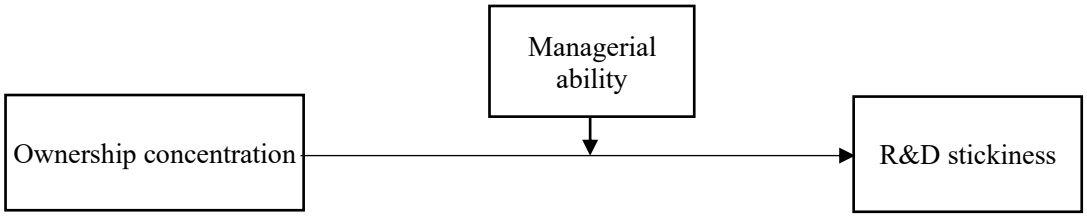

Figure 4–- Framework research Paper 2

Research indicates that institutional investors have distinct features. Because of their expertise and higher stake in the company, they have the motivation and capabilities to monitor and direct management decisions. In China, institutional investors often have links to the Chinese government and are instrumental in implementing the government's macro-economic imperatives set during the five-year plan. This can lead to sustained R&D expenses even when sales revenues are in decline. In a similar vein, institutional investors commonly have a longer shareholding horizon and are more interested in the long-term rather than short-term performance of firms. However, some evidence suggests that in countries with weak investor protection, institutional investors expatriate resources at the expense of minority shareholders who require a risk premium in terms of higher dividends.

The third research question within the second research paper is:

To what extent does managerial ability influence the relationship between institutional shareholding and R&D stickiness?

The third of the three research papers considers *Managerial Ability, Product Market Competition and the Asymmetrical Behaviour of R&D Expenses: Evidence from China*. Existing research shows conflicting results on the question of whether capable managers with their unique abilities, tacit and industry knowledge are able to enhance company performance. Following the resource-based view, managerial ability, as well as R&D, are dynamic

resources which are needed for firms to remain successful in competitive markets. Therefore, capable managers improve company performance (Demerjian et al., 2013). Managerial ability is a unique and important resource, as managers orchestrate the use of the firm's other resources, making managerial ability a crucial resource in its own right. However, capable managers who do not use their ability as stewards do not improve company performance or even decrease company performance (Gul et al., 2018). Capable managers who act more rationally consider innovation as the main engine of firm growth while being able to address the inherent uncertainty of R&D activities. Do capable managers retain R&D expenses when sales revenue decline? The first research question within the third research paper is:

To what extent does managerial ability impact on R&D investment decisions when a company is experiencing a sales revenue decline?

Management's commitment to R&D activities is not solely dependent on firm resources but also on product market competition (PMC). PMC can have two opposing effects on a firm's innovation decision. PMC can lower average profits within an industry, constraining available financial resources; combined with the risks of innovation failure it might discourage R&D expenses to retain short-term profitability. Therefore, firms allocate fewer resources to innovation when facing strong product market competition. Alternatively, managers can allocate more resources to R&D to retain or to achieve a competitive advantage in highly competitive markets. Therefore, companies are strongly motivated to allocate resources to R&D activities; PMC affects a company's R&D investment decision. In summary, there are conflicting views on whether R&D expenses are an avoidable burden or are resources necessary for competitive advantage. The second research question within the third research paper is:

To what extent does product market competition impact on the relationship between managerial ability and R&D investment when a company is experiencing downturn?

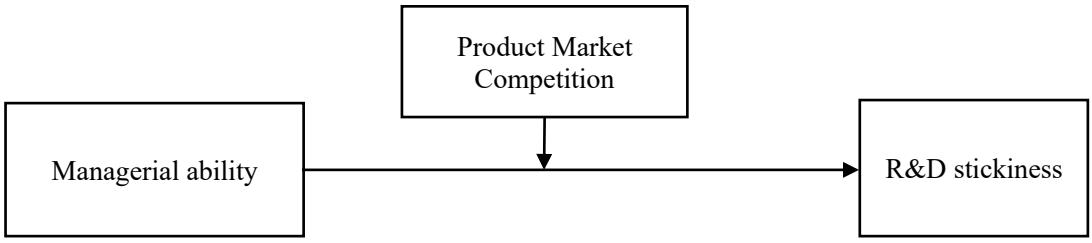

Figure 5–- Framework research Paper 3

1.4 Theoretical lenses

The first paper adopts agency theory to consider the effect of managers' earnings management motivation on R&D stickiness. Self-interested managers with an incentive to avoid losses or profit decreases accelerate cuts in slack resources, including R&D, in response to a sales decline, even if it is only temporary. These accelerated cuts of slack resources reduce cost which allows managers to meet their earnings targets while moderating the degree

of cost stickiness(Kama & Weiss, 2013). Our mechanism tests, considering institutional ownership (IO), board size (BSIZE), board independence (BINDP), analyst following (ANALYST) and management shareholding (Mshare), to control for catalysing or hampering factors of earnings management underpin the role of corporate governance. Despite increased R&D expenses are beneficial investments, the market is slow to recognize the full extent of this benefit. In turn, investors under-react to the benefit of an increase in R&D (Eberhart et al., 2004). Decisions about R&D expenses in times of sales revenue decline emphasize that it is not just up to the manager's probabilistic judgement as to whether sales revenue will recover, but also the manager's motivation to serve their own interest, even it is at the expense of shareholder value. Eberhart et al. (2004) found that reducing R&D expenses to manipulate earnings upwards is an inefficient way to pursue short-term earnings targets at the expense of long-term development. Adding to the principal-agent conflict, high-ability management is an essential determinant of corporate R&D success (Chen et al., 2015) and helps to overcome the two sources of investment inefficiency: over- and under-investment (Gan, 2019). In the line with Anderson et al. (2003), managers consider the trade-off between the cost of retaining slack resources and adjustment costs, and the foregone benefits of successful R&D projects. High-ability managers are associated with higher earnings quality (Demerjian et al., 2013), less financial reporting fraud (Wang, 2007) and higher credit ratings (Cornaggia et al., 2017). Additionally, corporate governance measures can be effective in aligning managements' with shareholders' long-term interest to retain R&D expenses.

The second paper extends the principal-agent consideration by adapting it to China's capital market characteristic of relatively high blockholding. In Western countries, blockholding and institutional investor shareholding is associated with higher monitoring of management, resulting in long-term profitability and fewer agency conflicts(Y.-F. Chen et al., 2015). In emerging markets such as China where investor protection and corporate governance are still evolving, institutional investors can extract resources from the firm through means other than dividend distributions, with the consequence of disadvantaging minority shareholders. An additional downside of blockholding or institutional shareholding is that there is less share trading compared to dispersed ownership with the result that the stock market price has less informational content while making starting a business relatively more difficult. Furthermore, blockholders are often able to either sit on the board or appoint their representatives which weakens the corporate governance function of the board and allows the blockholder to have a direct impact on the firm's future direction, including decisions on R&D expenses. These issues are summed up under the term principal-principal conflict under agency theory. Mechanism tests include our empirical findings and explore *board size* and *management shareholding* as drivers to control management and its earnings management activities.

The third and final paper considers product market competition (PMC) as a major driver of firm's R&D expenses. This paper adopted the resource-based view (RBV) of both R&D

expenses and managerial ability being crucial resources for firms to compete or maintain or develop a competitive advantage. The RBV puts forward that it is difficult to imitate resources that are the key to a firm's long-term success, while management's ability is a key resource and enabler to combine firm's resources. Following the RBV, this paper considers the resource allocation in terms of R&D stickiness and its interplay with managerial ability. Mechanism tests underpin this point. The effect of managerial ability is pronounced for more financially constrained firms or firms with higher financial risk.

1.5 Research methods

This study draws on firm-year data of firms listed on the Shanghai and Shenzhen Stock Exchange. After applying commonly used selection criteria, data was analysed using OLS and FE models. Mechanism tests follow and extend those used in existing literature including subsampling by major variables. Robustness tests include alternative measures of independent variables, adding more control variables to models, and dropping data because of events shock.

Variables are commonly tested with and without interaction terms for changes in sales revenue to determine the relative impact of variables on sales revenue increases versus sales revenue declines to measure the impact on R&D expenses and the existence or absence of stickiness and anti-stickiness.

Variable definitions follow existing research and were selected according to the research question and underlying theory. In order to check findings for robustness, alternate variable definitions are derived from suggestions in prior studies.

1.6 Expected contributions

This study will contribute to our understanding of R&D expense behaviour under different conditions including managements' motivation for earnings management, corporate governance features of blockholding and institutional investors' shareholding, and product market competition. The findings in each of these fields will make the following contributions:

1. Expanding agency theory to understand pathways for management's behaviour that priorities self-interest over R&D expenses and shareholder value. Prior research did not consider management's motivation of earnings management or the asymmetric behaviour of R&D expenses.
2. Managerial ability conflated into a consideration of agency provides additional motivation for management to retain or retire R&D expenses in times of sales revenue decline.
3. The second paper adds to our understanding of the interplay between blockholding or institutional investors' shareholding on R&D expenses (-stickiness) in China, extending the principal-principal consideration of agency theory. The ability of

management further contributes to our understanding.

4. The third paper adopts the RBV and finds that managerial ability and R&D expenses are important resources in the presence of PMC.
5. Overall, these papers extend the original idea of Anderson et al. (2003) to show that cost stickiness is not merely based on management's probabilistic assessment of changes in future sales revenue, nor merely on the firm specific adjustment costs of R&D expense increases or declines, but an array of other (management specific, motivational, ownership and even firm external PMC) factors.

1.7 Structure of the thesis

Chapter 1 provides an outline of the study. It describes the motivations and objectives, the theory chosen, the method of enquiry and the expected contributions. Chapter 2 reviews existing literature on factors which influence R&D investment decisions. Chapter 3presents the first paper which considers R&D stickiness, managerial ability and management's motivation to earnings management. Chapter 4presents the second paper which conflates ownership structure, managerial ability and R&D stickiness. Chapter 5 presents the third paper which combines PMC, managerial ability and R&D stickiness. Each of the three papers includes relevant literature, background to the study, hypothesis development, methodology, findings (including robustness tests) and contributions as well as bibliography. Chapter 6 provides a summary and concludes the study. Limitations of the research and possibilities for future research are also outlined.

1.8 Summary

This chapter outlined the motivation and objectives of this study and the 'tools' that will be used to arrive at a conclusion. To gain an understanding of R&D stickiness beyond management's consideration of adjustment costs and their probabilistic assessment of future sales revenue, this study draws on agency theory (principal-agent and principal-principal conflicts of interest) as well as applying the RBV and PMC as the drivers of R&D expense stickiness. The expected findings will shed light on the various factors that contribute to R&D expenses in Chinese firms. This will contribute to existing accounting theories.

2 Factors influencing R&D investment decisions

Innovation can be defined as the application of original and planned investigation to generate new production-methods, devices, products, processes, systems or services (Huang et al., 2021). Innovation can be differentiated from routine tasks by enabling firms to gain new scientific or technical knowledge. However, R&D activities increase a firm's probability of failure as R&D takes a long time to translate into profits (Holmstrom, 1989). Conversely, R&D activities are closely related to innovation, sustainable development and competitive advantages of a company (Schuster et al., 2018). Given the important role of R&D investment, a significant amount of academic research explores drivers of R&D activity decision making.

2.1 Financial constraints

Financial constraints are frictions that inhibit firms from funding their desired investments (Costa & Habib, 2021). Access to external finance is crucial for firm R&D investment decisions (Bougheas et al., 2003). Existing research shows that financing for R&D activities is difficult because R&D investments are long-term commitments and create intangible, knowledge-based assets which make it difficult for outsiders (shareholders and banks) to distinguish good R&D projects from bad R&D projects (Hall, 2002). The following sections introduce determinants of R&D activities to emphasise the research gap.

Equity market financing

Listed companies within external-finance-dependent industries allocate more resources to R&D activities. Based on US data, Acharya and Xu (2017) find that listed firms within external-finance-dependent industries have high investment in R&D because listed firms have access to capital markets for relatively low-cost capital to finance their R&D activities. Hsu et al. (2014) find that companies which are more dependent on external finance exhibit a higher level of R&D expenditure in better developed equity markets. This is because equity markets can reduce information asymmetry inherent in R&D activities through the equilibrium market price. Shareholders are also more flexible in acquiring and disposing of their shares, allowing for risk diversification. In general, there are three reasons that equity market financing positively influences R&D investment. First, equity market financing does not increase a company's risk for financial distress; second, an equity market supplies better information to the investor when it comes to finance innovation because, as Grossman (1976) states, the equity market supplies diverse information to investors; and third, an equity market supplies timely information on a company's investment decision.

Credit market financing

There are mixed results about whether credit market financing leads to higher R&D investment. It is difficult to finance R&D investment through credit market financing. Based on a sample of 132 firms from R&D intensive industries between 1991 and 1994, Shi (2003) finds that R&D risk impacts 80% of cross sectional variation in bond ratings and risk

premium. Therefore, R&D is risky for creditors because bondholders cannot diversity; they are locked in. Debtholders prefer physical assets against which to secure their loans, but R&D expenses create knowledge-based, intangible assets which can be firm specific and difficult to transfer. Based on Japanese data, Ogawa (2007) finds that there is a negative relationship between outstanding debt and R&D activities during the 1990s. Based on a cross-countries study including Europe, UK, Japan and USA, Bah and Dumontier (2001) find that R&D intensive firms have a lower debt level compared to firms that are not engaged in R&D. Conversely, increased credit supply to the real economy leads to an increase in company R&D investment. Due to the financial crisis in 2008, the Chinese government issued a plan to invest 4trillion yuan in infrastructure and social welfare. Zheng et al. (2018) find that the stimulus package positively influences companies' R&D investment because the stimulation eased access to bank loans.

R&D subsidies

Using a sample of German manufacturing firms, Czarnitzki and Toole (2007) find that R&D subsidies positively influence R&D investment because, to some extent, R&D subsidies deal with the problem of uncertainty of whether the company has sufficient cash-flow to fund R&D. Using data on Israeli manufacturing firms in the 1990s, Lach (2002) finds that R&D subsidies stimulate R&D for small firms but negatively influence R&D for large firms because small firms start R&D projects after they receive subsidies but large firms get subsidies for projects that would have been undertaken even in the absence of the subsidy.

Cash holding (own funds)

Internal finance is the most important funding source for investment in R&D (Himmelberg & Petersen, 1994). Because cash holding buffers R&D from shocks to finance, Brown et al. (2009) and Brown and Petersen (2011) find that there is a positive relationship between cash holding and R&D investment. Based on Italian data, Ughetto (2008) finds that internal cash flow finances 80% of R&D investments. Using data from German enterprises, Harhoff (1998) finds that cash flow leads to more R&D investment. Based on data from Denmark, Bloch (2005) finds that higher cash flow increases a company's R&D investment.

Financial support is important for company R&D investment decisions. If there are not enough funds for R&D, financial constraints lead to underinvestment in R&D.

2.2 Characteristics of managers and board members

Risk preference

Following Wally and Baum's (1994) model of the determinants of the pace of strategic decision-making, tolerance of risk is one of the factors associated with company decision-making pace. There are conflicting views about the relationship between the risk tolerance after financial misconduct and R&D investment decisions. Some research shows that, due to "play it safe" psychology, top executives reduce R&D investment following financial misconduct (Hess & Hess, 2020). Other research shows that restatements lead to an

increase in the cost of capital (Hribar & Jenkins, 2004), so managers are motivated to take a higher risk to meet the requirement for a higher return. Jia (2019) finds that restatement increases managers' risk appetite, which leads to a positive relationship between restatement and exploratory innovation.

Examining the effect of adopting universal demand laws in 23 US States (those which implemented this legislation) from 1989 to 2005, Lin et al. (2021) finds that reducing managers' litigation risk leads to more investment in R&D. Atanassov (2013) compared US companies incorporated in states that passed anti-takeover laws with companies in states that did not pass those laws and found antitakeover laws had a negative impact on R&D investment, because when threat of hostile takeovers is removed, the managers become less motivated to innovate.

Roychowdhury (2006) points out that managers trying to avoid losses act aggressively to improve margins by also reducing discretionary expenditures which includes R&D expenses. Similarly, Bushee (1998) considers all American firms from 1983-1994 and uses logit model regression introduced by Baber et al. (1991) and Berger (1993) to show that profit declines negatively affect R&D. That is, managers are motivated to cut R&D expenses to meet profit targets and to avoid profit declines. This finding was confirmed for French firms over the period. Bushee (1998) also analyses R&D investment manipulation to meet short-term earnings goal and the influence of institutional investors on the myopic investment behaviour in R&D. The sample covers all American firms for the period 1983-1994, with pre-R&D earnings that are below the prior year's level, but by an amount that could be reversed by reducing R&D. Inspired by the models of Baber et al. (1991) and Berger(1993), the logit model regression reveals that earnings declines' affect R&D cut and the institutional investors' effect in reducing pressure for this myopic behaviour2001-2010. Dumas (2012) showed that that managers adjust R&D expenses to avoid losses or to meet profit levels. Gunny (2005) found that the effect of reducing R&D expenses for managers to avoid losses or meet profit levels is pronounces when firms are limited in their ability to inflate accruals (limited accruals earnings management).

Career experience

Barker and Mueller (2002) find that a CEO's career experience influences a company's R&D spending. More specifically, they find that CEOs with career experience in either R&D, engineering, or marketing or sales positively influence R&D spending; while a CEO with career experience in finance or accounting, legal, or production or operations negatively influences R&D spending.

Academy (China Academy of Science[1]) fellow independent director

Based on Chinese data, Li et al. (2022) find that independent directors who are also academy fellows have a positive effect on R&D investment because these directors have greater motivation to monitor management to protect their reputation and they can better distinguish innovation failures with their knowledge and expertise in scientific discoveries.

Independent directors with technical knowledge

Drawing on data from listed companies in China from 2007 to 2017, Zhe Li et al. (2020) find that independent, technical directors encourage companies to spend more on R&D because they can fulfil their own oversight duties and they can also develop new ideas and put them into practice with their unique expertise.

Independent directors

Using data from all UK non-financial firms, Osma (2008) finds that boards with a greater number of independent directors constrain R&D expenditure because independent directors play a monitoring role to efficiently constrain opportunistic R&D spending.

Director tenure

Based on a sample of US firms from 1996 to 2006, Jia (2017) finds that extended director tenure leads to negative R&D investment because long executive tenure quashes the entrepreneurial spirit and hinders innovation (Marcus & Goodman, 1986). Barker and Mueller (2002) also find that longer tenure of the CEO negatively influences R&D spending. Dechow find that CEOs cut R&D expenditure to improve short-term earnings performance before they leave their positions as CEOs.

Culture

Adhikari and Agrawal (2016) find that gambling culture positively influences R&D investment based on US data because managers who likely share the community's gambling preferences find innovative projects attractive investment propositions.

Overconfident CEO

Overconfident CEOs may underestimate the likelihood of failure and are more likely to pursue innovation. Based on large publicly traded US firms from 1980 to 1994, Galasso and Simcoe (2011) find that overconfident CEOs invest more in R&D than other CEOs because they find that overconfident CEOs carry out roughly 18% more R&D than a typical CEO.

CEO age

Hambrick and Mason (1984) find that firms with younger managers will be more inclined to pursue risky strategies than firms with older managers because older executives may be less able to grasp new ideas and learn new behaviours. Barker and Mueller (2002) and Ryan and Wiggins (2002) find that there is a negative relationship between CEO age and R&D spending.

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[1] China Academy of Science is a major government research body focusing on natural science to nurture R&D, innovation and commercialization, for further details see https://english.cas.cn/about_us/introduction/201501/t20150114_135284.shtml

CEO education

Better education provides a greater ability to absorb new ideas and better understanding of technology. Barker find that there is a positive relationship between the amount of formal education achieved by its CEO and the firm's R&D spending.

Founder CEOs

Based on Japanese data, Kubota and Takehara (2019) find that founder CEOs enhance R&D investment because the founder may possess strong entrepreneurial skills and be in a strong position to monitor management of the firm because the founder usually owns large blocks of stock (Block, 2012).

2.3 Ownership structure

Share pledging

The loans borrowed via pledging shares are subject to a margin call; if the share price fails to comply with the margin call, the pledgees gain ownership of the pledged shares and insiders may be forced to sell additional shares at a depressed price. It follows, therefore, pledging shares may lead to risk aversion. Based on Chinese data, Wang et al. (2020) find that share pledging is associated with a 4.6% decline in R&D activities.

Family firms

Families as owners may primarily seek high dividends and pursue their private goals so the level of R&D intensity is lower in a family firm (Block, 2012). However, Kubota and Takehara (2019) find that innovation input by family firms is higher than that of non-family firms in Japan because family firms are more motivated to achieve long-term goals (Marques et al., 2014) than short-term profits.

SOEs

Zhang et al. (2020) point out that there are three reasons why SOEs spend less on R&D. First, policy burdens (Lin & Tan, 1999) make SOEs abandon their innovative investment projects and take short term investment decisions to achieve certain political goals (Gao et al., 2018); secondly, there is a lack of monitoring of SOE managers causing serious agency problems; and finally, administrative monopoly reduces competition(Zhang et al., 2020).

Institutional investor

Philoppe Aghion et al. (2013) find that greater institutional ownership is associated with more R&D expenditure because CEOs do not have career concerns in the face of profit decreases when institutional ownership is higher. Institutional investors can better monitor managers closely through site visits. Jiang and Yuan (2018) find that institutional investors' corporate site visits increase R&D investments. Because institutional ownership provides managerial oversight, Ryan and Wiggins (2002) find a positive relationship between institutional investors and R&D investment.

Blockholders

Due to their conservative attitude and risk avoidance, Tribo et al. (2007) find that there is a negative relationship between the percentage of shareholding and R&D investment when blockholders are banks; there is a positive relationship between the percentage of shareholding and R&D investment when blockholders are non-finance corporations because non-finance corporations rarely have a credit relationship with their shareholding company, and so a non-finance corporation is taking a lower risk compared with blockholders which are banks.

Management stockholding

Hill and Snell (1988) find that a high percentage of management stock-holding positively influences R&D investment as shareholders have often an interest in the long-term performance and success of the firm. Dechow and Sloan (1991) find that CEO stock ownership mitigates the CEO's incentive to manipulate earnings upward by cutting R&D expenses.

Ownership concentration

There are mixed results about the relationship between ownership concentration and R&D investment. Based on Korean data from 1980 to 2018, Lee (2021) finds that ownership concentration negatively influences R&D spending. Based on Chinese data from 2010 to 2014, Wen and Xia (2016) find that ownership concentration and company R&D investment are significantly negatively correlated. There is a positive relationship between ownership concentration and R&D investment (Baysinger et al., 1991; Francis & Smith, 1995; Hill & Snell, 1988; Lee & O'Neill, 2003; Yafeh & Yosha, 2003), and a negative relationship between ownership concentration and R&D investment (Minetti et al., 2015b; Vito et al., 2010).Table1 summarises authors and their findings in regard to the relationship between ownership concentration and R&D investment. Relationships were found to be either positive, negative or no relationship.

Table 1Relationship between ownership concentration and R&D investments

Author	Relationship
Baysinger et al. (1991)	Positive relationship
Minetti et al. (2015)	Negative relationship
Kim et al. (2008)	No relationship
Choi et al. (2011a)	No relationship
Lee and O'Neill (2003)	Positive relationship
Yafeh and Yosha (2003)	Positive relationship
Francis and Smith (1995)	Positive relationship
Bogliacino et al. (2013)	Positive relationship
Philoppe Aghion et al. (2013)	Positive relationship
Munari et al. (2010)	Negative relationship
Wen and Xia (2016)	Negative relationship
Faccio et al. (2011)	Negative relationship

Privately owned enterprises

Because private ownership imposes a stricter operational discipline which leads to higher competition, Madden and Savage (1999) find that private ownership enhances R&D investment.

Stock liquidity

High stock liquidity is associated with increased exposure to hostile takeovers. Fang et al. (2014) find that managers are not willing to invest in long-term investments such as innovation as liquidity rises.

2.4 Corporate governance

Reporting environment

Corporate transparency triggers companies to invest in R&D because corporate transparency reduces information asymmetry and lowers the information costs between firms and capital markets (Brown & Martinsson, 2019). Because transparency helps investors ensure resources allocated to R&D is directed to its best use so managers do not have career concerns even if innovation fails, Zhong (2018) finds there is a positive relationship between corporate transparency and resource allocation to R&D. Based on US data, Gordon et al. (2020) find that peer R&D disclosure positively influences a company's R&D investment because the company may feel competition pressure from peers. Increased reporting frequency leads to short term performance pressure, and Fu et al. (2020) find that increased reporting frequency negatively influences the number of patent applications.

Financial reporting quality

Managers are motivated to manipulate earnings for self-interest. There are conflicting views about whether cutting R&D is a tool to manipulate earnings. Roychowdhury (2006b) finds that managers cut R&D, SG&A and other costs to manipulate earnings upwards (Cohen & Zarowin, 2010; Gunny, 2010), however, R&D is a positive sign of a company's long-term development (Chan et al., 2001).Sun (2020) finds that R&D and other costs are treated differently so managers will keep R&D and cut other costs to manipulate earnings upwards.

Competition

Internationalization leads to increased competition and decreased agency problems in order to sustain competitive advantage. Chang et al. (2018) find that internationalization motivates firms to allocate resource to R&D. However, based on Chinese data, Bloom et al. (2016) find that Chinese import competition induced a rise in R&D investments. Using patents (citation-weighted patents) to proxy innovation, Hashmi (2013) finds that there is a negative relationship between ownership concentration and innovation because competition reduces profits, hence, there is less incentive to innovate.

Internal control

Based on a sample of Chinese listed firms, Li et al. (2017) find that high quality internal control reduces R&D expenditure because managers may use internal control requirements as excuses to relax their efforts towards innovation activities.

Board diversity

Powerful CEOs have the ability to make unchecked decisions, which result in more extreme outcomes (Adams et al., 2005). Using both demographic and cognitive factors (including gender, age, ethnicity, educational background, financial expertise, and breadth of board experience) to measure board diversity, Bernile et al. (2018) find that there is a positive relationship between board diversity and R&D investment because greater board diversity leads to less volatile outcomes.

Board networks

Based on data from US publicly listed firms, Chang and Wu (2021) find that firms with well-connected boards invest more in R&D activities, because networks facilitate information diffusion across firms and the enhanced information set improves board function in both advising management and evaluating managerial performance.

Compensation incentives

Following agency theory, managers will not invest in risky innovations because they are risk-averse(Jensen & Meckling, 1976). Agency theory also predicts that linking managerial compensation with company performance decreases risk-aversion (Fama & Jensen, 1983). Sheikh (2012) finds that there is a positive relationship between pay-performance sensitivity and R&D expenditure. Ryan and Wiggins (2002) investigate the relationship between the R&D investment decision and corporate compensation policy in 1,088 US firms in 1997 and find that there is a positive relationship between R&D investment and equity-based compensation. Separating equity compensation into stock options and restricted stock, Ryan and Wiggins (2002) find that stock options positively influence R&D investment but restricted stock negatively influences R&D investment because restricted stock does not motivate risk taking activities.

Based on US listed companies from 1992 to 2006, Amore and Failla (2020) find that greater disparity in variable executive pay leads to more R&D investment because lower paid executives will fill the pay gap to higher paid executives by putting in more effort, including more effort to spend on R&D activities. However, Amore and Failla (2020) also point out that greater disparity in fixed executive pay negatively influences R&D investment because lower paid executives cannot fill the pay gap to their higher-paid peers by working harder.

Employee-friendly workplace

Research shows no clear conclusion on whether employee-friendly workplaces enhance company R&D investments. Because employee-friendly workplace practices enhance the tolerance for failure, Chen et al. (2016) find that the employee-friendly workplace practices positively influence R&D investment. However, using the number of patents applied for and

the number of patent citations received to measure innovation, Francis et al. (2018) find that employee-friendly workplace practices negatively influence innovation because labour laws lead to a shirking inventor attitude and inefficient use of corporate resources (hiring or firing labour) due to high dismissal costs.

Unionization

Based on US data, Bradley et al. (2017) find that unionization has a negative effect on R&D spending because unionization cannot align incentives between employees and firms and so unionized employees demand higher wages once the innovation process has started and wage demands lead to underinvestment in innovation by firms.

Company size

Based on data from the pharmacy industry in the US, Acemoglu and Linn (2004) find that there is a positive relationship between market size and R&D investment. They find that a 1% increase in market size leads to 6% increase in the total number of new drugs entering the US market. Madden and Savage (1999) find that an increase of 1% in market size leads to a 0.03% increase in R&D investment. Fishman and Rob (1999) find that larger firms invest more in R&D because larger customers reduce costs and earn higher profits. In a review paper, Kamien and Schwartz (1975) point out that company size positively influences R&D spending and R&D success.

2.5 Government policy

Tax

Tax increases may lead to increased debt financing (Heider & Ljungqvist, 2015) and debt financing is not the favoured form of financing for risk taking activities. Mukherjee et al. (2017) find a negative relationship between tax increase and R&D investment. In order to constrain tax motivated income shifting, addback statutes have been adopted by many US State governments. Because addback statutes reduce company tax benefits from the creation of intangible assets such as patents, Li et al. (2021) find that addback statutes reduce innovation behaviour. Based on a refundable credit policy adopted in Ireland, Acheson and Malone (2020) find that tax incentives helped to increase R&D investment by firms because tax refunds to some extent mitigate the financial barriers to R&D investment.

Political connections

Company political connections decreased following CPC regulation in 2013 because independent directors with political connections were forced to resign. Qin and Zhang (2019) find that de-politicization led to increased R&D investment because companies needed to improve their competitiveness to sustain development after forfeiting their political ties.

Social capital

Because social capital (measured from data provided by NRCRD at Pennsylvania State University) could allay contracting problems in innovation within the firm and ease firm access to external financing, Hasan et al. (2020) find that social capital is positively associated

with R&D expenditures based on US data.

2.6 Discussion

Based on above literature review, we see there are several research gaps. First, R&D activities are important for a company's long term and sustainable development. However, Bougheas et al. (2003) mentioned that firms are not able to attract external funds to finance R&D projects because R&D projects face long term and uncertain payoffs so outside investors cannot distinguish the quality of R&D outcomes. Internal finance is the most important funding source for investment in R&D (Himmelberg & Petersen, 1994); Bougheas et al. (2003) find that R&D spending is strongly correlated with returns. It follows, therefore, that R&D spending depends on past profitability, and so the company will continue to allocate resources to R&D if past profits are sufficiently high. However, there is a lack of research investigating company decisions to allocate resources to R&D under the scenario of sales revenue decline. In this research, how firms alter their R&D expenses when sales revenue decline is tested.

Secondly, research shows that accounting quality influences R&D investment decisions (Cohen & Zarowin, 2010; Gunny, 2010; Roychowdhury, 2006b). However, there are opposing findings about the role of R&D when managers are motivated to manage earnings (Roychowdhury, 2006b; Sun, 2020). In this research, we will test whether managers with an earnings management motivation will cut R&D expenses when sales decrease.

Thirdly, existing research shows differing views on the relationship between competition and R&D activities (Gorodnichenko et al., 2010). The Schumpeterian effect shows that more competition reduces innovation (Schumpeter, 1942), while the 'escape competition effect' shows that the company needs to innovate to escape competition (Hashmi, 2013). There are, therefore, no conclusive results about the relationship between ownership concentration and R&D investment (Bloom et al., 2016; Chang et al., 2018; Hashmi, 2013). In this research, we will investigate whether ownership concentration influences R&D investment when sales decrease.

Finally, the characteristics of managers influence R&D investment decisions. Managers' risk preference (Hess & Hess, 2020; Jia, 2019; Wally & Baum, 1994), managers' career experience (Barker & Mueller, 2002; Li et al., 2022; Zhe Li et al., 2020) and managers' demographic characteristics influence decisions about R&D activities(Barker & Mueller, 2002; Galasso & Simcoe, 2011; Jia, 2017; Kubota & Takehara, 2019). However, there is a lack of research investigating how managerial ability influences R&D investment decisions. In this research, we will test to what extent managerial ability influences decisions about R&D activities when sales revenue decreases.

2.7 Summary

A company's research and development (R&D) expenses are the key driver for innovation, which could influence sustainable development and value creation in the business (Lee and O'Neill, 2003). Because of the importance of R&D in attaining economic goals, researchers are drawn to identify the determinants of R&D investments(Huang et al., 2021).However, there is a lack of research investigating company R&D investment decisions when the company is experiencing a downturn. We therefore chose to investigate the R&D allocation decision when the company is experiencing sales revenue declines and its influencing factors.

Existing research shows that both internal and external financial factors(Acharya & Xu, 2017; Costa & Habib, 2021), manager and board member's characteristics (Barker & Mueller, 2002; Hambrick & Mason, 1984; Osma, 2008), ownership structure (Aghion et al., 2005; Tribo et al., 2007) and corporate governance (Huang et al., 2021; Roychowdhury, 2006b) influence company's R&D investment decisions. However, there is contradicting evidence on whether a company will cut R&D when sales revenue decreases; to what extent both type one and type two agency problems could influence the R&D investment decision when sales decrease based on agency theory; and how managerial ability could influence the company's R&D investment decision when sales decrease, based on the upper echelons theory. This research addresses these research questions based on Chinese data.

3 R&D stickiness, earnings management and managerial ability

3.1 Abstract

In this study, we examine the effect of earnings management motivation on management's resource allocation and cost adjustment decisions through the lens of R&D stickiness in China. Using a sample of firms from the Shanghai and Shenzhen Stock Exchange markets in China, we find that managers who are motivated to avoid losses and to avoid profit decrease will not retain R&D expenses when the company faces a sales revenue decline. Furthermore, we analyse to what extent managerial ability influences the relationship between earnings management motivation and R&D stickiness. Employing data envelopment analysis (DEA) combined with Tobit regression to measure managerial ability, we find that managerial ability strengthened the negative relationship between earnings management incentive to avoid losses and to avoid profit decrease and R&D stickiness. This is consistent with the view that differences across individuals can have significant impact upon corporate outcomes. Capable managers are more likely to contribute to good corporate outcomes but they maybe also better at serving their self-interests at the expense of benefitting shareholders. Mechanism test to control for earnings management catalysing or hampering factors include institutional ownership, board size, board independence, number analyst following the firm and management shareholding; supporting the major findings. Our findings have practical implications and enhance agency theory.

3.2 Introduction

R&D costs and their link to the future performance of company investments and capital market reactions have attracted wide attention (Sougiannis, 1994)with evidence suggesting that R&D expense increases are beneficial investments because firms experience significantly positive long-term abnormal operating performance (Eberhart et al 2004). R&D exhibits significant, recurring cash expenditures and often impacts upon the volatility and growth of a company's profits. The accounting treatment and its implications have been widely discussed. Early research found that managers tend to underinvest in R&D to meet performance benchmarks (Baber et al., 1991b; Bushee, 1998a; Cooper & Selto, 1991; Francis et al., 2008; Gunny, 2010; Oswald & Zarowin, 2007). When researchers talk about manager's behaviour they usually mean real earnings management, where one dollar less spent on R&D means one dollar extra of pre-tax profit, though R&D capitalization has changed this incentive (Oswald & Zarowin, 2007).

Capitalization of R&D projects may lead to over-investment in R&D activities. Seybert (2010) reported such overinvestments, arguing that the evaluation of capitalized R&D projects is carried out over multiple accounting periods while abandoning the projects would lead to immediate impairment expenses. Managers may then appear to be responsible for

these expenses and for the failed projects. This raises the question to what extent a manager's motivation for earnings management will impact on R&D decisions in times of declining revenues and profits, and furthermore, how a manager's ability may influence this relationship.

Roychowdhury (2006) suggested that managers may alter operating activities to adjust earnings and to avoid annual losses. Managers may prefer to manipulate real activities rather than the accruals, as manipulating the accruals is likely to attract the scrutiny of auditors and regulatory bodies. Additionally, managers may be forced to manipulate real activities in addition to manipulating accruals because simply manipulating accruals was insufficient. Baber et al. (1991) found that managers were likely to cut R&D spending when they were failing to meet income thresholds, or because of their accounting based contractual requirements for compensation. These operations maybe observed and brought to an end by institutional investors that monitor such activities closely (Bushee, 1998), but as long as the incentives are there some managers would go along with these operations.

Apart from trying to avoid losses, it was reported that capable managers are more likely to manage and smooth earnings to meet capital market expectations (Demerjian et al., 2020). Income smoothing makes earnings and cash flows more predictable and in turn also makes stock prices more predictable (Baik et al., 2020; Demerjian et al., 2013).

However, when capable managers manage earnings, they tend to do it with more finesse, limiting the potential negative impact on firm performance (Bonsall IV et al., 2017; Huang & Sun, 2017). Better managers make better decisions that tend to enhance the market values of firms, and they are also less risk adverse. Consequently, capable managers tend to reduce capital expenditures and increase spending on R&D projects, and vice versa for those managers of lower capability (Yung & Chen, 2018; Yung & Nguyen, 2020). One can therefore argue that the more rational and less risk averse capable managers are more likely to take decisions that lead to less cost stickiness (Ziyang Li et al., 2020).

It is also argued that managers are varied in their management approaches, thus they leave their mark on the companies they manage. In particular, the impact of a CEO on a company can be unique. CEOs can be key drivers of firm performance (Bennedsen et al., 2020). However, CEOs, as capable managers, may be maximizing self-interest at the expense of other stakeholders. Conflicts of interest between agents and principals have been an on-going theme of research as far back as when Jensen and Meckling published their seminal work in 1976. Gul et al. (2018) provides evidence that capable managers serve their self-interest at the expense of shareholder benefits. In contrast, Haider et al. (2021) report that capable managers work to improve the performance of firms and thus benefit the shareholders.

Here we examine data of Chinese listed companies to see if we may find evidence that R&D stickiness can be a function of the ability of managers. Do capable managers work harder to retain R&D activities when facing a downturn, or do they more readily cut R&D

expenses as part of their real earnings management?

In this study we follow the widely accepted Kama and Weiss (2013) measure for real earnings management. As for cost stickiness, we draw on Anderson et al. (2003) which utilizes changes in sales revenue and log OLS regression to determine the respective cost stickiness. To measure managerial ability, we follow the two-stage process applied in Demerjian et al. (2012),which involves stripping a firm's performance of anything that can be attributed to firm characteristics and using what remains as a measure of managerial ability.

We conduct our analyses using a large sample of Chinese firms over the period 2010 to 2019. We first examine 16,575 firm-year observations of companies listed at the Shanghai and Shenzhen Stock Exchanges.Following Li and Lu (2022) mechanism tests are employed to cater for various venues in which managerial ability and management's motivation to avoid losses or profit declines can impact on R&D stickiness. Furthermore, a variety of robustness tests are then conducted to see if the results are robust to alternative empirical settings. Alternative measures of revenue are used, along with managerial ability and earnings management. The results of these additional tests are consistent with the main inference that first, R&D is sticky; secondly, managers cut R&D in order to avoid losses and to avoid revenue decreases, which decreases R&D stickiness; and at last, managerial ability further strengthens the R&D stickiness.

This study relates to the emerging stream of research on the role of managerial ability in determining R&D cost stickiness, and how that might play out under the principal-agent setting. We also contribute to the field of strategic management research on how resources are allocated during downturns. Finally, the study contributes to existing research on what determines cost stickiness.

The remainder of this paper is organized as follows. The following section provides a literature review and hypothesis development. Section 3.4 introduces research design. Section 3.5 provides descriptive statistics and empirical results. Section 3.6 contains the mechanism tests. Section 3.7 reports the robustness tests while in section 3.8 we discuss conclusions and limitations.

3.3 Literature review

In this section we elaborate on Consequences of earnings management (3.3.1), sticky and anti-sticky cost behaviour (3.3.2), managerial incentives and cost stickiness (3.3.3) followed by the hypotheses development for H1 R&D costs are sticky.

3.3.1 Consequences of earnings management

Previous studies find that earnings management has a variety of consequences including: company performance (Francis et al., 2016; Gunny, 2010; Subramanyam, 1996; Vorst, 2016), information disclosure (Black et al., 2017; Kim et al., 2021), accounting quality (Abad et al., 2018; Ettredge et al., 2010; Li, 2019), cost of capital (Chen et al., 2015; Kim et al., 2021; Li et

al., 2018; Oranzlin & Akhmetzhanov, 2019; Pappas et al., 2019) and corporate governance (Commerford et al., 2019; Greiner et al., 2017; Kim &Park, 2014; Schelleman & Knechel, 2010).

In order to acquire private control benefits, managers have an incentive to conceal true firm performance from outsiders. Controlling owners and managers can use their control to benefit themselves at the expense of stakeholders' interests (Jensen & Meckling, 1976). There are, therefore, conflicting interests between controlling owners or manager and outsiders. Controlling owners or managers have an incentive to reduce the likelihood of outsiders detecting their private control benefits because outsiders may take action to prevent controlling owners or managers from using their judgment in financial reporting to manipulate reported earnings to maximize their private benefits.

Following Healy and Wahlen (1999), this research defines earnings management as masking true firm performance to either mislead stakeholders or to influence contractual outcomes. Existing research shows that managers may manipulate reported earnings for different reasons, such as avoiding losses (Burgstahler & Dichev, 1997), gaining higher management compensation (Watts & Zimmerman, 1986), avoiding debt covenant violations (DeFond & Jimbalvo, 1994), and having more favorable conditions for equity offerings (Teoh et al., 1998).

There are conflicting views on the effect of earnings management on company performance. Gunny (2010) finds a positive relationship between earnings management and company performance because manipulating earnings to meet a benchmark is a signal from managers about the strength of future operations, which results in improved reputation and credibility (Gunny, 2010). Based on the sample from the US during 1973-1993, Subramanyam (1996) concludes that there is a positive relationship between discretionary accruals and a firm's future profitability because accruals have better information content than cash flows (Bowen et al.,1987) so discretionary accruals improve the ability of earnings to reflect economic value.

Conversely, earnings management is negatively associated with future performance, because cutting R&D or SG&A to manipulate reported earnings upward will lead to increased long-run economic costs. Based on a sample of US firms from 1983 to 2012, Vorst (2016) finds that real earnings management lowers future operating performance. Furthermore, based on US data from 1994 to 2009, Francis et al. (2016) find that real earnings management is positively associated with the company's future crash risk because the authors argue that hiding true growth prospects or negative growth prospects can cause future price crashes.

Earnings management motivation influences information disclosure. Kim et al. (2021) find that firms which manipulate earnings through accrual earnings management are more likely to delay information disclosure and there is no relation between measures of real earnings management and late announcement delays. Because accruals earnings management can occur after the fiscal year-end (Trueman, 1990), this causes announcement delays. In

contrast, real earnings management is limited in time by the fiscal year end, so it is unlikely that real earnings management will delay announcements. Based on the hand-collected non-GAAP quarterly earnings data[2] of US listed companies from 1998 to 2006, Black et al. (2017) find that managers are less likely to report a non-GAAP earnings metric when managers meet expectations after employing real and accrual earnings management. In sum, Black et al. (2017) point out that the non-GAAP earnings take place at a relatively later date chronologically than GAAP earnings to meet and beat benchmarks.

Earnings management motivation negatively influences accounting quality. Deriving samples from restatement announcements of US listed companies from 1995 to 2003 and using balance sheet bloat as a mechanism to measure real earnings management, Ettredge et al. (2010) find that earnings management leads to misstated financial statements. Using 161,941 firm-years observation from US listed companies from 1975 to 2016, Li (2019) finds firms that engage in real earnings management to manipulate earnings are negatively associated with earnings persistence for future cash flows, because the manipulated earnings will not persist into the future. Bhattacharya (2013) points out that accrual earnings management is associated with higher information asymmetry because earnings management activities garble the information provided by financial statements. Collecting data from non-financial firms listed on the Spanish Stock Exchange in the period 2001-2008, Abad et al. (2018) find that real earnings management activities increase the level of information asymmetry because manipulated earnings hinder information users from evaluating and assessing a firm's true performance.

Earnings management motivation increases the cost of capital. Pappas et al. (2019) find that earnings management activities lead to stricter loan contract terms because lenders are able to detect a company's earnings management activities; a lender could possess some private information from a borrower or the borrower's peer firms (Wight et al., 2009). However, based on the Chinese data, Li et al. (2018) find that banks cannot detect company earnings management activities, so that earnings management activities did not increase the cost of the loan. Earnings management makes accounting information less precise. By investigating 9,565 US bond observations from year 2001 to 2008, Chen et al. (2015) find that real earnings management positively impacts credit risk (bond yield spreads) because earnings management leads to investors having less precise knowledge of accounting information so investors may overestimate the mean value of a firm's assets. Collecting data from public companies listed in the Kazakhstan Stock Exchange from 2011 to 2016, Oranzlin and Akhmetzhanov (2019) find that accrual earnings management has a negative impact on the cost of debt because low accounting information quality decreases investors' ability to

[2]Non-GAAP measures are not in accordance with GAAP because managers calculate non-GAAP earnings by starting with Generally Accepted Accounting Principle (GAAP) earnings and exclude items that GAAP earnings require but managers deem to be less representative of core operation (Hsu et al., 2022). Non-GAAP earnings are not just subject to management discretion but also are not audited (Chen et al., 2021).

assess company's default risk and predict its future performance and the information risk is reflected in the cost of debt. Based on US bond issuance data from 1993 to 2009, Ge and Kim (2014) find that there is a negative relationship between the level of real earnings management and the cost of bond issuance because investors view earnings management as a risk factor, so they ask for a risk premium. Accounting information has been used by creditors to evaluate the riskiness of borrowers. Kim et al. (2021) find that the level of earnings management (both real earnings management and accrual earnings management) is positively related to the loan spread (higher interest rate, reduced loan limited, and shorter maturities on loans in the contracting stage) because banks view earnings management as a risk factor which hampers a borrower's capacity to repay a loan. Using a large sample of US public firms, Kim et al. (2021) find that real earnings management lowers credit investor's perceived risk because investors are likely to view the firm as having lower uncertainty while a manipulated earnings investor may see firms with manipulated earnings as low risk firms.

Stakeholders negatively view earnings management activities. Using data obtained using a survey in the Netherlands, Schelleman and Knechel (2010) find that there is a positive relationship between accrual earnings management and audit fees because auditors put more effort into the audit and use more supervisor, assistant and support time on audits that have high accrual earnings management levels. Furthermore, Greiner et al. (2017) find that real earnings management activities are positively associated with both current and future audit fees because auditors put more effort into the audit job to mitigate the possibility of an audit failure. To examine the impact of earnings management activities on the auditor-client relationship, Commerford et al. (2019) find that auditors are less likely to retain a client who is associated with real earnings management. Kim and Park (2014) find that auditors drop clients with aggressive real earnings management to avoid excessive risk. Accounting accruals are based on managers' subjective estimates of future outcomes, which cannot be confirmed objectively pre-occurrence, so auditors face higher audit risk when issuing a qualified opinion for a high accrual group. Francie and Krishnan (1999) find that there is a negative relationship between earnings management measured by abnormal accruals and the issuance of a qualified audit opinion. Investors negatively view company earnings management activities. Conducting a controlled 2*2 between-subject experiment, Hewitt et al. (2020) find that managers consider their self-interest to be above shareholders' interest (earnings management activities) leading to impaired investor trust in managers because managers may transfer the firm's resources away from shareholders to themselves.

3.3.2 Sticky and anti-sticky cost

Cost behaviour is a critical topic in management accounting research. Researchers usually distinguish between fixed and variable costs. Variable costs are expected to be in lockstep with the level of production, whereas fixed costs are expected to be more staggered. Using revenue as a proxy measure for the level of production, Anderson et al. (2003)

demonstrated that costs are related to the level of production but the association is stronger on the upside than on the downside. They find that SG&A costs increased 0.55% per 1% increase in revenue but fell only 0.35% per 1% decrease in revenue. This asymmetric cost behaviour is named "cost stickiness" in the literature (Anderson et al., 2003).

Costs are considered sticky if these "costs rise more with increases in activity volume than they fall with decreases" (Anderson et al., 2003, p. 48). When facing a fall in sales, a manager will have to decide whether to retain or retire slack resources. Managers are more likely to decide based on which choice yields lower costs and to change the level of committed resources based on the probability that a demand decline is only temporary. If managers decide to retain unutilized resources instead of incurring adjustment costs when volume declines, cost stickiness occurs - adjustment cost of reducing inputs under declining activities is higher than that of raising input under increasing activities (e.g., Jaramillo et al., 1993; Pfann and Palm, 1993; Pfann and Palm, 1997; Goux et al., 2001; Cooper and Haltiwanger, 2006; Balakrishnan et al., 2004; Balakrishnan and Gruca, 2008). Such a decision is also dependent on either the assessment of the likelihood that a drop in demand is temporary or because of their personal considerations reflecting agency costs. This observation ties in well with business cycle literature, where researchers argue that there are greater uncertainties during downturns and making choices during periods of high uncertainty will more likely lead to making costly mistakes, thus making the companies less responsive (Bloom et al., 2007). They also argued that making capital a stock adjustment is different from making a knowledge stock (R&D) adjustment because knowledge stock is intangible and typically cannot be bought or sold. Thus, unlike adjusting the capital stock which is a tangible stock, making adjustments to R&D spending is more like adjusting a flow (Bloom, 2007).

Another force that comes into play with how managers operate in the face of falling sales is agency costs. These are the costs incurred by managers making decisions that serve their own interests instead of those of stockholders (Jensen & Meckling, 1976). In short, there is a conflict of interest between the managers and the shareholders, and because the managers get to decide how things are done they may choose actions that benefit themselves but which come at a cost to the shareholders. Anderson et al. (2003) found that the degree of stickiness is lower when revenue falls over two consecutive periods, which indicates a more permanent decline. In contrast, there is greater stickiness during high growth periods as managers consider revenue declines temporary. Reducing committed resources has costs, and due to the size of the costs relative to the size of the company(being relatively smaller for large companies), stickiness is higher for companies with more employees and asset intensity (Anderson et al., 2003).

Subsequent studies adapted Anderson et al.'s (2003) measure to study companies' spending on R&D. A study of US companies showed no significant stickiness for R&D (Anderson & Lanen, 2007). This dovetails with earlier studies which indicate that managers

adjust R&D expenses to meet earnings forecasts (Baber et al., 1991a). Weiss (2010) examines how stickiness may make the earnings of a company harder to predict when compared to the forecasts made by analysts. Firms with cost stickiness show lower profits when the activity level declines compared to anti-sticky costs[3] (see Figure 6).

Additionally, the strength of cost stickiness is industry specific due to differences in production, operational, and economic environments. More intense competition within an industry may mean that firms must adjust to changing situations quickly lest they lose out to their more agile competitors. Subramaniam and Watson (2016) examined SG&A expenses and Costs of Good Sold (CGS) of US companies and found the highest stickiness in manufacturing, the least stickiness in merchandising, and some stickiness in financial and services. Cost stickiness is also observed in other countries (Calleja et al., 2006); it was observed in physical therapy clinics (Balakrishnan et al., 2004), as well as hospitals in Canada (Balakrishnan & Gruca, 2008) and Germany (Holzhacker et al., 2015).

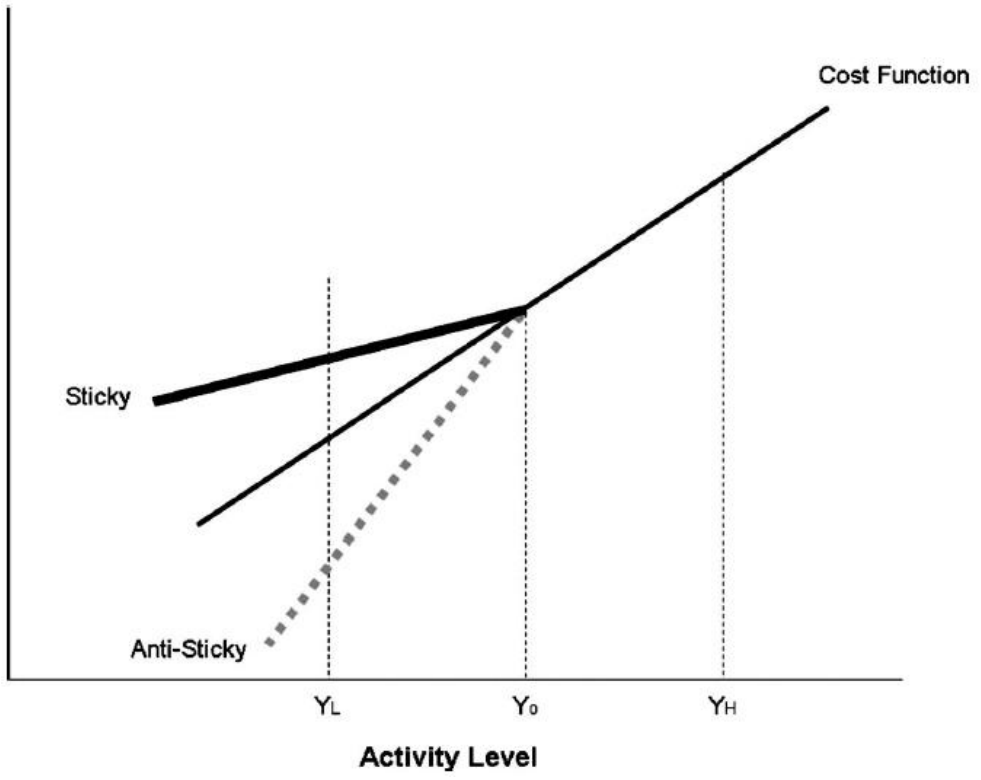


Figure 6–Cost asymmetry

Source: Weiss, 2010,p.1444

[3]Dierynck et al. (2012) found that managers of private Belgian firms are motivated to meet or beat the zero earnings benchmark, so they increase labour costs to a smaller extent when activity increases and decrease labour costs to a larger extent when activity decreases, which is opposite to the cost stickiness theory and are called “anti-sticky cost”.

Another industry-related determinant of stickiness is capacity. Studying aircraft capacity and sales volume data, Cannon (2014)reports that flight companies have asymmetric responses to increases and decreases in demand. Cannon argues that this is because, for a given unit of change, adjusting the capacity upwards is more expensive than adjusting downwards. Thus, flight companies increase ticket prices when demand rises, and reduce the tickets offered for sale when demand decreases. Asymmetric responses manifest as cost stickiness.

Product market competition can play a part in cost stickiness. Using a sample of US companies, it was found that higher competition would lead to less cost cutting during downturns. The impact is especially high for firms that are financially strong, as they would have more access to funds to make investments possible even when sales are falling (Li & Zheng, 2017). However, in emerging markets the effect is opposite. Higher competition in a product market is associated with reduced cost stickiness, though amongst state-owned enterprises this effect is attenuated (Li & Luo, 2021). State interventions may impact upon stickiness in the form of employment protection legislation, leading to higher levels of labour cost stickiness (Banker et al., 2013). Managers in state-owned enterprises may pursue goals other than profit maximization. It has been suggested that keeping the number of jobs stable in the local economy may be one of the goals, thus they would refrain from firing employees or reducing their wages even when sales decrease (Prabowo et al., 2018). Fixed tariffs were introduced to hospitals in Germany in 2003, which encouraged hospitals to increase the percentage of variable costs so that they may act with more flexibility and may more readily increase or decrease their level of production in response to demand changes, thus the increase and decrease of costs have since become more symmetrical (Holzhacker et al., 2015). Cost stickiness was found to be pervasive in China across industries and across regions, and is potentially related to the level of economic development (Xu & Sim, 2017). In a global level study, it was found that managers build up slack resources when they foresee political uncertainty (e.g., elections). The slack resources then appear as higher cost stickiness (Lee et al., 2020). Stickiness is not just impacted by legislative and political aspects[4]within an industry, but also by how managers respond to incentives and their personal characteristics (Table 2).

[4] For a comprehensive summary see also Guenther, T. W., Riehl, A., & Rößler, R. (2014). Cost stickiness: state of the art of research and implications. *Journal of Management Control*, *24*(4), 301-318. , ibid.

Table 2 Past cost stickiness studies

	SG&A	COGS	Operating cost	Cost of Service	Cost of Labour	Cost of Supporting Services
Anderson, Banker & Janakiraman (2003)	Sticky					
Subramaniam and Weidenmier (2003)	Sticky	Sticky				
Bugeja Lu and Shan (2015)			Sticky			
He (2019)	Sticky					
Ibrahim (2016)		Sticky				
Dalla Via and Perego (2014)	Not Sticky	Not Sticky	Not sticky		Sticky	
Bu, Wen and Banker (2015)	Sticky					
Xu and Sim (2017)			Sticky			
Magheed (2016)	Sticky	Sticky				
Dierynck, Landsman and Renders (2012)					Sticky	
Cohen et al. (2017)	Sticky			Anti-Sticky		
Balakrishnan and Cruca (2008)			(Core) Sticky			(Supporting) Not Sticky

3.3.3 Managerial incentives and cost stickiness

Managers operate differently depending on what incentives are driving them and these drivers can change over time. In a study on US firms (Kama & Weiss, 2013, p. 201), it was found that after sales revenue had fallen and managers were under pressure to meet earnings targets, they would adjust resources in order to meet targets. If they were not under pressure to meet targets, then stickiness remained. Banker and Byzalov (2014) points out that managers' expectation for future sales are more optimistic (pessimistic) if prior sales have increased (decreased). An increase in prior sales (optimistic) could lead to cost stickiness, and prior cost decrease (pessimistic) could lead to cost anti-stickiness (cutting costs more when sales decrease than increasing costs when sales increase). The influence of managerial characteristics, such as overconfidence of CFOs, on their operational resource adjustment decisions was documented by Chen et al. (2021). R&D or advertising expenses reductions for upward earnings management are considered an inefficient way to pursue short-term goals at the expense of long-term development (Eberhart et al. 2004).

The concept of corporate governance includes mechanisms to monitor or motivate managers (the agent) when there is a separation of ownership and control. These mechanisms are aimed at solving the widespread agency problem. Motivating and or monitoring are the main ways to solve the agency problem. When motivating managers, good corporate governance can support goal congruence between managers and the firm so that the manager will try to maximize firm value. Under the monitoring function of corporate governance reduces management opportunism while protecting principals' interests. Corporate governance also influences cost stickiness, e.g. managers' self-interested behaviour leads to

expense stickiness (Chen et al., 2008). SG&A cost stickiness is in this regard a proxy for empire building and represents the agency problem of managers furthering their own interests at the expense of the shareholders (Shleifer & Vishny, 1997). Corporate governance measures can mitigate this problem (see Larcker et al., 2007 for a review) and bring SG&A cost stickiness to an optimal level while limiting managers' empire building behaviour or unwillingness to downsize (Chen et al., 2012). Chen et al (2008) find firms with bigger board size or more independent directors (no chairman duality and more external independent directors), and directors who hold larger shareholdings exhibit lower level of expense stickiness. These corporate governance mechanisms work better in reducing expense stickiness when managers have empire building incentives. Similarly, and based on China's manufacturing industry Wan and Wang (2011) draw similar conclusion except that the larger boards impeded the control over free cash flow, which strengthened expense stickiness. Based on samples from 80 listed companies from Egypt, Ibrahim (2018) finds firms with larger boards, role duality and a higher ratio of non-executives exhibit greater cost stickiness than others; firms with higher economic growth and institutional ownership exhibit lower cost stickiness. In a cross-country study, including US, UK, France and Germany, Calleja et al. (2006) find that the level of stickiness appears to be higher in French and German firms compared to UK and US firms due to the different code-law governance (high cost to cut resources; stock market has a smaller control and oversight role; and managers look out for the interests for stakeholders (instead of shareholder value)).

Strong corporate governance also mitigates the three forms of earnings management: accrual earnings management, real earnings management and classification shifting. First, accruals earnings management occurs when managers use discretionary accruals to shift earnings or expenses between the current accounting period and future accounting periods in order to increase or decrease earnings for the current period (Abernathy et al., 2014, p. 603). Based on Australian data, Yang (2019) finds anti-sticky cost behaviour when firms have a limited ability to engage in accrual earnings management to manipulate earnings. However, there is no research which directly identifies whether accrual earnings management could influence cost stickiness. Secondly, real earnings management refers to managers manipulating real business activities to meet earnings targets. Roychowdhury (2006a) finds that firms trying to avoid losses improve margins by offering price discounts to temporarily increase sales, engaging in overproduction to lower the cost of goods sold (COGS), and aggressively reducing discretionary expenditures (discretionary expenses are defined as the sum of R&D, advertising, and SG&A expenses). The degree of cost stickiness is affected by real earnings management. Chen et al. (2012) show that managers may be driven by their own desire to 'build empires' and this can lead to sticky cost behaviour. Finally, classification shifting earnings management refers to misclassifying items within an income statement while net income remains unchanged (McVay, 2006). It is arguably a better method because, compared to real earnings management and accrual earnings management, this is harder to

discover by assessors and it does not have hangover effects which may cause managers to revise their figures in future years. Because different income statement items are informative to different information users (Bartov & Mohanram, 2014), managers are motivated to shift expenses from operating expense to non-recurring expenses in order to increase core earnings. Poonawala and Nagar (2019) find that managers shift cost from COGS to SG&A.

Table 3 summarizes the impact of the various types of earnings management on cost stickiness according to the literature: accrual earnings management (AEM), real earnings management, and classification shift earnings management. Managers relying on AEM to avoid earnings decreases or losses, if they have found that AEM alone is insufficient for the task, would readily cut costs. They more readily cut costs if revenue was in decline than if sales was in decline. Managers engaging in real earnings management are either motivated by empire building leading to higher cost stickiness, or they were seriously concerned about avoiding losses leading to lower cost stickiness. The literature makes no suggestion on cost behaviour for managers engaging in classification shift earnings management to inflate core earnings. It is likely that most managers would be using a combination of these three methods.

Table 3 Types of earnings management and cost stickiness

Earnings Management	Motivation	Influence on cost stickiness
Accrual earnings management (AEM)	Avoid earnings decrease	Anti-sticky
Real earnings management	Empire building	Sticky increase
	Avoid losses	Sticky decrease
Classification shift earnings management	Inflate core earnings	Not mentioned

Access to capital may determine SG&A cost stickiness and anti-stickiness, meaning companies would face less pressure to adjust costs quickly in response to changes in sales, changing how cost stickiness is sensitive to sales change (Cheng et al., 2018). The relation between excess funding and stickiness is also observed when there is IPO over-funding. The excess liquidity from IPO over-funding allows managers more flexibility to take on empire building and more leeway to operate less efficiently (Zhang et al., 2021). On the upside, cost stickiness reduces the stock price crash risk (defined as a function of difference between the firm's own return and the five-week average overall market returns). This impact is especially strong for companies with a younger CEO, high levels of product market competition, lower finance risk, poor performance, state-owned and concentrated ownership (Tang et al., 2020). Managers are faced with the difficult choice that cost stickiness reduces firm value in the short-term but increases it in the long-term. This intertemporal heterogeneous effect of cost stickiness on firm value is mainly manifested in higher adjustment cost, more optimistic manager expectations, and lower agency costs. Managers have to make a rational choice

weighing the short-term costs and long-term benefits of cost stickiness (Jiang et al., 2016).

Informal institutional setting factors such as proximity to religious sites negatively impact the cost stickiness of Chinese firms, particularly for those with higher agency costs, lower risk aversion, and a higher probability of corruption (Wan et al., 2021). In similar vein, good corporate governance can reduce stickiness, while Chinese non-earnings-management companies exhibit significantly expanded stickiness compared to earning managing firms. Managerial earnings management has a direct influence on current expenditure decisions while corporate governance has an indirect impact. The findings suggest that good corporate governance benefits firms by constructing a disciplined environment and restricting management opportunism(Xue & Hong, 2016). As for the external governance factor, auditors of the "Big Four" international audit firms with higher audit quality can reduce cost stickiness compared to Chinese domestic auditors, regardless of their size(Liang et al., 2014). Ownership structure for Chinese firms also impacts cost stickiness. SOEs and companies with executive shareholding exhibit more cost stickiness than their counterparts (non-SOE and without executive shareholding) (Bu et al., 2015b).

3.3.4 R&D cost stickiness

While research documented the SG&A cost stickiness of companies in China and elsewhere (Banker et al., 2018), R&D costs are different and show different cost behaviour (Anderson & Lanen, 2007). In its initial phase, R&D incurs cost to establish an R&D department, the acquisition of specific physical assets, hiring or training a specialized labour force, but also the acquisition of new technologies, learning about how organizations may have to make changes and adjustments due to the adoption of new technologies, among other things. These costs are partially or fully sunk costs. The costs associated with engaging scientists in ongoing research cannot be recovered and are considered sunk costs. One would argue that spending on R&D constitutes upkeeping of a knowledge base, an asset that is highly specific and tied to the operations of the firm which could be lost if R&D efforts were discontinued (Máñez et al., 2009).

It is perhaps possible to take the findings of early research to argue why there might be R&D stickiness. Drawing on Tobin's q theory of R&D investment, it was found that the market valuation of R&D activities amongst manufacturing firms in the United States had fallen sharply in the 1980s. They argued that one possibility is that the speed of depreciation of R&D spending, as a capital, had increased sharply. Thus,–to retain R&D activities it is necessary keep up with the spending, even when sales fall due to a sharp increase in depreciation rates, leading to R&D stickiness(Hall, 1993; Hall & Hayashi, 1989).

R&D has the potential to help companies to get ahead of competition and improve profits, but the decision on how much to spend and on what is complicated. Evolutionary economics literature highlights the uncertainty of technology and market evolution that underlies strategic decisions, similarly for R&D budgets, which follow simple rules for

decision making under bounded rationality (Dosi & Marengo, 2007). Accordingly, because managers cannot predict the returns on R&D investments, Dosi and Marengo (2007) argued that managers must deal with these four conditions when they decide their R&D budgets: technical opportunity conditions, appropriability conditions, cumulativeness of technological knowledge, and the spill-over effects on their competitors. Whether these considerations drive convergence or divergence in R&D investment within an industry is not clear (Coad, 2019).

Anderson et al. (2003) point out that the potential return of R&D activities might not be the only driver of R&D spending. Managers are also concerned about the costs of adjustment should they reduce expenses (SG&A and others) when sales decrease. Venieris et al. (2015) emphasize that the adjustment costs of cutting R&D are higher than to retain R&D expenses when sales decrease. Consequently, managers will keep R&D investment even when company is experiencing sales revenue declines if their probabilistic judgement foresees higher future returns. In that case the adjustment costs to cut R&D investment and free cash are higher than to keep R&D investment which may translate into higher future cashflows. Therefore, we predict that managers will retain R&D investment when sales decrease, which will lead to the R&D stickiness.

H1. R&D costs are sticky

The R&D cost stickiness and the underlying probabilistic judgement on future benefits of slack resources could be impacted by managers' motivation to avoid loss making or declining profits.

3.3.5 R&D cost stickiness and real earnings management

Agency theory states that there are conflicts of interest between shareholders (principals) and managers (agents) because of the separation of ownership and control and information asymmetry between agents and principals. Jensen and Meckling (1976) point out that managers are likely to be self-serving, instead of focusing on shareholder value maximization. Furthermore, existing research shows that managers adopt three ways to manage earnings for their self-interest: accrual earnings management (Hewitt et al., 2020), real earnings management (Sun, 2021) and classification shifting earnings management (Seve & Wilson, 2019). More specifically, Roychowdhury (2006) points out that firms trying to avoid losses act aggressively to improve margins by offering price discounts to temporarily increase sales, engaging in overproduction to lower cost of goods sold (COGS), and reducing discretionary expenditures (discretionary expenses are defined as the sum of R&D, advertising, and SG&A expenses). R&D investments are key to a company's long-term development. At the same time, R&D investments also bring risks to managers such as reputational damage when R&D investments fail, or the effect of R&D investment on company performance improvement is long-term but managers face pressure from the company's bad financial performance in the short-term. Based on agency theory, managers have an incentive to cut R&D to manipulate earnings upward at the expense of the company's long-term development in order to avoid

losses or avoid profit decreases in the short-term. When the company is in downturn, a manager's incentive to manipulate earnings upwards is strengthened because of the pressure from bad financial performance, which makes managers cut R&D investment when sales decrease. Earnings management incentives reduce R&D stickiness.

Returns from R&D projects are often uncertain, and this uncertainty is resolved over time as more information is realized. Companies seeking to avoid losses may reduce their discretionary expenditures, such as R&D expenses (as well as advertising, and SG&A expenses), offer temporary price discounts to boost sales, or engage in overproduction to lower COGS (Cohen et al., 2008; Roychowdhury, 2006a). When cost cutting is needed to meet predicted targets or to deal with a decline in sales, the uncertainty associated with the R&D returns may become particularly unattractive. Managers may see previous spending on R&D as sunk costs rather than an asset which requires further spending to maintain. The manager has to make a probabilistic assessment as to whether it is more worthwhile to maintain the pre-existing level of R&D spending and potentially benefit from this investment in the future or cut back to help free up resources which may be viewed negatively by the market.

Alongside these considerations, managers are likely to care about their own personal interests. For the sake of their own reputation as effective managers and to meet their own performance targets, they might be more driven to cut slack resources than they would have had they been purely considering what is good for the company. Managers might therefore be motivated to choose short-term gain for themselves over long-term benefits for the company. In their bid to cut costs so that they can meet earnings targets or avoid losses, cost stickiness may eventually evaporate entirely (Kama & Weiss, 2013).

Since investors are likely to know even less about the R&D projects that are being carried out compared to the managers, they are likely to be slow to recognize the potential of any given R&D project. This means that, even for worthwhile R&D projects, the market is likely to be sceptical in their responses and undervalue the R&D investments made (Eberhart et al., 2004). Thus, it is predicted that the motivation to avoid losses and profit declines will lead managers to practice upward earnings management activities. This in turn might diminish the level of R&D stickiness.

Eberhart et al. (2004) argue that any decision over R&D is a managerial decision and is about investment rather than finance. Increases are often not announced, and thus investors are slow to react to increases in R&D spending. It is, therefore, argued that if an increase in R&D investments can only be noticed by investors when there is a delay, the same can apply to a decrease in spending. Further, this gives greater incentives to managers to cut R&D expenses for short-term gain, as the change can go unnoticed for years.

H2. Management may cut R&D expenses in their bid to avoid losses and/or to avoid profit declines, and this reduces R&D expenditure stickiness

As a mirror image of H2, managers' probabilistic assessment would lead them to decide to spend on R&D, instead of cutting R&D expenses as part of real earnings management, even when sales revenue decreases. It has been observed that, though both SG&A and R&D are costs, they are likely to be treated differently when a manager is under pressure to manipulate earnings. Sometimes the resources assigned to SG&A are reduced but R&D is increased. This could have been done to reassure investors that management values future growth and has long-term development plans, which are closely followed despite short-term volatility the firm might be experiencing (Sun, 2021). It was argued that if real earnings management was the sole reason to cut R&D expenses, it may lead to fewer patents, less influential patent output, and lower innovative efficiency compared to other R&D cuts. Consequently, real earnings management may obstruct firms' technological progress and highlight the potential costs of managerial manipulation (Bereskin et al., 2018).Lev and Thiagarajan (1993) point out that cutting SG&A shows that the manager is serious about managing costs, which can be a positive sign to investors; but cutting R&D shows that the company is pursuing short-term earnings at the expense of its long-term development, and this is viewed negatively by investors. For firms listed in the A-share market from 2003 to 2010 Xue and Dong (2016) showed a difference in the reduction in stickiness between the earnings-management and non-earnings-management sub-samples. That is, the reduction is much more significant in other general expenses compared to R&D or advertising expenses. However, these studies have not considered managerial ability. Research is ambivalent on the interaction of managers' high- or low-ability with earnings management and R&D spending.

3.3.6 Effect of managerial ability

Based on the upper echelon theory, managers are not homogenous in decision making due to differences in their personal managerial characteristics. These individual characteristics include 'managerial ability' which is grounded in explicit and tacit knowledge about the firm's competitive environment and the ability to combine firm's resources to make best use of them. Management's knowledge and ability for (better or worse) resource utilization impacts also on R&D activities. Prior studies considering managerial ability and are summarized as follows:

Examining a sample of listed banks from 15 EU countries over the period 1997-2016, Curi and Lozano-Vivas (2020) find that managerial ability positively influences a company's franchise value, measured as Tobin's Q, because capable managers could better understand more advanced technology and industry trends, invest in higher-value projects, better monitor loan-granting processes, and manage their employees more efficiently compared with managers of low managerial ability. They also find a negative relationship between high-ability management with high franchise value and company's risk taking activities, because shareholders of more profitable companies lose more when risk taking activities fail.

Taking Chinese listed manufacturing corporations that executed cross-border M&As in

developed economies from 2010 to 2018 as a sample, Duan et al. (2022) find that managerial ability has a positive effect on the post-acquisition innovation performance of multinational corporations from emerging economies. This is, capable managers have a better understanding of the company's characteristics (Lin et al., 2021) and have greater relationship networks and social resources (Yung & Chen, 2018), ensuring that capable managers provide more forward-looking and realistic decisions that help the manager to transform corporate resources into corporate performance compared with lower ability mangers.

Based on the US data from 1993 to 2014, Yung and Nguyen (2020) find managerial ability is positively associated with market share growth. High-ability managers are found to invest more into R&D activities relative to capital expenditures when facing competitive threats. Therefore, managerial ability enhances firm value in the face of rivalry when faced with fierce market competition. While the effect of managerial ability persists after controlling for managerial overconfidence.

Using data from 8,379 US banks over the period 1990-2017, Vo et al. (2021) find that high-ability managers are positively associated with a higher volume of loans and loan quality.

Based on quarterly firm data from US listed companies during the Covid-19 crisis, Kumar and Zbib (2022) find that firms with high managerial ability had lower falls in stock returns during Covid-19. There is a positive and significant association between the management ability of the CEO and both the cumulative raw and abnormal returns. Firms with more capable CEO are more resilient and have higher ROE relative to their competitors. Finally, CEO's ability was positively associate with firms' higher pre-pandemic liquidity, partially explaining the better performance during the Covid-19 crisis. Above results confirm that managerial ability positively influences firms' performance (Demerjian et al., 2012).

Because short-term debt could signal capable managers' ability to outsiders and also reduce agency costs (Barnea et al., 1980; Barclay &Smith, 1995). Khoo and Cheung (2022) draws on 124,282 firm-year observations (12,612firms) from 1981–2016 find that firms with high-ability managers are associated with more short-term debt financing. That is, management with higher ability is associated with higher levels of accounts payable granted by suppliers. Suppliers are receptive to the superior management ability, and consequently willing to offer higher trade credit to the firms.

Using a large sample of 12,637 US firms from 1988 to 2018, Banerjee and Deb (2023) find that more able managers can reduce the length of the cash conversion cycle, and this is also an indication of better working capital management. In contrast, Ujah, et al. (2020) relying on non-financial and non-utility US firms from 1980 to 2016 (sample of 200,728 firm-year observations) find a negative relationship between managerial ability and working capital management, arguing that capable managers focus on the company's long term future instead of short term operational issues as a large proportion of their compensation is only linked to the success of long term projects.

Because capable managers can obtain a higher rate of return compared with lower ability managers, they are less concerned about paying larger dividends. Based on the sample of US corporations from 1989 to 2011, Jiraporn et al. (2016) find that firms with capable managers are more likely to pay dividends than firms without capable managers. High ability managers are confident in their ability to retain the firm's profit and therefore, are more willing to pay larger dividends because they are less concerned about the need to reduce future dividends.

Higher ability managers are risk takers. Using US data between 1980 and 2014, Yung and Chen (2018) find that higher ability managers spend significantly more on R&D projects while low-ability managers reduce R&D expenses significantly. They also find that high-ability managers are associated with increased firm value whereas low-ability managers are associated with decreased firm value. The authors conclude that managerial ability is essential to the long-term success of a firm.

Studying financial data gathered from US banks between 1990 and 2018, Luu et al. (2021) find that banks with capable managers experienced a lower probability of failure. In their analysis, Luu et al. (2021) find that banks with capable managers have a higher capital ratio, better asset quality, greater efficiency in allocation of resources, higher liquidity and lower risk.

Collecting data from US listed companies from 1991 to 2013, Gan (2019) finds that capable managers make more efficient investment decisions because they have better knowledge and judgment than their peers, so they are more able to anticipate future changes (Tureman, 1986).

Using US data from 1980 to 2014 of 120,642 firm-year observations and 18,284 unique firms, Tsai et al. (2022) find that a firm with high-ability managers could mitigate firm's financial constraints because high-ability CEOs could generate more internal cash flows. High ability management may invest firm's cash resources more efficiently to earn higher operating performance which is positively considered by investors.

Shi and Zhang (2019) find that compared with low-ability managers, high-ability mangers are less likely to lay off employees to enhance firm efficiency.

There are conflicting views on the relationship between managerial ability and stock price crash risk. Cui et al. (2019) using US data, find due to high compensation and reputation costs, capable managers are more likely to withhold bad news, resulting in stock price crash. However, using data from South Korea, Park and Jung (2017) find there is a lower risk of stock price crash for firms with capable managers. Further developing previous research (Cui et al., 2019; Park & Jung, 2017), Liu and Lei (2021) find that the relationship between capable managers and stock price crash risk is only positive only when managerial overconfidence is high. Following Kim et al. (2016), overconfident managers tend to overestimate future cash flows of negative net present value projects, which increased the risk of stock price crash in the future.

Capable managers are ethical. Using bank samples from nine different countries for

the period 2004-2010, Garcia-Meca and Garcia-Sanchez (2018) find that earnings quality increases with more able managers, so capable bank managers are less likely to manipulate earnings. Using a panel sample of US listed companies from 1987 to 2012, Huang and Sun (2017) find that managerial ability reduces real earnings management activities. Furthermore, they argue that managerial ability reduces the negative relationship between real earnings management and future firm performance. This is, because capable managers can mitigate any pressure of earnings management by generating higher sales revenue; further, they are aware that real earnings management damages a firm's long-term development. In contrast, capable managers face higher pressure of meeting or beating the earnings benchmarks to protect their reputation, so capable managers increase the negative relationship between REM and future firm performance. Demerjian (2012) finds that there is a positive relationship between managerial ability and CEO reputation.

Capable managers are competent self-seeking utility maximisers. The agency theory is applied to firms with high-ability managers. Based on data from the Compustat North America annual filings during the period of 1993 to 2006, Misha (2014) finds that capable managers increase investors' expected returns in firms featuring high levels of agency problems and poor quality governance. Capable managers may overemphasize their personal career advancement and take actions that worsen agency costs. Based on US data for the period 1987-2012, Habib and Hasan (2017) find that the risk of crash increases for firms with more able managers, because they also find that firms with high-ability managers over-invest compared to firms with lower ability managers. Based on US data from 1994 to 2013, Demerjian et al.(2017)find that high-ability managers are associated with earnings management to smooth earnings. Because high-ability managers have a better understanding of business than low-ability managers, they may use their superior skills to facilitate earnings management. Huang and Sun (2017) suggest that higher ability managers engage more in real earnings management for two reasons. First, all managers are facing the same pressure to meet or beat earnings targets. Even managers of higher ability have the same burden to meet or beat earnings targets. Second, capable managers have a better knowledge of business leading them to engage more in real earnings management. Managers also use managerial ability to engage more in accruals earnings management to intentionally smooth earnings (Demerjian et al., 2020). Based on Indonesian data from 2008 to 2016, Simamora (2021) finds that capable managers increase real earnings management where the firm is headquartered in a region with a higher crime rate while managerial ability reduces real earnings management where the firm is headquartered in region with a low crime rate. Agency theory influences the relationship between managerial ability and company cash holding. Magerakis (2022) finds a positive relationship between managerial ability and corporate cash savings and the relationship is weakened by the company's agency incentives. The research shows that agency incentive mitigates managerial ability on the level of corporate cash saving.

Effects of capable managers' ability on real practice is conditional. Based on the Chinese sample from 2008to 2020, Fu et al. (2022) find that managerial ability negatively influences stock price synchronicity, and the relationship varies depending on the opacity of financial reporting. More specifically, Fu et al. (2022) find that equity-based incentives strengthen the negative relationship between managerial ability and stock price synchronicity, because equity based incentives motivate managers to disclose more firm specific information and the disclosure mitigates any agency problem between managers and shareholders. Since high-ability managers lead to higher sales revenue, capable managers may have less need of earnings management. Powerful managers are aware of the destructive outcomes of real earnings management, so they do not consider the way to use real earnings management to manipulate earnings. Following those two reasons, Oskouei and Sureshjani (2020) find that there is the negative relationship between managerial ability and real earnings management and the relationship is more pronounced when there is an economic crisis. Considering a panel of US firms from 2003 to 2012, Yuan et al. (2019) find that firms' corporate social responsibility (CSR) performance increases with CEO ability, but the relationship is dependent on the company's corporate governance. More specifically, the positive relationship between managerial ability and CSR is weaker for a CEO who is also the chair of the board (low corporate governance). Daradkeh et al. (2022) find that there is a positive relationship between managerial ability and climate change disclosure and the relationship is moderated by corporate governance. In particular, they find that weak corporate governance mitigates the positive relationship between managerial ability and climate changes disclosure. The finding to some extent shows that even capable managers are conditionally ethical. Their ethical decisions are associated with good corporate governance, which is based on the upper echelon theory.

Using US data spanning 1982 to 2012, Cheung et al. (2017) find that capable managers increase firm performance, but the positive relationship between capable managers and firm performance is only pronounced for firms with better monitoring quality (corporate governance). Because capable managers are seen as trustworthy, and as such provide a positive signal to suppliers, Khoo and Cheung (2022) find that managerial ability is positively associated with accounts payable for those firms with high-ability managers compared to firms with low-ability managers. Abdulla et al. (2017) show that firms with greater access to cheap and less risky external capital are less reliant on trade credit financing. In that regard, Khoo and Cheung (2022) find that the positive relationship between managerial ability and accounts payable is moderated by credit quality.

Managerial ability acts as moderator. Using a dataset of all US-listed firms over the period 1983-2013, Driouchi et al. (2022) find that managerial ability reduces the negative relationship between ambiguity (uncertainty and vagueness about a firm's future prospects) and growth options value because the authors also find that managerial ability is positively associated with growth options value.

Managerial ability only increases the trend of firms. Using quarterly data of Chinese firms during 2020, Jebran and Chen (2022) point out that firms with higher ability managers only increased the trend that firms reduced investments, financing, and cash holdings during the Covid-19 crisis. Using a sample of US firms from 1994-2015, Khurana et al. (2018) find that managerial ability strengthened the positive relationship between the level of tax avoidance and investment efficiency because capable managers result in high investment efficiency (Garcia-Sanchez and Garcia-Meca, 2018) and can better evaluate investment opportunities (Demerjian et al, 2012). Based on Korean data from 2012 to 2017, Park and Byun (2021) find that managers' compensation positively influences company performance only in groups with capable managers and they do not find the relationship in groups with poor managerial skills. Based on US data from 1988 to 2015, Chen et al. (2020) find that macro uncertainty negatively influences analyst performance, and the relationship is mitigated by managerial ability. Using a sample of US energy firms operating between 1992-2013, Gong et al. (2020) find that CSR positively influences firm performance, and the relationship depends mainly on the factor of managerial ability because they argue that capable mangers are able to reduce information asymmetry between insiders and outsiders.

3.3.7 Managerial ability and cost stickiness

The personal characteristics of CEOs were found to have a significant impact on R&D spending. CEO tenure, the value of the firm's stocks held, and having advanced science-related degrees all tend to be associated with higher R&D spending. Long tenure may allow CEOs to make a greater impact on their firm's R&D strategy and also their own preferences may become more closely aligned with the shareholders through selection, and the CEO may become more heavily vested in their own company over time (Barker & Mueller, 2002). Managerial ability is a personal characteristic and is positively associated with innovative output and with a higher number of 'radical' innovations outside the firm's knowledge base. This indicates that high-ability managers invest more in R&D because they are more capable of managing the associated risks and uncertainties of R&D projects. Thus, high-ability management is essential to corporate R&D success (Y. Chen et al., 2015) and helps to overcome the two sources of investment inefficiency: over- and under-investment (Gan, 2019). In line with Anderson et al. (2003), managers consider the trade-off between the cost of retaining slack resources and adjustment costs, with the foregone benefits of successful R&D projects. High-ability managers are associated with higher earnings quality (Demerjian et al., 2013), less financial reporting fraud (Wang, 2007) and higher credit ratings (Cornaggia et al., 2017). These findings support the view that managerial ability improves cost allocation decisions and firm performance.

Following the viewpoint that capable managers look at company long-term development to benefit the firm and shareholders(Haider et al., 2021), managers can align their own and shareholders' interests so that the company will retain R&D expenses even though it is

experiencing downturn. Based on above research, we predict that capable managers are able to predict what R&D activities pay and what do not. These managers add value by applying their superior skill to maintaining R&D projects that they expect to be worthwhile in the long-run, even when sales revenue drops. Thus, companies managed by more capable managers are likely to display more R&D stickiness.

Michaels et al. (2001) reports that realized increases in sales revenue and profitability were usually temporary. However, following the viewpoint that capable managers may put their own interests before those of shareholders(Gul et al., 2018), managers are less like to take long-term risk and prefer short-term profits. In this case they would do the opposite of what is suggested in H3 above, and R&D stickiness would not be observed in these companies.

3.3.8 Earnings management, managerial ability and cost stickiness

Based on prior research, we consider two separate arguments for the effect of managerial ability on the relationship between earnings management incentives and R&D stickiness. The first considers the "rent extraction" perspective that capable manages are looking after their self-interests at the expense of shareholders' interests. In this case, we expect that high-ability managers could increase the negative effect of earnings management incentives and R&D stickiness for the following two reasons. First, CEOs are likely to behave opportunistically when they have an earnings management incentive to avoid revenue decrease or to avoid loss. Type one agency problem argues that separating ownership and control can lead to a conflict of interest between shareholders and managers (Jensen and Meckling, 1976). Consistent with this view, CEOs with higher ability may use their unique skill, knowledge and experience to manipulated earnings for the purpose of self-interest. Specifically, this self-interest exhibited by capable managers is evidence of the existence of agency problems inherent in resource allocation decisions (Misha, 2014). Indeed, the R&D investment decision when the company is experiencing downturn is primarily attributed to financial frictions and agency conflicts. In line with the fundamental premise agency theory, managers are motivated to cut R&D investment when the company is experiencing downturn to manipulate earning up in short term. Thus, we argue that capable managers could also cut R&D investment to manipulate earnings upwards when they have earnings management incentives to avoid revenue decrease or to avoid loss. Second, previous research shows that earnings management incentives negatively influence R&D investment when the company is in downturn. At the same time, Alzugaiby (2021) find that managerial ability is negatively related to risk-taking behaviour. In line with this research, both earnings management incentive and managerial ability is negatively associated with R&D investment. Therefore, we expect that managerial ability increases the negative relationship between earnings management incentives and R&D stickiness.

H3. High-ability managers may be better at determining what pre-existing R&D activities are worthwhile and hold on to them even when sales revenue falls; the ability of the manager thus works as a conduit for R&D stickiness.

The second argument considers an "efficient contracting" perspective, where high-ability managers could reduce the negative effect of earnings management incentives on R&D stickiness for the following two reasons. First, Demerjian et al. (2012) point out that high-ability managers have a better understanding of their firm and company environment, which enables them to make economic decisions. Thus, high-ability managers may not choose to cut R&D to manipulate earnings up when the company is in downturn because cutting R&D destroys a company's long-term value. Second, as noted in the prior literature, high-ability managers are ethical. Using a bank sample from nine different countries for the period 2004-2010, Garcia-Meca and Garcia-Sanchez (2018) find that earnings quality increases with more able managers so capable bank managers are less likely to manipulate earnings. Third, high-ability managers optimize the risk-taking benefits to improve firms' performance. Shao et al. (2020) find that innovation leads to firm development. Furthermore, while higher ability managers tend to take more risky investments (Yung &Chen, 2018) they can also reduce the costs of risk taking (Bonsall et al., 2017; Cui et al., 2019). Thus, a company with capable managers could align the conflicts of interest between managers and shareholders by maintaining R&D when the company is in a downturn, which reduces the negative relationship between earnings management incentives and R&D stickiness.

Accordingly, it is of great significance to consider whether managerial ability can moderate the relationship between earnings management incentives and R&D stickiness. In this study, we hold that capable mangers act in their own self-interest under the pressure of earnings management. Therefore, this study further analysed the mechanism which influences how managerial ability affects the relationship between earnings management incentives and R&D stickiness.

3.4 Methodology / Data

3.4.1 Data

We start with 50,108 firm-year observations of firms listed on the Shanghai and Shenzhen Stock Exchanges. We deleted 712 observations of firms that are classified as financial firms and excluded 1,047 firm-year observations of B-share companies. The difference between A-share and B-share is that A-shares are listed on domestic exchanges and trade in RMB, while B-shares are only held by foreign entities and foreign individuals and trade in US dollars in the Shanghai Stock Exchange Market and Hongkong dollars in the Shenzhen Stock Exchange Market. We further deleted 31,773 observations because of insufficient data on financial statements. Table 4 describes the sample selection process. The final sample consists of 16,575 firm-year observations.

Table 4 Sample selection

Process	*Firm-year observation*
Number of firm-year observations listed on the Shanghai and Shenzhen Stock Exchanges from 2010 to 2019	50,108
Less:	
R&D investment higher than operating revenue	1
Financial industry listed companies	712
B-share companies	1,047
Missing financial statement data	31,773
Number of firm-year observations in the full sample	16,575

After excluding the observations with missing values, our final sample consists of 16,575 firm-year observations. To mitigate the effect of outliers, we winsorise variables at the 1% and 99% levels.

3.4.2 Cost stickiness measure

The model follows Anderson, Banker and Janakiraman (ABJ) (2003) who state, "[t]he coefficient β_1 measures the percentage increase in SG&A cost with a 1% increase in sales revenues. $\beta_1+\beta_2$ measures the percentage increase in SG&A costs with 1% decrease in sales revenue." Though we follow the model structure of ABJ, instead of SG&A costs we look at the R&D costs. If R&D costs are sticky, the β_1 should be greater than $\beta1+\beta2$. Thus, the empirical hypothesis for stickiness, conditional on $\beta_1>0$ is $\beta_2<0$" (ABJ, 2003, p. 52-53).

$$\Delta ln(R\&D\ costs_{it}) = \beta_0 + \beta_1 \cdot \Delta ln(IncomeR_{it}) + \beta_2 \cdot \Delta ln(IncomeR_{it}) \cdot D_{it} \quad (1)$$

Where $\Delta ln(R\&D\ costs)$is the log change in R&D expenses from year t-1 to year t $ln(R\&Dcosts_t) - ln(R\&Dcosts_{t-1})$. The explanatory variable $\Delta ln(IncomeR)$ is the log change in operating revenue in the year, calculated the same way as the dependent variable. D takes the value of 1 if operating revenue in year t has fallen compared to the year before, and 0 otherwise.

"The advantage of Anderson et al.'s (2003) model is that researchers can add as many variables as they want to examine their effects, but as interaction terms" (Ibrahim et al., 2022, p.17). Their model is suitable for our research on the effect of R&D stickiness, and we enhance it by considering managerial ability and product competition.

3.4.3 Real earnings management measure

There are different measures to capture the use of earnings management, each brings with it different drawbacks, as discussed below. The main reason we used LOSS rather than the other ones, is that the coefficient calculated is easier to interpret. This is especially useful, as we have using LOSS to create interaction variables to capture the effects of LOSS in conjunction with other variables. Our study aims to capture the direction of the effects,

rather than the magnitude of the effects. As discuss below, the proxy-measures for accrual-based earnings management (AEM) and real earnings management (REM) are not accurate measures of the exact level of earnings management applied, thus there is no reason why we should made attempts to calculate the size of the impacts of these measures. Furthermore, the use of continuous interaction variables would require the calculation of marginal effects, which complicates the interpretation of results without adding any benefits.

Christensen et al. (2020, p.566) point out that the reason that most research continue use traditional accruals measure to proxy earnings management is because AEM is easy to calculate as "data available for a wide cross-section of firms and do not use future information". However, Badertscher et al. (2012, p.346) state that "discretionary accruals estimated via Jones-type models are noisy and non-diagnostic" because they do not find association between Jones-type model abnormal accruals and fraud (i.e., Accounting and Auditing Enforcement Releases or restatements). Furthermore, because the negative relationship between earnings management and company's future operating performance is a notable characteristic of earnings manipulation, similar with Badertscher et al. (2012), Christensen et al. (2020) find that the Jones-based abnormal accruals tend to associate positively with future performance, suggesting that the Jones-based AEM models generally do not reflect earnings manipulation.

Different from the AEM, Roychowdhury (2006) defines REM as "departures from normal operational practices, motivated by managers' desire to mislead at least some stakeholders into believing certain financial reporting goals have been met in the normal course of operations". There are two assumptions to the REM proxies that: 1. All firms in an industry share same cost and cash flow patterns when there are no earnings management; 2. Sales revenue is the only cost driver of costs and profitability in the normal course of business. However, Srivastava (2019) show that those two assumptions are systematically violated because he finds that cost patterns and cash profitability of firms in a given industry could differ because firms are in a different stage of their life-cycles and he also points out that firms make cost allocation decisions according to their competitive strategy. Furthermore, Cohen et al. (2020) point out that investment opportunity sets are the fundamental cost drivers of the variables used to construct REM measures, instead of sales revenue.

Both AEM and the dummy variable whether managers miss analysts' expectations has been used in Bratten et al. (2016) to measure earnings management. Compare with AEM which contain measurement error, Bartten et al. (2016) point out that the dummy variable whether managers meet or beat analysts' earnings forecasts is a more direct and comprehensive measure of earnings management.

Gunny (2010) suspects firm-year observations are those with reported earnings that just beat zero or last year's earnings (by less than 1% of total assets). Francis et al. (2016) point out that Gunny (2010)'s approach helps to address the long-time criticism in the earnings management literature that those commonly used model-estimated EM proxies (REM and

AEM) may fail to capture managers' intentional manipulations if their motives are not taken into consideration.

Similar to Francis et al. (2016) using dummy variable to measure earnings management, Sohn (2016) points out that using both REM and AEM to measure earnings management can capture the abnormal levels of business activities that are actually not related to managerial opportunism, such as management inefficiency, unique business models, and different business cycles. To reduce measurement errors in measuring earnings management variable, Sohn (2016) also use subsamples where the estimated variables are more likely to represent managers' opportunistic income manipulations: subsamples for small profits and small earnings increases.

We consider how to avoid the drawbacks of AEM and REM. That is, Abad et al. (2016, p.2) point out that "since the proxies for REM represent abnormal levels of cash flows from operations, production costs and discretionary expenses, they may contain noise that is unrelated to managerial opportunism and that may be capturing situations other than intentional manipulation (e.g. unusual business circumstances)". To address this concern, in this study, following Abad et al (2016) and Sohn (2016), we use dummy variable measure earnings management. More specifically, Kama and Weiss (2013) examine 97,547 firm-year observations for 11,758 different firms and uses LOSS as indicator variable equal to one if ROA is 0-1% or earnings change scaled by total assets is 0-1% and zero otherwise. The difference between LOSS and REM and AEM is that the LOSS measure is based on the outcome of earnings management and misclassifies firms that have earnings in the neighbourhood of meeting or just beating past year's earnings (the neighbourhood from zero to a small positive number) even in the absence of earnings management. REM and AEM is the process of earnings management (Lo et al., 2017).

Burgstahler and Dichev (1997) and Degeorge et al. (1999) found that earnings management helps to avoid reporting small losses and earnings decreases. Following Kama and Weiss (2013), we define type one agency problem as the company's management motivation to avoid loss (0<ROA<1%) and the company's management motivation to avoid sales decrease (0<change in annual earnings deflated by total assets at prior year end<1%). "Loss" is a dummy variable that equals 1 if "avoid loss=1" or "avoid sales decrease=1", and 0 otherwise.

3.4.4 Managerial ability measure

Following Demerjian et al. (2012), a two-stage process is used to estimate managerial ability. The logic is that "the most successful firms are those that produce the maximum sales (output) at the lowest cost (input)" (Demerjian et al., 2012, p.497). In the first stage, there are seven resources (Cost of Goods Sold; Selling, General, and Administrative Expenses; Net Property, Plant, and Equipment; Capitalized Operating Leases; Net Research and Development; Purchased Goodwill; and Other Intangible Assets) which will be used to

calculate the resource input. Following this, we use the DEA software to solve the optimization problem and find firm efficiency (FE) of firm *I* in period *t*:

$$\text{Max}(\text{FE}_{it}) = \frac{\text{Sales}_{it}}{V_1 \cdot \text{CoGS}_{it} + V_2 \cdot \text{SG\&A}_{it} + V_3 \cdot \text{PPE}_{it} + V_4 \cdot \text{OpsLease}_{it} + V_5 \cdot \text{R\&D}_{it} + V_6 \cdot \text{Goodwill}_{it} + V_7 \cdot \text{OtherIA}_{it}} \quad (2)$$

In the second stage, $\widehat{\text{FE}_{it}}$ calculated from EQ2 is used as the dependent variable in EQ 3. We use firm specific characteristics to explain $\widehat{FE_{it}}$, and whatever remains that cannot be explained by the firm characteristics are assumed to be the impact made by the manager. The firm characteristics applied are firm size, market share, positive free cash flow, and firm age. The estimated residual from this second stage equation, m_{it}, is the measure of managerial ability (MA) used in this research. Tobit regression is applied as the dependent variable $\widehat{\text{FE}_{it}}$ lies between 0 and 1.

$$\begin{aligned}\widehat{\text{FE}_{it}} = {} & \alpha_0 + \alpha_1 \cdot ln(\text{total asset})_{it} + \alpha_2 \cdot \text{Market Share}_{it} \\ & + \alpha_3 \cdot \text{Positive Free Cash Flow}_{it} + \alpha_4 \cdot ln(\text{Age})_{it} \\ & + \alpha_5 \cdot \text{Business Segment Concentration}_{it} \\ & + \alpha_6 \cdot \text{Foreign Currency Indictor}_{it} \\ & + \text{Year Indicators} + m_{it} \end{aligned} \quad (3)$$

All variable definitions are presented in Appendix 1.

3.5 Results

Table 5 reports descriptive statistics of the main variables used in the research using 16,575 observations. The mean log-changes in R&D expenditure are 0.200 (median=0.130). The mean log-changes in operating revenue are 0.120 (median=0.100). The log-changes in R&D expenditure are higher than sales revenues, which shows that R&D expenditure increases at a faster rate than operating revenue. One concern about examining R&D stickiness is whether the R&D investment variable and operating revenue variables have enough variation. The standard deviations of R&D investment and operating revenue are 0.64 and 0.34, respectively, significantly larger than their means 0.2 (0.12), which shows that those two variables have large variation. About 23% of our sample firm-years report an operating loss revenue during our sample period. In 12% of the observations, operating revenue decreases from year t-2 to year t. The average leverage is 42% (median=41%). The mean value of MA Score is -0.02 with a standard deviation of 0.150. These statistics are comparable to Bu, Wen and Banker's (2015) Chinese-based cost stickiness research.

Table 5 Descriptive statistic

Variable	N	mean	SD	min	p50	max
ΔLnCostR&D	16,575	0.200	0.640	-9.060	0.130	10.56
ΔLnIncome	16,575	0.120	0.340	-3.720	0.100	5.880
MA Score	16,575	-0.020	0.150	-0.320	-0.0400	0.440
FCF	16,575	0	0.190	-18.94	0.0200	2.780
Loss	16,575	0.230	0.420	0	0	1
Assets	16,575	0.650	0.610	-2.430	0.630	4.580
D twoyear	16,575	0.120	0.320	0	0	1
Lev	16,575	0.420	0.200	0.050	0.410	0.940

There are 16,575 observations will be used in the research; The p50 is the 50th percentile.

3.5.1 Changes in R&D costs on changes in sales revenue

The Anderson et al. (2003) model measures the response of R&D expenses on changes in a firm's revenues while distinguishing between years of sales decline and sales increase. This is achieved through the interaction variable, *D (Decrease_Dummy$_{i,t}$)* which takes the value of 1 when the firm faces a sales decline from period t-1 to t and is otherwise equal to zero. In this configuration, Model 1 tests R&D cost stickiness. Some of the variables are logged, and some of the variables are ratios calculated using the firm-size related variable (total assets) as the denominator, and for some variables both methods are applied. This is so that we may avoid having heteroscedasticity that is driven by firm size. The economic interpretation of this log specification estimated coefficients as follows. When sales increase, *D (Decrease_Dummy$_{i,t}$)* is equal to zero and the coefficient β_1 expresses the percentage increase of R&D costs with a 1% increase in sales. In the case of sales decrease, *D (Decrease_Dummy$_{i,t}$)* is equal to one, therefore, the total of $\beta_1 + \beta_2$ is a measure of R&D cost increases when sales decline by 1%.

Model 1:

$$\Delta ln(R\&D\ costs_{it}) = \beta_0 + \beta_1 \cdot \Delta ln(IncomeR_{it}) + \beta_2 \cdot \Delta ln(IncomeR_{it}) \cdot D_{it} + Industry\ dummies + Year\ dumies \quad (4)$$

Cost stickiness implies that the R&D cost increase under increasing revenue is higher than the decline of R&D cost under declining revenue. If we are not to reject hypothesis 1, i.e., that R&D costs are sticky, then $\beta_1$has to be positive and significant, and β_2 should be negative and significant, so that the impact of operating revenue change on R&D changes is $\beta_1 + \beta_2$ when operating revenue declines, smaller than β_1.

R&D expenses and net sales are the main variables obtained from the China Stock Market & Accounting Research Database (CSMAR), using annual data ranges from 2010-2019. Firms with missing observations on either R&D expenses or sales were omitted.

Data was also winsorised on 1% and 99% levels resulting in 16,575 total observations for 2,946 firms. On average there are 5.6 observations per firm.

In Table 6, Panel A provides a description about annual R&D costs and revenues over the 10-year sample. The mean of R&D costs as a percentage of sales is 4.42% (median = 3.40%, standard deviation = 5.30%). Table 6, Panel B shows the frequency of periods of each firm's sales decline (relative to the previous period) and R&D cost decline. In 23.21% of the observations the operating revenue had declined compared to last year. For R&D costs, again, 23.06% of the observations were lower than the year before. On average, sales decreased by 15.22% (median: 11.13%, standard deviation: 13.61%), and on average, R&D costs decreased by 20%.

Table 6 Descriptive statistic

Reported numbers are in hundred million Renminbi. Panel A:*The Distribution of Annual Revenue Costs* is for a sample of 16,575 firm-year observations from 2,946 firms in the CSMAR database. The following selection criteria apply: no missing revenue figures for either current or proceeding year, no missing values for R&D costs for either current or preceding year, and no firm-year observation in which R&D costs exceeded revenue. In Panel B: *Negative Percentual Change of Annual Revenue and R&D costs from 2010-2019.* Here, the first column reports the percentage of firm-year observations that had a negative year-on-year change. Then in columns two to six, we report the summary statics of the size of negative changes amongst those where the year-on-year change was negative.

Panel A: Distribution of Annual Revenue and R&D Costs from 2010-2019

	Mean	Standard Deviation	Median	Lower Quartile	Upper Quartile
Operating revenue	106.64	804.27	18.67	8.19	49.18
R&D costs	1.98	8.05	0.54	0.22	1.29
R&D costs as a percentage of revenue	4.42%	5.30%	3.40%	1.51%	5.19%

Panel B: Negative Percentual Change of Annual Revenue and R&D costs from 2010-19

	Percentage of Firm-Years with Negative percentage change from Previous Period	Mean Percentage decrease Across Periods	Standard Deviation of Percentage decrease Across Periods	Median Percentage decrease Across Periods	Lower Quartile of Percentage decrease Across Periods	Upper Quartile of Percentage decrease Across Periods
Operating Revenue	23.21%	15.22%	14.11%	11.13%	4.92%	20.95%
R&D costs	23.06%	20.47%	20.38%	13.61%	5.76%	27.99%

Table 7 presents the results of Model 1 for the pooled sample of 16,575 total observations. The results with year and firm-fixed effect models were similar. This model tests changes in R&D costs and changes in sales for one-year periods. The value of 0.616 for $\widehat{\beta_1}$ implies that R&D costs increase by 0.62% per 1% increase in sales. The value for $\widehat{\beta_2}$ of -0.216% which is statistically significant at 1% strongly underpins Hypothesis 1 that R&D costs are sticky. The sum of $\widehat{\beta_1}$ and $\widehat{\beta_2}$ is 0.40% (0.62%-0.22%). The significance level of less than one (p-values=0.001) for both $\widehat{\beta_1}$ as well as the sum of $\widehat{\beta_1}$ and $\widehat{\beta_2}$, is an indication of R&D cost stickiness; the disproportionate change of R&D costs by either sales increase or decrease. Model 2 considers other R&D cost influencing factors where $\widehat{\beta_1}$ equals 0.599 indicating an R&D cost increase by 0.60% per 1% increase in sales which is slightly lower than for Model 1. While the value for $\widehat{\beta_2}$ of -0.319% also strongly underpins Hypothesis 1 that R&D costs are sticky with the extension that other factors play a significant role. The sum of $\widehat{\beta_1}$ and $\widehat{\beta_2}$, is 0.28% (0.599 %-0.319%) at a significance level of less than one (p-values=0.001) for both $\widehat{\beta_1}$ as well as the sum of $\widehat{\beta_1}$ and $\widehat{\beta_2}$, indicates R&D cost stickiness but at a lower level compared to Model 1 (sum of $\widehat{\beta_1}$ and $\widehat{\beta_2}$, is 0.400% = 0.616%-0.216%).

Table 7 Results of regressing changes in R&D costs on changes in sales revenue for the 10-year period 2010-2019

Regression specification for Model (1):

$$\Delta \ln(Cost\ of\ R\&D) = \beta_0 + \beta_1 * \Delta \ln(IncomeR) + \beta_2 * \Delta \ln(IncomeR) * D + Industry\ dummies + Year\ dummies + \varepsilon$$

Regression specification for Model (2):

$$\Delta \ln(Cost\ of\ R\&D) = \beta_0 + \beta_1 * \Delta \ln(IncomeR) + \beta_2 * \Delta \ln(IncomeR) * D + \beta_5 Assets\ Intensity * \Delta Ln(IncomeR) * D + \beta_6 D_{twoyear} * \Delta Ln(IncomeR) * D + \beta_7 FCF * \Delta Ln(IncomeR) * D + \beta_8 Lev * \Delta Ln(IncomeR) * D + \beta_{11} Assets\ Intensity + \beta_{12} D_{twoyear} + \beta_{13} FCF + \beta_{14} Lev + Industry\ dummies + Year\ dummies + \varepsilon$$

	Model (1)	Model (2)
β_1ΔLn(IncomeR)	0.616***	0.599***
	(0.018)	(0.018)
β_2ΔLn(IncomeR)*D	**-0.216*** **	**-0.319*** **
	(0.041)	(0.090)
β_5Assets Intensity*ΔLn(IncomeR)*D		0.000
		(0.030)
β_6D_twoyear*ΔLn(IncomeR) *D		-0.046
		(0.071)
β_7FCF*ΔLn(IncomeR)*D		-0.645***
		(0.109)
β_8LevΔ*Ln(IncomeR)*D		0.096
		(0.130)
β_{11}Assets Intensity		-0.008
		(0.009)
β_{12}D_twoyear		-0.088***
		(0.019)
β_{13}FCF		-0.074*
		(0.040)
β_{14}Lev		0.061**
		(0.027)
Constant	0.290***	0.266***
	(0.050)	(0.052)
Obs.	16,575	16,575
Adj-R^2	0.1106	0.1150
F value	67.49	56.23

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model to test whether R&D is sticky. The sample period is 2010-2019. The sample consists of 16,575 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively.

Model 2 considers other R&D cost influencing factors where $\widehat{\beta_1}$ equals 0.599 indicating an R&D cost increase by 0.60% per 1% increase in sales which is slightly lower than for Model 1. While the value for $\widehat{\beta_2}$ of -0.319% also strongly underpins Hypothesis 1 that R&D costs are sticky with the extension that other factors play a significant role. The sum of $\widehat{\beta_1}$ and $\widehat{\beta_2}$, is 0.28% (0.599 %-0.319%) at a significance level of less than one

(p-values=0.001) for both $\widehat{\beta_1}$ as well as the sum of $\widehat{\beta_1}$ and $\widehat{\beta_2}$, indicates R&D cost stickiness but at a lower level compared to Model 1 (sum of $\widehat{\beta_1}$ and $\widehat{\beta_2}$, is 0.400% = 0.616%-0.216%).

Of the control variables introduced in Model 2, the interaction term $\widehat{\beta_7}$*FCF*ΔLn(IncomeR)*D* and $\widehat{\beta_{12}}$*D_twoyear*are significant. The first one describes the impact of free cashflow for annual firm periods in which there was a sales decline from t-1 to t, the value for $\widehat{\beta_7}$ of -0.645% at significance level of less than 1% suggesting that R&D cost was cut more when FCF is higher. As for the $\widehat{\beta_{12}}$it is -0.088% and significance level of less than 1%, showing that having two years of sales decline in a roll had a negative impact on R&D expenses.

3.5.2 Cost stickiness and earnings management

Model 3 is structured to measure how R&D expenses change in response to changes in firm's operating revenues under the condition that managers want to avoid loss in period t or earnings decrease. This is achieved through the interaction variables, *D (Decrease_Dummy$_{i,t}$)* and *Loss*. *Loss* takes the value of 1 when the firm's ROA or change in annual earnings deflated by total assets at prior year end is between 0 to 1%, and 0 otherwise; while the firm faced a sales decline from period t −1 and t indicated by *D (Decrease_Dummy$_{i,t}$).*

Structured this way, Model 3 can test the impact of earning manipulation on R&D cost stickiness. Under Models 1 and 2, a 1% increase in operating revenue is associated with a 0.603% increase in R&D expenses (Table 8). When operating revenue fell, a 1% fall in operating revenue is associated with a 0.237% (0.603 ($\widehat{\beta_1}$)-0.366($\widehat{\beta_2}$)) fall in R&D expenses.

However, the results in Model 3 also show that when there is need for profit manipulation, managers may be lured to cut costs in order to keep profits from falling too much. When sales are growing and there is profit manipulation, a 1% increase in operating revenue will be matched with a 0.532% (0.603($\widehat{\beta_1}$)-0.071($\widehat{\beta_{15}}$)) increase in R&D expenses. In turn, when operating revenues are falling AND there is profit manipulation, a 1% fall in sales will be matched with a 0.497% (0.603($\widehat{\beta_1}$)-0.366($\widehat{\beta_2}$) +0.331($\widehat{\beta_3}$)-0.071($\widehat{\beta_{15}}$) = 0.497) fall in R&D spending.

Table 8 Results of regressing changes in R&D costs on changes in sales revenue under earnings manipulation for the 10-year period 2010-2019

Regression specification for Model (3):

$$\Delta \ln(\text{Costs of R\&D}) = \beta_0 + \beta_1 * \Delta\ln(\text{IncomeR}) + \beta_2 * \Delta \ln(\text{IncomeR}) * \text{D} + \beta_3 * \Delta \ln(\text{IncomeR}) * D * Loss + \beta_5 * FCF * \Delta\ln(\text{IncomeR}) * D + \beta_6 * Asset\ intensity * \Delta\ln(\text{IncomeR}) * D + \beta_7 * D_{twoyear} * \Delta \ln(\text{IncomeR}) * D + \beta_8 * Lev * \Delta \ln(\text{IncomeR}) * D + \beta_{10} * Loss + \beta_{11} * Asset\ intenstiy + \beta_{12} * D_{twoyear} + \beta_{13} * FCF + \beta_{14} * Lev + \beta_{15}\Delta(IncomeR) * Loss + Industry\ dummies + Year\ dummies\ \varepsilon$$

	Model 3
β_1ΔLn (IncomeR)	0.603***
	(0.019)
β_2ΔLn(IncomeR)*D	-0.366***
	(0.094)
β_3ΔLn(IncomeR)*D*Loss	**0.331****
	(0.143)
β_5Assets Intensity*ΔLn(IncomeR)*D	0.002
	(0.030)
β_6D_twoyear*ΔLn(IncomeR)*D	-0.044
	(0.071)
β_7FCF*ΔLn(IncomeR)*D	-0.653***
	(0.109)
β_8Lev*ΔLn(IncomeR)*D	0.134
	(0.131)
β_{10}Loss	0.004
	(0.015)
β_{11}Assets Intensity	-0.008
	(0.009)
β_{12}D_twoyear	-0.087***
	(0.019)
β_{13}FCF	-0.075*
	(0.040)
β_{14}Lev	0.064**
	(0.027)
β_{15}ΔLn(IncomeR)*Loss	**-0.071**
	(0.061)
Constant	0.268***
	(0.052)
Obs	16,575
Adj-R2	0.1152
F value	52.39

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model to test to what extent earnings management motivation influences R&D stickiness. The sample period is 2010-2019. The sample consists of 16,575 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively.

In Hypothesis H2 (*Management may cut R&D expenses in their bid to avoid losses and/or to avoid profit declines, and this reduces R&D expenditure stickiness*), the motivation to avoid loss or avoid a decrease in profit which could diminish the level of R&D expenditure stickiness is supported if $\beta_3>0$. The opposite to H2 holds if $\beta_3<0$.

Results show that Hypothesis 2 is supported. The finding that upward earnings management reduces the stickiness of R&D (i.e., that managers will cut R&D when they are motivated to avoid loss or to avoid earnings decreases) indicates that managers' decisions to retain resources in times of declining sales (operating revenue) is not entirely dependent on their probabilistic judgement about future sales levels, but also their need to meet investors' expectations to avoid losses or high earnings decline. The trade-off made when eliminating R&D projects is filled with risk – that is, to free up resources and forgo potential future benefits, or to miss short-term goals but maintain long-term potential returns. Self-interested managers who are unsure about their future with their employers, are more likely to cut R&D costs in response to a sales decline even if it is only temporarily. These findings confirm findings in existing research that cutting back R&D expenses signals upwards earnings management (Kama & Weise, 2013). In short, they put their own preferences before those of the company (Cohen et al., 2008; Roychowdhury, 2006a). This manipulation is a particularly good candidate as investors were found to be slow to realize the potential of R&D projects and therefore also slow to respond to changes made in R&D investments (Eberhart et al., 2004).

The overall findings suggest that managers will intentionally adjust company resources and diminish cost stickiness to meet earnings targets, in line with Hypothesis 2. Additionally, managers motivated to avoid losses or decline in earnings are more aggressive in cutting costs (diminishing cost stickiness) compared to managers who do not face such incentives. The findings provide additional evidence that the level of cost stickiness is subject to managers' deliberation on R&D cost adjustment, emphasizing a principal-agent conflict of diverging interests. That is, managers aim to meet earnings targets by means of cutting R&D costs and potential future returns.

3.5.3 Cost stickiness and managerial ability

To test H3, we regress model 3 with the high managerial ability and low managerial ability sub-samples, separately. As H3 indicates, we expect a negative value of β_3 in the high managerial ability sub-sample when manager have earnings management motivation to avoid revenue decrease or to avoid loss. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. *MA* ($\text{Managerial\_Ability}_{i,t}$) measures managerial ability following the definition of Demerjian et al. (2012). Under this measure, efficiency, calculated based on the input-output combination under variable returns, measures the firm- and manager-specific efficiency. In the second, a Tobit regression by industry including year fixed

effects provides a residual which is the estimation of managerial ability (Table 9). The sample will split to high managerial ability and low managerial ability samples using the 50th percentile. Managerial ability equals 1 when managerial ability is greater than the 50th percentile (which represents high managerial ability) and 0 otherwise. If capable managers are looking for self-interests with their unique skill, we expect β_3 in the high managerial ability sub-sample to be positive and significant when managers have earnings management motivation. If H3 holds, because high-ability mangers may be better at determining what pre-existing R&D activities are worthwhile and have a better understanding to their company and firm's environment, we expect the value of β_3 in the high managerial ability sub-sample should be negative and significant.

Table 9 Descriptive statistic of managerial ability

The descriptive statistic of *Managerial Ability* is for a sample of 16,575 firm-year observations from 2,946 firms derived following Demerjian et al. (2012) On average managerial ability was -0.02 (median: -0.04, standard deviation: 0.15) with a minimum of -0.32 and maximum of 0.44.

	Obs.	**Mean**	**SD**	**Median**	**Minimum**	**Maximum**
MA	16,575	-0.02	0.15	-0.04	-0.32	0.44

Table 10 Results of regressing changes in R&D costs on changes in sales revenue under earnings manipulation and managerial ability for the 10-year period 2010-2019

Regression specification for Model (3):

$$\Delta \ln(\text{Costs of R\&D}) = \beta_0 + \beta_1 * \Delta\ln(\text{IncomeR}) + \beta_2 * \Delta \ln(\text{IncomeR}) * D + \beta_3 * \Delta \ln(\text{IncomeR}) * D * Loss + \beta_5 * Asset\ intensity * \Delta\ln(\text{IncomeR}) * D + \beta_6 * D_{twoyear} * \Delta\ln(\text{IncomeR}) * D + \beta_7 * FCF * \Delta \ln(\text{IncomeR}) * D + \beta_8 * Lev * \Delta \ln(\text{IncomeR}) * D + \beta_{10} * Loss + \beta_{11} * Asset\ intenstiy + \beta_{12} * D_{twoyear} + \beta_{13} * FCF + \beta_{14} * Lev + \beta_{15}\Delta(IncomeR) * Loss + Industry\ dummies + Year\ dummies + \varepsilon$$

	Low MA	High MA
β1ΔLn(IncomeR)	0.651***	0.567***
	(0.029)	(0.026)
β2ΔLn(IncomeR)*D	-0.340***	-0.266*
	(0.124)	(0.158)
β3ΔLn(IncomeR)*D*Loss	**0.057**	**0.784*** **
	(0.175)	**(0.249)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.036	-0.006
	(0.048)	(0.041)
β6D_twoyear*ΔLn(IncomeR)*D	0.106	-0.267*
	(0.083)	(0.139)
β7FCF*ΔLn(IncomeR)*D	-0.405**	-0.800***
	(0.158)	(0.169)
β8Lev*ΔLn(IncomeR)*D	-0.133	0.539**
	(0.161)	(0.230)
β10Loss	0.004	0.008
	(0.019)	(0.024)
β11Assets Intensity	-0.010	-0.017
	(0.013)	(0.013)
β12D_twoyear	-0.067***	-0.096***
	(0.023)	(0.034)
β13FCF	-0.155***	-0.091
	(0.057)	(0.063)
β14Lev	0.048	0.059
	(0.036)	(0.042)
β15ΔLn(IncomeR)*Loss	-0.005	-0.187*
	(0.079)	(0.096)
Constant	0.195*	0.310***
	(0.100)	(0.069)
	P=0.051 (Groups are significantly different)	
Obs	8,938	7,637
Adj-R2	0.1219	0.1128
F value	31.26	24.11

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model to test how managerial ability influences the relationship between earnings management motivation and R&D stickiness. The sample period is 2010-2019. The sample consists of 16,575 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

Regression results support the opposite of Hypotheses H3 (High-ability managers may be better at determining what pre-existing R&D activities are worthwhile and hold on to them even when sales revenue falls; the ability of the manager thus works as a conduit for R&D stickiness) (Table 10). Following the argument of Gul et al. (2018), high-ability management seeks to maximize its own benefits in the short term over the long-term benefits derived from R&D for shareholders. Simultaneously, high-ability managers are more cautious in committing resources to R&D when sales are increasing.

3.6 Possible Mechanism:

The research shows that earnings management motivation (motivation to avoid revenue decrease or avoid loss) reduces R&D expenditure stickiness. In this section, following Chen et al., (2012), we conduct the grouped regression model to identify the mechanisms underlying the negative relationship between earnings management motivation and R&D stickiness. We examine whether the effect of earnings management motivation on R&D stickiness is partly channeled by real earnings management/accrual earnings management. Managers have motivation to manipulate earnings when their company's performance is either too high or too low (DeFond and Park, 1997). Thus, we expect the negative relationship between earnings management incentive (motivation to avoid revenue decrease or avoid loss) and R&D stickiness is more obvious in sample of high real earnings management/accrual earnings management. The model proposed by Dechow (1998) and Roychowdhury (2006) has been adopted to measure the indicator of Real Earnings Management. Following Dechow (1995), the modified Jones Model has been adopted to measure indicator of Accrual Earnings Management.

$$\frac{TA_{i,t}}{A_{i,t-1}} = \beta_0 \frac{1}{A_{i,t-1}} + \beta_1 \frac{\Delta REV_{i,t}}{A_{i,t-1}} + \beta_2 \left(\frac{PPE_{i,t}}{A_{i,t-1}}\right) + \varepsilon_{i,t} (1)$$

$$NDA_{i,t} = \beta_0 \frac{1}{A_{i,t-1}} + \beta_1 \frac{\Delta REV_{i,t} - \Delta REC_{i,t}}{A_{i,t-1}} + \beta_2 \left(\frac{PPE_{i,t}}{A_{i,t-1}}\right) (2)$$

$$DA_{i,t} = \frac{TA_{i,t}}{A_{i,t-1}} — NDA_{i,t} (3)$$

Where:

TA: Total Accruals = Operating Profit - Net Cash Flow from Operating Activities;

NDA: non-discretionary accruals;

DA: discretionary accruals (the higher the absolute value of discretionary accruals, the larger space for earnings management and the lower the quality of accounting information);

ΔREV_t: changes in operating revenue;

ΔREC_t: changes in accounts receivable;

PPE_t: net fixed assets in period t;

A_{t-1}: taking total assets at the end of year *t-1* into calculation to eliminate the scale effect.

By taking the known items for each industry and year into Formula (1), the regression coefficients are derived and then brought into Formula (2) to obtain non-discretionary accruals (NDA), which are finally put into Formula (3) to get modified discretionary accruals (DA).

Industry classification: Manufacturing industry beginning with C is classified by the CSRC second-level code, represented by C13, C14, C15, etc., while other industries are classified by the CSRC first-level code represented by A, B, C, etc.

Measurement of real earnings management of a company by referring to the model proposed by Dechow (1998) and Sugata Roychowdhury (2006):

$$\frac{CFO_{i,t}}{A_{i,t-1}} = \alpha_0 + \alpha_1 \frac{1}{A_{i,t-1}} + \alpha_2 \frac{REV_{i,t}}{A_{i,t-1}} + \alpha_3 \frac{\Delta REV_{i,t}}{A_{i,t-1}} + \varepsilon_{i,t}$$

$$\frac{PROD_{i,t}}{A_{i,t-1}} = b_0 + b_1 \frac{1}{A_{i,t-1}} + b_2 \frac{REV_{i,t}}{A_{i,t-1}} + b_3 \frac{\Delta REV_{i,t}}{A_{i,t-1}} + b_4 \frac{\Delta REV_{i,t-1}}{A_{i,t-1}} + \varepsilon_{i,t}$$

$$\frac{DISEXP_{i,t}}{A_{i,t-1}} = c_0 + c_1 \frac{1}{A_{i,t-1}} + c_2 \frac{REV_{i,t-1}}{A_{i,t-1}} + \varepsilon_{i,t}$$

Abnormal cash flow from operating activitiesA_CFO;

Abnormal production costs A_PROD;

Abnormal discretionary expenses A_DISEXP;

$$TREM_{i,t} = (-1)A_{CFO_{i,t}} + A\_PROD_{i,t} + (-1)A\_DISEXP_{i,t}$$

$CFO_{i,t}$: net cash flow from operating activities of company i in year t;

$PROD_{i,t}$: production costs of the company, the sum of operating costs and changes in inventories of the company in the current period;

$DISEXP_{i,t}$: discretionary expenses of the company, the sum of selling expenses and administrative expenses of the company;

$REV_{i,t}$: operating revenue of company i in year t,

$\Delta REV_{i,t}$: changes in operating revenue of company i in year t

$\Delta REV_{i,\,t-1}$: changes in operating revenue of company i in year t-1;

$A_{i,t-1}$: taking total assets at the end of year t-1 into calculation to eliminate the scale effect.

Regression residual of each model, namely, each abnormal item, is obtained by taking the known items for each industry and year into calculation as listed in the left column.

Then,

$TREM_{i,t}$ is calculated by bringing each abnormal item into the last formula provided. The higher the value of $TREM_{i,t}$, the higher the degree of real earnings management.

Industry classification: Manufacturing industry beginning with C is classified by the CSRC second-level code represented by C13, C14, C15, etc., while other industries are classified by the CSRC first-level code, represented by A, B,C,etc.

Those with less than 10 sample codes and missing data after industry classification are excluded in calculation.

The sample is divided into two groups according to the median of earnings management indicators (both Real Earnings Management (Table 11) and Accrual Earnings Management (Table 12)). We re-estimate the model 3 using the subsamples and report the results in the table below. The estimated coefficient on β_3 is positive and significant in the groups with high earnings management (both Real Earnings Management and Accrual Earnings Management), but insignificant in the groups with low earnings management. Overall, results from the table below indicate that earnings management motivation (motivation to avoid revenue decrease or avoid loss) can reduce R&D stickiness by intensifying earnings management (both Real Earnings Management and Accrual Earnings Management). In line with Banker et al (2014) managers do not just consider the adjustment costs of reducing R&D expenses but in line with agency theory their own incentives above the interest of principal. While REM is often directly linked to adjustments of discretionary expenses including expenses for R&D activities, AEM does not have immediate impact on R&D through earnings management activities on accrual accounts. Our findings suggest a clear impact of sales decline and management's motivation to avoid losses on R&D stickiness. For firms in the low REM group show no signs of R&D stickiness, so sales decline did lead to cutting R&D expenditure as did sales increase lead to increase in R&D expenditure.

Furthermore, our findings suggest that firms' management in the high AEM subsample will proactively reduce R&D expense stickiness when sales decline while management has a motivation to avoid losses or profit declines.

Table 11 Results of regressing changes in R&D costs on changes in sales revenue under earnings manipulation for the 10-year period 2010-2019 and sample partitioned by Median of REM

Regression specification for Model (3):

$$\Delta \ln(\text{Costs of R\&D}) = \beta_0 + \beta_1 * \Delta\ln(\text{IncomeR}) + \beta_2 * \Delta \ln(\text{IncomeR}) * \text{D} + \beta_3 * \Delta \text{l n}(\text{IncomeR}) * D * Loss + \beta_5 * Asset\ intensity * \Delta\ln(\text{IncomeR}) * D + \beta_6 * D_{twoyear} Asset\ intensity * \Delta\ln(\text{IncomeR}) * D + \beta_7 * FCF * \Delta \ln(\text{IncomeR}) * D + \beta_8 * Lev * \Delta \ln(\text{IncomeR}) * D + \beta_{10} * Loss + \beta_{11} * Asset\ intenstiy + \beta_{12} * D_{twoyear} + \beta_{13} * FCF + \beta_{14} * Lev + \beta_{15}\Delta(IncomeR) * Loss + Industry\ dummies + Year\ dummies\ \varepsilon$$

	Low REM	High REM
β1ΔLn(IncomeR)	0.634***	0.579***
	(0.029)	(0.026)
β2ΔLn(IncomeR)*D	-0.202	-0.436***
	(0.159)	(0.129)
β3ΔLn(IncomeR)*D*Loss	**0.174**	**0.466****
	(0.198)	**(0.208)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.018	-0.005
	(0.072)	(0.036)
β6D_twoyear*ΔLn(IncomeR)*D	0.028	-0.041
	(0.109)	(0.098)
β7FCF*ΔLn(IncomeR)*D	-0.696***	-0.450**
	(0.150)	(0.176)
β8Lev*ΔLn(IncomeR)*D	-0.216	0.294*
	(0.217)	(0.174)
β10Loss	0.012	-0.001
	(0.020)	(0.023)
β11Assets Intensity	-0.012	-0.007
	(0.013)	(0.013)
β12D_twoyear	-0.073***	-0.090***
	(0.025)	(0.030)
β13FCF	-0.063	-0.143**
	(0.056)	(0.063)
β14Lev	0.073*	0.040
	(0.038)	(0.038)
β15ΔLn(IncomeR)*Loss	-0.103	-0.049
	(0.085)	(0.089)
Constant	0.277***	0.274***
	(0.077)	(0.070)
	P=0.082 (Groups are significantly different)	
Obs	8,227	8,348
Adj-R2	0.1161	0.1149
F value	28.02	26.80

Table 12 Results of regressing changes in R&D costs on changes in sales revenue under earnings manipulation for the 10-year period 2010-2019 and sample partitioned by Median of AEM

Regression specification for Model (3):

$$\Delta \ln(\text{Costs of R\&D}) = \beta_0 + \beta_1 * \Delta\ln(\text{IncomeR}) + \beta_2 * \Delta \ln(\text{IncomeR}) * \text{D} + \beta_3 * \Delta \ln(\text{IncomeR}) * D * Loss + \beta_5 * Asset\ intensity * \Delta\ln(\text{IncomeR}) * D + \beta_6 * D_{twoyear} * \Delta\ln(\text{IncomeR}) * D + \beta_7 * FCF * \Delta \ln(\text{IncomeR}) * D + \beta_8 * Lev * \Delta \ln(\text{IncomeR}) * D + \beta_{10} * Loss + \beta_{11} * Asset\ intenstiy + \beta_{12} * D_{twoyear} + \beta_{13} * FCF + \beta_{14} * Lev + \beta_{15}\Delta(IncomeR) * Loss + Industry\ dummies + Year\ dummies\ \varepsilon$$

	Low AEM	High AEM
β1ΔLn(IncomeR)	0.587***	0.605***
	(0.029)	(0.026)
β2ΔLn(IncomeR)*D	-0.343**	-0.250*
	(0.140)	(0.133)
β3ΔLn(IncomeR)*D*Loss	**0.212**	**0.470****
	(0.190)	**(0.223)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.119**	0.058
	(0.050)	(0.039)
β6D_twoyear*ΔLn(IncomeR)*D	0.034	-0.030
	(0.098)	(0.106)
β7FCF*ΔLn(IncomeR)*D	-0.080	-0.989***
	(0.174)	(0.156)
β8Lev*ΔLn(IncomeR)*D	0.423**	-0.152
	(0.188)	(0.187)
β10Loss	0.006	0.002
	(0.021)	(0.022)
β11Assets Intensity	0.009	-0.032**
	(0.012)	(0.013)
β12D_twoyear	-0.085***	-0.068**
	(0.026)	(0.028)
β13FCF	-0.043	-0.168***
	(0.060)	(0.058)
β14Lev	0.113***	0.032
	(0.037)	(0.039)
β15ΔLn(IncomeR)*Loss	-0.096	-0.050
	(0.089)	(0.084)
Constant	0.157**	0.378***
	(0.074)	(0.074)
	P=0.110 (Groups are no significantly different)	
Obs	8,246	8,329
Adj-R2	0.1075	0.1230
F value	25.82	28.82

Following Li and Lu (2022), institutional ownership (IO), board size (BSIZE), board independence (BINDP), analyst following (ANALYST) and management shareholding (Mshare) have been adopted for subsampling in order to control for catalyzing or hampering factors of earnings management. There is a negative relationship between IO and earnings management, because institutional investors have a much stronger motivation to monitor

companies and the institutional investors' presence reduces earnings management (Chuang and Zhang, 2011). Chen et al. (2015) find that financial analysts reduce earnings management because the management knows that their behavior is under scrutiny. Following Li and Lu (2022), board independent increases corporate governance quality, which shows that there is the negative relationship between board independent and earnings management. In addition, following Huang and Wang (2015), based on the Chinese data, they find that firms with small board size are more likely to engage in earnings management. Finally, following agency theory (Jensen and Mecklings 1976), there is a negative relationship between the ratio of management shareholding on total shares and earnings management activities.

We partition our sample into low and high by the median values of the earnings management variables (IO, BSIZE, BINDP, ANALYST and Mshare) and re-estimate model 3 for each subsample. The estimated coefficient on $\beta_3$is positive and significant in the groups with less external supervision, thus more opportunities for higher earnings management (low institutional ownership, small board size, less board independence, less analyst exposure and higher management shareholding), but insignificant in the groups with low earnings management. Overall, results from the tables below indicate that earnings management motivation (motivation to avoid profit decrease or avoid loss) can reduce R&D stickiness by intensifying earnings management (institutional ownership, board size, board independence, analyst following and management shareholding).Managers are likely to focus under strong governance on economic factors (e.g., adjustment costs when sales declines) instead of agency considerations (e.g. earnings management) when making resource allocation decisions. That is, stronger governance better aligns managements' interests with those of shareholders. The individual governance mechanisms are as follows:

3.6.1 Institutional ownership:

According to Dai et al. (2013) within half of the China's listed firms institutional investors are among the top 10 shareholders. Institutional investors have financial resources to discover firm's actual operating conditions and to supervise management. In the process of actively engaging in management supervision institutional investors effectively hamper accruals-based earnings management behavior (Prowse, 1990, Brous and Kini, 1994, Liu et al., 2019). Institutional investors, compared to retail investors, possess superior analytical skills also to be able to better decompose accruals into normal and discretionary components; allowing them to detect earnings management activities. In addition, institutional investors might have better information sources and tacit knowledge through conference calls and private conversations with management allowing them to detect earnings management more easily and/or quickly than individual investors(Ke and Petroni, 2004).

In contrast some studies found that investors who exhibit herd-like and short-sighted behavior facilitate earnings management and thus reduce earnings quality(Porter, 1992). This contrast is attributed to different types of institutional investors, short-term vs. long term.

Short-term (long-term) oriented institutional investors are associated with lower (higher) accuracy of accruals. This suggests that long-term investors play a role in monitoring management (Koh, 2007).

In the context of China Dai et al. (2013) drew the following conclusions: long term institutional investors, compared to relative short-term orient institutional investors, exercise more control over management which leads to less earnings management and higher earning quality.

In regard to cost stickiness higher institutional ownership is expected to better protect shareholder interests against agency risks, the effect of earnings management motivation (to avoid losses or profit declines) on R&D cost stickiness. Consequently, in the presence of high institutional ownership, managers will be driven to consider resources adjustment costs. In contrast, the agency problem is more severe under low institutional ownership, that R&D cost stickiness associated with earnings management motivation (LOSS)less which is consistent with the agency cost prediction in Hypothesis 1: ***Management may cut R&D expenses in their bid to avoid losses and/or to avoid profit declines, and this reduces R&D expenditure stickiness***.

Institutional ownership (*IO*) is defined as cumulative number of shares held by institutional investors divided by the total share outstanding obtained from CSMAR (Liu et al., 2019). By comparing the β_1 we can see that the firms with low IO were less willing to increase R&D when sales grow (Table 13). By comparing the total of β_1 and β_2, we can see that both groups of companies exhibited R&D stickiness when sales had fallen, though the impact is stronger in the high IO group. Finally, we should look at the scenario where sales had fallen and they were under pressure to implement earnings management, by comparing the total of β_1, β_2, β_3 and β_{15}. In the high IO group, the LOSS variables, introduced to capture the pressure to implement earnings management, were both insignificant. Thus, we can conclude that, for the high IO group, the pressure to earnings management had been alleviate due to the high IO. As for the low IO group, the increase in R&D spending had become smaller when pressure to EM exists, the impact going from 0.585 to 0.371 (latter being sum of β_1 and β_{15}). When sales had fallen and they were under the pressure to introduce earnings management, the decrease in R&D spending is at a higher level ($\beta_1 + \beta_2 + \beta_3 + \beta_{15} = 0.863$) than the increase when sales had increased ($\beta_1 + \beta_{15} = 0.371$). One may interpret that, when under pressure to implement earnings management, R&D stickiness may not be observed anymore amongst the low IO firms.

Table 13 Results of regressing changes in R&D costs on changes in sales revenue under earnings manipulation for the 10-year period 2010-2019 and sample partitioned by Median of IO

Regression specification for Model (1):

$$\Delta \ln(\text{Costs of R\&D}) = \beta_0 + \beta_1 * \Delta\ln(\text{IncomeR}) + \beta_2 * \Delta \ln(\text{IncomeR}) * \text{D} + \beta_3 * \Delta \text{l n}(\text{IncomeR}) * D * Loss + \beta_5 * Asset\ intensity * \Delta\ln(\text{IncomeR}) * D + \beta_6 * D_{twoyear} * \Delta\ln(\text{IncomeR}) * D + \beta_7 * FCF * \Delta \ln(\text{IncomeR}) * D + \beta_8 * Lev * \Delta \ln(\text{IncomeR}) * D + \beta_{10} * Loss + \beta_{11} * Asset\ intenstiy + \beta_{12} * D_{twoyear} + \beta_{13} * FCF + \beta_{14} * Lev + \beta_{15}\Delta(IncomeR) * Loss + Industry\ dummies + Year\ dummies\ \varepsilon$$

	Low IO (High EM)	High IO (Low EM)
β1ΔLn(IncomeR)	0.585***	0.612***
	(0.026)	(0.028)
β2ΔLn(IncomeR)*D	-0.225*	-0.595***
	(0.117)	(0.180)
β3ΔLn(IncomeR)*D*Loss	**0.717*** **	**-0.130**
	(0.181)	**(0.237)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.024	0.009
	(0.043)	(0.048)
β6D_twoyear*ΔLn(IncomeR)*D	0.126	-0.241*
	(0.082)	(0.134)
β7FCF*ΔLn(IncomeR)*D	-0.460***	-0.848***
	(0.135)	(0.198)
β8Lev*ΔLn(IncomeR)*D	-0.139	0.564**
	(0.151)	(0.263)
β10Loss	0.035*	-0.028
	(0.020)	(0.023)
β11Assets Intensity	-0.022*	0.009
	(0.012)	(0.014)
β12D_twoyear	-0.048**	-0.137***
	(0.023)	(0.032)
β13FCF	-0.082	-0.132*
	(0.051)	(0.073)
β14Lev	0.042	0.081*
	(0.033)	(0.045)
β15ΔLn(IncomeR)*Loss	-0.214**	0.028
	(0.087)	(0.088)
Constant	0.303***	0.234***
	(0.067)	(0.082)
	P=0.000 (Groups are significantly different)	
Obs	9,032	7,543
Adj-R2	0.1194	0.1155
F value	29.02	24.45

Note:This table presents the regression results from model (1) for the first governance subsamples. This set of partitioned samples is based on whether institutional ownership (INST) is higher or lower than the yearly median value.

3.6.2 Board size

The board of directors (often referred to as 'board') has as one of its most important roles to supervise firm's management to protect shareholders' interest. The impact of board size on its supervisory function and on firm performance is ambivalent.

Lipton and Lorsch (1992) argue that an increase in the number of directors causes many malfunctions of the board of directors. Furthermore, they propose that even if the monitoring capacity of the board increases as board size increased, the respective cost outweigh the benefits. Jensen (1993) claims that it is easier for the CEO faced with a larger board to influence and control board decisions. That is, larger boards are more captive to the CEO, making the CEO more powerful in decision making. Alexander (1993) suggests that larger boards are more diversified and subject to disputes while being less cohesive compared to smaller boards. In short, this line of research supports the view that overtly large board size may result in the aggravation of the principal-agent problem, thus smaller boards are more efficient. That is, small boards deal rapidly with changing competitive environment and are more likely to remove managers when the company was performing poorly.

However, it is also argued that larger board size can improve corporate performance. That is, board size resembles a firm's key resources to connect with the external environment, which reflected the general content of the company's contracting environment and the amount of expert advice provided by the board. Additionally, Pfeffer (1972) suggest that board size relates to a firm's ability to get access to external critical resources such as budget from the external environment. Consequently, higher uncertainty of the external environment (lack of information and mutability) leads to an increase in board size. Huang and Wang (2015) found that board size is negatively related with total accruals, current accruals and the variation in current accruals. To the extent that both the level and the variability of these accounting accruals items reflect earnings management, their results suggest that firms with larger boards engage in a lower degree of earnings management and vice versa. Cheng (2008) suggests that firms with larger boards are less likely to suffer agency problems. That is, the negative association between board size and firm performance variability is consistent with larger boards making less extreme decisions due to communication/coordination problems.

For Chinese boards, an additional element to consider is the presence of insiders or members with political connections. Chen, Fan, and Wong (2006) found for 621 firms' boards from 1993 to 2000 that about 52% of the directors were former or current employees of the largest shareholders, and that about 32% are current or former government bureaucrats. This makes the influence of Chinese boards on corporate policy choices and risk taking questionable. Second, Chinese legislation stipulates a specific range for the size of Chinese boards resulting in a relatively smaller variation in board size across Chinese firms. The China Securities Regulatory Commission (CSRC) Code explicitly requires the board of directors to be composed of not less than 5 but not more than 19 members. (Huang and Wang, 2015)

To summarize, prior research suggests that larger board size is diminishing the principal agent problem by providing more efficient supervision compared to smaller boards. Therefore, in regard to cost stickiness larger board size can exercise better monitoring function to limit the effect of earnings management motivation (to avoid losses or profit declines) on R&D cost stickiness. Consequently, we would argue that in the presence of a larger board, managers will be driven to consider resources adjustment costs. In contrast, other researchers suggested that smaller boards would cause agency problem to worsen, that R&D cost stickiness will lessen or even disappear entirely (***H2. Management may cut R&D expenses in their bid to avoid losses and/or to avoid profit declines, and this reduces R&D expenditure stickiness***). Our results below are consistent with the later, which has the benefit of being also consistent with Hypothesis 1.

By comparing the β_1 we can see that the firms with small BS were less willing to increase R&D when sales grow (Table 14). By calculating the total of β_1 and β_2, we can see that the firms with small BS exhibit R&D stickiness, but β_2 was insignificant in the regression for the large BS group and therefore they exhibited no R&D stickiness.

Companies with large BS were insensitive to the pressure to implement earnings management – their β_3 and β_{15} were both insignificant. As for the small BS companies, with pressure to implement earnings management, their R&D increases at 0.394 (sum of β_1 and β_{15}) when sales increased, and when sales had fallen the R&D decreases at 0.566 (sum of β_1, β_2, β_3 and β_{15}). They did not exhibit R&D stickiness, the cut was indeed sharper than the increase.

Table 14 Results of regressing changes in R&D costs on changes in sales revenue under earnings manipulation for the 10-year period 2010-2019 and sample partitioned by Median of Board size (BS)

Regression specification for Model (1):

$$\Delta \ln(\text{Costs of R\&D}) = \beta_0 + \beta_1 * \Delta\ln(\text{IncomeR}) + \beta_2 * \Delta \ln(\text{IncomeR}) * \text{D} + \beta_3 * \Delta \text{l n}(\text{IncomeR}) * D * Loss + \beta_5 * Asset\ intensity * \Delta\ln(\text{IncomeR}) * D + \beta_6 * D_{twoyear} * \Delta\ln(\text{IncomeR}) * D + \beta_7 * FCF * \Delta \ln(\text{IncomeR}) * D + \beta_8 * Lev * \Delta \ln(\text{IncomeR}) * D + \beta_{10} * Loss + \beta_{11} * Asset\ intenstiy + \beta_{12} * D_{twoyear} + \beta_{13} * FCF + \beta_{14} * Lev + \beta_{15}\Delta(IncomeR) * Loss + Industry\ dummies + Year\ dummies\ \varepsilon$$

	SmallBS (High EM)	LargeBS (Low EM)
β1ΔLn(IncomeR)	0.584***	0.621***
	(0.027)	(0.027)
β2ΔLn(IncomeR)*D	-0.439***	-0.165
	(0.123)	(0.157)
β3ΔLn(IncomeR)*D*Loss	**0.611*** **	**0.093**
	(0.202)	**(0.212)**
β5Assets Intensity*ΔLn(IncomeR)*D	0.021	-0.071
	(0.036)	(0.064)
β6D_twoyear*ΔLn(IncomeR)*D	-0.069	0.020
	(0.090)	(0.120)
β7FCF*ΔLn(IncomeR)*D	-0.554***	-0.744***
	(0.161)	(0.170)
β8Lev*ΔLn(IncomeR)*D	0.217	-0.078
	(0.164)	(0.222)
β10Loss	0.010	0.007
	(0.021)	(0.022)
β11Assets Intensity	-0.017	-0.001
	(0.012)	(0.014)
β12D_twoyear	-0.073***	-0.098***
	(0.025)	(0.030)
β13FCF	-0.113**	-0.094
	(0.057)	(0.064)
β14Lev	0.078**	0.043
	(0.036)	(0.040)
β15ΔLn(IncomeR)*Loss	-0.190*	-0.015
	(0.097)	(0.080)
Constant	0.160**	0.404***
	(0.068)	(0.082)
	P=0.004 (Groups are significantly different)	
Obs	8,982	7,593
Adj-R2	0.1043	0.1278
F value	25.91	27.42

3.6.3 Board independence

Two streams of arguments have been put forward to describe how board independence may impact upon its effectiveness in bringing along long term growth.

It has been argued that boards with higher proportion of outside or non-executive directors can more effectively carry out their duties to safeguard the interests of shareholders (Fama and Jensen, 1983). Such boards make better decisions especially on the appointment of CEOs (Dahya and McConnell, 2005). Furthermore, firms with a high percentage of outside directors had less financial fraud because outside directors have less incentives for firms to engage in fraud. Therefore, a greater number of outside directors can prevent or reduce the fraudulent behavior of the executive directors (Beasley, 1996, Hatice et al., 2004).

Xie et al. (2003) find for a sample of US firms a negative relationship between board independence and discretionary accruals. In similar vein for UK firms (Peasnell et al., 2000)show less income-increasing accrual management to avoid earnings losses or profit declines when there is a higher proportion of non-executive directors. Furthermore, there is a negative correlation between the extent of earnings management with board and audit committee independence(Klein, 2002). However, Vafeas (2005), Agrawal and Chadha (2005), and Larcker et al. (2007) found an insignificant correlation between the independence of board and/or audit committee and earnings management.

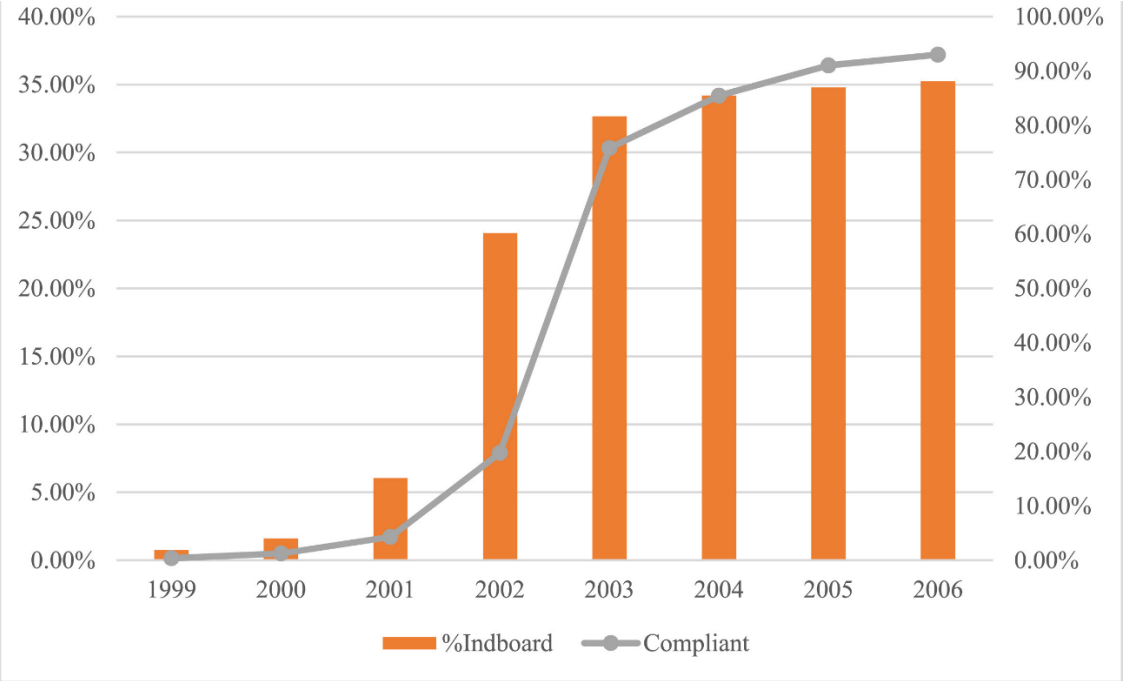
The mixed results could be attributed to the very nature of outside board members having less readily available information compared to managers. Raheja (2005) find that outside board members have access to management to obtain information face the challenge to get the information necessary for monitoring. Managers might be reluctant to share information necessary for outside board members to exercise their duty, knowing that independent directors are tougher monitors(Adams and Ferreira, 2007, Harris and Raviv, 2008). Both professionals and academics advance this point, e.g. Jensen (1993, p. 864) claiming: ‘‘[t]he CEO almost always determines the agenda and information given to the board. This limitation on information severely hinders the ability of even highly talented board members to contribute effectively to the monitoring and evaluation of the CEO and the firm’s strategy.’’

In China, August 2001, the CSRC released the “The Guideline for The Establishment of Independent Director System in Chinese Listed Companies” which mandates that listed firms should have at least two independent directors on their board by the end of June 2002and should include at least one-third independent directors by the end of June 2003. Consequently, firms which were not in compliance in 2001 had to significantly increase their board’s proportion of independent directors in the post-regulation period. This legislation explains why during 1999 and 2006 only a fraction of firms complied with the independence requirements. Between 2001 and 2003 saw a large increase of independent board members as firms began to change their board structure once the CSRC regulation was issued. From 2001 (6%) the proportion of independent directors on the board increased to 2006 (35%) with a compliance rate of about 95% (see Figure 7, below) (Gong et al., 2021).

The major objective on introducing independent directors is for them to prevent insiders such as controlling shareholders or management from using their superior information to the

detriment of both the corporation and of minority shareholders (Chen et al., 2007, Lo et al., 2010). To ensure the independence of outside board members, an independent director does not assume any position other than director in a firm, and should have no relationship with the firm or its controlling shareholders that might affect his or her independent, objective judgment. A major duty of independent board members is to review the financial statements and auditor's report(Chen et al., 2007, Liu and Lu, 2007). We therefore argue that, boards with more independence are likely to ensure that earnings management are less applied, and therefore the R&D spending is more likely to be maintained when a company comes under stress.

Figure 7 Trends of Board Independence



Source: (Gong et al., 2021) page 551

We run regression using two subsamples, separating our sample by the level of board independence. By comparing the β_1 we can see that the firms with less independent boards are more willing to increase R&D when sales grow (Table 15). By comparing the total of β_1 and β_2, we can see that less independent boards would allow more cuts to R&D when sales fall, thus showing less R&D stickiness. Finally, when sales had fallen and they are under pressure to implement earnings management, (compare total of β_1, β_2 and β_3), both types of firms had reduced their R&D stickiness, but the low independence board type cut their R&D more. Theoretically we should also consider β_{15}, but since it is insignificant different from zero in both sets of results we leave it aside. What is quite extraordinary is that the less independent boards, when under pressure to manage their earnings, would cut their R&D at a rate of 0.835 (0.664-0.268+0.439) when sales fall as against when they raised their R&D at a rate of 0.664 when sales increase. They more readily cut than they increase. This finding is consistent with the agency cost prediction outlined in Hypothesis 1.

Table 15Results of regressing changes in R&D costs on changes in sales revenue under earnings manipulation for the 10-year period 2010-2019 and sample partitioned by Median of Board independence (BI)

Regression specification for Model (1):

$$\Delta \ln(\text{Costs of R\&D}) = \beta_0 + \beta_1 * \Delta\ln(\text{IncomeR}) + \beta_2 * \Delta \ln(\text{IncomeR}) * \text{D} + \beta_3 * \Delta \text{l n(IncomeR)} * D * Loss + \beta_5 * Asset\ intensity * \Delta\ln(\text{IncomeR}) * D + \beta_6 * D_{twoyear} * \Delta\ln(\text{IncomeR}) * D + \beta_7 * FCF * \Delta \ln(\text{IncomeR}) * D + \beta_8 * Lev * \Delta \ln(\text{IncomeR}) * D + \beta_{10} * Loss + \beta_{11} * Asset\ intenstiy + \beta_{12} * D_{twoyear} + \beta_{13} * FCF + \beta_{14} * Lev + \beta_{15}\Delta(IncomeR) * Loss + Industry\ dummies + Year\ dummies\ \varepsilon$$

	Low BI (High EM)	High BI (Low EM)
β1ΔLn(IncomeR)	0.664***(0.028)	0.547*** (0.026)
β2ΔLn(IncomeR)*D	-0.268* (0.151)	-0.388*** (0.126)
β3ΔLn(IncomeR)*D*Loss	**0.439** (0.205)**	**0.307 (0.209)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.017 (0.064)	-0.011 (0.035)
β6D_twoyear*ΔLn(IncomeR)*D	-0.025 (0.117)	-0.031 (0.091)
β7FCF*ΔLn(IncomeR)*D	-0.620*** (0.169)	-0.590*** (0.159)
β8Lev*ΔLn(IncomeR)*D	-0.193 (0.213)	0.328** (0.167)
β10Loss	0.001 (0.021)	0.017 (0.022)
β11Assets Intensity	0.015 (0.013)	-0.033*** (0.012)
β12D_twoyear	-0.085*** (0.029)	-0.088*** (0.026)
β13FCF	-0.052 (0.063)	-0.112* (0.057)
β14Lev	0.044 (0.039)	0.079** (0.037)
β15ΔLn(IncomeR)*Loss	-0.074 (0.080)	-0.127 (0.098)
Constant	0.263*** (0.077)	0.268*** (0.070)
	P=0.244 (Groups are no significantly different)	
Obs	8,269	8,306
Adj-R2	0.1189	0.1112
F value	27.57	25.75

3.6.4 Analyst coverage

Analysts play their role in reducing the agency costs associated with the separation of ownership and control (Jensen and Meckling 1976). That is, they, "would expect monitoring activities to become specialized to those institutions and individuals who possess comparative advantages in these activities. One of the groups who seem to play a large role in these activities is composed of the security analysts employed by institutional investors, brokers and investment advisory services" (p.354). Analysts can govern firms through two mechanisms: Firstly, on a regular basis they keep track of firms' financial statements. Analysts engage directly with management to raise questions during earnings announcement conference calls which is considered direct monitoring. Analysts have played a major role compared to auditors and SEC to detect corporate fraud e.g. Compaq, Gateway, Motorola, and PeopleSoft (DYCK et al., 2010). Secondly, analysts distribute public and private information to the wider public through research reports and media e.g. newspapers and TV but also to institutional investors allowing them to identify managerial misbehaviour (Miller, 2006). A report shows that than 36% of managers consider analysts as the most important economic agent in setting the stock price(Graham et al., 2005).

Firms followed by more analysts exhibit less earning management (Yu, 2008). Degeorge et al. (2013) find that among 21 countries, firm with more analyst coverage engaged less in earnings management when the firm was in countries with highly developed financial systems. Irani and Oesch (2013) find that after reductions in analyst coverage the quality of financial reporting declined significantly. Finally, Chen et al. (2015) investigated the impact of analyst coverage on earnings management. They used absolute level of accruals-based earnings management and real activity manipulation as measures of earnings management, and find that, ceteris paribus, managers are involved in more earnings management activities after the firms experience an exogenous loss in analyst coverage.

Analyst following (AF) is the average number of analysts following for the firm. Missing analyst following numbers is replaced with zero. We run regression using two subsamples, separating our sample by the sample median of analyst numbers. By comparing the β_1 we can see that the firms that receive less scrutiny from analysts are more willing to increase R&D when sales grow (Table 16). By comparing the total of β_1 and β_2, we can see that firms that receive less analyst scrutiny would allow less cuts to R&D when sales fall, thus showing more R&D stickiness. Finally, when sales had fallen and they are under pressure to implement earnings management, (compare total of β_1, β_2 and β_3), both types of firms had reduced their R&D stickiness, but the low scrutiny type cut their R&D more. Again, β_{15} is insignificant in both sets of results and we leave it aside. However, the more scrutinized companies, when under pressure to manage their earnings, would cut their R&D at a rate of 0.592 (0.562-0.272+0.302) when sales fall as against when they raised their R&D at a rate of 0.562 when sales increase. Though one may argue that since the β_3 is not significantly different from zero, therefore

even though they were under pressure to administer earnings management, on average they refrain from doing it. This finding is consistent with the agency cost prediction outlined in Hypothesis 1.

Table 16Results of regressing changes in R&D costs on changes in sales revenue under earnings manipulation for the 10-year period 2010-2019 and sample partitioned by Median of Analyst following (AF)

Regression specification for Model (1):

$$\Delta \ln(\text{Costs of R\&D}) = \beta_0 + \beta_1 * \Delta\ln(\text{IncomeR}) + \beta_2 * \Delta \ln(\text{IncomeR}) * \text{D} + \beta_3 * \Delta \ln(\text{IncomeR}) * D * Loss + \beta_5 * Asset\ intensity * \Delta\ln(\text{IncomeR}) * D + \beta_6 * D_{twoyear} * \Delta\ln(\text{IncomeR}) * D + \beta_7 * FCF * \Delta \ln(\text{IncomeR}) * D + \beta_8 * Lev * \Delta \ln(\text{IncomeR}) * D + \beta_{10} * Loss + \beta_{11} * Asset\ intenstiy + \beta_{12} * D_{twoyear} + \beta_{13} * FCF + \beta_{14} * Lev + \beta_{15}\Delta(IncomeR) * Loss + Industry\ dummies + Year\ dummies\ \varepsilon$$

	Low AF (High EM)	High AF (Low EM)
β1ΔLn(IncomeR)	0.653***	0.562***
	(0.027)	(0.026)
β2ΔLn(IncomeR)*D	-0.438**	-0.272**
	(0.173)	(0.116)
β3ΔLn(IncomeR)*D*Loss	**0.416***	**0.302**
	(0.225)	**(0.190)**
β5Assets Intensity*ΔLn(IncomeR)*D	0.052	0.000
	(0.069)	(0.035)
β6D_twoyear*ΔLn(IncomeR)*D	-0.123	-0.077
	(0.130)	(0.088)
β7FCF*ΔLn(IncomeR)*D	0.755**	-0.728***
	(0.328)	(0.130)
β8Lev*ΔLn(IncomeR)*D	-0.207	0.165
	(0.244)	(0.160)
β10Loss	0.001	0.008
	(0.023)	(0.020)
β11Assets Intensity	-0.003	-0.010
	(0.014)	(0.012)
β12D_twoyear	-0.075**	-0.111***
	(0.029)	(0.026)
β13FCF	-0.058	-0.083*
	(0.071)	(0.050)
β14Lev	0.076*	0.045
	(0.041)	(0.036)
β15ΔLn(IncomeR)*Loss	-0.087	-0.127
	(0.107)	(0.098)
Constant	0.164**	0.343***
	(0.081)	(0.067)
	P=0.310 (Groups are not significantly different)	
Obs	6,817	9,758
Adj-R2	0.1244	0.1157
F value	24.61	30.26

3.6.5 Managers' shareholding

Managers' shareholding and the subsequent managerial incentives are explained by economic theory by two effects: the incentive alignment effect and the management entrenchment effect. Jensen and Meckling (1976) as part of traditional agency theory argue that shareholdings held by managers help align their interests with those of shareholders. The alignment effect predicts that higher managerial ownership will lead to higher corporate performance and simultaneously to less opportunistic, managerial behavior.

In contrast, greater ownership can provide managers with deeper entrenchment allowing them greater scope for opportunistic behavior, entrenchment effect (Morck et al.1988). Accordingly, the entrenchment effect is predominant during intermediate levels of management shareholding, while the alignment effect dominants during low and high levels of ownership, which is supported by empirical evidence (Morck et al., 1988;Short and Keasey, 1999). Evidence from China suggest a positive correlation between management shareholding and firm performance for low and high levels of managerial shareholding, supporting the alignment effect at these levels of ownership. Whereas for the intermediate levels of managerial ownership, consistent with the entrenchment effect there is an inverse relation between managerial ownership and firm performance(Dong et al., 2020)

In the UK firms with low managerial ownership exhibit more earnings management when faced with poor performance. Further, when firms report income-increasing discretionary accruals, the magnitude of abnormal accruals varies non-linearly with managerial ownership (O'Callaghan et al., 2018). Yang et al. (2008)find that discretionary accruals initially increase and then decrease with managerial ownership, like an inverted U-shaped relationship. The results suggest that managerial ownership reduces agency cost, thus enhancing information content of earnings.

In China managerial ownership is derived from following sources. Firstly, the adoption of employee stock ownership plans by some Chinese companies in the 1990s. However, Chinese regulators terminated employee stock ownership in the late 1990s due to concerns about inequality and illegality. Secondly, executive stock incentive plans in form of shares or share-options, which became popular after the share split reform in 2005–2006. Thirdly, management buy-outs (MBOs) in 2003–2005. Finally, managers of the firms who have been original shareholders of the firm before IPO. The percentage of equity held by management has continuously increased during the period of 2003–2014. On average, more than 67% of the firms have managerial ownership in 2003. At the end of 2014, more than 73% of firms have managerial ownership (Dong et al., 2020).We run regression using two subsamples, separating our sample by the sample median of management shareholding. By comparing the $\boldsymbol{\beta_1}$ we can see that the firms that have lower management shareholding were more willing to increase R&D when sales grow (Table 17). Noting that the $\boldsymbol{\beta_2}$ and $\boldsymbol{\beta_3}$ for the high management shareholding group are insignificant, and significant for the low

management shareholding group, we see that the latter group has very high R&D stickiness when sales fall. One may argue that with lower management shareholding, the managers are more willing to spend and less willing to save., as one would tend to care less about spending other people's money.

Table 17Results of regressing changes in R&D costs on changes in sales revenue under earnings manipulation for the 10-year period 2010-2019 and sample partitioned by Median of Management shareholding (Mshare)

Management shareholding (Mshare):

	Low Mshare (High EM)	High Mshare (Low EM)
β1ΔLn(IncomeR)	0.638***(0.031)	0.564*** (0.022)
β2ΔLn(IncomeR)*D	-0.552***(0.150)	-0.011 (0.129)
β3ΔLn(IncomeR)*D*Loss	**0.438* (0.225)**	**0.201 (0.176)**
β5Assets Intensity*ΔLn(IncomeR)*D	0.048 (0.042)	-0.132** (0.053)
β6D_twoyear*ΔLn(IncomeR)*D	-0.082 (0.109)	0.035 (0.092)
β7FCF*ΔLn(IncomeR)*D	-0.747*** (0.184)	-0.381*** (0.144)
β8Lev*ΔLn(IncomeR)*D	0.173 (0.210)	0.045 (0.173)
β10Loss	-0.006 (0.024)	0.017 (0.018)
β11Assets Intensity	-0.012 (0.015)	-0.001 (0.011)
β12D_twoyear	-0.076** (0.030)	-0.087*** (0.023)
β13FCF	-0.095 (0.070)	-0.064 (0.047)
β14Lev	0.017 (0.047)	0.069** (0.032)
β15ΔLn(IncomeR)*Loss	-0.006 (0.096)	-0.127 (0.098)
Constant	0.239*** (0.092)	0.307*** (0.055)
	P=0.130 (Groups are no significantly different)	
Obs	7,748	8,827
Adj-R2	0.1107	0.1395
F value	24.52	35.07

Notes: Partitioning the sample by relative shareholding means splitting the sample by size because firms with big amount of shares will have management with relatively small shareholding. However, using absolute shares would reflect on the value of managers in the company / utility but would ignore their relative power within the company, which is part of the Jensen and Meckling's (1976)argument

3.7 Robustness tests

The table below (Table 18) provides Pearson and Spearman correlations between our main variables, including the interaction terms. The upper right-hand half of the table presents Spearman rank-order correlations, and the lower left-hand half presents the Pearson product-moment correlations. Similar to Chen, Hu and Sougiannis (2012), there are significant but small in magnitude relationships between the main variables. We also conduct a multicollinearity diagnostic test for all dependent variables in the models, including the interaction terms. We find that all the variance inflation factors are lower than 10, suggesting that multicollinearity is not a concern in the estimation of our models (Table 18).

Table 18Variance inflation factor (VIF)multicollinearity test

	VIF
β1ΔLn(IncomeR)	1.77
β2ΔLn(IncomeR)*D	8.62
β3ΔLn(IncomeR)*D*Loss	1.35
β4ΔLn(IncomeR)*D*Loss*MA	1.15
β5Assets Intensity*ΔLn(IncomeR)*D	3.28
β6D_twoyear*ΔLn(IncomeR)*D	2.77
β7FCF*ΔLn(IncomeR)*D	2.76
β8Lev*ΔLn(IncomeR)*D	5.59
β9MA	1.78
β10Loss	1.14
β11Assets Intensity	1.55
β12D_twoyear	1.76
β13FCF	2.72
β14Lev	1.36

Following Choi (2001), Fisher-type panel tests have been adopted to see whether all the panels have stationarity. We find that those tests strongly reject the null hypothesis that all the panels contain unit roots. All variables including interaction terms have been tested and the results reject the null hypothesis that all panels contain unit roots, which shows that all the panels have stationarity:

Considering the existence of individual heterogeneity of the coefficient of each individual variable, the results of the F test show that there is significant difference between the coefficients of each individual variable and each individual variable (including interaction terms) significantly influences Y.

Table 19 Correlation matrix of variables used in the main analyses – Pearson (Spearman) in the upper (lower) diagonals

	ΔLn(IncomeR)	t1	t2	t3	t4	t5	t6	t7	MA	FCF	Loss	Assets	D_twoyear	lev
ΔLn(IncomeR)	1	0.78*	0.27*	-0.11*	0.64*	0.48*	0.16*	0.78*	0.18*	-0.01	-0.02*	-0.13*	-0.47*	-0.03*
t1=D*ΔLn(IncomeR)	0.61*	1	0.35*	-0.14*	0.82*	0.61*	0.21*	1.00*	0.18*	0.02*	0.08*	-0.18*	-0.60*	-0.03*
t2=D*ΔLn(IncomeR)*Loss	0.19*	0.27*	1	-0.39*	0.28*	0.21*	0.09*	0.35*	0.04*	0.01	-0.41*	-0.05*	-0.21*	0.00
t3=D*ΔLn(IncomeR)*Loss*MA_Score	-0.06*	-0.09*	-0.32*	1	-0.15*	-0.09*	-0.03*	-0.14*	-0.19*	-0.01	0.16*	0.07*	0.09*	-0.01
t4=D*ΔLn(IncomeR)*Assets	0.45*	0.80*	0.18*	-0.08*	1	0.53*	0.15*	0.81*	0.23*	0.03*	0.07*	-0.35*	-0.52*	0.02*
t5=D*ΔLn(IncomeR)*D_twoyear	0.42*	0.70*	0.19*	-0.11*	0.54*	1	0.11*	0.60*	0.15*	0.03*	0.05*	-0.15*	-0.99*	0.01
t6=D*ΔLn(IncomeR)*FCF	-0.06*	-0.10*	0.00	-0.03*	-0.02*	-0.12*	1	0.21*	0.02*	-0.45*	0.01*	0.00	-0.11*	0.02*
t7=D*ΔLn(IncomeR)*lev	0.52*	0.88*	0.18*	-0.07*	0.76*	0.61*	-0.07*	1	0.18*	0.02*	0.08*	-0.17*	-0.59*	-0.08*
MA	0.16*	0.13*	0.04*	-0.14*	0.11*	0.11*	0.01	0.11*	1	0.04*	-0.00	-0.31*	-0.14*	-0.03*
FCF	0.01	0.06*	-0.00	0.01	0.01	0.06*	-0.79*	0.05*	-0.01	1	-0.01	-0.07*	-0.03*	-0.02*
Loss	-0.03*	0.08*	-0.27*	0.07*	0.05*	0.05*	-0.01*	0.07*	0.00	0.02*	1	0.02*	-0.05*	0.04*
Assets	-0.15*	-0.24*	-0.08*	0.07*	-0.32*	-0.18*	-0.01*	-0.18*	-0.28*	-0.02*	0.02*	1	0.15*	-0.17*
D_twoyear	-0.36*	-0.39*	-0.16*	0.07*	-0.23*	-0.61*	0.05*	-0.29*	-0.13*	-0.04*	-0.05*	0.16*	1	-0.01*
Lev	-0.01	-0.06*	0.01	-0.01	-0.03*	-0.03*	0.01	-0.21*	-0.02*	0.00	0.04*	-0.16*	-0.00	1

Notes: The table reports the Pearson (Spearman) correlation coefficients for variables in the main analysis at the lower (upper) diagonal. The sample period is 2010-2019. The sample consists of 16,575 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. * denotes significance at 10% level.

3.7.1 Overview-Robustness checks

We perform several robustness checks, and our results are confirmed by those checks (Table 20).

Table 20 Overview of robustness checks

	Hypothesis1		**Hypothesis2**	**Hypothesis3**	
	H1 holds if β2<0.		H2 holds if β3>0 H2 rejected if β3<0	**Low MA**	**High MA**
				H3 holds if β3<0 in high MA group H3 rejected if β3>0 in high MA group	
Robustness test for Hypothesis1, Hypothesis2 and Hypothesis3:					
1-Individual fixed effects model	β2=-0.321*** β2<0, H1 holds	β2=-0.389*** β2<0, H1 holds	β3=0.279* β3>0, H2 holds	β3=0.146	β3=0.575*(β3>0, H3 rejected)
				P=0.030 (Groups are significantly different)	
2-Replace operating- with total revenue	β2=-0.216***	β2=-0.322***	β3=0.228**	β3=0.048	β3=0.510**
				P=0.066 (Groups are significantly different)	
3-2013 combat corruption policy		β2=-0.617***	β3=0.230*	β3=0.044	β3=0.491**
				P=0.080 (Groups are significantly different)	
4-Add control variable to models-Dual		β2=-0.375***	β3=0.237**	β3=0.067	β3=0.463**
				P=0.006 (Groups are significantly different)	
Robustness test for Hypothesis1:					
9-Following Xue and Hong (2016)	β2=**-0.261***	β2=**-0.158***			
Robustness test for Hypothesis2:					
5-Alternative way to measure earnings management			β3=0.180*		
6-Change ROA from 0<ROA<0.01 to 0<ROA<0.014			β3=0.395***		
11– "market capitalization" to measure Return on Assets (ROA)			β3=0.234**		
Robustness test for Hypothesis3:					
7-CEO's oversea background to measure managerial ability				β3=0.124	β3=1.245***
				P=0.031 (Groups are significantly different)	
8-Use CEO's media presence to measure managerial ability				β3=0.262	β3=0.518***
				P=0.060 (Groups are significantly different)	
Interpretation	Companies keep on R&D costs when sales decrease (R&D costs are sticky).		Managers cut R&D costs when they are motivated to avoid loss or sales decreases	Firms with capable managers strengthened the negative relationship between the incentive to avoid loss and to avoid profit decrease and the level of R&D costs' stickiness	

3.7.2 Fixed effects model

Considering the issue of the unobserved time-invariant firm characteristics that may affect research results, a fixed effects model has been adopted. Both column 1 and column 2 in Table 21 show that $\beta_2<0$ and significant at a 1% level, which indicates that R&D costs are sticky; column 3 in Table 21 shows that $\beta_3>0$ and significant at a 10% level, which indicates that earnings management incentive has a negative influence on R&D costs stickiness (earnings management leads to R&D investment reduction when the company is in downturn); column 5 in Table 21 shows that $\beta_3>0$ and significant at a 10% level, which shows that managerial ability strengthened the negative relationship between earnings management incentive and R&D stickiness. However, column 4 in Table 21 shows that $\beta_3>0$ but not significant, which means that earnings management incentive does not influence R&D stickiness in the low managerial ability group. The difference between those two groups is statistically significant (P value=0.030). Therefore, we find evidence consistent with our main results.

Table 21 Fixed effects model

	H1		***H2***	***H3***	
Model:	1	2	3	3	
				Low MA	High MA
β1ΔLn(IncomeR)	0.624***	0.611***	0.609***	0.662***	0.581***
	(0.042)	(0.044)	(0.044)	(0.060)	(0.069)
β2ΔLn(IncomeR)*D	**-0.321*****	**-0.389*****	-0.428***	-0.430**	-0.333
	(0.082)	(0.163)	(0.165)	(0.184)	(0.281)
β3ΔLn(IncomeR)*D*Loss			**0.279***	**0.146**	**0.575***
			(0.168)	**(0.181)**	**(0.334)**
β5Assets Intensity*ΔLn(IncomeR)*D		-0.010	-0.007	-0.079	-0.023
		(0.068)	(0.067)	(0.073)	(0.089)
β6D_twoyear*ΔLn(IncomeR)*D		-0.025	-0.021	0.135	-0.372
		(0.120)	(0.119)	(0.105)	(0.319)
β7FCF*ΔLn(IncomeR)*D		-0.554***	-0.564***	-0.510***	-0.410
		(0.167)	(0.165)	(0.162)	(0.547)
β8Lev*ΔLn(IncomeR)*D		0.060	0.094	-0.090	0.561
		(0.256)	(0.254)	(0.246)	(0.476)
β10Loss			-0.011	0.013	-0.025
			(0.014)	(0.019)	(0.021)
β11Assets Intensity		0.023	0.025	-0.023	0.026
		(0.024)	(0.024)	(0.029)	(0.039)
β12D_twoyear		-0.100***	-0.099***	-0.074***	-0.132**
		(0.026)	(0.026)	(0.027)	(0.057)
β13FCF		-0.074	-0.076	-0.175***	-0.081
		(0.059)	(0.058)	(0.065)	(0.105)
β14Lev		-0.056	-0.060	0.054	-0.161
		(0.064)	(0.064)	(0.082)	(0.113)
Constant	0.278***	0.296***	0.300***	0.288***	0.374***
	(0.052)	(0.058)	(0.058)	(0.076)	(0.095)
				P=0.030 (Groups are significantly different)	
YEAR	Control	Control	Control	Control	Control
Obs	16,575	16,575	16,575	8,938	7,637

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 16,575 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50thpercentile.To control for error dependence of firm observations, we use Rogers (1993) standard errors clustered at the firm level as well as robust standard errors.

3.7.3 Use total revenue to replace operating revenue

In our main results, we run our tests using operating revenue. Following Bradbury and Scott (2018) as a robustness test, we use total revenue to replace operating revenue and run the models again. Both column 1 and column 2 in Table 23 show that $\beta 2<0$ and significant at a 1% level, which indicates that R&D costs are sticky; column 3 in Table 23 shows that $\beta 3=0.228>0$ and significant at a 5% level, which indicates that earnings management incentive negatively influences R&D costs stickiness; column 5 in Table 23 shows that $\beta 3=0.510>0$ and significant at a 5% level, which shows that managerial ability strengthened the negative relationship between earnings management incentive and R&D stickiness. However, column 4 in Table 23 shows that $\beta 3>0$ but not significant, which means that earnings management incentive does not influence R&D stickiness in the low managerial ability group. The difference between those two groups is statistically significant (P value=0.066). Therefore, we find evidence consistent with our main results.

Table 22 Descriptive statistic of *Ln(TotalRevenue)*

The descriptive statistic of *Ln(TotalRevenue)* is for a sample of 16,575 firm-year observations from 2,946 firms following Bradbury and Scott (2018). On average *Ln(TotalRevenue)* was 0.12 (median: 0.11, standard deviation: 0.34) with a minimum of -3.18 and maximum of 5.88.

	Obs.	Mean	Standard Deviation	Median	Minimum	Maximum
Ln(TotalRevenue)	16,575	0.12	0.34	0.11	-3.18	5.88

Table 23Use total revenue to replace operating revenue

	H1		*H2*	*H3*	
Model:	1	2	3	3	
				Low MA	High MA
β1ΔLn(TotalRevenue)	0.616***	0.599***	0.597***	0.651***	0.554***(0.025)
	(0.018)	(0.018)	(0.018)	(0.027)	
β2ΔLn(TotalRevenue)*D	**-0.216*** **	**-0.322*** **	-0.357***	-0.339***	-0.240
	(0.041)	(0.090)	(0.093)	(0.123)	(0.157)
β3ΔLn(TotalRevenue)*D*Loss			**0.228** **	**0.048**	**0.510** **
			(0.112)	**(0.134)**	**(0.202)**
β5AssetsIntensity*ΔLn(TotalRevenue)*D		0.001	0.003	-0.036	-0.008
		(0.029)	(0.029)	(0.048)	(0.040)
β6D_twoyear*ΔLn(TotalRevenue)*D		-0.043	-0.041	0.108	-0.258*
		(0.071)	(0.071)	(0.083)	(0.138)
β7FCF*ΔLn(TotalRevenue)*D		-0.647***	-0.655***	-0.407***	-0.798***
		(0.109)	(0.109)	(0.158)	(0.169)
β8Lev*ΔLn(TotalRevenue)*D		0.094	0.128	-0.135	0.518**
		(0.129)	(0.130)	(0.161)	(0.229)
β10Loss			-0.007	0.003	-0.021
			(0.012)	(0.015)	(0.018)
β11Assets Intensity		-0.008	-0.008	-0.010	-0.017
		(0.009)	(0.009)	(0.013)	(0.013)
β12D_twoyear		-0.087***	-0.086***	-0.067***	-0.092***
		(0.019)	(0.019)	(0.023)	(0.034)
β13FCF		-0.075*	-0.076*	-0.156***	-0.091
		(0.040)	(0.040)	(0.057)	(0.063)
β14Lev		0.060**	0.062**	0.046	0.057
		(0.027)	(0.027)	(0.036)	(0.042)
Constant	0.289***	0.266***	0.269***	0.197**	0.310***
	(0.050)	(0.052)	(0.052)	(0.100)	(0.069)
				P=0.066 (Groups are significantly different)	
Obs	16,575	16,575	16,575	8,938	7,637
Adj-R2	0.1106	0.1150	0.1152	0.1220	0.1125
F value	67.52	56.25	53.65	32.05	24.61

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 16,575 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

3.7.4 2013 Combat corruption policy

Corruption could influence innovation. Corruption shifts firms' ethical norms (Lyon &Maher, 2005) and is one of the factors which influence investment and economic growth (La Porta et al., 1999). Based on the survey data from Central and Eastern Europe (CCEs), Chadee, Roxas and Kouznetsov (2021) find that there is a negative relationship between corruption and innovation. In December 2012, the Chinese Government issued an important policy – "Eight-Point Regulation", which has been recognized as a forceful anti-corruption movement since Xi Jinping assumed power (Chen et al., 2020). The anti-corruption movement could influence our research, so the *Post* is a dummy variable (1 if it is after the 2013 anti-corruption movement, 0 otherwise).

Results estimated adding *Post* and its interaction term to model are robust to the conclusions we made earlier. Column 1 in Table 25 show that $\beta2<0$ and significant at a 1% level, which indicates that R&D costs are sticky; column 2 in Table 25 shows that $\beta3>0$ and significant at a 5% level, which indicates that earnings management incentive negatively influences R&D costs stickiness; column 4 in Table 25 shows that $\beta3>0$ and significant at a 5% level, which shows that managerial ability strengthened the negative relationship between earnings management incentive and R&D stickiness. However, column 3 in Table 25 shows that $\beta3>0$ but not significant, which means that earnings management incentive does not influence R&D stickiness in the low managerial ability group. The difference between those two groups is statistically significant (P value=0.080). Therefore, we find evidence consistent with our main results.

Table 24 Descriptive statistic of *Post*

The descriptive statistic of Post is for a sample of 16,575 firm-year observations. The Post is a dummy variable (1 if it is after the 2013 anti-corruption movement, 0 otherwise).

	Obs.	Mean	Standard Deviation	Median	Minimum	Maximum
Post	16,575	0.85	0.35	1.00	0.00	1.00

Table 25:2013 Combat corruption policy

	H1	H2	H3	
Model	2	3	3	
			Low MA	High MA
β1ΔLn(IncomeR)	0.711***	0.710***	0.619***	0.977***
	(0.047)	(0.047)	(0.055)	(0.089)
β2ΔLn(IncomeR)*D	**-0.617*** **	-0.657**	-0.155	-1.903***
	(0.150)	(0.152)	(0.178)	(0.334)
β3ΔLn(IncomeR)*D*Loss		**0.230** **	**0.044**	**0.491** **
		(0.112)	**(0.134)**	**(0.202)**
β5AssetsIntensity*ΔLn(IncomeR)*D	-0.004	-0.002	-0.032	-0.031
	(0.030)	(0.030)	(0.048)	(0.041)
β6D_twoyear*ΔLn(IncomeR)*D	-0.056	-0.054	0.116	-0.320**
	(0.071)	(0.071)	(0.083)	(0.140)
β7FCF*ΔLn(IncomeR)*D	-0.642***	-0.650***	-0.413***	-0.780***
	(0.109)	(0.109)	(0.158)	(0.169)
β8Lev*ΔLn(IncomeR)*D	0.093	0.127	-0.134	0.494**
	(0.130)	(0.131)	(0.161)	(0.230)
β10Loss		-0.007	0.004	-0.021
		(0.012)	(0.015)	(0.018)
β11Assets Intensity	-0.008	-0.008	-0.009	-0.017
	(0.009)	(0.009)	(0.013)	(0.013)
β12D_twoyear	-0.089***	-0.088***	-0.066***	-0.095***
	(0.019)	(0.019)	(0.023)	(0.034)
β13FCF	-0.073*	-0.074*	-0.154***	-0.085
	(0.040)	(0.040)	(0.057)	(0.063)
β14Lev	0.061**	0.062**	0.048	0.058
	(0.027)	(0.027)	(0.036)	(0.042)
β_{15}*Post*	**-0.110*** **	**-0.110*** **	**-0.167*** **	**-0.007**
	(0.034)	**(0.034)**	**(0.043)**	**(0.055)**
β_{16}L_revenuepost***	**-0.131** **	**-0.132*** **	**0.041**	**-0.456*** **
	(0.051)	**(0.051)**	**(0.063)**	**(0.092)**
β_{17}D_oneyear* L_revenuepost***	**0.348** **	**0.354** **	**-0.221**	**1.847*** **
	(0.140)	**(0.140)**	**(0.155)**	**(0.330)**
Constant	0.233***	0.235***	0.204**	0.196***
	(0.053)	(0.053)	(0.101)	(0.073)
			P=0.080 (Groups are significantly different)	
Obs	16,575	16,575	8,938	7,637
Adj-R2	0.1153	0.1155	0.1220	0.1166
F value	53.71	51.36	30.57	24.44

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 16,575 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

3.7.5 Add more control variables to models-Dual

The Ordinary Least Squares (OLS) are likely to be biased due to the omission of variables correlated with both type one agency problems (management to avoid losses and to avoid profit decline) and R&D stickiness. For example, our controls for R&D stickiness may be imperfect. Chen, Lu and Sougiannis (2012) find that corporate governance is one of the factors that influences cost stickiness. To address this potential problem of endogeneity, following Bugeja, Lu and Shan (2015), we add a dummy variable of whether the board chair and CEO are one person (*Dual*) as a control variable to the models. *Dual* is a Dummy variable, equals to 1 if the positions of board chair and CEO are occupied by one person, and 0 otherwise.

Table 26 Descriptive statistic of Dual

	Obs.	Mean	Standard Deviation	Median	Minimum	Maximum
Dual	16,575	0.28	0.45	0.00	0.00	1.00

Column 1 in Table 27 show that $\beta 2<0$ and significant at a 1% level, which indicates that R&D costs are sticky; column 2 in Table 27 shows that $\beta_3>0$ and significant at a 5% level, which indicates that earnings management incentive negatively influences R&D costs stickiness; column 4 in Table 27 shows that $\beta_3>0$ and significant at a 5% level, which shows that managerial ability strengthened the negative relationship between earnings management incentive and R&D stickiness. However, column 3 in Table 27 shows that $\beta 3>0$ but not significant, which means that earnings management incentive does not influence R&D stickiness in the low managerial ability group. The difference between those two groups is statistically significant (P value=0.006). Therefore, we find evidence consistent with our main results.

Table 27Add more control variable to models-*Dual*

	H1	***H2***	***H3***	
Model:	2	3	3	
			Low MA	High MA
β1ΔLn(IncomeR)	0.606***	0.604***	0.643***	0.575***
	(0.022)	(0.022)	(0.032)	(0.030)
β2ΔLn(IncomeR)*D	**-0.375*** **	-0.412***	-0.369***	-0.444**
	(0.097)	(0.090)	(0.128)	(0.176)
β3ΔLn(IncomeR)*D*Loss		**0.237** **	**0.067**	**0.463** **
		(0.113)	**(0.134)**	**(0.203)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.005	-0.003	-0.038	0.002
	(0.030)	(0.030)	(0.048)	(0.041)
β6D_twoyear*ΔLn(IncomeR)*D	-0.004	-0.042	0.105	-0.191
	(0.071)	(0.072)	(0.083)	(0.142)
β7FCF*ΔLn(IncomeR)*D	-0.632***	-0.639***	-0.397**	-0.791***
	(0.109)	(0.109)	(0.158)	(0.170)
β8Lev*ΔLn(IncomeR)*D	0.123	0.159	-0.108	0.660***
	(0.131)	(0.132)	(0.162)	(0.236)
β10Loss		-0.007	0.004	-0.022
		(0.012)	(0.015)	(0.018)
β11Assets Intensity	-0.005	-0.004	-0.008	-0.016
	(0.009)	(0.009)	(0.013)	(0.013)
β12D_twoyear	-0.085***	-0.084***	-0.067***	-0.086**
	(0.019)	(0.019)	(0.023)	(0.034)
β13FCF	-0.073*	-0.074*	-0.155***	-0.092
	(0.040)	(0.040)	(0.057)	(0.063)
β14Lev	0.065**	0.066**	0.046	0.061
	(0.027)	(0.027)	(0.036)	(0.042)
β15Dual*ΔLn(IncomeR)*D	0.213**	0.217**	0.090	0.485***
	(0.096)	(0.096)	(0.119)	(0.186)
β16Dual	0.001	0.001	-0.012	0.018
	(0.014)	(0.014)	(0.018)	(0.021)
β17Dual*ΔLn(IncomeR)	-0.024	-0.024	0.029	-0.065
	(0.039)	(0.039)	(0.059)	(0.052)
Constant	0.258***	0.261***	0.190*	0.298***
	(0.052)	(0.052)	(0.100)	(0.069)
			P=0.006 (Groups are significantly different)	
Obs	16,575	16,575	8,938	7,637
Adj-R2	0.1143	0.1145	0.1221	0.1129
F value	51.94	49.73	29.90	23.09

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 16,575 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

3.7.6 Use alternative way to measure earnings management

This is an alternative way to measure incentives to manage earnings instead of the ROA ratio. In Burgstahler and Dichev (1997), they argued that managers are motivated to manipulate earnings whenever there are losses. Therefore, they created a dummy that equals to one if the profit was negative the year before, and zero otherwise *(LossDummy).*

Table 28 Descriptive statistic of *LossDummy*

	Obs.	Mean	Standard Deviation	Median	Minimum	Maximum
LossDummy	16,575	0.07	0.25	0.00	0.00	1.00

The empirical results show that this new definition of loss avoidance also has a positive and significant coefficient, just like the loss avoidance variable defined using the ROA ratio. Arguably, this does a better job as the F-statistics at 54.65 is higher than the one presented in Table 8, at 52.39. This means that the overall model is performing better with this definition of loss avoidance.

Column 3 in Table 29shows that β3 is positive (0.870) and significant at a 1% level, which indicates that earnings management incentive (turn loss into gain) negatively influences R&D costs stickiness. Therefore, we find evidence consistent with our main results.

Table 29 Use negative profit the year before as motivation for applying earnings management

	H2	*H3*	
Model:	3	3	
		Low MA	High MA
β1ΔLn(IncomeR)	0.608***	0.664***	0.562***
	(0.018)	(0.027)	(0.025)
β2ΔLn(IncomeR)*D	-0.362***	-0.359***	-0.338**
	(0.091)	(0.121)	(0.156)
β3ΔLn(IncomeR)*D*LossDummy	**0.180***	**-0.080**	**0.870*****
	(0.096)	**(0.111)**	**(0.192)**
β5Assets Intensity*ΔLn(IncomeR)*D	0.015	-0.033	0.009
	(0.030)	(0.049)	(0.041)
β6D_twoyear*ΔLn(IncomeR)*D	-0.091	0.117	-0.358**
	(0.074)	(0.087)	(0.139)
β7FCF*ΔLn(IncomeR)*D	-0.629***	-0.412***	-0.710***
	(0.109)	(0.158)	(0.170)
β8Lev*ΔLn(IncomeR)*D	0.087	-0.107	0.580**
	(0.130)	(0.162)	(0.230)
β10LossDummy	-0.106***	-0.142***	-0.017
	(0.021)	(0.024)	(0.037)
β11Assets Intensity	-0.007	-0.006	-0.017
	(0.009)	(0.013)	(0.013)
β12D_twoyear	-0.087***	-0.058**	-0.100***
	(0.019)	(0.023)	(0.034)
β13FCF	-0.078*	-0.166***	-0.078
	(0.040)	(0.057)	(0.063)
β14Lev	0.077***	0.073**	0.063
	(0.027)	(0.036)	(0.042)
Constant	0.270***	0.192*	0.303***
	(0.052)	(0.099)	(0.069)
			P=0.001 (Groups are significantly different)
Obs	16,575	8,938	7,637
Adj-R2	0.1172	8,938	7,637
F value	54.65	0.1255	0.1144

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 16,575 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

3.7.7 Change the definition of LOSS avoidance: ROA ratio cutoff change from0.01 or lower to0.014 or lower

In Section 3.4.3 we evaluated how the desire to avoid sales decrease may motivate managers to engage in real earnings management. We defined that this motivation exists when the ROA ratio is between 0 and 0.01. We are, however, worried that the OLS results are

sensitive to the cut-off value we have chosen. If we have, say, chosen 0.014 instead of 0.01, would we have come to a different conclusion?

In here, we experiment by changing the definition of loss avoidance and revenue decrease avoidance. We use 0.014 as cutoff rather than 0.01. In table 31, the value of $\beta_3$is 0.331 (Loss defined with 0.01) and 0.395 (Loss defined with 0.014), indicating that earnings management motivation to avoid revenue decrease or to avoid loss diminish the level of R&D expenditure stickiness. Therefore, we find evidence consistent with our main results.

Table 30 Descriptive statistic of *Loss*

	Obs.	Mean	Standard Deviation	Median	Minimum	Maximum
Loss	16,575	0.31	0.46	0.00	0.00	1.00

Table 31 Compare different ROA cut-offs for defining motivation to avoid loss-H2

	H2	
Model	3	3
	(Loss = 0.01)	(Loss = 0.014)
β1ΔLn(IncomeR)	0.603***	0.615***
	(0.019)	(0.019)
β2ΔLn(IncomeR)*D	-0.366***	-0.393***
	(0.094)	(0.096)
β3ΔLn(IncomeR)*D*Loss	**0.331****	**0.395****
	(0.143)	(0.120)
β5Assets Intensity*ΔLn(IncomeR)*D	0.002	0.004
	(0.030)	(0.030)
β6D_twoyear*ΔLn(IncomeR)*D	-0.044	-0.049
	(0.071)	(0.071)
β7FCF*ΔLn(IncomeR)*D	-0.653***	-0.668***
	(0.109)	(0.109)
β8Lev*ΔLn(IncomeR)*D	0.134	0.149
	(0.131)	(0.131)
β10Loss	0.004	-0.010
	(0.015)	(0.014)
β11Assets Intensity	-0.008	-0.007
	(0.009)	(0.009)
β12D_twoyear	-0.087***	-0.087***
	(0.019)	(0.019)
β13FCF	-0.075*	-0.078*
	(0.040)	(0.040)
β14Lev	0.064**	0.065**
	(0.027)	(0.027)
β15ΔLn(IncomeR)*Loss	-0.071	-0.152
	(0.061)	(0.052)
Constant	0.268***	0.268***
	(0.052)	(0.052)
Obs	16,575	16,575
Adj-R2	0.1152	0.1157
F value	53.63	52.64

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 16,575 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

Both column 1and column 3 in Table 32 show that the value of β_3 is positive and significant (β_3=0.057 and 0.127), which indicates that managers' motivation to avoid revenue decrease or to avoid loss. However, column 2 and column 4 in Table 32 show that there is the positive relationship between managers' motivation to avoid revenue decrease or to avoid loss and R&D stickiness (β_3=0.784*** and 0.798***), which means that managerial ability is unique and capable managers further cut R&D when managers have upwards earnings management motivation. The difference between low managerial ability group and high managerial ability group is statistically significant (P value=0.051 and 0.027). Therefore, we find evidence consistent with our main results.

Table 32 Compare different ROA cut-offs for defining motivation to avoid loss-H3

Change the table to this instead:

- Columns 1 &2: H3 (Loss = 0.01), regression results split by MA low, MA high
- Columns 3 &4: H3 (Loss = 0.014), regression results split by MA low, MA high
- Remove H1 and H2

	H3		***H3***	
	3(0<ROA<0.01)		3(0<ROA<0.014)	
	1	2	3	4
	Low MA	High MA	Low MA	High MA
β1ΔLn(IncomeR)	0.651***	0.567***	0.659***	0.582***
	(0.029)	(0.026)	(0.030)	(0.026)
β2ΔLn(IncomeR)*D	-0.340***	-0.266*	-0.348***	-0.320*
	(0.124)	(0.158)	(0.126)	(0.165)
β3ΔLn(IncomeR)*D*Loss	**0.057**	**0.784*** **	0.127	0.798***
	(0.175)	**(0.249)**	(0.146)	(0.215)
β5AssetsIntensity*ΔLn(IncomeR)*D	-0.036	-0.006	-0.037	-0.004
	(0.048)	(0.041)	(0.048)	(0.041)
β6D_twoyear*ΔLn(IncomeR)*D	0.106	-0.267*	0.099	-0.245*
	(0.083)	(0.139)	(0.083)	(0.140)
β7FCF*ΔLn(IncomeR)*D	-0.405**	-0.800***	-0.416***	-0.796***
	(0.158)	(0.169)	(0.160)	(0.169)
β8Lev*ΔLn(IncomeR)*D	-0.133	0.539**	-0.126	0.566**
	(0.161)	(0.230)	(0.162)	(0.232)
β10Loss	0.004	0.008	-0.003	-0.029
	(0.019)	(0.024)	(0.018)	(0.022)
β11Assets Intensity	-0.010	-0.017	-0.008	-0.017
	(0.013)	(0.013)	(0.013)	(0.013)
β12D_twoyear	-0.067***	-0.096***	-0.070***	-0.099***
	(0.023)	(0.034)	(0.023)	(0.034)
β13FCF	-0.155***	-0.091	-0.153***	-0.090
	(0.057)	(0.063)	(0.057)	(0.063)
β14Lev	0.048	0.059	0.048	0.061
	(0.036)	(0.042)	(0.036)	(0.042)
β15ΔLn(IncomeR)*Loss	-0.005	-0.187*	-0.063	-0.293***
	(0.079)	(0.096)	(0.069)	(0.082)
Constant	0.195*	0.310***	0.195*	0.310***
	(0.100)	(0.069)	(0.100)	(0.069)
	P=0.051 (Groups are significantly different)		**P=0.027** (Groups are significantly different)	
Obs	8,938	7,637	8,938	7,637
Adj-R2	0.1219	0.1128	0.1221	0.1136
F value	31.26	24.11	31.32	24.29

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 16,575 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

3.7.8 Use CEO's overseas background to measure managerial ability

Following Yuan and Wen (2018), this research also uses the CEO's overseas background to measure managerial ability. *MA* is a dummy variable (Dummy variable, equal to 1 if the CEO has overseas background, and 0 otherwise.).

Table 33 Descriptive statistic of *MA*

	Obs.	Mean	Standard Deviation	Median	Minimum	Maximum
MA	16,543	0.08	0.27	0.00	0.00	1.00

Column 2 in Table 34 shows that the value of β_3 is positive and significant, in the high managerial ability sub-sample, which means that managerial ability is unique and capable managers use their ability further cut R&D when managers have motivation to avoid revenue decreases or to avoid loss(β_3=1.245***). Column 1 in Table 34 shows that there is positive relationship between earnings management motivation and R&D stickiness but the positive relationship is not significant, which means that managers' motivation to avoid revenue decreases or to avoid loss does not lead to R&D stickiness in the low managerial ability group (β_3=0.124). The difference between those two groups is statistically significant (P value=0.031). Therefore, we find evidence consistent with our main results.

Table 34CEO's overseas background as an ability indicator

	H3	
	1	2
	Low MA	High MA
β1ΔLn(IncomeR)	0.591***	0.699***
	(0.019)	(0.062)
β2ΔLn(IncomeR)*D	-0.379***	-0.194
	(0.097)	(0.331)
β3ΔLn(IncomeR)*D*Loss	**0.124**	**1.245*** **
	(0.120)	**(0.313)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.009	0.131
	(0.031)	(0.111)
β6D_twoyear*ΔLn(IncomeR)*D	-0.057	0.585**
	(0.074)	(0.267)
β7FCF*ΔLn(IncomeR)*D	-0.606***	-1.131
	(0.113)	(0.890)
β8Lev*ΔLn(IncomeR)*D	0.220	-1.189**
	(0.137)	(0.476)
β10Loss	-0.006	-0.015
	(0.013)	(0.031)
β11Assets Intensity	-0.013	0.051**
	(0.009)	(0.025)
β12D_twoyear	-0.092***	0.062
	(0.020)	(0.061)
β13FCF	-0.052	-0.356***
	(0.043)	(0.123)
β14Lev	0.062**	0.036
	(0.028)	(0.075)
Constant	0.274***	0.319
	(0.054)	(0.247)
	P=0.031 (Groups are significantly different)	
Obs	15,206	1,328
Adj-R2	0.1146	0.1799
F value	50.22	8.46

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 16,543 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Yuan and Wen (2018). The sample were split to high managerial ability and low managerial ability samples using whether CEO has oversea background. CEO with oversea background has high managerial ability, while CEO without oversea background has low managerial ability.

3.7.9 Use CEO's media presence to measure managerial ability

Following Haider, Singh and Sultanna (2021), we use media presence to measure managerial ability. Because of insufficient data on CEO's media presence, the sample consists of 13,960 firm-year observations. We calculate managerial ability by taking the sum of the number of press articles with the name of each member of the entire management team in the news media for each year. There is a positive relationship between the number of times managers appear in the media and their managerial ability.

Table 35 Descriptive statistic of *MA*

The descriptive statistic of *MA* is for a sample of 13,960 firm-year observations from 2,889 firms. On average the sum of the number of press articles in the news media for each year was 253.55 (median: 101, standard deviation: 481.94) with a minimum of 1 and maximum of 3,186.

	Obs.	Mean	Standard Deviation	Median	Minimum	Maximum
MA	13,960	253.55	481.94	101.00	1	3186

We find a significant and positive coefficient, β_3 equals to 0.518, in column 2 in Table 36. This suggests that managerial ability is unique and capable managers further cut R&D when managers have upwards earnings management motivation. Column 1 in Table 36 shows that earnings management motivation to avoid revenue decreases or to avoid loss does not lead to R&D stickiness in the low managerial ability group (β_3=0.262). The difference between those two groups is statistically significant (P value=0.042). Therefore, we find evidence consistent with our main results.

Table 36Number of press articles

	H3	
	Low MA (less media press)	High MA (more media press)
β1ΔLn(IncomeR)	0.576***	0.569***
	(0.028)	(0.026)
β2ΔLn(IncomeR)*D	-0.646***	-0.294**
	(0.172)	(0.115)
β3ΔLn(IncomeR)*D*Loss	**0.262**	**0.518*** **
	(0.172)	**(0.161)**
β5Assets Intensity*ΔLn(IncomeR)*D	0.070	0.007
	(0.055)	(0.037)
β6D_twoyear*ΔLn(IncomeR)*D	-0.326**	0.073
	(0.142)	(0.091)
β7FCF*ΔLn(IncomeR)*D	-0.674***	-0.498***
	(0.176)	(0.144)
β8Lev*ΔLn(IncomeR)*D	0.919***	0.048
	(0.265)	(0.166)
β10Loss	-0.004	-0.004
	(0.019)	(0.016)
β11Assets Intensity	0.005	-0.019*
	(0.015)	(0.011)
β12D_twoyear	-0.115***	-0.099***
	(0.031)	(0.026)
β13FCF	-0.051	-0.077
	(0.067)	(0.054)
β14Lev	0.160***	0.008
	(0.043)	(0.036)
Constant	0.176**	0.076
	(0.083)	(0.113)
	P=0.060 (Groups are significantly different)	
Obs	7,008	6,952
Adj-R2	0.1198	0.1266
F value	24.25	26.19

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 13,960 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Singh and Sultanna (2021). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

3.7.10 Stickiness measure by Xue and Hong (2016)

Although Xue and Hong (2016) follow Anderson et al.'s (2003) literature on measuring stickiness, they use *CAPR* (Capital intensity) and *TOBQ* (Growth rate) as control variables in a logarithmic model to measure expense stickiness.

Table 37 Descriptive statistic of CAPR and TOBQ

The descriptive statistic of *CAPR and TOBQ* is for a sample of 16,628 firm-year observations from 2,968 firms.

	Obs.	Mean	Standard Deviation	Median	Minimum	Maximum
CAPR	16,628	2.37	3.22	1.88	0.09	289.89
TOBQ	16,628	2.12	1.36	1.68	0.89	9.44

Both column 1 and column 2 in Table 38 show that β2<0 and significant at a 1% level, which indicates that R&D costs are sticky.

Table 38Following Xue and Hong (2016)

	H1	
	1	2
β1ΔLn(IncomeR)	0.631***	0.625***
	(0.018)	(0.018)
β2ΔLn(IncomeR)*D	**-0.261*** **	**-0.158*** **
	(0.038)	(0.060)
β5CAPR*ΔLn(IncomeR)*D		-0.008***
		(0.002)
β6TOBQ*ΔLn(IncomeR)*D		-0.014
		(0.014)
β9CAPR		-0.007***
		(0.002)
β10TOBQ		-0.008**
		(0.004)
Constant	0.255***	0.295***
	(0.048)	(0.050)
Obs	16,628	16,628
Adj-R2	0.1094	0.1109
F value	66.85	60.28

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 16,628 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively.

3.7.11 Using "market capitalization" to scale Return on Assets (ROA)

Following Xue and Hong (2016), we are using earnings changes scaled by total assets to measure earnings management motivation in our baseline model. Alternatively, following Kama and Weiss (2013), we also use changes in annual earnings deflated by market capitalization to measure earnings management motivation (in the original measure annual earnings are deflated by total assets). In the research, Kama and Weiss (2013) argue that firms in the interval (net income scaled by market capitalization) between 0 and 0.01 are motivated to manage earnings. Kama and Weiss (2013) suggest deflating annual earnings by market capitalization of shareholders' equity at prior year end, which is the total number of shares issued multiplied by its closing price. Their rationale is that market capitalization is less subject to manipulation compared to *Total Assets* which is altered as part of earnings management behaviour. E.g. inflating revenues would cause an increase in accounts receivable which is part of *total assets*.

Similar to Kama and Weiss (2013) our findings do not change significantly.

Table 39 Descriptive statistic of Loss

	Obs.	Mean	Standard Deviation	Median	Minimum	Maximum
Loss	16,575	0.27	0.44	0.00	0.00	1.00

Column 3 in Table 40 shows that the value of β_3 is positive and significant. Therefore, we find evidence consistent with our main results.

Table 40 Use "market capitalization" to scale Return on Assets (ROA) for LOSS

	H2
	3
β1ΔLn(IncomeR)	0.596***
	(0.018)
β2ΔLn(IncomeR)*D	-0.351***
	(0.093)
β3ΔLn(IncomeR)*D*Loss	**0.234****
	(0.108)
β5Assets Intensity*ΔLn(IncomeR)*D	-0.000
	(0.030)
β6D_twoyear*ΔLn(IncomeR)*D	-0.051
	(0.071)
β7FCF*ΔLn(IncomeR)*D	-0.653***
	(0.109)
β8Lev*ΔLn(IncomeR)*D	0.137
	(0.131)
β10Loss	-0.015
	(0.011)
β11Assets Intensity	-0.008
	(0.009)
β12D_twoyear	-0.088***
	(0.019)
β13FCF	-0.075*
	(0.040)
β14Lev	0.060**
	(0.027)
Constant	0.275***
	(0.052)
Obs	16,575
Adj-R2	0.1154
F value	53.72

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 16,575 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively.

3.8 Conclusion

This study provides evidence on the R&D cost stickiness prevalent within Chinese companies. The basic R&D cost stickiness model follows Anderson et al. (2003) and suggests the existence of R&D cost stickiness when sales decline; managers retain R&D expenses despite sales decline. Expanding on Anderson et al. (2003), our model shows that the lack of free cash flow plays a strong role in managers' decision to retire R&D costs. During sales declines and decline in free cash flow managers retire more R&D costs and diminish R&D cost stickiness. This finding supports the argument that managers consider R&D not as sunk costs but appreciate the long-term commitment of R&D. However, under cash flow constraints the R&D cost commitments are diminished to free liquidity. Besides evidence on R&D cost stickiness and liquidity, this study examines whether agency considerations of company management (to avoid loss or to avoid earnings decrease in order to meet earning targets) is a determinant of R&D stickiness. Findings show that when operating revenue falls, managers cut R&D costs more aggressively if they are motivated to avoid loss or to avoid profit decrease. The mechanism test further refines our hypothesis and are supportive that governance arrangement further restrain management from earnings management activities to support R&D cost stickiness. Our findings are robust, using an alternative earnings management measurement to turn loss to profit or to control for a different set of fixed effects (individual fixed effects model), or additional variables such as whether the positions of board chair and CEO are occupied by one person that may be correlated with costs stickiness (Chen et al., 2012).In additional analyses, there is strong and robust evidence that managerial ability strengthened the negative relationship between type one agency problem and R&D stickiness. The question of whether capable managers maximize self-interest at the expense of company's interests or whether they add value to the firm by their superior skills is a long-debated topic. Gul et al. (2018) point out that a capable manager serves their self-interests at the expense of shareholders' benefits. In contrast, Haider et al. (2021) find that capable managers are looking for benefits for firms and shareholders. By using Demerjian et al.'s (2012) model to measure managerial ability, we find the negative association between type one agency problems and R&D stickiness is more pronounced for a company with capable managers. This is consistent with the view that each individual presents with different behaviours and this can significantly impact on corporate outcomes (Hambrick &Mason, 1984).

This study contributes to the literature by showing how R&D expenses change when operating revenue decreases as a result of the conflicting interest between agent and principal suggested by agency theory. This paper extends agency theory by providing evidence of managements' motivation to manipulate earnings given managements' relative ability when making R&D expense decisions when the company faces sales revenue declines.

4 Ownership concentration, managerial ability and the asymmetrical behaviour of R&D expenses: Evidence from China

4.1 Abstract

The primary objective of this paper is to examine the associations among ownership concentration, institutional shareholding, managerial ability and management's R&D related resource allocation and cost adjustment decisions in China. Based on 15,267 samples from the Shanghai and Shenzhen Stock Exchanges in China during the period 2010 to 2019, we first find that the increased level of ownership concentration and institutional shareholding leads to higher R&D expense stickiness. Second, higher managerial ability strengthened the impact of ownership concentration on R&D stickiness. The results suggest that the increase in ownership concentration is beneficial to the firm's continued R&D activities and the level of ownership concentration aligns interests between principals and agents so high-ability managers tend to keep on investing in research and development even when sales decrease. High-ability management can use resources more rationally and efficiently to retain R&D stickiness during periods of sales revenue decline when either high ownership concentration or institutional shareholding is present. However, institutional investors do not have a significant impact on R&D expenses. Mechanism test shed further light onto the impact of corporate governance factors such as management shareholding and board size on R&D stickiness. In line with prior literature, institutional investors might be risk adverse and have other priorities. Contributions and limitations are discussed.

4.2 Introduction

Research and Development (R&D) activities are wildly accepted as a major contributor to firms' competitiveness, viability and long-term growth by enhancing the firm's knowledge capital and innovation input (Chan et al., 1990; Dalziel et al., 2011). China has declared innovation as one of the top national priorities and the Chinese government encourages firms to invest in innovation (Fu & Mu, 2014). However, economic growth in the PRC slowed from 6.8% in 2017 to 6.6% in 2018 and growth was predicted to further moderate to 6.3% in 2019 and 6.1% in 2020 (AsianDevelopmentBankInstitute, 2019).

Investment in R&D can help a firm to achieve growth and increase competitive advantage (Kim & Park, 2012), outperform competitors (Geroski et al., 1993), be a driving force of economic performance (Guellec, 2001), and have a long-term effect on value creation and long-term sustainable development (Mazzi et al., 2019). However, R&D activities can be costly, with uncertain future benefits and they rarely result in immediate financial gains to the firm, while they are necessary to improve firms' innovative capabilities. Innovative success also depends on managerial ability which enhances innovative output (e.g., valuable new products) leading to a better pay-off from R&D expenses (Y. Chen et al., 2015).

While R&D can benefit firm's long-term development, it can impair the managers' ability to meet their earnings targets and maximize their compensation. That is, R&D has a high start-up cost, higher riskiness, informational opaqueness and is set for a long-term horizon which brings about uncertainties when evaluating an agent's performance. Besides, shareholders oriented to the short-term undervalue expenses into long-term R&D and innovation. Consequently, managers tend to underinvest in innovation (Manso, 2011). Agency theory predicts that when there is a misalignment of the agent's and principal's interests, the agent choses actions which benefit themselves rather than shareholders (Jensen & Meckling, 1976). This issue is pronounced for R&D given its risky nature and its inherent reliance on tacit knowledge. In general, corporate governance mechanisms can mitigate this principal-agent conflict (Shleifer & Vishny, 1997) and ownership concentration as part of corporate governance can align conflicting interests between agents and principals (Jensen & Meckling, 1976). Institutional and large shareholders are focused on long-term monitoring of managers and force them to engage in R&D expenses to yield long-term innovation.

However, findings about the role of institutional investors to enhance R&D are mixed. Controlling shareholders are the main beneficiary of a company's long-term development (Lee & O'Neill, 2003) and are more highly motivated than minority shareholders to monitor management to prevent self-serving activities. It might serve the interest of controlling shareholders for management to retain R&D costs and sustain R&D activities despite declines in sales to ensure long-term benefits. However, institutional investors, through their sizable equity stakes, may extract private benefits or make decisions to serve their own self-interest that are detrimental to minority shareholders. Large shareholders are more risk averse and this can cause them to distort R&D expenses into risk innovations (Bolton & Von Thadden, 1998). Risk aversion can be related to potential loss of resources through unsuccessful R&D investment. Controlling shareholders may collude with management, rather than simply monitoring management, to maximize their self-interests at the expense of minority shareholder interests (Jensen & Meckling, 1976). Controlling shareholders and management may choose to collude. For example, controlling shareholders may support managers to cut R&D expense to manipulate earnings upwards for short-term benefits when sales decrease; thus, reducing R&D cost stickiness.

Anderson et al. (2003) proposed asymmetric cost behaviour (cost stickiness) which suggests that managers may choose to over- or under-proportionally decrease costs when sales decline.

> *Managers choose resource levels subject to various constraints (e.g., demand conditions, production technology, resource adjustment costs, strength of corporate governance, debt covenants, government regulation), incentives (e.g., performance compensation, earnings targets, ownership type, stakeholder activism), and biases (e.g., overconfidence).*
>
> (Banker et al., 2018, p.190)

Managers will balance the costs of setting resources free when sales go down against acquiring resources when sales go up. An important cost component is R&D cost which is impacted by corporate governance measures. Studies suggest dispersed ownership allows for more innovation because investors can diversify their risk (Philippe Aghion et al., 2013) while concentrated ownership is unwilling to dedicate resources away from traditional business to invest in risky new technologies (Onida, 2004). Conversely, concentrated and stable ownership can exert control and monitor firm's management more tightly by taking a long-term view and maintaining sustained R&D spending. Institutional investors have a fiduciary obligation to maximize long-term value ensuring stable returns through long-term investments such as R&D to secure future profitability. Managers may prefer to maximize short term utility and cut investments in R&D, in contrast to institutional investors who care about both the short-term and long-term returns and are more motivated to invest in R&D. Institutional investors can only hold such power if their ownership stake is sufficient (Minetti et al., 2015a). Additionally, the type of institutional ownership makes a difference. Firms with concentrated share ownership or inside ownership have lower R&D investment compared to firms with a high level of state ownership which spend more on R&D (Zeng & Lin, 2011).

Ownership structure is one factor which influences managers' cost allocation decision (Ting et al., 2020). A corresponding factor is managers' incentives to build empires (Chen, Lu, & , 2012) or to meet earnings targets (Kama & Weiss, 2013). Literature on the impact of ownership concentration on R&D expenses and innovation is limited and mainly focuses on the United States. While there is low ownership concentration in the US, there is a positive correlation between R&D expenses and institutional ownership (Eng & Shackell, 2001). In the presence of institutional investors, managers are less likely to diminish R&D expenses to reverse a decline in earnings (Bushee, 1998). This effect is pronounced for CEOs in US firms with less protection from takeovers (Philippe Aghion et al., 2013). The relatively low ownership concentration in the US does not consider entrenchment of concentrated ownership and large shareholders and the effect on R&D expenses. There is a lack of research as to what extent concentrated ownership as a corporate governance mechanism could influence a company's R&D cost stickiness. Closely related to the function of corporate governance on ownership concentration is managers' capability. Gul et al. (2018) point out that capable managers serve their self-interests at the expense of shareholder benefits. In contrast, Haider et al. (2021) find that capable managers are looking for benefits for firms and shareholders.

This study examines whether the conflicting interests between controlling shareholders and minority shareholders, as well as managerial ability, could trigger R&D cost stickiness. We explore the effect of ownership structure (ownership concentration) on R&D expense decisions through the lens of cost stickiness. We provide evidence that high ownership concentration strengthens the stickiness of R&D costs. Following Anderson et al.'s (2003) asymmetric model of SG&A, we examine to what extent ownership structure (ownership concentration) influences the sensitivity of R&D expenses to sales changes, contrasting the

difference between sales increase and sales decrease. Then, the definition of managerial ability is taken from Demerjian et al. (2012) and we investigate how managerial ability may impact on R&D cost stickiness. Using a sample of 15,267 firm-year observations from 2,803 firms listed at Chinese stock markets over the period 2010 to 2019, we find that the level of R&D expense decreases less during periods with sales decrease than it rises during periods with increasing sales. We also found that the level of stickiness increases with the level of ownership concentration; managers will keep on investing in R&D when ownership concentration is increasing.

Furthermore, we find that higher managerial ability strengthens the positive relationship between ownership concentration and R&D stickiness. That is, ownership concentration leads to capable managers retaining R&D expenses even when their company is facing sales decline. The question of whether higher managerial ability strengthens the level of R&D expenses stickiness is still being debated and results from prior literature are inconclusive. We provide evidence that managerial ability further strengthens the positive relationship between ownership concentration and R&D stickiness. Therefore, companies with capable managers will retain R&D expenses when the level of ownership concentration is increasing, which is consistent with the view that ownership concentration plays a significant role in aligning conflicting interests between agents and principals (Jensen & Meckling, 1976). In a similar vein, controlling shareholders are more motivated than minority shareholders to monitor management to prevent their self-serving, short-term activities which imply a reduction in R&D costs. This effect is pronounced for capable managers who are more rational in their resource allocation to mitigate controlling shareholders' risk-aversion. Therefore, controlling shareholders effectively monitor the agent, while capable managers are further contributing to company's long-term development to retain R&D expenses even though their company is facing declining sales revenues.

Our paper contributes to several streams of research. First, this research adds novel evidence to the debate on whether controlling shareholders serve their self-interest at the expense of minority shareholders' interest by negatively impacting the R&D expense decision in the setting of cost stickiness. Secondly, this research extends the scope of agency theory by examining the effect of principal-principal conflicts of interests on R&D expense allocation during sales revenue decline, whereas existing research has only considered cost stickiness in the light of principal-agent problems. Thirdly, this research also contributes to cost stickiness literature by examining managers' myopic activities. Different from SG&A stickiness research, which only focuses on how managers efficiently allocate SG&A resources when sales decrease, this research considers managers' myopic activities during sales revenue decline through the lens of R&D expense stickiness. R&D as a predecessor of innovation and success is an essential resource for long-term success. Lastly, in China innovation is becoming one of the top national priorities and firms are encouraged by the Chinese Government to invest in innovation (Chen et al., 2014). What factors could influence company innovation?

This research adds evidence to the debate from the angle of conflicts of interest between principals and principals (type two agency problem). This research could be useful to policy makers, company management teams and company shareholders.

The remainder of this paper is organized as follows. Section 4.3 describes the literature review and hypothesis development. Section 4.4 explains research design. Section 4.5 provides descriptive statistics and research results. Section 4.6 contains the mechanism tests. Section 4.7 reports the robustness tests and section 4.8 concludes.

4.3 Literature review

4.3.1 The impact of controlling shareholder on company decision

Controlling shareholders play an important role in company's decision making. Existing research has explored a series of attributes of controlling shareholders that may affect decision making.

There is no doubt that controlling shareholders would want to decide on whether dividends are paid; and if dividends are being paid, how quickly and how much. Cash dividends is a more direct way of realizing profit gain for shareholders, one does not need to sell the shares in order to realize the monetary gain. Thus, arguably, cash dividends are of better value to minority shareholders, while controlling shareholders might instead prefer to hold off paying cash dividends and retain value within firms. Though of course, whether who prefers what are determined by many things, such as the time preferences of the particular shareholders, and the transaction costs of buying and selling shares. Given these considerations, conflicting evidence had been reported in the literature, with the existence of controlling shareholders leading to more cash dividends being paid (Easterbrook, 1984; Fluck, 1998, 1999) in coexistence with those that reported otherwise (Easterbrook, 1984; Jiang et al., 2017).

Share pledging, however, introduce more complications to this relationship. Based on Chinese data, Xu and Huang (2021) and Li et al. (2020) find that the presence of controlling shareholders who had share pledged led to lower cash dividends. Similar evidence had been reported in terms of the magnitude of share pledging. Again, based on Chinese data, Liu et al. (2014) find that a reduction in the largest shareholder's ownership leads to a reduction in cash dividends, because the controlling shareholders would prefer to retain value in the companies rather than pay out dividends to those whom the shares had been pledged to.

Controlling shareholders would have a say on how much risks a firm takes on. Controlling shareholders are the key decision-makers in the company, so they are responsible for evaluating debt default risk based on the changing economic environment. Taking the listed companies that publicly issue bonds in the Chinese bond market as a research sample, Wang et al. (2022) find that controlling shareholders tend to know the debt default risk of the company. Using a sample of banks, Shehzad et al. (2010) find that ownership concentration

reduces bank riskiness, using non-performing loans and capital adequacy as indicators of riskiness. More specifically, they find that ownership concentration significantly reduces a bank's non-performing loans ratio and improves the capital adequacy ratio, which shows that ownership concentration matters when a bank assesses riskiness. However, based on the unique Chinese data about controlling shareholders in Chinese listed firms from 2003 to 2020 whose shareholdings have been judicially frozen, Li and Sun (2023) find that there is a positive correlation between the credit risk of the controlling shareholder and the credit risk of the firm in subsequent quarters.

4.3.2 Costs and benefits of controlling shareholders

Concentrated ownership has both positive and negative effects according to agency theory. Ownership concentration mitigates type one agency problems (there are conflicts of interest between principal and agent) (Anderson & Reeb, 2003; Davis et al., 1997). Because controlling shareholders have invested the majority of their wealth in a single firm, they have a strong incentive to monitor management. Shleifer and Vishny (1986) argue that ownership concentration enhances the monitoring of management, so ownership concentration can align the interests of managers with shareholders; however, ownership concentration leads to type two agency problems (there are conflicting interests between controlling shareholders and minority shareholders) (Burkart et al., 2003). Controlling shareholders extract private benefits from minority shareholders through "tunnelling".

Exacerbating effect of controlling shareholders on type two agency problem:

Controlling shareholders can mitigate type one agency problems between managers (agents) and shareholders (principles) but controlling shareholders can also pursue interests at the expense of minority shareholders (Burkart, Gromb, & Panunzi, 1997; Grossman & Hart, 1980; Shleifer & Vishny, 1986). Shleifer and Vishny (1997) point out that controlling shareholders expropriate minority shareholders in different forms, from outright theft of corporate assets to self-serving financial transactions.

Using 88 publicly traded Chinese firms that issued loan guarantees to their controlling block holders as an example, Berkman et al. (2009) find that firms which issued loan guarantees to their controlling blockholders have significantly lower firm value and significantly higher leverage. The research shows that controlling shareholders use loan guarantees to expropriate wealth from minority shareholders.

Controlling shareholders have an incentive to issue overpriced shares because although the issuance of overpriced shares leads to smaller fractions of future dividends to controlling shareholders, these dividends are of higher value. Larrain and Urzua (2013) find that the issue of overpriced shares predicts poor future returns. More specifically, minority shareholders who buy overpriced shares lose on average 20% in a year compared to investing in non-issuers. Controlling shareholders issue overpriced shares to expropriate wealth from minority shareholders.

Entrenched controlling shareholders tends to opportunistically utilize related-party transactions to expropriate wealth from minority shareholders (Shen et al., 2023). Considering non-financial acquiring firms listed on the Korean Security Exchange between 1981 and 1997, Bae et al. (2002) find that controlling shareholders transfer wealth from biding firms to the other firms within the group by having the firm performing well in the group merge with firms performing poorly within the group. They find that the acquisition announcement negatively influences firm value to the bidding firm but adds value to the rest of firms within the group. Using 375 publicly listed firms with connected transactions from 1998, 1999, and 2000 in Hong Kong as examples, Cheung et al. (2006) find that connected transactions are associated with significantly lower returns and the abnormal returns are negatively related to the percentage ownership of the main shareholder. Related-party transaction has been adopted by controlling shareholders to expropriate wealth from minority shareholders.

Using a sample of European commercial banks over the period 2004-2009, Bouvatier et al. (2014) find that banks with more concentrated ownership use discretionary loan loss provisions to smooth their income, but they do not find income smoothing behaviour with low levels of ownership concentration. The finding shows that controlling shareholders manipulate earnings for their self-interest, which leads to interference by other stakeholders (minority shareholders, debtholders and regulators).

Using Indian data to measure the extent of tunnelling activities, Bertrand et al. (2002) find that controlling shareholders expropriate minority shareholders by transferring resources from firms where they carry a low level of cash flow rights to firms where controlling shareholders carry high a level of cash flow rights by manipulating non-operating components of profits.

Tunnelling is usually achieved through collusion between controlling shareholders and executives. Both Wang and Xiao (2011) and Zhang et al. (2014) hypothesise and find that controlling shareholders' tunnelling activities reduces the sensitivity between company performance and executive compensation because the strong association between company performance and executive compensation strengthened executives' incentive to improve company performance and decreased executives' willingness to collude with controlling shareholders.

Examining Korean merger activity during the 1981 to 1997 period, Bae et al. (2002) find that merging a member firm which is doing poorly within a group is bad news for the minority shareholders because the merge announcement is negatively related to the bidder announcement returns so the minority shareholders of the bidding firm within a group make an acquisition loss, while it is a good news for owner managers because they find that the acquisition enhances of the value of other firms in the group. That is, controlling shareholders transfer wealth from the bidding firm to the other firms in the group. The research shows that controlling shareholders expropriate minority shareholders for self-interests.

Mitigating effect of controlling shareholders on type one agency problem:

Controlling shareholders have both the incentive and ability to monitor managers. The incentive to monitor managers comes from the fact that controlling shareholders invest an important part of their wealth in the firm, so they are more sensitive to changes in firm performance than other investors. Controlling shareholders are able to monitor managers because they are in a better position than others to do so. Controlling shareholders to some extent take part in a firm's daily operations because they are in a position to hire or fire top managers if they deem it necessary. Managers will only act in the interests of controlling shareholders because controlling shareholders can elect their representatives to the board of directors who will appoint managers. The type one agency problem that there are conflicts of interest between managers and shareholders can be minimized by the controlling shareholders. In a concentrated ownership structure, CEOs or general managers are responsible for the implementation of firm decisions that are always made by controlling shareholders.

Controlling shareholders are looking for the firm's long-term development, however, it is not enough that only controlling shareholders focus on long run value. Controlling shareholders must induce managers of the firm to act in a way that maximizes long run values. At this time, controlling shareholder's interests are aligned with the manager's interests. Controlling shareholders can eliminate the conflict of interest between mangers and shareholders by paying close attention to ensure that managers focus on the company's long run value. Using Korean data from 2001 to 2011, Kang et al. (2017) find that the conflicts of interest between managers and shareholders is handled well by controlling shareholders because they find that controlling shareholders have greater explanatory power over long term development (measured by Tobin's Q) than short term profits (measured by EBITDA). Both controlling shareholders and managers maximise the firm's long-run value.

Despite the increasing importance of controlling shareholders, it remains disputable whether they are playing "tunnelling" roles or "governance" roles. The question of whether controlling shareholders add value to firms or transfer wealth from firms for the benefit of themselves has long been argued. Khanna and Palepu (1997, 2000) claims that controlling shareholders add value to their member firms. In contrast, Johnson (2000) states that controlling shareholders have a strong incentive to transfer wealth from the firm for their self-interests. Holderness and Sheehan (1988) find that ownership concentration (family firm) affects firm performance less than in a company with a lower level of ownership concentration (nonfamily firms). However, Anderson and Reeb (2003) find that there is a positive relationship between ownership concentration and firm performance. Using data from Indian corporations, Li and Sun (2023) find that controlling shareholders are negatively associated with firm performance (measured by Tobin's Q). The findings are consistent with Burkart et al. (1997) but contrast with Anderson and Reeb (2003) in the US context. Due to the arguable role played by the controlling shareholder, this research will test how ownership concentration influences a company's R&D investment decision when the company is

experiencing downturn.

4.3.3 Ownership-concentration and R&D cost stickiness

The allocation of R&D expenses relies on managers' tacit knowledge and is risky in its nature with uncertain outcomes. Information asymmetry exists between managers and shareholders – managers are more knowledgeable on whether the pre-existing R&D expense allocation is worthwhile and how R&D activities should be managed to maximize a firm's long-run financial performance (Greenwald & Stiglitz, 1990). Although it has been argued that remuneration schemes that align principals' and agents' preferences can be designed (Mirrlees, 1999), there is still tacit knowledge and a degree of uncertainty involved in R&D expenditure which makes it difficult for managers to inform shareholders about potential future benefits. From a shareholder perspective and especially for minority shareholders, it is difficult to grasp the features of R&D expenses and their potential, long-term implications for future performance. One may argue that the manager is employed to manage the firm precisely because they are better at doing so than the principals, thus the managers have expert knowledge (Sharma, 1997). However, the short-term implications of R&D expenditure, especially on the firm's profitability, are highly visible and a concern to shareholders which has implications for firm governance. First, in the short-run R&D expense allocation can hardly be linked to managers' performance assessment but rather to financial performance. Secondly, information asymmetry about the features of R&D expenses and the implication for future performance means that shareholders might prefer short-term gains over long-term R&D expenses with uncertain outcomes. Additionally, self-interested managers consider their personal utility when they adjust resources committed to activities, such as R&D costs, not only the value of the firm (Cohen et al., 2008; Roychowdhury, 2006a). Managers who are under pressure to meet earning targets to avoid losses or profit declines, accelerate cuts of slack resources to reduce cost and to allow managers to meet their earnings targets while moderating the degree of cost stickiness (Kama & Weiss, 2013). Another agency conflict is managerial 'empire building'. That is, managers grow the firm beyond its optimal size or retain slack resources with the intention of enhancing their personal utility from either status, prestige, compensation or power (Hope & Thomas, 2008; Jensen, 1986; Masulis et al., 2007; Stulz, 1990).

Concentrated ownership efficiently prevents agency problems (Claessens & Djankov, 1999; Shleifer & Vishny, 1997) and monitors R&D activities (Belloc, 2012). Institutional investors have the capacity to supervise and to influence management's R&D decision; contrary to small shareholders who do not have the resources necessary to monitor management, nor would profit in doing so.

Corporate governance could influence "stickiness". Chen et al. (2012) find that corporate governance mitigates the impact of agency problems on the nature and extent of asymmetric cost behaviour. Corporate governance is expected to alleviate agency problems (Shleifer &

Vishny, 1997), which discourages managers from increasing costs excessively in response to sales decrease. Based on samples from 80 listed companies from Egypt, Ibrahim (2016) finds that firms with larger boards, role duality and a higher ratio of non-executives exhibit greater cost asymmetric behaviours than others; firms with higher economic growth and institutional ownership exhibit lower cost stickiness. In a cross-country study, including US, UK, France and Germany, Calleja et al. (2006) find that the level of stickiness appears to be higher in French and German firms than in UK and US firms due to their code-law governance and are historically less subject to market corporate control pressure.

In emerging economies such as China in which ownership is frequently highly concentrated, external governance mechanisms are still in the development phase. In such an environment, conflicts between controlling and minority shareholders are well documented and occur more frequently and to a higher magnitude in firms with a higher degree of ownership concentration (Gul et al., 2010; Young et al., 2008). Most of the literature focuses on how institutional ownership, as part of corporate governance mechanisms, affects firm financial and market performance (Mutlu et al., 2018). Concentrated ownership spurs R&D and innovation activities within firms as these are crucial long-term and increase profitability. Furthermore, concentrated ownership can have positive effects on firm innovation performance (Chang et al., 2006; Mahmood & Mitchell, 2004; Shleifer & Vishny, 1997).

While some studies have shown the role of ownership structures and identity on form' R&D performance (Choi et al., 2011b; Rong et al., 2017), existing research shows mixed results about the relationship between ownership concentration and R&D costs (Table 41).

Table 41 Overview of past literature

This table summarizes authors and their findings in regard to the relationship between ownership concentration and R&D expenses. Relations were found to be either positive or negative.

Author	Ownership concentration and R&D expenses
Baysinger et al. (1991)	Positive relationship
Bogliacino et al. (2013)	Positive relationship
Philoppe Aghion et al. (2013)	Positive relationship
Chio, Lee and Williams (2011)	No relationship
Kim, Kim and Lee (2008)	No relationship
Munari et al. (2010)	Negative relationship
Faccio et al. (2011)	Negative relationship
Wen and Xia (2016)	Negative relationship

Controlling shareholders are the main beneficiary of firm long-term development (Lee & O'Neill, 2003), therefore they will support management to retain R&D costs even when sales

decrease, enhancing R&D cost stickiness. The presence or absence of a controlling shareholder may have a different effect on managers' R&D investment decisions. Due to the separation of ownership and control and information asymmetry between agents and principals, Jensen and Meckling (1976) point out that agents are likely to be self-serving, instead of focusing on shareholder value maximization. In order to meet short-term earnings targets, agents are motivated to look for short-term profit increases at the expense of the company's long-term development. Concentrated ownership could, to some extent, reduce the conflicting interests between agents and principals (Jensen & Meckling, 1976). That is, controlling shareholders have greater incentives than minority shareholders to monitor management to ensure the company's long-term development is maintained, which could limit the myopic activities of agents. Controlling shareholders encourage R&D expenses and innovation, which in turn can increase the firm's innovation performance. These long-term R&D expenses increase firm stability rather than maximizing short-term profit (Chang et al., 2006; Chang & Hong, 2000; Mahmood & Mitchell, 2004; Shleifer & Vishny, 1997). Thus, managers will keep on investing in R&D even when sales revenue decreases because controlling shareholders monitor their myopic activities.

H2. The higher the ownership concentration, the higher the level of R&D stickiness

In contrast, other studies found a negative or insignificant relationship between ownership concentration and R&D activities. Concentrated ownership can diminish private benefits of control, causing expropriation of minority shareholders, and reduced diversification of risk (Barclay & Holderness, 1989; Demsetz & Lehn, 1985)

Additionally, compared to minority shareholders, controlling shareholders are the main risk takers of the R&D activities (Vito, Laurin, & Bozec, 2010). Thus, controlling shareholders may support management decisions to reduce R&D expense when sales decrease, inducing a conflict of interest between controlling and minority shareholders.

Principal-principal conflicts between minority and controlling shareholders may result in differing preferences for resources allocation. The divergence between insider voting rights and cash flow rights, may cause controlling shareholders to align their self-interest with agents at the expense of minority shareholder interests. In that case, controlling shareholders may support managers to diminish R&D expense when sales decrease to meet short-term earnings targets at the expense of the company's long-term development, inducing lower R&D cost stickiness. In this case concentrated ownership will diminish R&D stickiness, serving majority shareholders' short-term interest at the expense of the firm's long-term benefit and minority shareholder interests.

4.3.4 Managerial ability, ownership concentration, and R&D stickiness

The personal characteristics of CEOs have a significant impact on R&D spending. CEO tenure, wealth invested into firm's stocks, and CEOs who have advanced science-related degrees increased R&D. Tenure may indicate that CEOs mould their firm's R&D expenses to

match their own preferences (Barker & Mueller, 2002). Managerial ability is another personal characteristic and is positively associated with innovative output and with a higher number of 'radical' innovations from outside of the firm's knowledge base. This indicates that high-ability managers incur more R&D expenses, because they act more rationally and are capable of better managing the risks and uncertainties associated with R&D. Thus, high-ability management is essential to corporate R&D success (Y. Chen et al., 2015) and helps to overcome R&D related inefficiency in terms of over- and under-location of R&D expenses (Gan, 2019). In line with Anderson et al. (2003), managers consider the trade-off between the cost of retaining slack resources and adjustment costs, and the foregone benefits of successful R&D projects. High-ability managers are associated with higher earnings quality (Demerjian et al., 2013), less financial reporting fraud (Wang, 2007) and higher credit ratings (Cornaggia et al., 2017). These findings support the view that managerial ability improves cost allocation decisions and firm performance.

Existing research shows that managerial ability improves company performance. Barney (1991) states that managers who are deemed 'able' are those who can improve firms' overall economic resource performance by integrating skills including technical skills, human skills and conceptual skills, so managers are able to use their ability to improve firm performance (Demerjian et al., 2013). Following the viewpoint that capable managers are looking for benefits for the firm and shareholders (Haider et al., 2021), capable managers are looking at the company's long-term development. Thus, managers can align their own and shareholder interests as well as meeting minority and majority shareholders' needs that the company will retain R&D expenses even though it is experiencing downturn. Based on the above research, we predict that capable managers add value by retaining R&D projects during periods of decreasing sales by their superior skill.

This chapter shifts in focus from type one agency problem (conflict of interest between managers and shareholders) to type two agency problem (conflict of interest between controlling shareholders and minority shareholders). Following the type one agency problem, there is a conflict of interests between managers and shareholders where managers are looking for their self-interest at the expense of shareholders' interests. However, existing research shows that controlling shareholders can mitigate type one agency problem and managers will only act in the interests of controlling shareholders (Kang et al., 2017).

What are the controlling shareholders' interests in terms of R&D investment decision when the company is in downturn? Existing research shows different views on whether a controlling shareholder will continue to invest in R&D when the company is in a downturn. Controlling shareholders are the main risk taker when R&D investment fails. Therefore, following type two agency problem, there is a conflict of interest between controlling shareholders and minority shareholders. Controlling shareholders have no incentive to take the risk of R&D failure, so they will sacrifice the company's long-term development and cut R&D when the company is in downturn, which expropriates wealth from minority shareholders. However, controlling

shareholders also get the most of benefits from R&D investment success because of the ownership structure. Therefore, controlling shareholders will have a strong motivation to take the risk that R&D may fail, so they will make the decision to keep on doing R&D investment when the company is in downturn. We expect that high-ability managers could increase the positive effect of ownership concentration and R&D stickiness for the following two reasons. First, the conflict of interests between managers and shareholders are well monitored by controlling shareholders. Both managers and high-ability managers are acting in the controlling shareholders' best interests. Second, because controlling shareholders are taking most of the benefits from R&D investment decisions, controlling shareholders have a strong motivation to take the risk to continue with R&D even when the company is in downturn. Thus, ownership concentration could align the conflict of interest between managers and shareholders so ownership concentration will lead to increased R&D stickiness and capable managers with unique skills will increase the positive relationship between ownership concentration and R&D stickiness.

H3. Managerial ability strengthens the positive relationship between the level of ownership concentration and the level of R&D expenditure stickiness

In contrast, capable managers may maximize their self-interest at the expense of shareholder benefit (Gul et al., 2018). Handfield-Jones et al. (2001) reported that higher ability managers only temporarily improve 'book' performance. Managers driven by myopic motivation will maximize short-term profits and will have no motivation to align the conflicting interests of controlling and minority shareholders. Therefore, managers cut R&D expenses (over-)proportionally when the company experiences sales revenue declines resulting in diminishing R&D cost stickiness.

4.3.5 Institutional investors and R&D cost stickiness

A blockholder owns a large proportion of a firm's shares or bonds. Over recent decades, blockholders have become very powerful institutional investors. Their monitoring power to discipline and influence firm management has not just a positive effect on financial performance but also on strategic direction in general including R&D and product development (David et al., 2001; Del Guercio & Hawkins, 1999; Grossman & Hart, 1980; Tihanyi et al., 2003). The monitoring power of institutional investors can help to reduce dysfunctional and adverse behaviour of management and consequently can reduce agency costs. Institutional investors with their large shareholding not only have the opportunity to monitor and discipline management but also are strongly motivated as there is more at stake for them. For this reason, they pressure management to focus on firm performance. The extensive role of institutional investors' type (commercial banks, insurance companies, mutual and hedge fund and venture capital) and institutional investors' activism (forced CEO turnover, corporate governance proposals, and the direct selling of shares) is well documented (Gillan & Starks, 2000). Institutional investors can also alleviate the risk of managements'

adverse career concerns associated with the unknown outcome and financial effects of R&D activities by incentivizing innovation (Philippe Aghion et al., 2013). In emerging markets such as China, banks and their associated investment firms take an essential role as institutional investors. The four major banks in China are state owned with the major aim of ensuring social welfare instead of profit maximization (Jin et al., 2022), underpinning the cooperation and relationship between these institutional investors and the government. In a similar vein, institutional investors function as coordinator among various stakeholders such as boards of directors, the government, employees, and suppliers. Institutional investor involvement is further deepened by having a major shareholding in the firm while being a key figure in the national economy with close alignment to government at all levels. Consequently, institutional investors put pressure on the firm's long-term vision of pursuing social welfare, instead of short-term profit maximization (Chang et al., 2006). Furthermore, institutional investors reinforce their goals by closely monitoring firms for changes in corporate governance and firm performance. They will not dispose of their shares when the firm experiences temporary lower performance as they have better information about the firms' actual situation and are often major creditors too. Research documents the positive role of institutional investors on firm's R&D investment behaviour (Bushee, 1998; Opler & Sokobin, 1995). Therefore, institutional investors as monitors, coordinators, and financial resource providers for innovation reduce agency costs and enhance firms' stability and competitiveness. We propose that institutional investors retain R&D expenses when sales decline, imposing R&D expense stickiness.

H4. The higher the institutional ownership, the higher the level of R&D stickiness

If H4 is not supported, it can be explained by Shleifer and Vishny (1986) who found evidence that blockholders' wealth is often tied up within the firm, without the opportunity to diversify risk. As a result, institutional investors become risk averse. R&D expenses have unknown economic benefits, leading to irreversible adverse effects, thus increasing the riskiness for institutional investors' blockholding (Kothari et al., 2002; Oriani & Sobrero, 2008). Therefore, risk averse institutional investors will diminish R&D stickiness when firms face sales revenue declines.

4.4 Methodology / Data:

4.4.1 Sample selection

Our initial sample consists of all publicly listed firms that have A-shares traded on the Shanghai and Shenzhen Stock Exchanges from 2010 to 2019. The sample period starts in 2010 because data from the 2009 financial crisis could influence our research. During the 2007 to 2009 crisis, low-ability managers cut R&D by 25% and high-ability managers only cut R&D by 14.8% (Yung & Nguyen, 2020). Following Anderson, Banker and Janakiraman (2003), we drop invalid observations that have missing or non-positive values for sales,

SG&A costs, administration costs and R&D costs. Furthermore, we dropped 712 observations from financial companies. To reduce the impact of outliers, we also winsorise 1% extreme values on each tail for all regression variables. All data is obtained from the CSMAR database, and Wind database and the Stata16 was used for the data analysis.

We start with 51,884 firm-year observations that are traded on the Shanghai and Shenzhen Stock Exchanges. We drop six observations that R&D investment was higher than operating revenue. We delete 712 observations from listed companies in the financial industry. We also delete 1,167 firm-year observations of B-share companies; the difference between A-share and B-share is that A-share are listed on domestic exchanges and trade in RMB, while B-shares are only held by foreign entities and foreign individuals. We further delete 34,732 observations because of insufficient data on financial statements. The final sample consists of 15,267 observations. Table 42 provides the details of our sample selection procedure.

Table 42 Sample selection

Process	*Firm-year observation*
Number of firm-year observations that are traded on the Shanghai and Shenzhen Stock Exchanges from 2010-2019	51,884
Removed observations for the following reasons:	
R&D investment higher than operating revenue	6
Financial industry listed companies	712
B-share companies	1,167
Missing financial statement data	34,732
Number of firm-years in the full sample	15,267

4.4.2 Ownership concentration measurement

Following Balsmeier and Czarnitzki (2017) and Iturriage and Lopez-Millan (2016), we compute the ownership concentration using the square of percentage ownership of the five largest shareholders.

*Ownership concentration=**Top1^2+Top2^2+Top3^2+Top4^2+Top5^2**.*

We also use the square of percentage ownership of the three largest shareholders,

*Ownership concentration=**Top1^2+Top2^2+Top3^2***

and the square of percentage ownership of each firm's largest shareholder to measure ownership concentration as a robustness check.

*Ownership concentration=**Top1^2***

In order to test the power of the shareholder with highest shareholding relative to the next (Top2 to Top5) shareholders we construct the following ratio (Kang & Kim, 2012):

$$Percentagetop1 = \frac{\boldsymbol{Percentagetop1_{i,t}}}{\boldsymbol{Sum\ of\ Percentagetop2\ to\ 5_{i,t}}}$$

If the ratio is bigger than 1, the shareholder with the highest shares has in sum more shares than the next four shareholders and can more easily make decisions. In order to control the absolute size of the top1 shareholder's blockholding, we divided the sample into percentagetop1 0-20% (investment) and 20-50% (significant influence); larger than 50% was omitted due to assumed control by the top shareholder.

4.4.3 Institutional shareholding measurement

The definition of institutional investor shareholding follows (Chang & Hong, 2000; David et al., 2006) and is defined as the proportion of shares held by "domestic non-bank financial institutions, including securities firms, trust and investment companies, finance and insurance companies, and mutual funds" of firm's total shares (Choi et al., 2011b, p. 446, p. 446).

$$Institutional\ Investor\ Shareholding = \frac{\boldsymbol{Institutional\ Shareholding_{i,t}}}{\boldsymbol{Total\ Shares_{i,t}}}$$

The residual from the estimation of the Tobit regression model above is the main measure of managerial ability (MA) in this research. All variable definitions are presented in the Appendix 1.

4.5 Empirical models and results

4.5.1 Data description

Table 43 reports descriptive statistics of the main variables used in the research. There are 15,267 observations. The mean (p50) log-changes in R&D expenses are 0.200 (median = 0.140). The log-changes in R&D expenses are higher than sales revenues, which shows that R&D expenses are increasing at a faster rate than operating revenue. One concern about examining R&D stickiness is whether R&D expenses and operating revenue variables have enough variation. The standard deviations of R&D expenses and operating revenues are 0.63 and 0.32 respectively, significantly larger than their means 0.2 (0.13), which shows that those two variables have sufficiently large variations. The mean (p50) values of ownership concentration (Concern) are 0.16 (0.13) and the standard deviation is 0.11. In 11% of the observations, operating revenue decreases from year t-2 to year t. The average leverage is 42% (median=41%). The mean value of MA Score is -0.02 with a standard deviation of 0.140.

These sample characteristics are comparable to a study by Bu, Wen and Banker (2015) on Chinese based cost stickiness.

Table 43 Data description

Variable	N	mean	SD	min	p50	Max
ΔLnCostR&D	15,267	0.200	0.630	-6.230	0.140	10.56
ΔLnIncome	15,267	0.130	0.320	-2.750	0.110	5.530
D twoyear	15,267	0.110	0.320	0	0	1
Lev	15,267	0.420	0.200	0.050	0.410	0.940
FCF	15,267	0.010	0.110	-2.010	0.020	2.780
Nature	15,267	0.660	0.480	0	1	1
MA Score	15,267	-0.020	0.140	-0.320	-0.040	0.440
REM	15,267	0.140	0.140	0	0.100	0.840
Concern	15,267	0.160	0.110	0.010	0.130	0.570
Assets	15,267	0.640	0.600	-2.430	0.630	4.390
Da	15,267	0.010	0.090	-0.330	0.010	0.350

There are 15,267 observations which will be used in the research; The p50 is the 50th percentile (median).

4.5.2 Ownership concentration and R&D cost stickiness

Under Models 1 and 2 (see Table 7 in Chapter 3) R&D expenses grown with sales increase, but fall at a lower rate with sales decrease. For example, in Model 2, the spending in R&D grown at the rate of a 0.599% in response to a 1% increase in sales. But when sales are falling, the corresponding adjustments in R&D expenses for 1% decrease in sales was 0.280% (0.599%($\widehat{\beta_1}$) - 0.319%($\widehat{\beta_2}$)) fall in R&D.

Model 3 tests Hypothesis 2, that is, the higher level of ownership concentration the higher level of R&D expenditure stickiness. The model allows measurement of the response of R&D expenses on changes in firm revenues given ownership concentration (*concern*) in year t. This is achieved through the interaction variables, *D (Decrease_Dummy$_{i,t}$)* and *Concern*. *Concern* is equal to the ownership concentration as calculated in Section 4.4.2; whereas *D (Decrease_Dummy$_{i,t}$)* equals to one when the firm experienced a sales decline from period t-1 to period t.

For each 1% increase in sales, the R&D expense increase at a rate of 0.612%, and this impact is significant at less than 1%. Concentration is found to lead to lower R&D expenses, with the coefficient at -0.093 and significant at 10%.

When sales are falling AND there is ownership concentration,a negative coefficient on the Concern interaction term (β_3) would indicate a greater degree of cost asymmetry, the coefficient on the Concern interaction term is significantly negative at the 5 percent level with a two-tailed test (coefficient=**-0.870,**t=0.399), suggesting that when sales fell the reduction in R&D costs was even lower amongst firms with higher ownership concentration (Table 44).

Table 44 Results: Ownership concentration level of R&D stickiness

Model 3:

$$\Delta ln(\text{Costs R\&D}) = \beta_0 + \beta_1 * \Delta ln(\text{IncomeR}) + \beta_2 * \Delta ln(\text{IncomeR}) * D + \beta_3 * \Delta ln(\text{IncomeR}) * D * Concern + \beta_5 * FCF * \Delta ln(\text{IncomeR}) * D + \beta_6 * Asset\ intensity * \Delta ln(\text{IncomeR}) * D + \beta_7 * D_{twoyear} * \Delta ln(\text{IncomeR}) * D + \beta_8 * Lev * \Delta ln(\text{IncomeR}) * D + \beta_9 * da * \Delta ln(\text{IncomeR}) * D + \beta_{10} * REM * \Delta ln(\text{IncomeR}) * D + \beta_{11} * Nature * \Delta ln(\text{IncomeR}) * D + \beta_{13} * Concern + \beta_{14} * Asset\ intenstiy + \beta_{15} * D_{twoyear} + \beta_{16} * FCF + \beta_{17} * Lev + \beta_{18} * da + \beta_{19} * REN + \beta_{20} * Nature + Industry\ dummies + Year\ dummies + \varepsilon$$

	H2
β1ΔLn(IncomeR)	0.612***
	(0.020)
β2ΔLn(IncomeR)*D	-0.345**
	(0.149)
β3ΔLn(IncomeR)*D***Concern**	**-0.870****
	(0.399)
β5Assets Intensity*ΔLn(IncomeR)*D	-0.104**
	(0.047)
β6D_twoyear*ΔLn(IncomeR)*D	0.120
	(0.085)
β7FCF*ΔLn(IncomeR)*D	-0.439**
	(0.180)
β8Lev*ΔLn(IncomeR)*D	0.333**
	(0.161)
β9da*ΔLn(IncomeR)*D	0.790***
	(0.298)
β10REM*ΔLn(IncomeR)*D	0.066
	(0.263)
β11Nature*ΔLn(IncomeR)*D	0.114
	(0.087)
β13Concern	-0.093*
	(0.048)
β14Assets Intensity	-0.012
	(0.010)
β15D_twoyear	-0.069***
	(0.021)
β16FCF	-0.163***
	(0.048)
β17Lev	0.079***
	(0.029)
β18da	0.178***
	(0.058)
β19REM	0.058
	(0.037)
β20Nature	-0.034***
	(0.012)
Constant	0.227***
	(0.053)
Obs	15,267
Adj-R2	0.1147
F value	44.96

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model to test to what extent earnings management motivation influences R&D stickiness. The sample period is 2010-2019. The sample consists of 15,267 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. All models include year- and industry- fixed effects. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively.

4.5.2.1 Managerial ability, ownership concentration and R&D cost stickiness

To test H3, we use split-sample regressions, i.e., we estimate model 3 separately for the high managerial ability and low managerial ability samples. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. MA (Managerial_Ability$_{i,t}$) measures managerial ability following the definition of Demerjian et al. (2012). Under this measure, efficiency, calculated based on the input-output combination under variable returns, measures the firm- and manager-specific efficiency. In the second, a Tobit regression by industry including year fixed effects provides a residual which is the estimated value of managerial ability (Table 45). The sample is split to high managerial ability and low managerial ability samples by the 50th percentile. Managerial ability equals 1 when managerial ability is greater than the 50th percentile (which represents high managerial ability) and 0 otherwise. We predict that R&D stickiness will increase with concentration at a higher rate amongst firms with high ability managers than firms with low ability managers.

On testing Hypothesis H3, that is, managerial ability strengthens the positive relationship between the level of ownership concentration and the level of R&D expenditure stickiness, the hypothesis holds if $\beta_3$is smaller in the high ability compared to the low ability group.

Table 45 Descriptive statistic of managerial ability

The descriptive statistic of *Managerial Ability* is for a sample of 15,267 firm-year observations from 2.803 firms in the period 2010-2019 derived following Demerjian et al. (2012). On average managerial ability was -0.02 (median: -0.04, standard deviation: 0.14) with a minimum of -0.32 and maximum of 0.44.

	Obs.	Mean	Standard Deviation	Median	Minimum	Maximum
MA	15,267	-0.02	0.14	-0.04	-0.32	0.44

Table 46 Managerial ability, ownership concentration and R&D expense stickiness

	Low MA	***High MA***
Model	***3***	
β1ΔLn(IncomeR)	0.623***	0.602***
	(0.030)	(0.027)
β2ΔLn(IncomeR)*D	-0.212	-0.704**
	(0.176)	(0.287)
β3ΔLn(IncomeR)*D***Concern**	**-0.566**	**-1.728****
	(0.478)	**(0.748)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.077	-0.017
	(0.058)	(0.091)
β6D_twoyear*ΔLn(IncomeR)*D	0.225**	-0.297*
	(0.099)	(0.173)
β7FCF*ΔLn(IncomeR)*D	-0.678**	-0.369
	(0.271)	(0.258)
β8Lev*ΔLn(IncomeR)*D	-0.008	1.211***
	(0.195)	(0.306)
β9da*ΔLn(IncomeR)*D	0.422	1.462***
	(0.383)	(0.539)
β10REM*ΔLn(IncomeR)*D	-0.230	0.284
	(0.328)	(0.469)
β11Nature*ΔLn(IncomeR)*D	0.008	0.370**
	(0.102)	(0.179)
β13Concern	-0.129*	-0.057
	(0.068)	(0.070)
β14Assets Intensity	-0.007	-0.015
	(0.014)	(0.014)
β15D_twoyear	-0.053**	-0.114***
	(0.025)	(0.036)
β16FCF	-0.173***	-0.164**
	(0.066)	(0.071)
β17Lev	0.061	0.097**
	(0.039)	(0.045)
β18da	0.190**	0.177**
	(0.080)	(0.085)
β19REM	0.066	0.063
	(0.064)	(0.046)
β20Nature	-0.040**	-0.024
	(0.016)	(0.018)
Constant	0.183*	0.226***
	(0.108)	(0.071)
	P=0.092 (Significant difference between groups)	
Obs	8,245	7,022
Adj-R2	0.1167	0.1147
F value	26.32	21.22

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model to test how managerial ability influences the relationship between earnings management motivation and R&D stickiness. The sample period is 2010-2019. The sample consists of 15,267 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

By looking at the two regressions in Table 46, we can compare how controlling shareholders work in conjunction of the ability of the managers in leading to R&D stickiness. First of all, β_1 is larger in the low ability group, showing that the less abled managers would adjust R&D investments more sharply in response to increase in sales. Then we look at β_2 to compare the R&D stickiness in these two groups. This value is insignificant in the low ability group but significant at the high ability group. For the high ability group, the sum of β_1 and β_2 tells us how R&D stickiness looks like in for these firms. Interesting, this value is equal to -0.102 (0.602-0.704), which means that when sales fell the managers actually increase the R&D spending.

Now let us turn to the key result for Hypothesis 3, that is β_3. The value of β_3 in high managerial ability sub-sample is negative (-1.728) and statistically significant at the 5% level and the value of β_3 in low managerial ability sub-sample is negative (-0.566) but not statistically significant. This indicates that capable managers could strengthen the positive relationship between ownership concentration and R&D stickiness. But for the firms manged by less capable managers, higher ownership concentration has no impact to R&D stickiness. The overall difference in the two regressions is statistically significant (P value=0.092).

In contrasts with Choi et al. (2011), who found that ownership concentration does not have a positive impact on innovation (as measured in patents) through their controlling and monitoring role over management, our findings suggested that higher shareholder concentration can actually lower R&D investments. The coefficient for shareholder concentration, β_{13}, is significant and negative for the low ability group but insignificant for the high ability group.

4.5.2.2 Managerial ability, Top 1 ownership concentration relative to Top2-5 ownership concentration and R&D cost stickiness

In this section we explore how dominating the largest shareholder has to be relative to the 2nd to 5th largest shareholders added together, in order to cause any differences in R&D stickiness. We break down the sample by the percentage of shares held by the largest shareholder: 20% or less, larger than 20% but less than 50%.

Regression shown in Table 47restricts the sample to those firms where the largest shareholders held less than 20% of shares. The variable*Percentagetop1*, represents the power of the Top1 (largest) shareholder in relation to the sum of Top2 to Top5 (2nd to 5th largest) shareholders. The results shown that the size of the largest shareholder has no significant impact on R&D expenses (β_{13}) and R&D expense stickiness (β_3) when Top1's shareholding is equal to or less than 20%. The findings suggest that the Top1 shareholder in this blockholder bracket does not have sufficient power to enhance or hamper the firm's R&D activities. Combined with the findings reported in the last section, only the Top5 shareholders taken together have power to retain R&D expenses when the firm is facing sales revenue declines and only when the managers were of high ability.

Table 47 Managerial ability, Top 1 Ownership concentration relative to Top2-5 ownership concentration and R&D cost stickiness when the top 1 shareholder owns 20% or less of firm's total shares

	H3	H4	
	3	3	
		Low MA	High MA
β1ΔLn(IncomeR)	0.482*	0.366	0.737**
	(0.281)	(0.448)	(0.334)
β2ΔLn(IncomeR)*D	-0.274	-0.041	-1.624*
	(0.552)	(0.673)	(0.859)
β3ΔLn(IncomeR)*D* Percentagetop1	**0.044**	**0.089**	**0.248**
	(0.099)	**(0.147)**	**(0.157)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.322**	0.223	-0.826***
	(0.142)	(0.247)	(0.253)
β6D_twoyear*ΔLn(IncomeR)*D	0.140	0.218	-0.242
	(0.202)	(0.205)	(0.481)
β7FCF*ΔLn(IncomeR)*D	-0.422	-2.683	0.560
	(0.677)	(1.735)	(0.946)
β8Lev*ΔLn(IncomeR)*D	0.549	-0.113	3.162***
	(0.658)	(0.935)	(1.090)
β9da*ΔLn(IncomeR)*D	0.733	-2.021	-0.060
	(1.221)	(1.584)	(1.601)
β10REM*ΔLn(IncomeR)*D	-0.557	-2.162**	3.047
	(1.550)	(0.936)	(1.365)
β11Nature*ΔLn(IncomeR)*D	0.538	-0.143	1.073
	(0.489)	(0.655)	(0.897)
β13 Percentagetop1	0.005	0.031	-0.010
	(0.010)	(0.019)	(0.012)
β14Assets Intensity	-0.021	0.015	-0.046
	(0.024)	(0.036)	(0.038)
β15D_twoyear	-0.074	-0.076	-0.110
	(0.047)	(0.056)	(0.085)
β16FCF	-0.245*	-0.571***	0.015
	(0.127)	(0.217)	(0.203)
β17Lev	0.147	0.152	0.213
	(0.099)	(0.130)	(0.148)
β18da	0.150	0.007	0.213
	(0.167)	(0.217)	(0.263)
β19REM	-0.049	0.031	-0.051
	(0.094)	(0.160)	(0.105)
β20Nature	0.014	-0.020	0.043
	(0.050)	(0.065)	(0.084)
β22Percentagetop1 *ΔLn(IncomeR)	-0.033	-0.105	0.012
	(0.055)	(0.108)	(0.064)
β23Assets Intensity*ΔLn(IncomeR)	0.165**	-0.117	0.264***
	(0.081)	(0.192)	(0.096)
β24D_twoyear*ΔLn(IncomeR)	omitted	omitted	omitted
β25FCF*ΔLn(IncomeR)	-0.189	1.242	-0.897
	(0.571)	(1.279)	(0.713)
β26Lev*ΔLn(IncomeR)	-0.094	0.117	-0.296
	(0.326)	(0.651)	(0.359)
β27da*ΔLn(IncomeR)	-0.610	-0.168	-1.227
	(0.700)	(1.101)	(0.980)

	H3	H4	
	3	3	
		Low MA	High MA
β28REM*ΔLn(IncomeR)	0.427	0.696*	0.269
	(0.267)	(0.398)	(0.290)
β29Nature*ΔLn(IncomeR)	-0.156	0.181	-0.406*
	(0.229)	(0.363)	(0.240)
β33D*ΔLn(IncomeR) *ROA	-0.515	0.443	3.159
	(1.100)	(2.730)	(2.057)
β34 ROA*ΔLn(IncomeR)	1.929***	2.104	2.207***
	(0.667)	(2.040)	(0.796)
β35 ROA	-0.008	0.173	0.082
	(0.215)	(0.292)	(0.365)
Constant	0.217	0.028	0.201
	(0.188)	(0.321)	(0.217)
Obs	2,707	1,521	1,186
R2	0.1557	0.1484	0.2478
F value	9.49	5.31	19.82

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model to test to what extent the Top 1 ownership concentration relative to Top2-5 ownership concentration when the Top 1 shareholder owns 20% or less of firm's total shares influences R&D stickiness. The sample period is 2010-2019. The sample consists of 2,707 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

Table 48 illustrates that *Percentagetop1*, the relative power of the Top1 shareholder over Top2 to Top5 shareholder, has no significant impact on R&D expenses and R&D expense stickiness when the largest shareholder held more than 20% but less than 50% of all shares. Similar to Table 47, the findings suggest that the Top1 shareholder in this blockholder bracket does not have sufficient power to reinforce or hamper the firm's R&D activities, despite the Top1 shareholding constituting significant influence. Combined with the above findings, only the Top5 shareholders taken together have sufficient power to retain R&D expenses when the firm is facing sales revenue declines.

Table 48 Managerial ability, Top 1 Ownership concentration relative to Top2-5 ownership concentration and R&D cost stickiness when the top 1 shareholder owns more than 20% and less than 50% of firm's total shares

	H3 3	H4 3	
		Low MA	High MA
β1ΔLn(IncomeR)	0.540***	0.920***	0.395*
	(0.139)	(0.212)	(0.206)
β2ΔLn(IncomeR)*D	-0.453	-0.937***	-0.749
	(0.300)	(0.356)	(0.612)
β3ΔLn(IncomeR)*D*	0.011	0.038	-0.003
Percentagetop1	(0.020)	(0.026)	(0.043)
β5Assets	-0.192	0.046	-0.174
Intensity*ΔLn(IncomeR)*D	(0.148)	(0.199)	(0.333)
β6D_twoyear*ΔLn(IncomeR)*D	0.019	0.155	-0.251
	(0.150)	(0.142)	(0.298)
β7FCF*ΔLn(IncomeR)*D	1.000	-1.312**	3.930**
	(0.910)	(0.665)	(1.564)
β8Lev*ΔLn(IncomeR)*D	0.586	0.970**	1.223
	(0.403)	(0.448)	(1.001)
β9da*ΔLn(IncomeR)*D	0.152	-0.451	1.783
	(1.060)	(1.050)	(1.863)
β10REM*ΔLn(IncomeR)*D	-0.488	-0.111	-1.441
	(0.607)	(0.730)	(1.030)
β11Nature*ΔLn(IncomeR)*D	0.216	0.241	0.660
	(0.222)	(0.230)	(0.492)
β13 Percentagetop1	0.001	0.004	-0.001
	(0.003)	(0.004)	(0.004)
β14Assets Intensity	-0.019	0.030	-0.047*
	(0.019)	(0.027)	(0.028)
β15D_twoyear	-0.061**	-0.052*	-0.078
	(0.030)	(0.027)	(0.057)
β16FCF	0.007	-0.218**	0.296*
	(0.101)	(0.091)	(0.172)
β17Lev	0.141***	0.164***	0.171**
	(0.049)	(0.062)	(0.077)
β18da	0.038	0.050	0.108
	(0.108)	(0.136)	(0.142)
β19REM	-0.107*	-0.036	-0.156**
	(0.062)	(0.113)	(0.071)
β20Nature	-0.015	-0.033	0.023
	(0.021)	(0.026)	(0.034)
β22Percentagetop1 *ΔLn(IncomeR)	-0.019*	-0.030*	-0.020
	(0.012)	(0.018)	(0.015)
β23Assets Intensity*ΔLn(IncomeR)	0.125**	-0.054	-1.804***
	(0.059)	(0.136)	(0.606)
β24D_twoyear*ΔLn(IncomeR)	omitted	omitted	omitted
β25FCF*ΔLn(IncomeR)	-0.817**	0.271	-0.865**
	(0.405)	(0.355)	(0.395)
β26Lev*ΔLn(IncomeR)	0.052	-0.293	0.223
	(0.184)	(0.256)	(0.262)
β27da*ΔLn(IncomeR)	0.359	0.461	0.010
	(0.356)	(0.514)	(0.349)

	H3	H4	
	3	3	
		Low MA	High MA
β28REM*ΔLn(IncomeR)	0.209	0.003	0.389*
	(0.167)	(0.276)	(0.200)
β29Nature*ΔLn(IncomeR)	-0.106	-0.134	-0.147
	(0.101)	(0.128)	(0.154)
β33D*ΔLn(IncomeR) *ROA	0.472	0.575	-0.254
	(1.523)	(1.701)	(2.674)
β34 ROA*ΔLn(IncomeR)	0.512	1.344	0.621
	(0.581)	(1.300)	(0.828)
β35 ROA	0.443***	0.443*	0.461*
	(0.163)	(0.234)	(0.256)
Constant	0.177*	0.104	0.145
	(0.091)	(0.137)	(0.132)
Obs	10,204	5,540	4,664
R2	0.1265	0.1319	0.1434
F value	16.18	10.10	8.14

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model to test to what extent the Top 1 ownership concentration relative to Top2-5 ownership concentration when the Top 1 shareholder owns more than 20% and less than 50% of firm's total shares influences R&D stickiness. The sample period is 2010-2019. The sample consists of 10,204 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

4.5.2.3 Summary

Our findings provide evidence that the blockholding of the five largest shareholders has a significant impact on R&D expenses stickiness when the firm's sales revenues are declining. This finding aligns with the argument put forward by Shleifer and Vishny's (1997), that blockholders have stronger motivation and more channels to monitor and direct the actions of the managers, potentially contributing to higher long-term profitability via stronger R&D stickiness. At the same time, it is necessary for firms to pay minority shareholders stable dividends, given the higher blockholding allows for expropriation by blockholders. Furthermore, blockholding means less shares are freely traded, thus limiting the amount of information that could have been revealed through stock-price fluctuations. This effect is especially pronounced in China as there is less formal governance and minority shareholder protection. This sharpens the agency issue of principal-principal conflicts, that majority shareholders could either bond with management, or extract resources from the firm at the expense of minority shareholders. Faced with such uncertainty, minority shareholders request stable and higher dividends as well as increasing share prices. Consequently, if firms exhaust their ability to manage earnings, management will diminish R&D stickiness in times when sales revenue decline.

Besides the nature of the firms, managerial ability adds an important layer to our understanding of R&D stickiness, as blockholders own the majority of shares but delegate decision making to management, which is the agent. We found that high-ability management does not affect R&D expenses in general, but in times of increasing sales the impact is significant. R&D expenses are retained during periods of sales revenue decline when high ownership concentration is present. High-ability management acts more rationally compared to low-ability management in retaining R&D stickiness when firm sales revenue declines, given high ownership concentration supports the long-term visions. High-ability management has tacit and industry specific knowledge as well as the ability to assess if sales revenue declines will be prolonged before triggering R&D expense cuts. Alternatively, high-ability management can more efficiently convert inputs to production or services into outputs. This ability allows for sustained R&D expenditure during times of sales revenue decline(triggering higher R&D expense stickiness) given high ownership concentration.

Our findings also show that the single Top1 shareholder does not significantly impact on R&D expenses in general during sales revenue increases, or when sales revenues decline. Despite the Top1 blockholder having significant influence under IFRS 3 by holding more than 20% but less than 50% of a firm's shares, compared to the Top2 to Top5 shareholders their power does not significantly impact on R&D stickiness.

4.5.3 Institutional investors, R&D cost stickiness

Model 5 tests the influence of institutional investors' shareholding ($Instshareholding_{i,t}$) on R&D expense allocation. Model 5 measures the response of R&D expenses on changes in firm revenues given institutional investors' shareholding ($Instshareholding_{i,t}$) in year *t* for firm *i*. Under this measure, institutional investors' shareholding is calculated as a ratio of institutional investors' shareholding over the firm's total outstanding shares. The interaction variable *D (Decrease_Dummy*$_{i,t}$*)* combined with the variables *institutional investors' shareholding (Instshareholding*$_{i,t}$*)* allows analysis of the firm's R&D stickiness for this specific group of firms. We expect *institutional investors' shareholding (Instshareholding*$_{i,t}$*)*leads to higher R&D expense stickiness.

Table 49 Descriptive statistic of institutional investors' shareholding

The descriptive statistic of *Institutional Investors' Shareholding* is for a sample of 11,881 firm-year observations of2,093 firms in the period 2010-2019, we followed the definition used by Choi et al., (2011b). On average, 43% of firm's shares were held by institutional shareholders (median: 0.45, standard deviation: 0.25), the figure ranges from 0%to 94%.

	Obs.	Mean	Standard Deviation	Median	Minimum	Maximum
Institutional Investors' Shareholding	11,881	0.43	0.25	0.45	0	0.94

Model 5 enables the impact of Institutional Investors' Shareholding on R&D cost stickiness to be examined (Table 50). The dummy D (Decrease_Dummyi,t) is 1 when the firm faces a sales revenue decline from period t−1 to t, and 0 otherwise. If there is a sales decline, institutional investors' shareholding has a positive and significant impact on R&D expenses (-0.911 ($\widehat{\beta_3}$)), indicating that firms with higher institutional investors' shareholding continue R&D activities despite declining sales.

The results shown under Hypothesis 4, shows how institutional shareholding had influence the level of R&D expenses changed in response to change in sales. The coefficient for the variable ΔLn(IncomeR)*__Instshareholding__ is 0.058, showing that when sales increases, the amount of increase is positively correlated to the percentage of shares held by institutional shareholders. The second variable we should look at, is ΔLn(IncomeR)*D*__Instshareholding__, which has a negative coefficient at -0.911 and it is significant at 1%. This means that when sales were falling, the amount of reduction in R&D is larger when percentage of shares of institutional shareholders is higher. Comparing the size of the two coefficients, we can tell that the impact of institutional shareholder is not the same for sale increases as for decreases. Though higher institutional shareholding is increasing with R&D spending when sales increase, it causes sharper falls in R&D spending when sales decreases.

We regress model 5 with the high managerial ability and low managerial ability sub-samples to examine the impact of managerial ability in conjunction with institutional investor shareholding on R&D cost stickiness (Table 50). Within the high ability manager group, higher institutional investor shareholding is associated with stronger R&D stickiness (β3 is equal to -1.820 and significant at 1%). Whereas within the low ability manager group, no association between institutional shareholding and R&D stickiness can be found. Regression results across these two groups is statistically significant (P value=0.092).

Regression specification for Model 5:

$$
\begin{aligned}
\Delta ln(\text{Costs of R\&D}) = {} & \beta_0 + \beta_1 * \Delta ln(\text{IncomeR}) + \beta_2 * \Delta ln(\text{IncomeR}) * D + \beta_3 * \Delta ln(\text{IncomeR}) * D * Instsharehold \\
& + \boldsymbol{\beta_4} * \Delta \boldsymbol{ln}(\textbf{IncomeR}) * \boldsymbol{D} * \boldsymbol{Instsharehold} + Industry\ dummies + Year\ dummies \\
& + \beta_5 * Assets\ Intensity * \Delta Ln(IncomeR) * D + \beta_6 * D\_twoyear * \Delta Ln(IncomeR) \\
& + \beta_7 * FCF * \Delta Ln(IncomeR) * D + \beta_8 * Lev * \Delta Ln(IncomeR) * D \\
& + \beta_9 * da * \Delta Ln(IncomeR) * D + \beta_{10} * REM * \Delta Ln(IncomeR) * D \\
& + \beta_{11} * Nature * \Delta Ln(IncomeR) * D + \beta_{12} * MA + \beta_{13} * \boldsymbol{Instsharehold} \\
& + \beta_{14} * Asset\ intenstiy + \beta_{15} * D_{twoyear} + \beta_{16} * FCF + \beta_{17} * Lev \\
& + \beta_{18} * da + \beta_{19} * REM + \beta_{20} * Nature + \beta_{22} * \Delta Ln(IncomeR) * \boldsymbol{Instsharehold} \\
& + \beta_{23} * Assets\ Intensity * \Delta Ln(IncomeR) + \beta_{25} * FCF * \Delta Ln(IncomeR) \\
& + \beta_{26} * Lev * \Delta Ln(IncomeR) + \beta_{27} * da * \Delta Ln(IncomeR) + \beta_{28} * REM * \Delta Ln(IncomeR) \\
& + \beta_{29} * Nature * \Delta Ln(IncomeR) + \beta_{33} * D * \Delta Ln(IncomeR) * ROA + \beta_{34} * ROA * \Delta Ln(IncomeR) \\
& + \beta_{35} * ROA + \varepsilon
\end{aligned}
$$

Table 50 Institutional investor shareholding and R&D expense stickiness

	H2	***H3***	
Model	5	5	
		Low MA	High MA
β1ΔLn(IncomeR)	0.359***	0.428**	0.294***
	(0.090)	(0.182)	(0.109)
β2ΔLn(IncomeR)*D	0.199	0.066	0.300
	(0.222)	(0.328)	(0.429)
β3ΔLn(IncomeR)*D***Instshareholding**	**-0.911*** **	**-0.507**	**-1.820*** **
	(0.260)	**(0.340)**	**(0.519)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.233***	-0.066	-0.447***
	(0.067)	(0.096)	(0.127)
β6D_twoyear*ΔLn(IncomeR)*D	-0.042	0.142	-0.316
	(0.095)	(0.113)	(0.228)
β7FCF*ΔLn(IncomeR)*D	-0.534**	-0.734	-0.321
	(0.270)	(0.454)	(0.384)
β8Lev*ΔLn(IncomeR)*D	0.939***	0.760**	1.148**
	(0.263)	(0.368)	(0.504)
β9da*ΔLn(IncomeR)*D	1.296***	1.893***	4.615***
	(0.425)	(0.593)	(0.891)
β10REM*ΔLn(IncomeR)*D	-1.226***	-1.284***	-0.163
	(0.337)	(0.448)	(0.623)
β11Nature*ΔLn(IncomeR)*D	-0.007	-0.223	0.551**
	(0.128)	(0.179)	(0.247)
β13 **Instshareholding**	-0.033	0.021	-0.100**
	(0.030)	(0.043)	(0.044)
β14Assets Intensity	-0.015	0.018	-0.046***
	(0.012)	(0.017)	(0.017)
β15D_twoyear	-0.082***	-0.040	-0.145***
	(0.023)	(0.029)	(0.042)
β16FCF	-0.178***	-0.196**	-0.210**
	(0.062)	(0.088)	(0.091)
β17Lev	0.149***	0.143**	0.150**
	(0.040)	(0.056)	(0.059)
β18da	0.121	0.240**	0.157
	(0.078)	(0.115)	(0.109)
β19REM	-0.136***	-0.104	-0.132**
	(0.048)	(0.072)	(0.066)
β20Nature	-0.035**	-0.038	-0.031
	(0.016)	(0.024)	(0.023)
β22ΔLn(IncomeR)***Instshareholding**	0.058	-0.116	0.232**
	(0.082)	(0.141)	(0.106)
β23Assets Intensity*ΔLn(IncomeR)	0.087***	-0.003	0.136***
	(0.031)	(0.057)	(0.039)

	H2	***H3***	
Model	5	5	
		Low MA	High MA
β24 D_twoyear *ΔLn(IncomeR)	omitted	omitted	omitted
β25FCF*ΔLn(IncomeR)	-0.081	-0.330	0.079
	(0.150)	(0.249)	(0.207)
β26Lev*ΔLn(IncomeR)	-0.053	0.034	-0.053
	(0.116)	(0.207)	(0.146)
β27da*ΔLn(IncomeR)	-0.093	-0.919***	0.067
	(0.147)	(0.295)	(0.173)
β28REM*ΔLn(IncomeR)	0.484***	0.393***	0.481***
	(0.085)	(0.152)	(0.105)
β29Nature*ΔLn(IncomeR)	0.064	0.211**	-0.030
	(0.050)	(0.094)	(0.062)
β33D*ΔLn(IncomeR) *ROA	0.894	1.299	-2.290**
	(0.607)	(0.997)	(1.121)
β34 ROA*ΔLn(IncomeR)	-0.105	0.199	-0.067
	(0.356)	(0.717)	(0.435)
β35 ROA	0.406***	0.372**	0.450**
	(0.129)	(0.183)	(0.197)
Constant	0.216***	0.151	0.261***
	(0.067)	(0.094)	(0.096)
		P=0.039 (Groups are significantly different)	
Obs	11,881	6,454	5,427
Adj-R2	0.1241	0.1199	0.1424
F value	31.61	17.28	17.38

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model to test to what extent institutional investor shareholding influences R&D stickiness. The sample period is 2010-2019. The sample consists of 11,881 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

4.5.3.1 Summary

Institutional investors have the means and incentives to monitor firm management. In Western countries, these two characteristics have led into higher long-term firm performance and reduced agency costs. Additionally, the firm's management (agent) either represents or are themselves the institutional shareholder allowing management to circumvent the board of directors or other traditional monitoring mechanisms. Alongside institutional blockholding comes reduced share liquidity which reduces the information content reflected in share prices

while diminishing the monitoring capacity of capital markets. Consequently, institutional investors' blockholding might reduce firm competitiveness, increase firm costs of capital through higher dividends, and discourage minority shareholder participation (Young et al., 2008).

However, in developing countries corporate governance is structured differently and similar actions may lead to diametrically different outcomes. Institution shareholders in developing countries may not enjoy the same access to low monitoring costs enjoyed by their Western counterparts. It had been reported that institutional investors in China refrain from monitoring or intervening with management's activities, but rather aim for maintaining business relations and they were found to be more risk averse in how they deal with management(Choi et al., 2011b). However, since these earlier findings were published the institutional environment has changed significantly in China. Institutional shareholding has grown over the years while businesses are increasingly demanded to help out with fulfilling macroeconomic targets laid down by political leaders.

For example, the four major Chinese banks are state owned and they are tasked with ensuring social welfare instead of profit maximization (Jin et al., 2022). Businesses have to work with institutional investors to bring government targets to fruition, close collaborations between government and businesses is a feature across all levels of corporate environment (Chang et al., 2006). Therefore, it is no surprise that our findings shows that stronger institutional investors presence tends to strengthen R&D stickiness, and this effect is more pronounced amongst better managed (more profitable) companies.

4.6 Possible mechanism

The main results have shown that higher ownership concentration has led to more R&D stickiness. However, the conduit between these two factors could be further explored. Here, we show how these two things can be related. We explored the insights provided in the literature by considering a range of theoretical arguments, including agency theory and stakeholder theory, on the role of larger shareholders on R&D stickiness and long-term profitability of companies(section 4.6.1-4.6.5).

Table 51: Pearson (Spearman) correlation matrix for variables in the main analysis at the lower (upper) diagonal.

	REM	Concentration	AEM	Management shareholding	Board Size
REM	1	-0.01	0.07*	0.02*	-0.01
Concentration	-0.00	1	0.04*	-0.17*	0.01
AEM	0.07*	0.04*	1	0.04*	0.04*
Management Shareholding	0.01*	-0.09*	0.03*	1	-0.20*
Board Size	-0.01	0.04*	0.04*	-0.21*	1

Notes: The table reports the Pearson (Spearman) correlation coefficients for variables in the main analysis at the lower (upper) diagonal. The sample period is 2010-2019. The sample consists of 11,881 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. * denotes significance at 10% level.

Table 51 above can be summarised as follows: *Real earnings management (REM)* is negatively correlated with *concentration*. This finding is in line with our expectation that higher ownership *concentration* engages less in *Real earnings management* and therefore, also retains R&D expenses instead of sacrificing them to meet profit targets. Yet, to meet profit targets highly concentrated firms engage in more *accruals earnings management (AEM)* indicated by positive correlation between *accruals earnings management* and *concentration*. Dai et al. (2013) supports this finding that relative short-term orient institutional investors exercise less control over management which can lead to more earnings management and lower earning quality. This suggests that investor avoid *Real earnings management* which could diminish R&D while exercising less control over management that to engage in accrual-based earnings management.

Similar supervisory pattern was found for board size. There is a negative correlation between *Real earnings management* and *board size* and positive correlation *accruals earnings management* and *boardsize*. One could interpret these correlations as larger boards discouraging *Real earnings management* and the decline of R&D while larger boards are less effective in supervising the CEO in its attempt to manage earnings upwards. Huang and Wang (2015), based on the Chinese data find that firms with small board size are more likely to engage in accrual earnings management but did not find such association with real earnings management. The positive correlation between *management shareholding* and *accruals earnings management* as well as *management shareholding* and *Real earnings management* indicates that higher management share leads to both forms of earnings management. This finding is in support of the myopic utility maximising assumption about managers. While managers have in relative terms low shareholding this finding is inline with an inverted U-shaped relation between earnings manipulation and management shareholding. Yang et al. (2008)find that discretionary accruals initially increase and then decrease with managerial ownership, like an inverted U-shaped relationship.

The above table also supports prior findings that higher *accruals earnings management* is associated with higher *Real earnings management*. Cohen and Zarowin (2010) find that management engages in both *Real Earnings Management* and *Accrual Earnings Management* when they have earnings management motivations. The negative correlation between concentration and management share is intuitive that firms with high concentration try to exercise their control directly through representation on boards or direct conversations with management instead of setting contracts with try to align management interests to shareholders by incorporating higher management shareholding. In similar vein *management shareholding* is negatively correlated with *board size* indicating that management with shares prefer smaller boards indicating less supervision.

4.6.1 Concentrated ownership positively affects R&D (stickiness) because it favours financial commitments and organizational integration

Owners with substantial shareholding have an increased financial commitment within the firms. That is, owners with large shareholding in the firm keep their participation for a longer period of time because the so called 'Wall Street walk', owners sell their shares if they disagree with executive managements' decisions, is costly as selling large amounts of shares would impact on the share price negatively. Therefore, the 'exit' option is expensive and large shareholders have strong motivation to engage in activism to make their voice heard (Smith, 1996, Pound, 1992). The long-term commitment and participation within the firm allows large shareholders to accumulate knowledge of firm's activities and their monitoring capabilities. As a result, larger shareholders are supportive of R&D activities and could signal managers that they will "forgive" poor short-term performances, if management pursues long-term strategies. Concentrated ownership, therefore, reduces managements' pursuit for short run profits, firm market value at expense of long-term objectives such as R&D projects (Lacetera, 2001).

Managers were found to have applied real earnings management (REM) and accrual earnings management (AEM) in order to avoid being punished by the market for their short-term poor performances. As large shareholder concentrations mean that the managers are less likely to get punished for short-term poor performance, it mitigates the Type One agency problem (Jensen and Merckling, 1976). Managers may therefore carry-on making R&D investments even when the company suffers downturns.

Research has identified various means for large shareholder to influence the actions of management: shareholder activism, buy-and-hold strategy, amongst others (Connelly et al., 2010).

4.6.1.1 Shareholder activism

Shareholder activism is triggered by higher shareholding concentration, the availability of business information from multiple sources, as well as the heightened expertise of institutional shareholders. Large and pressure-resistant owners with long investment horizon

engage in activism (Ryan and Schneider, 2002). Activism can take various forms such as private meetings with managers or media campaigns. Large shareholders or their representatives can meet managers behind the scenes to intervene in firm's decision-making including R&D investments. Also, large shareholders can put forward proposals which is associated with low cost (Sundaramurthy and Lyon, 1998). Other activities to put pressure on senior management are: withholding votes on board members potentially harming the reputation of directors; placing board members to initiate votes on critical decisions (including R&D investments) (Del Guercio et al., 2003).

With the shareholders and managers better connected, the visions for the company would be better aligned between these two groups, plus what they have in mind about what level and kind of R&D activities the company should carry on doing (David et al 2001). Thus, the level of resources dedicated to R&D are less likely to change due to short-term variations in profitability.

4.6.1.2 Buy-and-hold

Large shareholders which follow a buy and hold strategy have an interest for the firm's long-term ability to compete and excel in the market. Such investors can foster more R&D efforts to sustain competitiveness (Hoskisson et al., 2002, Bushee, 1998). Patient capital provided by large shareholders reduces relatively the pressure exerted by transient ownership to achieve monthly, consistent and positive earnings. In contrast to patient capital, transient ownership limits strategic competitive actions or hampers R&D investments that may diminish short-term earnings with long-term potential benefits. In addition, small shareholders with limited resources and information may mimic large shareholder with buy and hold strategy, further enhancing the patient capital effect.

It is argued that companies with a few large shareholders have less share price volatility than companies owned by large number of diversified shareholders (Jankensgård & Vilhelmsson, 2018). The argument goes that, small shareholders tend to have piecemeal information about the company, and the information carried by each shareholders are different. However, with a few large shareholders, information regarding the company is better shared between the shareholders, thus they will tend to hold similar views about the company. With less volatility in share prices, the managers will have less pressure to apply earnings management to responds to rapid changes in share prices.

4.6.2 Concentrated ownership positively affects R&D (stickiness) because it tightens reputation constraints and favours long-term relations

Mayer (1997) emphasized that concentrated shareholding is relatively more committed compared to dispersed shareholding structures because latter can walk away from relations with employees, suppliers, and purchasers while not suffering any adverse effects or costs. Concentrated shareholders, however, cannot sell their shares anonymously while being held accountable for the effect of their actions. These investors often align their interests with the

long-term success of the firm, maintaining and enhancing their returns over an extended period. This alignment fosters a culture of innovation, where investments in R&D can have a long-term horizon.

Furthermore, negative consequences to stakeholder resulting from the disposal of concentrated owners' shares can result in large shareholder's reputational damage. This effect is pronounced for processes which require large involvements and investments by stakeholders such as R&D processes. Therefore, ownership structure can promote commitment and trust. Additionally, the heightened awareness of reputational constraints can promote a culture of innovation, which causes firms to make higher investments in R&D to enhance their long-term image.

These arguments are in line with Tang et al (2020) who suggest that concentrated ownership triggers a more efficient allocation of resources when sales are declining, compared to dispersed ownership which leads to higher R&D cost stickiness as well as decreased stock price crash risk.

4.6.3 Concentrated ownership negatively affects R&D (stickiness) because it exacerbates asymmetric bargaining power problems

A counter argument to the above 4.6.2 section is that concentrated ownership can negatively impact on firm's R&D spending and stickiness. In support of section 4.6.2 shareholder theory in line with agency theory suggests that larger shareholders overcome the issue of dispersed ownership whereas small shareholders do not have incentives and means to thoroughly monitor management while other shareholders might free ride. This free rider issue is overcome by large shareholding, because of the relative advantage in monitoring due to larger resources and power. In contrast stakeholder theory predicts a negative association of concentrated ownership. That is, large shareholders may cause asymmetric bargaining between themselves and other firm's stakeholders. In turn these stakeholders, including management, reduce ex ante their efforts depending on the anticipated extend of ex post opportunistic actions post by concentrated shareholders (Grossman and Hart, 1988; Harris and Raviv, 1988; Aghion and Tirole, 1997; Burkart et al., 1997). This ex-post rent is pronounced for R&D activities, while research itself is a complex, collective, and cumulative process which requires financial, physical, and human capital-specific resources and commitments rendering stakeholders less committed if they expect ex post opportunistic actions.

Another aspect of concentrated ownership hampering R&D relates to the decision making autonomy of managers in firms with large shareholders. Large shareholders have often the authority to decide of firm's strategy without adequate checks and balances. This can lead to a decline in R&D because employees and managers do not have the freedom to follow their creative ideas (Belloc et al., 2016). One reason for large shareholders to be risk adverse and reduce R&D is their fiduciary duty as fund managers. Consequently, such concentrated ownership may prefer near-term, certain earnings over uncertain, long-term returns. Therefore,

such shareholders pressure managers to engage into myopic investment behaviour, which includes reducing R&D expenses that could take years to yield profits. The risk aversion of concentrated ownership will instil managers risk aversion by the former limiting managers incentives to invest in risky and novel R&D (Tian and Wang, 2014, Manso, 2011).

If the stakeholder theory point of view holds, under concentrated ownership the R&D resource allocation is not related to the adjustment costs of R&D, nor management, and its probabilistic view on the development of sales. Therefore, concentrated management can reduce R&D in general. When sales are declining, it will diminish R&D stickiness or even cause anti-stickiness.

4.6.4 Dispersed ownership positively affects innovation because it favours managers' flexibility and specialization

In additional to reasons laid out in 4.6.3, dispersed ownership provides management with higher flexibility to allocate resources for R&D based on adjustment costs and probability of future sales numbers. Thus, arguably concentrated ownership is worse in causing R&D stickiness. Ortega-Argiles et al. (2005) provide evidence that dispersed shareholding supports firm's R&D investment as the former provides greater flexibility to managers to use their specialised knowledge and industry expertise. In contrast, concentrated ownership could interfere with firm's decision-making as part of stronger control over management resulting in less R&D investments. Dispersed ownership and the lack of power and resources to tightly control management provides managers with the flexibility to use their capabilities, absorb outside knowledge to decide on R&D investments. That is, managers have to consider the high specificity and intangibility of R&D project which are associated with high risk of failure and information asymmetries towards outside stakeholders. In regard to specificity and heterogeneity of R&D activities these vary across sector. Management's capabilities are necessary for R&D activities to integrate "human resources (teams of qualified scientists and technicians with experience in R&D and innovative activities), commercial resources (determinants of the reputation and image of a firm in the eyes of its customers) and organisational resources (the efficiency and synergies existing between marketing and R&D, the communication capability within the firm, the managing and organisational excellence, the promoting of the integration of knowledge through teamwork and the fostering of learning from external sources)" (p. 640). Suggesting that management flexibility is essential for managers to successfully engage in R&D. In line with this argument concentrated ownership could have no superior impact on R&D cost stickiness, as dispersed ownership provides better conditions for management to make their R&D resource allocation decisions based on the best of their knowledge.

4.6.5 Concentrated ownership affects R&D (stickiness) according to a nonlinear relationship

Another aspect to take into account is a nonlinear relationship between concentrated ownership and R&D stickiness. The initial argument brought forward by Jensen and Meckling (1976) that shareholders are wealth maximiser with the objective to foster long-term value of shareholding while agents (management) are utility maximiser aimed at advancing personal power, status, security and wealth.

There are empirical observations and propositions which found either disperse or concentrated shareholding supporting R&D: For firms with diffused ownership, shareholders might prefer riskier R&D projects because they can hold more diversified investment portfolio. However, in a situation in which manager are rewarded on short-term performance, large shareholders can be more strategic and patient with focus on long-term benefits of R&D projects (Hoskisson et al., 2002). Finally, concentrated ownership allows collaboration between large shareholder and top management to review managements' actions and to nurture R&D to pursue shareholders' interests in regard to innovation activities.

However, there are also empirical observations and propositions shading light on how shareholders can hamper R&D activities. Concentrated ownership tend to extract private benefits of control from company resources (Dyck & Zingales,2004) causing principal-principal conflicts which can also diminish the resources available for R&D (Su et al., 2007; Young et al., 2008). Controlling shareholders can appoint management who are relatives or acquaintances lowering firms' management ability and or diminishing the supervisory role of the board of directors. Additionally, large shareholder can build corporate structures in which resources are funnelled from the firm to its holding thus advancing personal and political agendas that create no economic and financial value to the company (Chen, Li, &Shapiro, 2011). Principal-principal conflicts are pronounced in emerging markets such as China. These markets are almost absent of stringent internal and external mechanisms to address such conflicts. One of such mechanisms is the threat for potential takeovers if firm's share value falls. Also, the legal protection of minority shareholders based on a developed property-rights regimes is often not or only partially enforced in developing countries, further weakening the position of the minority shareholders. Finally, legal monitoring through (quasi-)government bodies as well as tax compliance enforcement on company-I internal transfers is weakly executed: because property rights are difficult to enforce, small shareholders are confronted with the possibility of expropriation by large shareholders, who frequently control the decisions made at the boardroom through their appointed directors" (Su et al. 2007: 18). That is, large shareholders can direct management to diversify their individual risk associated with blockholding while small shareholders prefer high-risk, high-return innovation projects due to their more diversified portfolio. As a result, large shareholders divert resources for their own benefit at expense of R&D activities (Chenet

al., 2011). Evidence from China showed that ownership concentration has an inverted U-shaped (first positive, then negative) relationship with R&D activities (Chen et al., 2014).

For A-share listed firms in China from 2002 to 2017firms headquartered in regions of high social trust tend to engage in more R&D activities. While there are three mechanisms through which social trust can spur corporate R&D activities. First, social trust is negatively associated with managers' career risk stemming from innovation as there is higher tolerance for failure. Second, social trust helps diminishes financial constraints to allow for more R&D activities. Finally, social trust is a substitute for legal institutions to reduce intellectual property risk. The effect of social trust is stronger for firms with managers who face larger career risk and in firms that are located in less financially developed regions and regions with weaker legal environments(Ding et al., 2023). The above discussion underpins a nonlinear relationship between concentrated ownership and R&D activities within turn could be reflected in managements resource allocation when sales are falling; R&D cost stickiness.

4.6.6 Evidence related to Earnings Management

In table below, the estimated coefficient on β_3 is negative and significant in the groups with low earnings management (Real Earnings Management only (Table 52) but not in Accrual Earnings Management (Table 53)), but insignificant in the groups with high earnings management. Roychowdhury (2006) find that managers prefer real earnings management to accrual earnings management in managing earnings because real earnings management is not easy detected by external governance mechanisms but real earnings management costs firms' long-term value (Achleitner et al., 2014). Overall, results from the table below indicate that ownership concentration can increase R&D stickiness by reducing real earnings management but not the accrual earnings management. The finding consists with view that there is the trade-off relationship between real earnings management and accrual earnings management after tightened corporate governance (Zang, 2012) and high degree of ownership concentration (family firms in Germany) engage less in real earnings management (avoid long-term value damage) and exhibit more in accrual earnings management (Achleitner et al., 2014).

Table 52 R&D cost stickiness for the sample partitioned by high and low Real Earnings Management (REM)(Roychowdhury 2006)

	Low REM	***High REM***
Model	***3***	
β1ΔLn(IncomeR)	0.511***	0.713***
	(0.028)	(0.028)
β2ΔLn(IncomeR)*D	-0.145	-0.464**
	(0.189)	(0.230)
β3ΔLn(IncomeR)*D*Concern	**-0.993****	**-0.867**
	(0.506)	**(0.649)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.176***	-0.074
	(0.062)	(0.070)
β6D_twoyear*ΔLn(IncomeR)*D	0.287**	-0.036
	(0.113)	(0.135)
β7FCF*ΔLn(IncomeR)*D	-0.356	-0.466**
	(0.281)	(0.236)
β8Lev*ΔLn(IncomeR)*D	0.168	0.438*
	(0.228)	(0.226)
β11Nature*ΔLn(IncomeR)*D	0.251**	-0.026
	(0.117)	(0.135)
β13Concern	-0.136**	-0.034
	(0.063)	(0.075)
β14Assets Intensity	-0.028**	0.005
	(0.013)	(0.014)
β15D_twoyear	-0.066**	-0.063*
	(0.026)	(0.035)
β16FCF	-0.045	-0.255***
	(0.066)	(0.070)
β17Lev	0.092**	0.037
	(0.038)	(0.045)
β20Nature	-0.031**	-0.035*
	(0.016)	(0.018)
Constant	0.223***	0.275***
	(0.071)	(0.079)
	P=0.394 (No significant difference between groups)	
Obs	8,748	6,519
Adj-R2	0.0869	0.1519
F value	21.31	29.47

Table 53 R&D cost stickiness for the sample partitioned by high and low Accrual Earnings Management (AEM) (Dechow 1995)

	Low AEM	***High AEM***
Model	*3*	
β1ΔLn(IncomeR)	0.574***	0.656***
	(0.029)	(0.027)
β2ΔLn(IncomeR)*D	-0.372*	-0.278
	(0.210)	(0.207)
β3ΔLn(IncomeR)*D*Concern	**-0.791**	**-0.796**
	(0.553)	**(0.581)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.219***	-0.035
	(0.061)	(0.075)
β6D_twoyear*ΔLn(IncomeR)*D	0.007	0.213*
	(0.119)	(0.128)
β7FCF*ΔLn(IncomeR)*D	0.185	-0.778***
	(0.271)	(0.241)
β8Lev*ΔLn(IncomeR)*D	0.773***	-0.057
	(0.231)	(0.228)
β11Nature*ΔLn(IncomeR)*D	0.126	0.150
	(0.130)	(0.120)
β13Concern	-0.058	-0.118*
	(0.068)	(0.068)
β14Assets Intensity	-0.007	-0.022
	(0.013)	(0.014)
β15D_twoyear	-0.116***	-0.018
	(0.029)	(0.030)
β16FCF	-0.066	-0.229***
	(0.067)	(0.069)
β17Lev	0.131***	0.023
	(0.042)	(0.041)
β20Nature	-0.018	-0.048***
	(0.017)	(0.017)
Constant	0.163**	0.323***
	(0.081)	(0.071)
	P=0.394 (No significant difference between groups)	
Obs	7,567	7,700
Adj-R2	0.1067	0.1229
F value	23.03	27.32

Furthermore, following Li and Lu (2022), board size (BSIZE) and management shareholding (Mshare) have been individually used to generate subsamples. According to Huang and Wang (2015), based on the Chinese data from 2003-11, firms with small board size are more likely to engage in earnings management. Another factor impacting on earnings management is management shareholding. Proponents of agency theory (Jensen & Meckling 1976) put forward that there is the negative relationship between the ratio of management shareholding over total shares and earnings management activities.

We partition our sample into low and high by the median values of the corporate governance variables which have been shown to reduce earnings management and re-estimate model 3 for each subsample. The estimated coefficient on β_3 is negative and significant in the

groups with low earnings management (board size (Table 54) and management shareholding (Table 55)), but insignificant in the groups with high earnings management. Overall, results from the table below indicate that ownership concentration can increase R&D stickiness by reduce earnings management (board size and management shareholding).

Table 54 R&D cost stickiness for the sample partitioned Board Size(BS)

	Low BS(High EM)	***High BS(Low EM)***
Model	***3***	
β1ΔLn(IncomeR)	0.620***	0.609***
	(0.028)	(0.029)
β2ΔLn(IncomeR)*D	-0.527***	-0.183
	(0.200)	(0.235)
β3ΔLn(IncomeR)*D*Concern	-0.251	-1.585**
	(0.525)	(0.624)
β5Assets Intensity*ΔLn(IncomeR)*D	-0.122**	-0.068
	(0.062)	(0.079)
β6D_twoyear*ΔLn(IncomeR)*D	0.077	0.228
	(0.110)	(0.141)
β7FCF*ΔLn(IncomeR)*D	-0.427**	-0.631
	(0.214)	(0.388)
β8Lev*ΔLn(IncomeR)*D	0.478**	0.193
	(0.207)	(0.263)
β9da*ΔLn(IncomeR)*D	0.772**	0.879*
	(0.382)	(0.514)
β10REM*ΔLn(IncomeR)*D	0.091	-0.102
	(0.366)	(0.400)
β11Nature*ΔLn(IncomeR)*D	0.170	0.107
	(0.122)	(0.130)
β13Concern	0.082	-0.294***
	(0.063)	(0.074)
β14Assets Intensity	-0.018	-0.003
	(0.013)	(0.015)
β15D_twoyear	-0.053*	-0.079**
	(0.027)	(0.032)
β16FCF	-0.168***	-0.164**
	(0.063)	(0.075)
β17Lev	0.113***	0.044
	(0.039)	(0.044)
β18da	0.195**	0.152*
	(0.076)	(0.089)
β19REM	0.019	0.102*
	(0.049)	(0.055)
β20Nature	-0.010	-0.055***
	(0.016)	(0.018)
Constant	0.093	0.404***
	(0.069)	(0.087)
	P=0.002 (Significant difference between groups)	
Obs	8,246	7,021
Adj-R2	0.1158	0.1156
F value	24.99	21.39

Table 55 R&D cost stickiness for the sample partitioned by Management Shareholding

	Low Mshare (High EM)	***High Mshare (Low EM)***
Model	***3***	
β1ΔLn(IncomeR)	0.664***	0.562***
	(0.034)	(0.023)
β2ΔLn(IncomeR)*D	-0.530**	0.098
	(0.218)	(0.222)
β3ΔLn(IncomeR)*D*Concern	-0.485	-1.741***
	(0.581)	**(**0.575)
β5Assets Intensity*ΔLn(IncomeR)*D	-0.043	-0.171***
	(0.072)	(0.064)
β6D_twoyear*ΔLn(IncomeR)*D	0.137	0.068
	(0.131)	(0.111)
β7FCF*ΔLn(IncomeR)*D	-0.218	-0.467**
	(0.361)	(0.187)
β8Lev*ΔLn(IncomeR)*D	0.289	0.253
	(0.265)	(0.209)
β9da*ΔLn(IncomeR)*D	0.696	0.631*
	(0.511)	(0.359)
β10REM*ΔLn(IncomeR)*D	-0.010	0.328
	(0.396)	(0.359)
β11Nature*ΔLn(IncomeR)*D	0.060	-0.003
	(0.135)	(0.153)
β13Concern	-0.127*	-0.065
	(0.076)	(0.061)
β14Assets Intensity	-0.016	-0.004
	(0.016)	(0.011)
β15D_twoyear	-0.051	-0.077***
	(0.033)	(0.025)
β16FCF	-0.247***	-0.082
	(0.086)	(0.052)
β17Lev	0.064	0.071**
	(0.051)	(0.034)
β18da	0.273***	0.104*
	(0.104)	(0.063)
β19REM	0.093	0.041
	(0.071)	(0.038)
β20Nature	-0.019	-0.051***
	(0.020)	(0.018)
Constant	0.195**	0.275***
	(0.096)	(0.059)
	P=0.010 (Significant difference between groups)	
Obs	6,925	8,342
Adj-R2	0.1128	0.1317
F value	21.01	29.11

4.7 Robustness tests

In this research, the empirical results show that the $\beta_1>0$, which means R&D expense increases by 0.599% in model 2 when revenue increases by 1%. But when sales are falling, the corresponding adjustments in R&D expenses for 1% decrease in sales was 0.280% (0.599%($\widehat{\beta_1}$) - 0.319%($\widehat{\beta_2}$)) fall in R&D.(Table 7 in Chapter 3).

The empirical result shows that the value of β_3 (-0.870) is negative and statistically significant at the 5% level, indicating that high concentration (type two agency problem) strengthens the stickiness of R&D (managers will keep on investing in R&D when ownership concentration is increasing) (Table 44, Section 4.5.2).

The value of β_3 is negative (-1.728) and statistically significant at the 5% level in high managerial ability sub-sample and the value of β3 in low managerial ability sub-sample is negative (-0.566) but not statistically significant, indicating that capable managers could strengthen the relationship between firm ownership concentration and R&D stickiness relative to those without capable managers (capable managers would further retain R&D even though ownership concentration increases) (Table 46, Section 4.5.2).

The table below provides Pearson and Spearman correlations between our main variables, including the interaction terms (Table 57). The Pearson (Spearman) correlation matrix for variables in the main analysis is at the lower (upper) diagonal. Similar to Chen et al. (2012), there are significant but small in magnitude relationships between the main variables. We also conduct multicollinearity diagnostic tests for all dependent variables in the models, including the interaction terms. We find that most of the variance inflation factors are lower than 10, suggesting that multicollinearity is not a concern in the estimation of our models (Table 56).

Table 56 Variance inflation factor (VIF)

	VIF
β1ΔLn(IncomeR)	1.80
β2ΔLn(IncomeR)*D	16.64
β3ΔLn(IncomeR)*D***Concern**	3.77
β4ΔLn(IncomeR)*D*Concern***MA**	1.55
β5Assets Intensity*ΔLn(IncomeR)*D	4.46
β6D_twoyear*ΔLn(IncomeR)*D	2.75
β7FCF*ΔLn(IncomeR)*D	1.28
β8Lev*ΔLn(IncomeR)*D	5.30
β9da*ΔLn(IncomeR)*D	1.38
β10REM*ΔLn(IncomeR)*D	2.24
β11Nature*ΔLn(IncomeR)*D	3.87
β12MA	1.98
β13Concern	1.27
β14Assets Intensity	1.62
β15D_twoyear	1.90
β16FCF	1.23
β17Lev	1.51
β18da	1.28
β19REM	1.26
β20Nature	1.41

Following Choi's (2001) research, Fisher-type panel tests have been adopted to see whether all the panels have stationarity. We find that those tests strongly reject the null hypothesis that all the panels contain unit roots. All variables including interaction terms have been tested and the results reject the null hypothesis that all panels contain unit roots, which shows that all the panels have stationarity.

Considering the existence of individual heterogeneity of coefficient of each individual variable, results of the F test show that there is a significant difference between the coefficients of each individual variable and each individual variable (including interaction terms) significantly influences Y.

Table 57 Correlation matrix

	LR	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	D_2yr	lev	FCF	nature	MA	REM	Conc'n	Assets	da
ΔL_revenue (LR)	1	0.77*	0.77*	-0.35*	0.63*	0.07*	0.76*	0.56*	0.18*	0.77*	0.47*	-0.46*	-0.02*	-0.02*	0.14*	0.18*	0.14*	-0.03*	-0.12*	0.09*
t1=D*LR	0.60*	1	0.99*	-0.45*	0.82*	0.09*	0.99*	0.72*	0.24*	1.00*	0.61*	-0.60*	-0.02*	0.01*	0.07*	0.18*	0.07*	0.01	-0.17*	0.07*
t2=D*LR*Conc'n	0.48*	0.76*	1	-0.45*	0.81*	0.10*	0.99*	0.71*	0.25*	0.99*	0.61*	-0.60*	-0.02*	0.01	0.08*	0.17*	0.07*	-0.04*	-0.16*	0.06*
t3=D*LR* Conc'n *MA	-0.23*	-0.39*	-0.46*	1	-0.48*	0.05*	-0.44*	-0.31*	-0.09*	-0.45*	-0.33*	0.33*	0.02*	-0.02*	-0.04*	-0.48*	-0.07*	-0.01	0.18*	-0.08*
t4=D*LR*Assets	0.46*	0.82*	0.53*	-0.42*	1	0.07*	0.81*	0.64*	0.17*	0.81*	0.53*	-0.52*	0.02*	0.02*	0.02*	0.23*	0.07*	0.04*	-0.33*	0.06*
t5=D*LR*da	-0.06*	-0.12*	0.03*	0.12*	-0.23*	1	0.10*	0.02*	0.11*	0.08*	0.02*	-0.02*	0.04*	-0.04*	0.04*	-0.05*	-0.03*	-0.05*	-0.01*	-0.45*
t6=D*LR*REM	0.40*	0.69*	0.53*	-0.20*	0.56*	0.07*	1	0.72*	0.24*	0.99*	0.60*	-0.59*	-0.02*	0.01	0.07*	0.17*	0.02*	0.01	-0.16*	0.06*
t7=D*LR*nature	0.47*	0.79*	0.46*	-0.29*	0.75*	-0.20*	0.54*	1	0.17*	0.70*	0.44*	-0.43*	0.10*	0.01	-0.31*	0.14*	0.05*	0.09*	-0.19*	0.08*
t8=D*LR*FCF	-0.04*	-0.08*	-0.01	-0.01	-0.03*	0.15*	-0.06*	-0.13*	1	0.24*	0.13*	-0.13*	0.02*	-0.43*	0.02*	0.03*	0.02*	-0.05*	0.00	-0.03*
t9=D*LR*lev	0.52*	0.88*	0.66*	-0.34*	0.73*	-0.15*	0.63*	0.65*	-0.05*	1	0.60*	-0.59*	-0.06*	0.01	0.08*	0.18*	0.07*	0.01	-0.16*	0.07*
t10=D*LR*D_2yr	0.40*	0.67*	0.53*	-0.31*	0.56*	-0.11*	0.44*	0.52*	-0.11*	0.58*	1	-0.99*	0.02*	0.02*	0.04*	0.15*	0.07*	-0.01	-0.15*	0.07*
D_2yr	-0.36*	-0.40*	-0.36*	0.19*	-0.28*	0.06*	-0.22*	-0.28*	0.04*	-0.32*	-0.65*	1	-0.02*	-0.02*	-0.04*	-0.14*	-0.07*	0.02*	0.15*	-0.07*
lev	-0.00	-0.04*	-0.05*	0.02*	-0.00	0.03*	-0.03*	0.03*	0.00	-0.21*	-0.01	-0.02*	1	-0.01*	-0.31*	-0.02*	-0.05*	0.06*	-0.18*	-0.08*
FCF	-0.02*	0.05*	0.01	-0.01	0.03*	-0.07*	0.03*	0.06*	-0.40*	0.04*	0.05*	-0.02*	0.03*	1	0.02*	0.03*	0.01	0.08*	-0.08*	0.03*
nature	0.09*	0.04*	0.10*	-0.02*	-0.01	0.03*	0.02*	-0.19*	0.01*	0.07*	0.03*	-0.04*	-0.32*	-0.01	1	0.01	0.05*	-0.20*	0.11*	0.01
MA	0.16*	0.15*	0.11*	-0.31*	0.16*	-0.07*	0.06*	0.12*	-0.00	0.13*	0.12*	-0.13*	-0.01	0.01	0.01	1	0.19*	0.05*	-0.30*	0.11*
REM	0.19*	0.03*	0.03*	-0.04*	0.02*	-0.04*	-0.18*	0.02*	0.00	0.02*	0.03*	-0.08*	-0.04*	-0.02*	0.06*	0.23*	1	-0.01	-0.13*	0.07*
Conc'n	0.00	0.02*	-0.21*	0.06*	0.04*	-0.04*	0.02*	0.08*	-0.03*	0.01	0.01	0.02*	0.08*	0.08*	-0.21*	0.05*	-0.01	1	-0.10*	0.04*
Assets	-0.13*	-0.22*	-0.14*	0.17*	-0.33*	0.05*	-0.13*	-0.21*	0.01	-0.16*	-0.17*	0.15*	-0.17*	-0.07*	0.10*	-0.28*	-0.14*	-0.08*	1	0.02*
da	0.09*	0.07*	0.02*	-0.06*	0.07*	-0.36*	0.00	0.08*	-0.05*	0.08*	0.08*	-0.08*	-0.07*	0.06*	0.00	0.13*	0.07*	0.04*	0.01	1

Notes: The table reports the Pearson (Spearman) correlation coefficients for variables in the main analysis at the lower (upper) diagonal. The sample period is 2010-2019. The sample consists of 16,575 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. * denotes significance at 10% level.

LR = ΔL_revenue; D_2yr = D_twoyear, Conc'n = Concern

4.7.1 Overview–- Robustness checks

Table 58 Robustness checks

We perform several robustness checks, and our results are confirmed by those checks:

	Hypothesis2	**Hypothesis3**	
	H2 holds: β3<0 H2 rejected: β3>0	H3 holds: β3<0 in high managerial ability sub-sample H3 rejected: β3>0 in high managerial ability sub-sample	
Robustness test for Hypothesis1, Hypothesis2 and Hypothesis3:			
1) Fixed effects model	β3=**-1.051*** β3>0, H2a holds	Low MA	High MA
		β3=**-0.830**	β3=**-1.958***
		P=0.092 (Groups are significantly different)	
2) Replace operating revenue with total revenue	β3=**-0.879****	β3=**-0.572**	β3=**-1.680****
		P=0.002 (Groups are significantly different)	
3) Combat corruption policy 2013	β3=**-0.985****	β3=**-0.546**	β3=**-1.862****
		P=0.084 (Groups are significantly different)	
4) Add more control variable to models-Dual	β3=**-0.930****	β3=**-0.589**	β3=**-1.841****
		P=0.000 (Groups are significantly different)	
5) Add earnings management and its interaction with managerial ability from Chapter3 to our baseline model	β3=**-0.867****	β3=**-0.569**	β3=**-1.719****
		P=0.002 (Groups are significantly different)	
6) Perform mean-centering for all continuous variables before creating the interaction terms to deal with multicollinearity problem	β3=**-0.538***	β3=**-0.369**	β3=**-1.083****
		P=0.018 (Groups are significantly different)	
Robustness test for Hypothesis2:			
7) Top three ownership concentration (Concern=Top1^2+Top2^2+Top3^2)	β3=**-0.877****		
8) Top one ownership concentration (Concern=Top1^2)	β3=**-0.940****		
9) Dummy: 1 if top five ownership concentration>media, and 0 otherwise)	β3=**-0.190****		
Robustness test for Hypothesis3:			
10) Use CEO tenure measure managerial ability		β3=**0.069**	β3=**-1.388***
		P=0.095 (Groups are significantly different)	
Interpretation	Firms's management remains R&D expenses when ownership concentration is higher.	Firms with capable managers sustain R&D expenses when ownership concentration increases.	

4.7.2 Fixed effects model

Considering the issue of omitted time-invariant firm characteristics that may affect research results, the fixed effects model has been adopted and we find evidence consistent with our main results.

Column 1 in Table 59 shows that β3<0 and is significant at the 10% level, which indicates that ownership concentration positively influences R&D cost stickiness (The higher the ownership concentration, the higher the level of R&D stickiness); column 2 in Table 59 shows that there is a negative relationship between ownership concentration and R&D stickiness but the negative relationship is not significant, which means that ownership concentration does not lead to R&D stickiness in the low managerial ability group (β3=-0.830); column 3 in Table 59 shows that, in the high managerial ability sub-sample, a higher level of ownership concentration leads to R&D stickiness (β3=-1.958*), which means that managerial ability is unique and capable managers better serve the company's long term development when they are monitored by controlling shareholders. The difference between these two groups is statistically significant (P value=0.092). Therefore, we find evidence consistent with our main results.

Table 59 Individual fixed effects model

	H2	***H3***	
	1	2	3
		Low MA	High MA
β1ΔLn(IncomeR)	0.622***	0.622***	0.643***
	(0.041)	(0.067)	(0.055)
β2ΔLn(IncomeR)*D	-0.349	-0.354	-0.731
	(0.246)	(0.281)	(0.454)
β3ΔLn(IncomeR)*D***Concern**	**-1.051***	**-0.830**	**-1.958***
	(0.571)	(0.693)	(1.127)
β5Assets Intensity*ΔLn(IncomeR)*D	-0.113	-0.128	-0.105
	(0.083)	(0.086)	(0.196)
β6D_twoyear*ΔLn(IncomeR)*D	0.139	0.298**	-0.333
	(0.160)	(0.138)	(0.352)
β7FCF*ΔLn(IncomeR)*D	-0.368	-0.762**	-0.390
	(0.335)	(0.371)	(0.503)
β8Lev*ΔLn(IncomeR)*D	0.278	0.183	1.259**
	(0.359)	(0.335)	(0.627)
β9da*ΔLn(IncomeR)*D	0.740	0.456	1.597
	(0.479)	(0.528)	(1.356)
β10REM*ΔLn(IncomeR)*D	0.238	0.250	0.212
	(0.498)	(0.655)	(1.035)
β11Nature*ΔLn(IncomeR)*D	0.010	0.026	0.259
	(0.124)	(0.154)	(0.280)
β13Concern	-0.453***	-0.351	-0.558*
	(0.174)	(0.234)	(0.323)
β14Assets Intensity	0.011	-0.033	0.018
	(0.025)	(0.032)	(0.046)
β15D_twoyear	-0.074**	-0.048*	-0.127**
	(0.029)	(0.028)	(0.061)

	H2	*H3*	
	1	2	3
		Low MA	High MA
β16FCF	-0.141**	-0179**	-0.159
	(0.060)	(0.076)	(0.102)
β17Lev	-0.070	0.111	-0.191
	(0.065)	(0.081)	(0.128)
β18da	0.142**	0.115	0.160
	(0.071)	(0.092)	(0.121)
β19REM	0.105*	0.131	0.088
	(0.058)	(0.096)	(0.082)
β20Nature	-0.019	-0.039	0.106
	(0.058)	(0.076)	(0.084)
Constant	0.371***	0.342***	0.386***
	(0.078)	(0.103)	(0.122)
YEAR	Control	Control	Control
		P=0.092 (There are significant difference between groups)	
Obs	15,267	8,245	7,022

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 15,267 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50thpercentile.To control for error dependence of firm observations, we use Rogers (1993) standard errors clustered at the firm level as well as robust standard errors.

4.7.3 Replace operating revenue with total revenue

In our main results, we run our tests using operating revenue. Following Bradbury and Scott's (2018) research, to test for robustness we use total revenue to replace operating revenue and run the models again. Column 1 in Table 60 shows that β3=-0.879<0 and is significant at a 5% level, which indicates that ownership concentration positively influences R&D cost stickiness (higher ownership concentration leads to a higher level of R&D stickiness); column 3 in Table 60 shows that β3=-1.680<0 and is significant at a 5% level and the value of β3 in low managerial ability sub-sample is negative (-0.572) but not statistically significant and the value of β3 in low managerial ability sub-sample is negative (-0.572) but not statistically significant, which shows that managerial ability strengthened the positive relationship between ownership concentration and R&D stickiness relative to those without capable managers. The regression results are statistically significantly different across the two groups (P value=0.002). Therefore, we find evidence consistent with our main results.

Table 60 Replace operating revenue with total revenue

	***H2**(3)*	***H3**(3)*	
		Low MA	High MA
β1ΔLn(TotalRevenue)	0.612***	0.623***	0.603***
	(0.020)	(0.030)	(0.027)
β2ΔLn(TotalRevenue)*D	-0.348**	-0.212	-0.719**
	(0.149)	(0.176)	(0.287)
β3ΔLn(TotalRevenue)*D***Concern**	**-0.879****	**-0.572**	**-1.680****
	(0.398)	**(0.479)**	**(0.739)**
β5Assets Intensity*ΔLn(TotalRevenue)*D	-0.102	-0.077	-0.023
	(0.046)	(0.057)	(0.091)
β6D_twoyear*ΔLn(TotalRevenue)*D	0.123	0.228**	-0.282
	(0.085)	(0.099)	(0.172)
β7FCF*ΔLn(TotalRevenue)*D	-0.443**	-0.688**	-0.369
	(0.180)	(0.271)	(0.258)
β8Lev*ΔLn(TotalRevenue)*D	0.332**	-0.007	1.219***
	(0.161)	(0.195)	(0.305)
β9da*ΔLn(TotalRevenue)*D	0.794***	0.437	1.435***
	(0.298)	(0.383)	(0.537)
β10REM*ΔLn(TotalRevenue)*D	0.064	-0.234	0.278
	(0.263)	(0.327)	(0.468)
β11Nature*ΔLn(TotalRevenue)*D	0.116	0.008	0.379**
	(0.087)	(0.102)	(0.179)
β13Concern	-0.095**	-0.131*	-0.058
	(0.048)	(0.068)	(0.070)
β14Assets Intensity	-0.012	-0.007	-0.014
	(0.010)	(0.014)	(0.014)
β15D_twoyear	-0.068***	-0.052**	-0.111***
	(0.021)	(0.025)	(0.036)
β16FCF	-0.163***	-0.174***	-0.164**
	(0.048)	(0.066)	(0.071)
β17Lev	0.078***	0.060	0.096**
	(0.029)	(0.040)	(0.045)
β18da	0.178***	0.191**	0.176**
	(0.058)	(0.080)	(0.085)
β19REM	0.058	0.067	0.063
	(0.037)	(0.064)	(0.046)
β20Nature	-0.034***	-0.040**	-0.024
	(0.012)	(0.016)	(0.018)
Constant	0.227***	0.183*	0.226***
	(0.053)	(0.108)	(0.071)
		P=0.002	(Significant difference between groups)
Obs	15,267	8,245	7,022
Adj-R2	0.1149	0.1167	0.1150
F value	45.02	26.33	21.28

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 15,267 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

4.7.4 Combat corruption policy 2013

Corruption could influence innovation. Corruption shifts firms' ethical norms (Lyon & Maher, 2005) and is one of the factors which influence investment and economic growth (Porta et al., 1999). Based on the survey data from Central and Eastern Europe (CCEs), Chadee et al. (2021) find that there is a negative relationship between corruption and innovation. In December 2012, the Chinese Government issued an important policy "Eight-Point Regulation", which has been recognized as a forceful anti-corruption movement since Xi Jinping assumed power (Chen et al., 2020). The anti-corruption movement could influence our research, so the *Post* is a dummy variable (1 if it is after the 2013 anti-corruption movement, 0 otherwise) has been added to our baseline model and we run the model again. We find evidence consistent with our main results.

Column 1 in Table 61 shows that $\beta3=-0.878<0$ and is significant at a 5% level, which indicates that ownership concentration positively influences R&D cost stickiness (higher ownership concentration leads to a higher level of R&D stickiness); column 3 in Table61 shows that $\beta3=-1.862<0$ and is significant at a 5% level and the value of $\beta3$ in low managerial ability sub-sample is negative (-0.546) but not statistically significant which shows that managerial ability strengthens the positive relationship between ownership concentration and R&D stickiness relative to those without capable managers. The difference between these two groups is statistically significant (P value=0.084). Therefore, we find evidence consistent with our main results.

Table 61 Combat corruption policy 2013

	H2	H3	
Model	3	3	
		Low MA	High MA
β1ΔLn(IncomeR)	0.675***	0.548***	0.951***
	(0.053)	(0.067)	(0.089)
β2ΔLn(IncomeR)*D	-0.469**	0.152	-2.122***
	(0.196)	(0.225)	(0.405)
β3ΔLn(IncomeR)*D***Concern**	**-0.878****	**-0.546**	**-1.862****
	(0.399)	**(0.478)**	**(0.747)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.103**	-0.073	-0.031
	(0.047)	(0.058)	(0.091)
β6D_twoyear*ΔLn(IncomeR)*D	0.117	0.245**	-0.358**
	(0.086)	(0.100)	(0.173)
β7FCF*ΔLn(IncomeR)*D	-0.438**	-0.664**	-0.343
	(0.180)	(0.271)	(0.257)
β8Lev*ΔLn(IncomeR)*D	0.333**	-0.015	1.148***
	(0.161)	(0.195)	(0.306)
β9da*ΔLn(IncomeR)*D	0.792***	0.382	1.531***
	(0.299)	(0.384)	(0.539)
β10REM*ΔLn(IncomeR)*D	0.061	-0.232	0.177
	(0.264)	(0.328)	(0.468)
β11Nature*ΔLn(IncomeR)*D	0.113	0.016	0.278
	(0.087)	(0.102)	(0.181)
β13Concern	-0.094*	-0.128*	-0.063
	(0.048)	(0.068)	(0.069)
β14Assets Intensity	-0.012	-0.006	-0.015
	(0.010)	(0.014)	(0.014)
β15D_twoyear	-0.070***	-0.050**	-0.116***
	(0.021)	(0.025)	(0.036)
β16FCF	-0.162***	-0.172***	-0.159**
	(0.048)	(0.066)	(0.071)
β17Lev	0.079***	0.062	0.095**
	(0.029)	(0.039)	(0.045)
β18da	0.178***	0.191**	0.188**
	(0.058)	(0.080)	(0.085)
β19REM	0.057	0.066	0.052
	(0.037)	(0.064)	(0.046)
β20Nature	-0.034***	-0.040**	-0.025
	(0.012)	(0.016)	(0.018)
β21Post	-0.094***	-0.158***	0.009
	(0.035)	(0.046)	(0.055)
β22L_revenue*post	-0.073	0.092	-0.379***
	(0.057)	(0.074)	(0.092)
β23D_oneyear* L_revenue*post	0.145	-0.442**	1.691***
	(0.151)	(0.172)	(0.348)
Constant	0.209***	0.202*	0.134*
	(0.055)	(0.109)	(0.074)
YEAR	Control	Control	Control
INDUSTRY	Control	Control	Control
		P=0.084 (Significant difference between groups)	
Obs	15,267	8,245	7,022
Adj-R2	0.1147	0.1172	0.1180
F value	43.08	25.32	20.98

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 15,267 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50^{th} percentile.

4.7.5 Add control variables to models-Dual

The OLS are likely to be biased due to the omission of variables correlated with both ownership concentration and R&D stickiness. For example, our controls for R&D stickiness may be imperfect. Chen et al. (2012) find that corporate governance is one of the factors that influence cost stickiness. To address this potential problem of endogeneity, following Bugeja et al. (2015), we add a dummy variable where the board chair and CEO roles are occupied by one person (Dual) as control variable to models. Dual = Dummy variable, taken as 1 if the positions of board chair and CEO are occupied by one person, and 0 otherwise.

Column 1 in Table 62 shows that $\beta3=-0.932<0$ and is significant at a 5% level, which indicates that ownership concentration positively influences R&D cost stickiness (higher ownership concentration leads to a higher level of R&D stickiness); column 3 in Table 62 shows that $\beta3=-1.841<0$ and is significant at a 5% level and the value of $\beta3$ in low managerial ability sub-sample is negative (-0.589) but not statistically significant, which shows that managerial ability strengthens the positive relationship between ownership concentration and R&D stickiness relative to those without capable managers. The difference between these two groups is statistically significant (P value=0.000). Therefore, we find evidence consistent with our main results.

Table 62 Add control variables to models-Dual

	H2*(3)*	H3*(3)*	
		Low MA	High MA
β1ΔLn(IncomeR)	0.616***	0.594***	0.633***
	(0.024)	(0.036)	(0.033)
β2ΔLn(IncomeR)*D	-0.362**	-0.184	-0.764***
	(0.150)	(0.178)	(0.289)
β3ΔLn(IncomeR)*D***Concern**	**-0.932****	**-0.589**	**-1.841****
	(0.401)	**(0.479)**	**(0.757)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.098**	-0.070	-0.021
	(0.047)	(0.058)	(0.091)
β6D_twoyear*ΔLn(IncomeR)*D	0.127	0.220**	-0.264
	(0.085)	(0.099)	(0.176)
β7FCF*ΔLn(IncomeR)*D	-0.449**	-0.675**	-0.381
	(0.180)	(0.271)	(0.259)
β8Lev*ΔLn(IncomeR)*D	0.348**	0.003	1.234***
	(0.161)	(0.196)	(0.306)
β9da*ΔLn(IncomeR)*D	0.779***	0.411	1.384**
	(0.299)	(0.384)	(0.547)
β10REM*ΔLn(IncomeR)*D	0.025	-0.264	0.249
	(0.265)	(0.329)	(0.470)
β11Nature*ΔLn(IncomeR)*D	0.077	-0.033	0.346*
	(0.090)	(0.106)	(0.183)
β13Concern	-0.095**	-0.133**	-0.060
	(0.048)	(0.068)	(0.070)
β14Assets Intensity	-0.012	-0.006	-0.015
	(0.010)	(0.014)	(0.014)
β15D_twoyear	-0.068***	-0.053**	-0.109***
	(0.021)	(0.025)	(0.037)
β16FCF	-0.163***	-0.175***	-0.160**
	(0.048)	(0.066)	(0.071)
β17Lev	0.080***	0.060	0.099**
	(0.029)	(0.040)	(0.045)
β18da	0.177***	0.183**	0.180**
	(0.058)	(0.080)	(0.085)
β19REM	0.057	0.067	0.062
	(0.037)	(0.064)	(0.046)
β20Nature	-0.035***	-0.042**	-0.024
	(0.012)	(0.016)	(0.019)
β21Dual*ΔLn(IncomeR)*D	0.177	0.009	0.306
	(0.113)	(0.142)	(0.212)
β22Dual	0.007	-0.012	0.023
	(0.015)	(0.020)	(0.022)
β20Dual*ΔLn(IncomeR)	-0.015	0.096	-0.095*
	(0.041)	(0.063)	(0.055)
Constant	0.223***	0.181*	0.216***
	(0.054)	(0.108)	(0.071)
Obs	15,267	8,245	7,022
		P=0.000 (Significant difference between groups)	
Adj-R2	0.1147	0.1168	0.1148
F value	42.21	24.70	19.97

Notes: The table reports the coefficients based on Anderson et al. (2003) model. The sample period is 2010-2019. The sample consists of 15,267 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

4.7.6 Add earnings management from Chapter 3 to the baseline model

To test H2, that higher the ownership concentration leads to a higher level of R&D stickiness, after adding earnings management from Chapter 3 to our baseline model in Chapter 4, our research results still show the higher the ownership concentration, the higher the level of R&D stickiness. The empirical results show that the value of β_3 (-0.867) is negative and statistically significant at the 5% level, indicating that high ownership concentration strengthens the stickiness of R&D (Table 63).

To test H3 that managerial ability strengthens the positive relationship between the level of ownership concentration and the level of R&D expenditure stickiness, after adding earnings management from Chapter 3 to our baseline model, our research results still show that managerial ability strengthens the positive relationship between the level of ownership concentration and the level of R&D expenditure stickiness.

Column 3 in Table 63 below shows that ownership concentration has a negative effect on R&D stickiness (the higher the ownership concentration, the higher the level of R&D stickiness) when managerial ability is high (β_3=-1.719**). Column 2 in Table 63 shows that ownership concentration has no impact on R&D stickiness in the lower managerial ability group (β3=-0.569).

Table 63 Add earnings management from Chapter3 to baseline model

	H2*(3)*	H3*(3)*	
		Low MA	High MA
β1ΔLn(IncomeR)	0.608***	0.621***	0.596***
	(0.020)	(0.031)	(0.027)
β2ΔLn(IncomeR)*D	-0.334**	-0.208	-0.689**
	(0.150)	(0.177)	(0.288)
β3ΔLn(IncomeR)*D*Concern	**-0.867****	**-0.569**	**-1.719****
	(0.400)	**(0.479)**	**(0.749)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.104**	-0.078	-0.015
	(0.047)	(0.058)	(0.091)
β6D_twoyear*ΔLn(IncomeR)*D	0.115	0.222**	-0.311*
	(0.085)	(0.100)	(0.173)
β7FCF*ΔLn(IncomeR)*D	-0.442**	-0.680**	-0.380
	(0.180)	(0.271)	(0.259)
β8Lev*ΔLn(IncomeR)*D	0.339**	-0.004	1.229***
	(0.162)	(0.196)	(0.306)
β9da*ΔLn(IncomeR)*D	0.788***	0.421	1.456***
	(0.298)	(0.384)	(0.540)
β10REM*ΔLn(IncomeR)*D	0.062	-0.228	0.267
	(0.264)	(0.328)	(0.469)
β11Nature*ΔLn(IncomeR)*D	0.111	0.006	0.367**
	(0.087)	(0.102)	(0.179)
β13Concern	-0.091*	-0.129*	-0.053
	(0.048)	(0.068)	(0.070)
β14Assets Intensity	-0.012	-0.007	-0.013
	(0.010)	(0.014)	(0.014)
β15D_twoyear	-0.071***	-0.053**	-0.115***
	(0.021)	(0.025)	(0.036)
β16FCF	-0.163***	-0.172***	-0.166**
	(0.048)	(0.066)	(0.071)
β17Lev	0.080***	0.061	0.102**
	(0.029)	(0.039)	(0.045)
β18da	0.177***	0.190**	0.173**
	(0.058)	(0.080)	(0.085)
β19REM	0.056	0.066	0.059
	(0.037)	(0.064)	(0.047)
β20Nature	-0.036***	-0.041**	-0.026
	(0.012)	(0.016)	(0.018)
β22Loss	-0.019	-0.009	-0.034*
	(0.012)	(0.016)	(0.018)
β23Loss*ΔLn(IncomeR)*D	0.007	0.020	0.013
	(0.115)	(0.137)	(0.213)
Constant	0.232***	0.185*	0.233***
	(0.054)	(0.108)	(0.071)
		P=0.002 (Significant difference between groups)	
Obs	15,267	8,245	7,022
Adj-R2	0.1148	0.1165	0.1150
F value	43.11	25.16	20.41

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model to test how managerial ability influences the relationship between level of ownership concentration and R&D stickiness. The sample period is 2010-2019. The sample consists of 15,267 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

4.7.7 Perform mean-centering for all continuous variables before creating the interaction terms to deal with the problem of multicollinearity

β_2ΔLn(IncomeR)*D has a VIF=16.64, therefore we now address the impact of high VIF in the following three aspects: First, Ibrahim et al. (2022) point out that one of the advantages of Anderson et al.'s (2003) model is that researchers can add as many variables as they want to examine their effects, but as interaction terms. However, the interaction terms could increase the multicollinearity problem. Ibrahim et al. (2022) also noted that the multicollinearity problem can be managed by carrying out mean-centering for all continuous variables before creating the interaction terms. This method of dealing with multicollinearity has been adopted by Chen et al. (2012) and Ibrahim (2018). Secondly, the overall mean VIF for all variables is still less than 10 (overall mean VIF=3.57).Thirdly, we have followed Chen et al. (2012) and Ibrahim (2018) and performed mean-centering for all continuous variables before creating the interaction terms to reduce the multicollinearity problem. After mean-centering, the VIF decreases to 4.64 (Table 64) and our results are unchanged (Table 65 and Table 66).

Table 64 Variance inflation factor (VIF) before and after mean-centering

	VIF	
	Before Center	After Center
β1ΔLn(IncomeR)	1.80	1.90
β2ΔLn(IncomeR)*D	16.64	4.64
β3ΔLn(IncomeR)*D***Concern**	3.77	1.57
β4ΔLn(IncomeR)*D*Concern***MA**	1.55	1.55
β5Assets Intensity*ΔLn(IncomeR)*D	4.46	1.83
β6D_twoyear*ΔLn(IncomeR)*D	2.75	3.99
β7FCF*ΔLn(IncomeR)*D	1.28	1.35
β8Lev*ΔLn(IncomeR)*D	5.30	1.35
β9da*ΔLn(IncomeR)*D	1.38	1.47
β10REM*ΔLn(IncomeR)*D	2.24	1.20
β11Nature*ΔLn(IncomeR)*D	3.87	3.71
β12MA	1.98	1.98
β13Concern	1.27	1.38
β14Assets Intensity	1.62	1.54
β15D_twoyear	1.90	3.13
β16FCF	1.23	1.33
β17Lev	1.51	1.61
β18da	1.28	1.34
β19REM	1.26	1.26
β20Nature	1.41	1.52
Mean VIF	3.57	3.20

Table 65 Results: Ownership concentration level of R&D stickiness before and after mean-centering

	H2	
	Before Center	After Center
β1ΔLn(IncomeR)	0.612***	0.621***
	(0.020)	(0.021)
β2ΔLn(IncomeR)*D	-0.345**	-0.337***
	(0.149)	(0.062)
β3ΔLn(IncomeR)*D*Concern	**-0.870****	**-0.538***
	(0.399)	**(0.300)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.104**	-0.079**
	(0.047)	(0.038)
β6D_twoyear*ΔLn(IncomeR)*D	0.120	0.057
	(0.085)	(0.080)
β7FCF*ΔLn(IncomeR)*D	-0.439**	-0.419***
	(0.180)	(0.157)
β8Lev*ΔLn(IncomeR)*D	0.333**	0.175
	(0.161)	(0.132)
β9da*ΔLn(IncomeR)*D	0.790***	0.584**
	(0.298)	(0.249)
β10REM*ΔLn(IncomeR)*D	0.066	0.069
	(0.263)	(0.214)
β11Nature*ΔLn(IncomeR)*D	0.114	0.104
	(0.087)	(0.068)
β13Concern	-0.093*	-0.096*
	(0.048)	(0.050)
β14Assets Intensity	-0.012	-0.014
	(0.010)	(0.010)
β15D_twoyear	-0.069***	-0.089***
	(0.021)	(0.027)
β16FCF	-0.163***	-0.176***
	(0.048)	(0.050)
β17Lev	0.079***	0.074**
	(0.029)	(0.030)
β18da	0.178***	0.182***
	(0.058)	(0.060)
β19REM	0.058	0.058
	(0.037)	(0.037)
β20Nature	-0.034***	-0.031**
	(0.012)	(0.012)
Constant	0.227***	0.315***
	(0.053)	(0.050)
YEAR	Control	Control
INDUSTRY	Control	Control
Obs	15,267	15,267
Adj-R2	0.1147	0.1146
F value	44.96	44.93

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model to test how managerial ability influences the relationship between level of ownership concentration and R&D stickiness. The sample period is 2010-2019. The sample consists of 15,267 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively.

Table 66 Managerial ability, ownership concentration and R&D expense stickiness before and after mean-centering

	Before Center		After Center	
	Low MA	***High MA***	***Low MA***	***High MA***
β1ΔLn(IncomeR)	0.623***	0.602***	0.634***	0.611***
	(0.030)	(0.027)	(0.032)	(0.028)
β2ΔLn(IncomeR)*D	-0.212	-0.704**	-0.325***	-0.334***
	(0.176)	(0.287)	(0.079)	(0.110)
β3ΔLn(IncomeR)*D***Concern**	**-0.566**	**-1.728****	**-0.369**	**-1.083****
	(0.478)	**(0.748)**	**(0.366)**	**(0.539)**
β5Assets	-0.077	-0.017	-0.101**	0.040
Intensity*ΔLn(IncomeR)*D	(0.058)	(0.091)	(0.048)	(0.072)
β6D_twoyear*ΔLn(IncomeR)*D	0.225**	-0.297*	0.161*	-0.308**
	(0.099)	(0.173)	(0.094)	(0.156)
β7FCF*ΔLn(IncomeR)*D	-0.678**	-0.369	-0.581**	-0.409*
	(0.271)	(0.258)	(0.232)	(0.225)
β8Lev*ΔLn(IncomeR)*D	-0.008	1.211***	-0.076	0.819***
	(0.195)	(0.306)	(0.161)	(0.242)
β9da*ΔLn(IncomeR)*D	0.422	1.462***	0.306	1.073**
	(0.383)	(0.539)	(0.319)	(0.439)
β10REM*ΔLn(IncomeR)*D	-0.230	0.284	-0.212	0.346
	(0.328)	(0.469)	(0.275)	(0.359)
β11Nature*ΔLn(IncomeR)*D	0.008	0.370**	0.039	0.252*
	(0.102)	(0.179)	(0.080)	(0.131)
β13Concern	-0.129*	-0.057	-0.134*	-0.064
	(0.068)	(0.070)	(0.071)	(0.072)
β14Assets Intensity	-0.007	-0.015	-0.013	-0.011
	(0.014)	(0.014)	(0.015)	(0.014)
β15D_twoyear	-0.053**	-0.114***	-0.060*	-0.168***
	(0.025)	(0.036)	(0.032)	(0.048)
β16FCF	-0.173***	-0.164**	-0.191***	-0.175**
	(0.066)	(0.071)	(0.069)	(0.073)
β17Lev	0.061	0.097**	0.051	0.101**
	(0.039)	(0.045)	(0.041)	(0.046)
β18da	0.190**	0.177**	0.194**	0.181**
	(0.080)	(0.085)	(0.083)	(0.087)
β19REM	0.066	0.063	0.058	0.069
	(0.064)	(0.046)	(0.066)	(0.047)
β20Nature	-0.040**	-0.024	-0.036**	-0.022
	(0.016)	(0.018)	(0.017)	(0.019)
Constant	0.183*	0.226***	0.262**	0.327***
	(0.108)	(0.071)	(0.103)	(0.064)
	P=0.006 (Significant diff. between groups)		P=0.018 (Significant diff. between groups)	
Obs	8,245	7,022	8,245	7,022
Adj-R2	0.1167	0.1147	0.1168	0.1139
F value	26.32	21.22	26.36	21.06

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model to test how managerial ability influences the relationship between level of ownership concentration and R&D stickiness. The sample period is 2010-2019. The sample consists of 15,267 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability

samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

4.7.8 Ownership concentration: top three percentage ownership of firms

To explain, the results from OLS are not due to how ownership concentration is measured (Concern=Top1^2+Top2^2+Top3^2+Top4^2+Top5^2); we also conduct an empirical test again in another way (Concern=Top1^2+Top2^2+Top3^2).

Table 67 Descriptive statistic of Concern

The descriptive statistic of *Concern* is for a sample of 15,267 firm-year observations from 2,803 firms. On average *Concern* was 0.15 (median: 0.12, standard deviation: 0.11) with a minimum of 0.01 and maximum of 0.57.

	Obs.	Mean	Standard Deviation	Median	Minimum	Maximum
Concern	15,267	0.15	0.11	0.12	0.01	0.57

Column 1 in Table 68 shows that β3 is negative (-0.877) and is significant at a 5% level, which indicates that ownership concentration positively influences R&D cost stickiness. Column 2 and Column 3 in Table 68 shows that the value of β3 is negative (-1.725**) and is significant at a 5% level in high managerial ability sub-sample and the value of β3 in low managerial ability sub-sample is negative (-0.573) but not statistically significant, which means capable managers strengthen the positive relationship between ownership concentration and R&D stickiness. The difference between these two groups is statistically significant (P value=0.002). Therefore, we find evidence consistent with our main results.

Table 68 Ownership concentration: top three percentage ownership of firms

	H2(3)	H3(3)	
		Low MA	High MA
β1ΔLn(IncomeR)	0.611***	0.623***	0.602***
	(0.020)	(0.030)	(0.027)
β2ΔLn(IncomeR)*D	-0.334**	-0.211	-0.706**
	(0.148)	(0.175)	(0.286)
β3ΔLn(IncomeR)*D***Concern**	**-0.877****	**-0.573**	**-1.725****
	(0.397)	**(0.477)**	**(0.744)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.104**	-0.078	-0.016
	(0.047)	(0.058)	(0.091)
β6D_twoyear*ΔLn(IncomeR)*D	0.120	0.225**	-0.298*
	(0.085)	(0.099)	(0.173)
β7FCF*ΔLn(IncomeR)*D	-0.438**	-0.677**	-0.368
	(0.180)	(0.271)	(0.258)
β8Lev*ΔLn(IncomeR)*D	0.333**	-0.008	1.211***
	(0.161)	(0.195)	(0.306)
β9da*ΔLn(IncomeR)*D	0.791***	0.422	1.461***
	(0.298)	(0.384)	(0.539)
β10REM*ΔLn(IncomeR)*D	0.066	-0.230	0.285
	(0.263)	(0.328)	(0.469)
β11Nature*ΔLn(IncomeR)*D	0.113	0.007	0.368**
	(0.087)	(0.102)	(0.180)
β13Concern	-0.093*	-0.128*	-0.059
	(0.048)	(0.067	(0.069)
β14Assets Intensity	-0.012	-0.007	-0.015
	(0.010)	(0.014)	(0.014)
β15D_twoyear	-0.069***	-0.053**	-0.114***
	(0.021)	(0.025)	(0.036)
β16FCF	-0.163***	-0.173***	-0.164**
	(0.048)	(0.066)	(0.071)
β17Lev	0.079***	0.061	0.097**
	(0.029)	(0.039)	(0.045)
β18da	0.178***	0.189**	0.177**
	(0.058)	(0.080)	(0.085)
β19REM	0.058	0.066	0.063
	(0.037)	(0.064)	(0.046)
β20Nature	-0.034***	-0.040**	-0.024
	(0.012)	(0.016)	(0.018)
Constant	0.227***	0.182*	0.226***
	(0.053)	(0.108)	(0.071)
		P=0.002	(Significant difference between groups)
Obs	15,267	8,245	7,022
Adj-R2	0.1147	**0.1213**	**0.1147**
F value	44.96	26.32	21.22

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 15,267 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

4.7.9 Ownership concentration: top one percentage ownership

To explain, the results from OLS are not due to how ownership concentration is measured (Concern=Top1^2+Top2^2+Top3^2+Top4^2+Top5^2), we also conduct empirical tests again in another way (Concern=Top1^2).

Table 69 Descriptive statistic of *Concern*

The descriptive statistic of *Concern* is for a sample of 15,267 firm-year observations from 2,803 firms. On average *Concern* was 0.14 (median: 0.10, standard deviation: 0.11) with a minimum of 0.01 and maximum of 0.56.

	Obs.	Mean	Standard Deviation	Median	Minimum	Maximum
Concern	15,267	0.14	0.11	0.10	0.01	0.56

Column 1 in Table 70 shows that β3 is negative (-0.940) and is significant at a 5% level, which indicates that ownership concentration positively influences R&D cost stickiness. Column 2 and Column 3 in Table 70 shows that the value of β3 is negative (-1.724**) and is significant at a 5% level in high managerial ability sub-sample and the value of β3 in low managerial ability sub-sample is negative (-0.649) but not statistically significant, which means capable managers strengthen the positive relationship between ownership concentration and R&D stickiness. The difference between these two groups is statistically significant (P value=0.004). Therefore, we find evidence consistent with our main results.

Table 70 Ownership concentration: top one percentage ownership

	***H2**(3)*	***H3**(3)*	
		Low MA	High MA
β1ΔLn(IncomeR)	0.611***	0.623***	0.602***
	(0.020)	(0.030)	(0.027)
β2ΔLn(IncomeR)*D	-0.345**	-0.207	-0.730***
	(0.145)	(0.172)	(0.280)
β3ΔLn(IncomeR)*D*Concern	**-0.940****	**-0.649**	**-1.724****
	(0.399)	**(0.480)**	**(0.746)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.103**	-0.078	-0.015
	(0.047)	(0.057)	(0.091)
β6D_twoyear*ΔLn(IncomeR)*D	0.119	0.224**	-0.294*
	(0.085)	(0.099)	(0.173)
β7FCF*ΔLn(IncomeR)*D	-0.435**	-0.674**	-0.371
	(0.180)	(0.271)	(0.258)
β8Lev*ΔLn(IncomeR)*D	0.336**	-0.007	1.224***
	(0.161)	(0.195)	(0.305)
β9da*ΔLn(IncomeR)*D	0.797***	0.430	1.468***
	(0.299)	(0.384)	(0.539)
β10REM*ΔLn(IncomeR)*D	0.061	-0.236	0.275
	(0.264)	(0.328)	(0.468)
β11Nature*ΔLn(IncomeR)*D	0.107	0.002	0.359**
	(0.088)	(0.102)	(0.182)
β13Concern	-0.096**	-0.127*	-0.063
	(0.047)	(0.067)	(0.068)
β14Assets Intensity	-0.012	-0.007	-0.015
	(0.010)	(0.014)	(0.014)
β15D_twoyear	-0.069***	-0.053**	-0.113***
	(0.021)	(0.025)	(0.036)
β16FCF	-0.163***	-0.174***	-0.163**
	(0.048)	(0.066)	(0.071)
β17Lev	0.080***	0.062	0.097**
	(0.029)	(0.039)	(0.045)
β18da	0.178***	0.189**	0.178**
	(0.058)	(0.080)	(0.085)
β19REM	0.058	0.065	0.063
	(0.037)	(0.064)	(0.046)
β20Nature	-0.035***	-0.040**	-0.025
	(0.012)	(0.016)	(0.018)
Constant	0.226***	0.180*	0.226***
	(0.053)	(0.108)	(0.070)
		P=0.004 (Significant difference between groups)	
Obs	15,267	8,245	7,022
Adj-R2	0.1148	0.1167	0.1148
F value	44.98	26.33	21.22

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 15,267 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Each manager has an independent value each year and that the same company (thus same manager) can be present in both high managerial ability and low managerial ability samples. This research utilizes the measure of managerial ability developed by Demerjian et al. (2012). The sample were split to high managerial ability and low managerial ability samples using the 50th percentile.

4.7.10 Dummy variable to measure top five ownership concentration

To explain, the results from OLS are due to the particular way we measure ownership concentration (Concern=Top1^2+Top2^2+Top3^2+Top4^2+Top5^2). We also conduct empirical tests again in another way (Use dummy variable to measure top five ownership concentration). Concern = Dummy variable, taken as 1 if top five ownership concentration>median, and 0 otherwise.

Table 71 Descriptive statistic of concentration

The descriptive statistic of *Concern* is for a sample of 15,267 firm-year observations from 2,803 firms. On average *Concern* was 0.46 (median: 0.00, standard deviation: 0.50) with a minimum of 0.00 and maximum of 1.00.

	Obs.	Mean	Standard Deviation	Median	Minimum	Maximum
Concern	15,267	0.46	0.50	0.00	0.00	1.00

Column 1 in Table 72 shows that β3 is negative (-0.190) and is significant at a 5% level, which indicates that ownership concentration positively influences R&D cost stickiness. Column 2 and Column 3 in Table 72 shows that the value of β3 is negative (-0.500***) and is significant at a 1% level in high managerial ability sub-sample and the value of β3 in low managerial ability sub-sample is negative (-0.133) but not statistically significant, which means capable managers strengthen the positive relationship between ownership concentration and R&D stickiness. The difference between these two groups is statistically significant (P value=0.029). Therefore, we find evidence consistent with our main results.

Table 72 Dummy variable to measure top five ownership concentration

	H2 (3)	*H3 (3)*	
		Low MA	High MA
β1ΔLn(IncomeR)	0.611***	0.623***	0.601***
	(0.020)	(0.030)	(0.027)
β2ΔLn(IncomeR)*D	-0.404***	-0.240	-0.732***
	(0.134)	(0.160)	(0.262)
β3ΔLn(IncomeR)*D***Concern**	**-0.190****	**-0.133**	**-0.500*****
	(0.083)	**(0.098)**	**(0.165)**
β5Assets Intensity*ΔLn(IncomeR)*D	-0.108**	-0.082	-0.024
	(0.047)	(0.058)	(0.091)
β6D_twoyear*ΔLn(IncomeR)*D	0.134	0.234**	-0.315*
	(0.085)	(0.100)	(0.173)
β7FCF*ΔLn(IncomeR)*D	-0.420**	-0.668**	-0.350
	(0.181)	(0.271)	(0.258)
β8Lev*ΔLn(IncomeR)*D	0.336**	-0.006	1.177***
	(0.161)	(0.195)	(0.306)
β9da*ΔLn(IncomeR)*D	0.808***	0.462	1.577***
	(0.299)	(0.387)	(0.541)
β10REM*ΔLn(IncomeR)*D	0.086	-0.224	0.341
	(0.263)	(0.328)	(0.469)
β11Nature*ΔLn(IncomeR)*D	0.133	0.017	0.349**
	(0.085)	(0.100)	(0.174)
β13Concern	-0.013	-0.017	-0.001
	(0.010)	(0.014)	(0.016)
β14Assets Intensity	-0.012	-0.007	-0.014
	(0.010)	(0.014)	(0.014)
β15D_twoyear	-0.068***	-0.052**	-0.118***
	(0.021)	(0.025)	(0.036)
β16FCF	-0.165***	-0.175***	-0.170**
	(0.048)	(0.066)	(0.071)
β17Lev	0.080***	0.060	0.097**
	(0.029)	(0.039)	(0.045)
β18da	0.179***	0.189**	0.181**
	(0.058)	(0.080)	(0.085)
β19REM	0.058	0.066	0.063
	(0.037)	(0.064)	(0.046)
β20Nature	-0.032***	-0.037**	-0.022
	(0.012)	(0.016)	(0.018)
Constant	0.216***	0.169	0.215***
	(0.053)	(0.107)	(0.070)
YEAR	Control	Control	Control
INDUSTRY	Control	Control	Control
		P=0.029	(Significant difference between groups)
Obs	15,267	8,245	7,022
Adj-R2	0.1147	0.1165	0.1153
F value	44.94	26.28	21.34

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 15,267 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively.

4.7.11 Measure managerial ability using CEO tenure

Following research by Walters et al. (2007), we also use managers' tenure to measure managerial ability. If the matching between the CEO and the company is good, then they carry on.

Table 73 Descriptive statistic of *tenure and D_tenure*

The descriptive statistic of *tenure* is for a sample of 14,952 firm-year observations from 3,887 firms. On average *tenure* was 48.41 months (median: 40 months, standard deviation: 38.63) with a minimum of 1 month and maximum of 156 months. The D_tenure is a dummy variable (1 if tenure>median, 0 otherwise). D_tenure equals 1, which means managers have high managerial ability because the longer tenure the better match between the CEO and the company. While D_tenure equals 0, which means managers have low managerial ability.

	Obs.	Mean	Standard Deviation	Median	Minimum	Maximum
tenure	14,952	48.41	38.63	40.00	1.00	156.00
D-tenure	14,952	0.44	0.50	0.00	0.00	1.00

Regression result in Table 74 shows that the value of β3 is negative (-1.388*) and is significant at a 10% level in high managerial ability sub-sample and the value of β3 in low managerial ability sub-sample is negative (0.069) but not statistically significant, which means capable managers strengthen the positive relationship between ownership concentration and R&D stickiness. The difference between these two groups is statistically significant (P value=0.095). Therefore, we find evidence consistent with our main results.

Table 74 Measure managerial ability using CEO tenure

	H3	
	Low MA	High MA
β1ΔLn(IncomeR)	0.656***	0.512***
	(0.026)	(0.033)
β2ΔLn(IncomeR)*D	-0.881***	0.055
	(0.212)	(0.225)
β3ΔLn(IncomeR)*D***Concern**	**0.069**	**-1.388***
	(0.595)	**(0.557)**
β5Assets Intensity*ΔLn(IncomeR)*D	0.080	-0.152**
	(0.078)	(0.071)
β6D_twoyear*ΔLn(IncomeR)*D	0.005	0.075
	(0.128)	(0.126)
β7FCF*ΔLn(IncomeR)*D	0.865**	-0.521**
	(0.376)	(0.222)
β8Lev*ΔLn(IncomeR)*D	0.787***	-0.144
	(0.228)	(0.273)
β9da*ΔLn(IncomeR)*D	0.477	0.703
	(0.466)	(0.439)
β10REM*ΔLn(IncomeR)*D	0.188	0.163
	(0.358)	(0.409)
β11Nature*ΔLn(IncomeR)*D	0.033	0.241*
	(0.124)	(0.129)
β13Concern	-0.048	-0.182***
	(0.067)	(0.069)
β14Assets Intensity	-0.015	-0.006
	(0.014)	(0.014)
β15D_twoyear	-0.092***	-0.075**
	(0.029)	(0.030)
β16FCF	-0.178***	-0.088
	(0.068)	(0.069)
β17Lev	0.099**	0.032
	(0.042)	(0.042)
β18da	0.196**	0.129
	(0.082)	(0.082)
β19REM	0.067	0.045
	(0.051)	(0.054)
β20Nature	-0.026	-0.043***
	(0.017)	(0.017)
Constant	0.228***	0.189**
	(0.074)	(0.083)
	P=0.095(Significant difference between groups)	
Obs	8,310	6642
Adj-R2	0.1295	0.0963
F value	28.46	17.08

Notes: The table reports the coefficients based on Anderson et al.'s (2003) model. The sample period is 2010-2019. The sample consists of 15,267 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. The sample were split to high managerial ability and low managerial ability samples using the 50th percentile of tenure.

4.7.12 Summary

The robustness tests support our initial hypotheses. Alternative measures of revenue, ownership concentration or managerial ability as well as additional control variables return findings in support of our major hypothesis.

4.8 Conclusion

Existing research shows mixed results about the relationship between ownership concentration and a company's R&D decisions. While concentrated ownership can exercise its power to monitor and direct management to increase R&D expenses for more innovation, in developing countries blockholders were found to bond with management and expropriate firm resources at the expense of minority shareholders. In the latter case, minority shareholders require a risk premium in the form of higher dividends. We examine the effect of ownership concentration on the R&D investment decision when a company is experiencing downturn. Using Anderson et al.'s (2003)model to measure R&D stickiness and Iturriage and Lopez-Millan's (2016) model to measure ownership concentration, we find the top five shareholders' ownership concentration results in higher R&D expense stickiness when firm sales decline. This finding supports Shleifer et al.'s (1986) finding that concentrated ownership monitors and directs management with a long-term vision; the vision includes uncertain R&D activities which can lead to innovation and sustained competitive advantage. Yet, minority shareholders demand for relatively higher returns in the form of dividends ensures that management reduces R&D stickiness when accrual-based earnings management is relatively high and triggering potential issues with auditors. The significance of these findings refers to the top five shareholders' blockholding while the result on R&D stickiness was not significant when considering only the power of the top shareholder, even though their power would constitute a 'significant influence'.

Additionally, we found managerial ability had a significant impact; when operating revenue fell, high-ability managers act more rationally and cut R&D costs less aggressively in the presence of high ownership concentration. Our findings are robust using alternative ways of measuring ownership concentration or controlling for different sets of fixed effects (individual fixed effects model), or additional variables such as whether the positions of board chair and CEO are occupied by one person, a factor which may be correlated with costs stickiness (Chen et al., 2012).

Research documents conflicting views about the relationship between managerial ability and firm performance. Some researchers argue there is a positive relationship between managerial ability and firm performance (Demerjian, 2012); others argue that capable managers maximize self-interest to engage in earnings manipulation to meet short term goals at the expense of long-term success (Francis et al., 2008). Our study focuses on the moderating roles of managerial ability on the relationship between principal-principal agency problem (ownership concentration) and R&D stickiness.

We provide evidence that higher managerial ability strengthens the positive relationship between ownership concentration and R&D stickiness. Collectively, our findings suggest that ownership concentration enables capable managers to fully utilize their talents to sustain R&D expenses even when the firm faces sales revenue declines.

Under institutional ownership, the long-term focus is even more pronounced that sales revenue decline has no significant impact on R&D expense stickiness. In turn, free cash flow and higher ROA have a positive effect while higher leverage, and more accrual-earnings management have a negative effect on R&D stickiness. This long-term focus, decoupled from sales revenue changes, is in line with the argument that institutions often follow the Chinese Government's macroeconomic policies which are to promote innovation.

This research contributes to the literature by adding more evidence to the debate on whether controlling or institutional shareholders expatriate resources to maximize self-interest at the expense of minority shareholder interests or support R&D activities. Our study extends the scope of agency theory by examining the effect of principal-principal conflicts between majority and minority shareholders on R&D investment decisions in the setting of cost stickiness. Our findings suggest that firms have to sustain dividends to minority shareholders to compensate for potential governance shortcomings associated with blockholding. Blockholders encourage R&D stickiness and this effect is even more pronounced for high-ability management who can allocate resources more rationally, especially during times of sales revenue decline.

Our study also contributes to the literature by providing evidence on ownership concentration and institutional ownership, managerial ability and R&D stickiness, to gain an in-depth understanding of R&D cost stickiness under various governance factors. Managerial ability strengthens R&D cost stickiness under ownership concentration and institutional blockholding, while accrual earnings management remains a critical factor. Concentrated and institutional ownership does not limit earnings management activities during sales revenue increases, and even diminishes R&D expenses when accrual earnings management is exhausted during sales revenue declines.

Our study has implications for investors and auditors. While sustained R&D expenses sends a signal of investment in the firm's future and innovative power, they might merely support blockholders' intention to comply with the China Government's macro-economic policy of higher R&D spending. When the scope of prevailing earnings management is exhausted or free cashflow, declines firms will diminish R&D expenses. Therefore, at first glance the previously identified principal-principal conflict between blockholder and minority shareholder is kept latent, it still prevails under conditions of profit decline or cash shortage. However, high capability management can mitigate this issue by using their tacit and industry specific knowledge to act more rationally and use resources more efficiently to retain R&D expenses during sales revenue decline.

This study is not without limitations. While CSMAR provides the R&D expenses of listed firms, there is no more refined data available about R&D capitalization and subsequent patents. While our study sheds light onto the role of corporate governance factors on R&D stickiness, future research could consider other factors which could either impact the probabilistic assessment of management's judgement on the future need for R&D resources, or firm-external factors which could impact on R&D expenses.

5 Managerial ability, market competition and R&D resource allocation

5.1 Abstract

Making good resource allocation is as important as having resources. Drawing on the Resource Based View (RBV), we explore how companies change their R&D expenditure when facing operating cash constraints. The data used is drawn from 16,279 firm-year observations of companies listed in Shanghai and Shenzhen Stock Exchanges from 2010 to 2019. We found that the change in R&D expenditure in response to falling sales is of a smaller magnitude to that of an increase (R&D stickiness). We discovered that managerial ability strengthens this asymmetry; that higher ability leads to fewer cuts in R&D when facing falling sales. Finally, we found that managers of high-ability do not introduce sharper cuts to R&D expenditure even when operating in highly competitive product markets. The mechanism test further assures our findings showing that under financial constraints or higher financial risk managerial ability's impact on R&D stickiness is pronounced. Contributions and limitations are discussed.

Keywords: Managerial Ability, Product Market Competition, R&D resource allocation, RBV

5.2 Introduction

The resource-based view (RBV) puts forward that firms are a collection of resources that form the basis upon which they compete in product markets (Testoni, 2022; Wernerfelt, 1984). RBV draws on companies' resources and capabilities to explain competitive heterogeneity (Helfat & Peteraf, 2003). Managers make resource allocation decisions based on their probabilistic judgement about how sales might change to retain or retire resources. The importance of such decision making is more pronounced while sales decline, as when cash becomes more limited the importance of resource allocation increases. Traditionally, real options theory suggests that postponing resource allocation with uncertain outcomes can add value because future cashflows and investment values are uncertain, and this raises the opportunity cost of making decisions now rather than when the outlook becomes more stable (McDonald & Siegel, 1986; Pindyck, 1986). Feng and Ho (2016), Lee et al. (2009), and Martzoukos (2001) drew on real options theory in a managerial decision making and investment context, which suggested that in the absence of competition, a firm's best option is to hold on to their current resource allocation unless the net present value is relatively high. However, the value of waiting decreases in the presence of competition, as the firms competing in the same market are interdependent. One firm's decision about their own resource allocation will impact upon the net present values of their competitors' resource allocation strategies, and vice versa. Therefore, managers must take into account on how their

competitors will respond when they make decisions on resource allocation (Alimov, 2014; Haushalter et al., 2007). While the impact of market competition on R&D resources is inconclusive with empirical evidence both negative (Hashmi, 2013) and positive (Le et al. (2021). An additional resource is managerial ability, which has the capacity to transform scarce resources such as R&D to enhance the value of a company (Demerjian et al., 2012). RBV scholars put forward that the possession of resources is just as important as their optimal utilization, which can be determined by the ability of managers. Managerial ability originates from experience as well as tacit knowledge about the firm and industry which makes it an important but difficult to imitate resource (Hitt et al., 2001; Kor, 2003). High-ability and low-ability managers have opposing effects on the resource utilization and value of the firm. Managers with high-ability are receptive to risk-taking, such as when allocating R&D resources, while low-ability managers are risk averse and might reconsider R&D resource allocations against other factors. Consequently, high-ability managers can reduce capital expenditure and be able to make way for increasing spending on R&D resources, whereas low-ability managers reduce both capital expenditures and R&D spending (Yung & Chen, 2018; Yung & Nguyen, 2020). High-ability managers are rational and can optimize resource allocation, and thus exhibit less cost stickiness compared to risk-averse low-ability managers (Ziyang Li et al., 2020).

Market competition and managerial ability impact upon resource allocation decisions within a firm. With the flexibility introduced that resources are not only those that appear on a balance sheet, there are good reasons to question the traditional assumption that the relationship between revenue and resources (measured in costs) should be linear: if a 1% increase in revenue triggers a 1% increase in costs, then a 1% fall in revenue should be matched by a 1% fall in costs. In 2003, Anderson, Banker and Janakiraman (ABJ) put forward empirical evidence that the relationship between revenue and the allocation of resources measured in costs is nonlinear. They reported that selling, general, and administrative (SG&A) costs respond differently to upward or downward changes in sales units. They found that SG&A costs increased 0.55% per 1% increase in revenue but fell only 0.35% per 1% decrease in revenue. ABJ named this asymmetric resource allocation and cost behaviour as “sticky”. Since then, a great amount of research has been conducted on this topic, and conflicting results on the relationship between product market competition and costs stickiness reported. Based on data from the United States, Huang and Sun (2017) find a positive relationship between product market competition and operating cost stickiness. In China, Li and Luo (2021) find a negative relationship between product market competition and operating cost stickiness. However, the specific allocation of resources (cost of goods sold, administration, sales and R&D expenses) is not defined, and authors combined bundles of resources which are worth being considered in separate, as their nature is inherently different. R&D has a unique role in allowing for firm innovation and long-term success.

Research has also been conducted on the allocation of resources to R&D activities. One stream of research suggests that R&D resources are partially or fully sunk costs. That is, in its initial phase, resource allocation into R&D means incurring costs for the establishment of an R&D department, the acquisition of specialized physical assets, hiring or training specialized labour, but also the acquisition of information on new technologies, organizational changes and adjustments to new technologies, among other things. The costs associated with scientists engaging in research cannot be recovered and therefore constitute sunk costs (Máñez et al., 2009).

In contrast, R&D can constitute a knowledge base, if it is highly specific and tied to the operations of the firm which could be lost without continuing R&D efforts. In this case, R&D activities become an asset. From the standpoint of evolutionary economics, managers must make decisions with bounded rationality (Dosi& Marengo, 2007). Managers have to make resource allocations decisions about how much they spend on R&D with unknown amounts and time of financial returns. These R&D resources can cover a broad range of factors including the knowledge of technical opportunities, cumulative technological knowledge, and a knowledge base about the industry (Coad, 2019). Managers have to consider very carefully the implications for their firm if they were to reduce spending on R&D resources. Consequently, just like the SG&A costs are sticky, so are R&D costs (Anderson et al., 2003).

Our study examines how managerial ability affects a company's R&D investment decision through the lens of R&D cost stickiness in the face of product market competition. There are two main goals of this study. First, we investigate whether managerial ability affects asymmetric cost behaviour of R&D resource allocations. Secondly, we examine how a company's operating environment affects the firm's R&D resource allocation. This research utilizes data from listed companies in the Chinese (Shanghai and Shenzhen) stock market from 2010 to 2019, comprising 16,279 observations. We employ Anderson et al.'s (2003) asymmetric model of SG&A to examine to what extent managerial ability influences the sensitivity of R&D expense to sales changes when sales increase versus when sales decrease. Following Demerjian et al. (2012), managerial ability can be proxied by using a two-stage process to estimate managerial ability. The logic is that "the most successful firms are those that produce the maximum sales (output) at the lowest cost (input)" (Demerjian et al., 2012, p. 497). We follow Philoppe Aghion et al. (2013), and use the Lerner index to measure product market competition. The results of our tests are consistent with our hypotheses. Using industry fixed effects to control for cross-industry differences and year fixed effects to control for common time trends, we provide evidence that managerial ability strengthens the stickiness of R&D resources. That is, a firm with capable managers will retain R&D resources when sales decrease compared to companies without capable managers. This finding is consistent with the view that managers with high-ability benefit the company and shareholders in the long-run by retaining valuable resources (Haider et al., 2021). These capable managers perhaps began their resource allocation into R&D activities with better

acumen, meaning that it is more worthwhile retaining these R&D activities even when facing downturns. Furthermore, using the industry-level competition measured by the Lerner's index and alternative competition measurement Herfindahl-Hirschman Index as a robustness test, we find that managerial ability tends to rise with R&D stickiness. This relationship intensifies with increase in product market competition. Our result is consistent with the finding reported in Huang and Sun's (2017), that is, cost stickiness increases with competition. The empirical results are robust toa battery of robustness tests. We use the individual fixed effects model to control individual effects on the relationship between managerial ability and R&D stickiness.

Our study makes numerous contributions. First, previous research shows that managers' personal characteristics (such as over-confidence) could influence resource allocation in the form of cost stickiness (Holcomb et al., 2009; Yang, 2019). However, the extent to which managerial ability influences R&D resource allocation in the form of cost stickiness has not drawn much attention from researchers. This research provides empirical evidence to the debate.

Second, our paper contributes to the literature by conflating the impact of product market competition on R&D resource allocation in times of declining sales revenue (cost asymmetry) considering the resource of managerial ability. We find this resource increases the degree of R&D cost stickiness in the presence of intense product market competition. We extend the RBV by providing evidence of how managerial ability and R&D resources interact in times of declining sales revenue and how managers make probability judgments about future sales revenue while they take into account the external factor of product market competition. Both R&D and managerial ability are crucial resources which enable managers to retain or even extend their competitive advantage within product markets. Resource allocation increases in importance when managers face a shortage of operational cash in-flows from sales.

Third, by examining the effect of product market competition on capable managers through the lens of R&D stickiness, this research adds more evidence to the stream of research that product market competition acts as an external governance mechanism to force managers to increase resource allocation efficiency.

Fourth, different from Anderson et al.'s (2003) research, by focusing on how managers efficiently allocate resources (SG&A) when sales decrease, this research looks at manager's myopic activities when the company is experiencing a downturn through the lens of R&D expense stickiness.

The remainder of this paper is organized as follows. Section 5.3 describes the literature review and hypothesis development. Section 5.4 explains the research design and descriptive statistics. Section 5.5 provides research results. Section 5.6 contains the mechanism tests. Section 5.7 reports the robustness tests and Section 5.8 concludes.

5.3 Literature review and hypothesis development

5.3.1 Managerial ability and R&D resource allocation

Demerjian et al. (2013) find that earnings quality is positively associated with managerial ability. Wang et al. (2017) find that increased managerial ability leads to less financial reporting fraud. Cornaggia et al. (2017) find that higher-ability managers obtain more favourable credit ratings. These studies support the view that managerial ability could improve firm performance. In contrast, Handfield-Jones et al. (1999) reported that realized increases in sales and profitability were usually temporary. Gul et al. (2018) observe that financially distressed firms with higher-ability managers display lower quality accruals and a higher likelihood of restatement. Previous research shows that higher ability managers often face a dilemma on how to balance the conflict of interest between managerial self-interest and shareholder interests. Wang et al. (2017) predict that capable managers are less likely to produce fraudulent financial reporting because managerial ability would reduce firms' financial pressure. Barney (1991) states that managers who are deemed 'able' are those who can improve firms' overall economic resource performance by integrating skills including technical skills, human skills and conceptual skills.

R&D resource allocation may not yield any profits for the firm if innovation fails, or returns may take a very long time to be realized. Managerial ability implies (tacit) firm- and industry-knowledge which is difficult to imitate. This knowledge vested in high-ability managers allows them to retain R&D activities when sales revenue decreases because they know its benefits to the company's long-term development. For instance, R&D resources help a company to achieve growth and competitive advantages (Kim & Park, 2012), outperform their competitors (Geroski et al., 1993), drive economic performance (Lee, 2012), and has a long-term effect on value creation and sustainable development (Mazzi et al., 2019).

We argue that managerial ability is positively associated with a company's R&D resource allocation even when it is in an economic downturn. There are several factors which support this view. First, capable managers are rational and benefit the firm and its shareholders (Haider et al., 2021) supported by a positive relationship between R&D resource allocation and the company's long-term development (Cho et al., 2016). We predict that a capable manager will maintain the pre-existing level of R&D expense for the company's long-term development even when sales decrease. Second, capable managers make rational R&D resource allocations, reducing innovation failure, and retaining R&D resources even when the firm is in downturn. Faced with declining sales revenue and cash shortage, the importance of resource allocation rises. It is during such times that managerial ability has crucial implications on resource allocation. Third, capable managers' rational R&D resource retention during the firm's downturn enhances shareholder value. Demerjian et al. (2013) point out that capable managers gain shareholders' trust. We hypothesize:

H2. Stronger R&D stickiness should be observed under more capable managers

However, high-ability managers may not continue R&D activities when sales decrease since managers gain related benefits in the short-term. Additionally, R&D activities could seriously worsen the company's current financial condition, which may cause high-ability managers to reduce the ongoing R&D expenditures. Thus, capable managers may decide to allocate fewer R&D resources especially when sales decrease. This is because it may damage their reputation if the investment failed (Chen, 2015) or if managers are motivated to boost current profits at the expense of long-term interests because they fear stocks may become undervalued due to low earnings when they are facing takeover pressure (Stein, 1988). Following the viewpoint that capable managers may look after their self-interests at the expense of shareholder benefits (Gul et al., 2018), in this case H2 may be rejected. Therefore, we shall observe a decline in R&D spending in line with or even beyond the decline in revenue.

5.3.2 Product market competition and managerial ability

Under the classic economics premise of market structure, in markets with high competition, products are similar and substitutable and there is little leeway to do anything different, resulting in only normal profit. Alternatively, if producers have some market power, such as those in monopolistic competition or in markets dominated by just a few firms, then the firms have more options over the products they offer and how much they charge. This gives them an incentive to consider how they may do things differently so that they may gain an improved market share (Mankiw, 2017). With these considerations in mind, one may hazard a guess that when facing a downturn, the competitive nature of the market may have an impact on the choices they make on R&D spending.

Jagannathan and Srinivasan (1999) find that managers from firms with similar skills, technology and product features will maximize the value of the firm. Due to the more standardized characteristics of the firms, it is easier for investors to make comparisons between firms, thus forcing the managers to work harder to maximize the value of the firms they manage. Baggs and Bettignies (2007) find that competition tends to improve efficiency as well as product quality; competition elicits more effort from management to "steal" market share from rivals. Competition forces managers to reduce inefficiency and mitigate information asymmetry between principals and agents (Holmstrom, 1982; Schmidt, 1997), reduce the company's marginal cost of eliciting effort from agents (Baggs & Bettignies, 2007), and enable principals to monitor the agents more effectively due to the positive relationship between competition and the quality of information disclosure (Iqbal et al., 2016).

Competition can influence a company's choice of cash resources. There is a positive relationship between firm's cash holding and higher product market competition; firms facing greater risk of predation hold more cash (Alimov, 2014; Haushalter et al., 2007). Xu (2012) finds that there is a negative relationship between competition and leverage ratios;

competition reduces profitability and increases volatility of profits, thus companies would prefer to finance their operations with something other than debt.

Product market competition influences company strategic decisions. One might wish to think that spending money on work related to corporate social responsibility is similar to spending money on R&D activities. Both activities do not bring immediate returns and if there are going to be any returns, they are fraught with uncertainties. Corporate environmental responsibility helps a company to build a good reputation and thereby achieves competitive advantage. Based on listed manufacturing companies from 2006 to 2008 in China, Meng et al. (2016) find that product market competition fosters corporate social responsibility (CSR). Conversely, product market competition exerts strong pressure on costs, which means companies are not motivated to implement corporate environmental responsibility. Lee et al. (2018) find that more competitive product markets are less engaged in corporate social responsibility activities based on Korean firms listed on the Korea Exchange from 2010 to 2013.

There is conflicting evidence as to whether competition can better serve innovation decisions. Based on UK data, Aghion et al. (2005) find an inverted U relationship between competition and innovation. They argued that whether firms innovate under low competition or high competition (defined by an index like Lerner) is dependent on the difference in technology level across firms. The model assumes that innovation can be easily copied with some lags, therefore in the low competition scenario, if the firms are operating on a similar level of technology ("head-to-head") then there is no incentive to innovate because their effort would soon be copied by others. At the other extreme when there is high competition and the level of technology used by firms is varied ("unlevelled"), the innovations are only pursued by the tech-followers to prevent themselves from being eliminated. The costs do not justify the returns and followers are deterred from staying in the industry and therefore little innovation happens. Using data from publicly traded manufacturing firms in the United States, Hashmi (2013) finds a negative relationship between competition and innovation. Based on US manufacturing industries, Correa and Ornaghi (2014) observe faster technological advances in more competitive markets. Developing Correa and Ornaghi's (2014) research, Le et al. (2021) point out that in order to escape from competition pressure, firms with high product market competition allocate more resources to R&D.

H3: Under a competitive environment, R&D stickiness maintains or increases under capable managers

If this hypothesis is not rejected, firms will retain more R&D resources, even when there is a shortage of cash, because of the presence of product market competition. This triggers the question of managerial efficiency in allocating resources.

5.3.3 CEOs and competition

This section provides further arguments on why H3 may apply. Product market competition influences management and can trigger CEO turnover. DeFond and Park (1999) find that the ability of boards of directors to identify whether CEOs are fit for their job increases in highly competitive industries. In a competitive environment management ability becomes an even more important resource that drives good resource allocation including decisions on R&D. Eisfeldt and Kuhnen (2013) find that "CEOs are more likely to be forced out if their performance is poor relative to the industry average". Since higher product market competition increases the likelihood of bankruptcy, product market competition motivates managers to be more efficient in their resource allocation in order to stay in business (Schmidt, 1997). The increase in product market competition will potentially have two opposing effects on a company's innovation decision. One possibility is that, since maximizing profits is a firm's primary goal, product market competition leads to a decline in average profits while the firm faces risks of innovation failure. This can demotivate companies to allocate resources to innovation when they are facing strong product market competition. Alternatively, in order to achieve a competitive advantage in highly competitive markets, companies are strongly motivated to allocate resources to innovation. Accordingly, product market competition will affect a company's R&D investment decision. The key point of the conflict in the opinion of various researchers is whether innovation brings a burden of cost or a competitive advantage. Product market competition thus forces capable managers to use their specific skills in the best interests of shareholders.

Capable managers and companies match with each other. Groysberg et al. (2006) find that CEOs are only successful in their new jobs if the company matches their personality characteristics. CEOs look for firms which match with their personal managerial attitudes. Good matching between the CEO and the firm is helpful. Graham et al. (2013) find that risk-tolerant CEOs are more likely to be working at high growth firms, given that high returns tend to be related to high risks. This is another example that shows good matching is helpful. Capable managers match with companies when they are in downturn because those companies are looking for capable managers to deal with their problems; conversely, capable managers are more likely to be working at the company when it is in downturn because they are more confident to take risks with their unique abilities. Chen (2015) finds that there is a positive relationship between managerial ability and innovation success. Maintaining R&D investment when the company is in downturn is a risk-taking activity, but the capable manager will maintain investment in R&D when the company is in downturn. We argue that managerial ability is positively associated with R&D stickiness when the company is in downturn in the face of product market competition. If the company uses innovation resources as a strategy to achieve long term development, then we should see a positive link between product market competition and R&D investment even when company is in downturn.

If this hypothesis holds, then capable managers have the ability to utilize their firm and industry-tacit knowledge to contribute to firm competitive advantage by retaining R&D resources despite the shortage of cash in high market competition. However, Cai and Liu (2009) find that there is a negative relationship between product market competition and the average profit margin. Furthermore, Ven and Jeurissen (2005) find that a high degree of product market competition and profit decrease could make firms adopt a low-cost strategy. Consistent with the view of cost concern, we demonstrate that capable managers in more competitive environments will diminish R&D resources when the company faces declining sales revenue. The alternative to H3 is that the ability of the managers makes no difference on the strength of R&D stickiness.

5.4 Research design and summary statistics

5.4.1 Sample selection

Our initial sample consists of all publicly traded firms that have A-shares traded on the Shanghai and Shenzhen Stock Exchanges from 2010 to 2019. The sample period starts in 2010 because the financial crisis of 2007 to 2009 influenced R&D investment. That is, low-ability managers diminished their R&D resources by 25% and high-ability managers only reduced R&D resources by 14.8% during the 2007 to 2009 crisis (Yung & Nguyen, 2020). Following Anderson et al. (2003), we drop invalid observations that have missing or non-positive values for operating revenues and R&D costs. Furthermore, we dropped financial companies, totalling 712 dropped observations. To reduce the impact of outliners, 1% of extreme values on each tail were winsorised for all regression variables. All data are obtained from the CSMAR database and Wind database.

From an initial 52,641 firm-year observations traded on the Shanghai and Shenzhen Stock Exchanges, we delete an additional 1,169 firm-year observations of B-share companies (A-share are listed on domestic exchanges and trade in RMB, while B-shares are only held only by foreign entities and foreign individuals). We further delete 34,480 observations because of insufficient data on financial statements. Table 75 describes the sample selection process. The final sample consists of 16,279 observations.

Table 75Sample selection

Number of firm-year observations that are traded on the Shanghai and Shenzhen Stock Exchanges from 2010-2019	52,641
Removed observations for the following reasons:	
R&D investment higher than operating revenue	1
Financial industry listed companies	712
B-share companies	1,169
Missing financial statement data	34,480
Number of firm-years in the full sample	16,279

5.4.2 Product market competition measure

Following Sheikh (2018) and Philoppe Aghion et al. (2013), we used the Lerner index as the primary measure of product market competition. The higher the Lerner index the better the profitability and the lower the competition. Firms within a given industry were assigned the same Lerner value for that year.

$$\text{Lerner Index} = \frac{\text{Operating Revenue} - \text{Operating Costs} - \text{Sales Costs} - \text{Admin Costs}}{\text{Operating Revenue}} \quad (4)$$

As a robustness check we also used the Herfindahl-Hirschman Index (HHI) in place of the Lerner index, following Kao and Chen (2013). To calculate the HHI, we take the market shares of firms within an industry, square them and add them together. For example, if it is a monopoly the single firm will have 100% market share and the HHI will be 100,000. Therefore, the smaller the HHI is, the more competition there is in the market.

All variable definitions are presented in Appendix 1.

5.4.3 Descriptive statistics

Table 76 reports descriptive statistics of the main variables used in this research. There are 16,279 observations used in the research. The mean (p50) log-changes in R&D expenditure are 0.200 (0.130). The mean (p50) log-changes in operating revenue are 0.120 (0.100). The log-changes in R&D expenditure are higher than sales revenues, which shows that R&D expenditure is increasing at a faster rate than operating revenue. One concern about examining R&D stickiness is whether the R&D investment variable and operating revenue variables have enough variation. The standard deviations of R&D investment and operating revenue are 0.620 and 0.330, respectively, significantly larger than their means 0.200 (0.120), which shows that those two variables have large variation. The mean (p50) values of product market competition (Com) are 0.110 (0.090) and the standard deviation is 0.060. In 12% of the observations, operating revenue decreases from year t-2 to year t. The mean value of MA Score is -0.02 with a standard deviation of 0.140. These statistics are comparable to Bu et al.'s (2015a) Chinese based cost stickiness research.

Table 76Summary statistics

Variable	N	Mean	SD	Min	p50	Max
ΔL randd	16,279	0.200	0.620	-6.230	0.130	10.56
ΔL revenue	16,279	0.120	0.330	-3.040	0.100	5.530
Com	16,279	0.110	0.0600	-0.110	0.0900	0.390
D twoyear	16,279	0.120	0.320	0	0	1
REM	16,279	0.140	0.140	0	0.100	0.840
FCF	16,279	0	0.110	-2.010	0.0200	2.780
da	16,279	0.0100	0.0900	-0.330	0.0100	0.350
Assets	16,279	0.650	0.600	-2.430	0.630	4.390
MA Score	16,279	-0.0200	0.140	-0.320	-0.0400	0.440

There are 16,279 observations which will be used in the research; The p50 is the 50th percentile.

5.5 Results

5.5.1 Managerial ability and R&D stickiness

To test H2, we add managerial ability (MA) and In(IncomeR)*D*MA to Model 2 and estimate the following regression:

Model 3:

$$\begin{aligned}\Delta ln(\text{R\&D Costs}_{it}) = {} & \beta_0 + \beta_1 * \Delta ln(IncomeR_{it}) + \beta_2 * \Delta ln(IncomeR_{it}) * D_{it} \\ & + \beta_3 * \Delta ln(IncomeR_{it}) * D_{it} \ * MA_{it} + Industry\ dummies \\ & + Year\ dummies + \beta_5 * FCF_{it} * \Delta ln(IncomeR_{it}) * D_{it} \\ & + \beta_6 * Asset\ intenstiy_{it} * \Delta ln(IncomeR_{it}) * D_{it} \\ & + \beta_7 * D_{twoyear,it} * \Delta ln(IncomeR_{it}) * D_{it} \\ & + \beta_8 * da_{it} * \Delta ln(IncomeR_{it}) * D_{it} \\ & + \beta_9 * REM_{it} * \Delta ln(IncomeR_{it}) * D_{it} + \beta_{12} * Asset\ intenstiy_{it} \\ & + \beta_{13} * D_{twoyear,it} + \beta_{14} * FCF_{it} + \beta_{15} * da_{it} + \beta_{16} * REM_{it} + \varepsilon_{it} \quad (6)\end{aligned}$$

where MA is an indicator for managerial ability. Coefficient β3 indicates the relation between MA and the degree of cost stickiness. Testing hypothesis H2, managerial ability could strengthen the level of R&D expenditure stickiness if $\beta_3<0$. The hypothesis H2 holds **if $\beta_3>0$.**

Table 77Managerial ability and R&D stickiness

	3
β_1ΔLn(IncomeR)	0.608***
	(0.019)
β_2ΔLn(IncomeR)*D	-0.280***
	(0.081)
β_3ΔLn(IncomeR)*D*MA	**-0.586*** **
	(0.210)
β_5FCF*ΔLn(IncomeR)*D	-0.461***
	(0.135)
β_6Assets Intensity*ΔLn(IncomeR)*D	-0.104***
	(0.040)
β_7D_twoyear*ΔLn(IncomeR)*D	0.038
	(0.074)
$\beta_8$da*ΔLn(IncomeR)*D	0.595**
	(0.249)
β_9REM*ΔLn(IncomeR)*D	0.119
	(0.245)
β_{11}MA	-0.159***
	(0.045)
β_{12}Assets Intensity	-0.027***
	(0.009)
β_{13}D_twoyear	-0.081***
	(0.019)
β_{14}FCF	-0.144***
	(0.045)
β_{15}da	0.188***
	(0.055)
β_{16}REM	0.066*
	(0.036)
Constant	0.269***
	(0.049)
Obs	16,279
Adj-R2	0.1152
F value	52.71

Notes: The table reports the coefficients based on Anderson et al. (2003) model to test to what extend managerial ability influences R&D stickiness. The sample period is 2010-2019. The sample consists of 16,279 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively.

The regression results of managerial ability on R&D stickiness are reported in Table 77. The empirical result shows that the value of β_3 (-0.586) is negative and statistically significant at the 1% level (-0.586***), indicating that capable managers strengthen the stickiness of R&D.

That is, the higher is the capability of the manager the stickier it is for R&D spending. Capable managers were retaining more R&D spending during downturns. The finding confirms existing research that there is a positive relationship between managerial ability and risk-taking behaviour (Andreou et al., 2016).

5.5.2 Competition, R&D stickiness and managerial ability

Testing the hypothesis H3 (H3: When competition is high, R&D stickiness maintains or increases under capable managers), we regress model 3 with the high product market competition and low product market competition sub-samples, separately. As H3 indicates, we expect $\beta_3<0$ in the high product market competition sub-sample when firm with capable managers. In order to escape from competition pressure, firm with capable managers allocate more resources to R&D even when firm is in downturn. Following Sheikh (2018) and Philoppe Aghion et al. (2013), Lerner index has been adopted to measure product market competition. The higher the Lerner index the lower the product market competition. The sample is split to high product market competition and low product market competition samples using the 50th percentile.

Table 78Competition, managerial ability and R&D expense stickiness

	H3	
Model	3	
	Low Lerner index (strong competition)	High Lerner index (weak competition)
β_1ΔLn(IncomeR)	0.635***	0.582***
	(0.029)	(0.025)
β_2ΔLn(IncomeR)*D	-0.352***	-0.154
	(0.116)	(0.115)
β_3ΔLn(IncomeR)*D*MA	**-1.723*** **	**0.068**
	(0.375)	**(0.253)**
β_5FCF*ΔLn(IncomeR)*D	-0.873***	-0.162
	(0.226)	(0.168)
β_6Assets Intensity*ΔLn(IncomeR)*D	-0.217***	-0.101**
	(0.070)	(0.051)
β_7D_twoyear*ΔLn(IncomeR)*D	0.115	0.026
	(0.117)	(0.098)
$\beta_8$da*ΔLn(IncomeR)*D	1.128***	0.250
	(0.423)	(0.313)
β_9REM*ΔLn(IncomeR)*D	0.261	-0.136
	(0.358)	(0.344)
β_{11}MA	-0.232***	-0.137**
	(0.074)	(0.055)
β_{12}Assets Intensity	-0.053***	-0.008
	(0.014)	(0.013)
β_{13}D_twoyear	-0.058**	-0.096***
	(0.027)	(0.028)
β_{14}FCF	-0.195***	-0.099*
	(0.067)	(0.060)
β_{15}da	0.255***	0.136*
	(0.079)	(0.078)

		H3
Model		3
β_{16}REM	0.069	0.054
	(0.055)	(0.047)
Constant	0.309***	0.226**
	(0.062)	(0.097)
	P=0.050 (Significant difference between groups)	
Obs	8,615	7,664
Adj-R2	0.1168	0.1174
F value	30.97	26.48

Notes: The table reports the coefficients based on Anderson et al. (2003) model to test how product market competition influences the relationship between managerial ability and R&D stickiness. The sample period is 2010-2019. The sample consists of 16,279 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. All models include year- and industry-fixed effects. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Following Sheikh (2018) and Philoppe Aghion et al. (2013), we used Lerner index as the primary measure of product market competition. The higher the Lerner index the lower the competition. The sample were split to high product market competition and low product market competition samples using the 50th percentile. If Lerner index is higher than median, that is low product market competition. While if Lerner index is lower than median, that is high product market competition.

Table 78 shows the regression results of the effects of product market competition on the relationship between managerial ability and R&D stickiness. The value of β_3 is negative (-1.723)and statistically significant at the 1% level in high product market competition sub-sample and the value of $\beta_3$ispositive but not significant (0.068), indicating that high product market competition could strengthen the positive relationship between managerial ability and R&D stickiness relative to those companies with low product market competition (high product market competition would lead capable managers to continue to invest in R&D when the company is in downturn).

Table 79 provides Pearson and Spearman correlations between our main variables, including the interaction terms. The Pearson (Spearman) correlation matrix for variables in the main analysis is at the lower (upper) diagonal. Similar, to Chen et al (2012), there are significant but small in magnitude relationships between the main variables.

Table 79 Correlation matrix

	ΔL_revenue	t1	t2	t3	t4	t5	t6	t7	t8	Com	D_twoyear	REM	FCF	da	Assets	MA
ΔL_revenue	1	0.78*	-0.35*	-0.33*	0.64*	0.03*	0.17*	0.77*	0.47*	0.06*	-0.47*	0.14*	-0.01	0.11*	-0.12*	0.18*
t1=D*Δ L_revenue	0.62*	1	-0.45*	-0.43*	0.82*	0.04*	0.22*	0.99*	0.61*	0.06*	-0.60*	0.07*	0.02*	0.09*	-0.18*	0.18*
t2=D*Δ L_revenue*MA	-0.30*	-0.51*	1	0.98*	-0.48*	0.07*	-0.09*	-0.43*	-0.33*	-0.07*	0.33*	-0.07*	-0.02*	-0.09*	0.19*	-0.49*
t3=D*Δ L_revenue*MA*Com	-0.26*	-0.47*	0.85*	1	-0.47*	0.08*	-0.08*	-0.42*	-0.32*	-0.04*	0.31*	-0.07*	-0.02*	-0.09*	0.19*	-0.48*
t4=D*Δ L_revenue*Assets	0.48*	0.83*	-0.56*	-0.53*	1	0.03*	0.16*	0.81*	0.53*	-0.02*	-0.52*	0.08*	0.03*	0.07*	-0.34*	0.23*
t5=D*Δ L_revenue*da	-0.14*	-0.28*	0.33*	0.24*	-0.39*	1	0.11*	0.05*	-0.01	0.02*	0.00	-0.04*	-0.05*	-0.47*	-0.00	-0.06*
t6=D*Δ L_revenue*FCF	-0.11*	-0.22*	0.00	0.00	-0.19*	0.30*	1	0.23*	0.12*	0.03*	-0.12*	0.02*	-0.45*	-0.04*	0.00	0.02*
t7=D*Δ L_revenue*REM	0.43*	0.71*	-0.31*	-0.28*	0.57*	-0.06*	-0.13*	1	0.59*	0.06*	-0.59*	0.02*	0.02*	0.08*	-0.17*	0.17*
t8=D*ΔL_revenue*D_twoyear	0.42*	0.67*	-0.38*	-0.30*	0.55*	-0.15*	-0.21*	0.47*	1	0.06*	-0.99*	0.07*	0.02*	0.07*	-0.15*	0.15*
Com	0.02*	0.01*	-0.01	0.07*	-0.03*	-0.01	-0.00	0.01	0.03*	1	-0.06*	0.03*	0.03*	-0.03*	0.21*	0.11*
D_twoyear	-0.36*	-0.38*	0.19*	0.14*	-0.27*	0.07*	0.05*	-0.23*	-0.63*	-0.05*	1	-0.07*	-0.02*	-0.07*	0.15*	-0.15*
REM	0.19*	0.03*	-0.04*	-0.03*	0.02*	-0.04*	-0.00	-0.17*	0.03*	0.02*	-0.08*	1	0.01	0.07*	-0.14*	0.19*
FCF	-0.00	0.08*	-0.03*	-0.04*	0.06*	-0.11*	-0.40*	0.05*	0.08*	0.03*	-0.03*	-0.02*	1	0.04*	-0.08*	0.03*
da	0.11*	0.10*	-0.12*	-0.09*	0.10*	-0.35*	-0.08*	0.02*	0.09*	0.03*	-0.08*	0.07*	0.09*	1	0.01	0.12*
Assets	-0.14*	-0.22*	0.20*	0.17*	-0.33*	0.08*	0.03*	-0.13*	-0.18*	0.21*	0.15*	-0.14*	-0.07*	0.00	1	-0.31*
MA	0.17*	0.15*	-0.33*	-0.27*	0.15*	-0.08*	-0.01	0.07*	0.12*	0.10*	-0.14*	0.23*	0.01	0.14*	-0.28*	1

Notes: The table reports the Pearson (Spearman) correlation coefficients for variables in the main analysis at the lower (upper) diagonal. The sample period is 2010-2019. The sample consists of 16,575 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. * denotes significance at 10% level.

We also conduct multicollinearity diagnostic tests for all dependent variables in the models, including the interaction terms (Table 80).

Table 80Variance inflation factors (VIF)

	VIF
β_1ΔLn(IncomeR)	1.85
β_2ΔLn(IncomeR)*D	6.40
β_3ΔLn(IncomeR)*D*MA	4.50
β_4ΔLn(IncomeR)*D*MA*Com	3.96
β_5FCF*ΔLn(IncomeR)*D	1.42
β_6Assets Intensity*ΔLn(IncomeR)*D	4.27
β_7D_twoyear*ΔLn(IncomeR)*D	2.75
$\beta_8$da*ΔLn(IncomeR)*D	1.62
β_9REM*ΔLn(IncomeR)*D	2.28
β_{10}Com	1.65
β_{11}MA	2.00
β_{12}Assets Intensity	1.58
β_{13}D_twoyear	1.82
β_{14}FCF	1.23
β_{15}da	1.28
β_{16}REM	1.26

We find that all the variance inflation factors (VIF) are lower than 10, suggesting that multicollinearity is not a concern in the estimation of our models.

Following Choi's (2001) research, Fisher-type panel tests have been adopted to see whether all the panels have stationarity. We find that those tests strongly reject the null hypothesis that all the panels contain unit roots. All variables including interaction terms have been tested and the results reject the null hypothesis that all panels contain unit roots, which shows that all the panels have stationarity.

Considering the existence of individual heterogeneity of the coefficient of each individual variable, the results of the F test shows that there is a significant difference between the coefficients of each individual variable and each individual variable (including interaction terms) significantly influences Y.

5.6 Possible Mechanism

We conduct two additional tests to identify the mechanisms underlying the positive relationship between managerial ability and R&D stickiness. First, we examine whether the effect of managerial ability on R&D stickiness is partly channeled by the level of financial constraints. The rationale is that firms with sufficient funds or have access to external finance are able to invest more on R&D even when firms are in downturn. Financial constraints are frictions that prevent firms from funding their desired investment (Costa & Habib, 2021), in that managerial ability increases R&D stickiness because capable managers are able to relieve financial constraint. Thus, we expect that R&D stickiness is intensified by managerial ability and the role of managerial ability is more likely to play a significant role in firms with less financial constraint. We follow Hadlock and Pierce (2010) and Kaplan &Zingales (1997), both SA index and KZ index have been used to measure financial constraint (detailed explanations about both scores see in below section 5.6.2.1 SA and 5.6.2.2 KZ index).

The sample is divided into two groups according to the median of financial constraints (both SA index and KZ index). We re-estimate the model 3 using the subsamples and report the results in the table below. The estimated coefficient on β_3 is negative and significant in the groups with low financial constraint (both SA index (Table 81) and KZ index (Table 82)), but insignificant in the groups with high financial constraint. Overall, results from the table below indicate that managerial ability can increase R&D stickiness by lower financial constraint (both SA index and KZ index).

Second, we test whether managerial ability aggravates R&D stickiness by relieving financial risks. Financial risks lowered by capable managers might help a firm to keep on doing R&D investment when firms are in downturn. Thus, we predict that the positive effect of managerial ability on R&D stickiness might be more pronounced when firms have relieved financial risks.

The tables below report the results based on model 3 using the subsamples. We follow Altman (1968) and Ohlson (1980), both Z-score and O-score have been used to measure the level of financial risks. The sample is divided into two groups according to the median of financial risks (Z-score (Table 83) and O-score (Table 84)). It can be seen from the table below that in the sample with low financial risks, the regression coefficient on **β3** is significantly negative at the level of 1%. However, it is not significant in the high financial risk group. It demonstrates that the positive effect of managerial ability on R&D stickiness is more significant in the low financial risk group. Therefore, managerial ability can increase R&D stickiness by relieving financial risks.

Overall, the results in table below suggest that the positive relationship between managerial ability and R&D stickiness is partly channeled through facilitating access to capital and relieved financial risks.

5.6.1 Managerial ability and Financial Constraints

The information environment in which firms operate and finance themselves is essential in determining financial constraints with higher information uncertainty leading to higher corporate bond yield spreads(Lu et al., 2010). High ability management can enhance firms' information environment (measured by: the number of analyst following, analyst forecast error, trading volume, and bid-ask spread) even though corporate governance is weak (Baik et al., 2018). Pan et al 2015 proposes that market participants actively learn and assess managers performance-related competencies which is eased by a better information environment induced by high-ability managers. This learning by investors is pronounced in more competitive industries and in industries in which firms do more R&D and introduce new products more frequently; found in a study of 1,873 CEOs in 1,582 U.S. publicly traded firms between 1992 and 2009(Pan et al., 2015). Within the debt market higher management ability is associated with lower information risk and asymmetry (Petkevich and Prevost, 2018). Covering US firms during the fiscal years 1994–2013 the authors found that outside investors demand less information sensitive loan covenants and accept longer bond maturity while demanding less senior secured debt. Higher ability management is also able to reduce the risk premium demanded by investors on information-sensitive debt. Therefore, the authors conclude that managerial ability mitigates information risk with strong and direct impact on the structure and pricing of corporate debt. Bonsall IV et al. (2017) show that higher ability management is associated with higher credit ratings as credit rating agencies come up with lower assessments of credit risk for high ability management. The impact of managerial ability is supported that the turn over of chief executive officer (CEO) causes credit ratings to increase (decrease) when CEOs are replaced with more (less) able CEOs.

In similar vein research based on a large sample of US bank loans show that higher ability management results in lower bank-loan prices. This effect is pronounced for high information risk firms suggesting that higher ability management improves financial disclosure to mitigate information asymmetry to improve bank-loan pricing. This effect is even stronger when the firms exhibit weak business fundamentals reinforcing that high ability management is expected to improved business performance(De Franco et al., 2017).

However, research also showed that high ability management, concerned about their career prospects, has stronger incentives to delay the disclosure of firm-level, private and negative information. This could lead to higher ability management making use of their superior business knowledge to cover up bad news with a set of operational arrangements(Kothari et al., 2006). While prior research has identified a positive relationship between managerial ability and share price crash risk (Cui et al., 2019) an negative impact on bank lending or bond market has not been research (for a comprehensive literature review see: Anggraini and Sholihin, 2023). Based on prior studies we expect that higher ability managements are able to reduce information risk to debt providers and therefore reduce

financial constraints.

5.6.2 Financial Constraints and R & D

One stream of research indicates that moral hazards, information asymmetry, and negligible collateral value of R&D contribute financial constraints which affect the level of R&D investment.

A study of European firms found there is find little or no evidence that financial constrains impact on R&D if only R&D-cash flow sensitivity is considered. When taking into accounting stock issues as a source of funds and changes in cash holdings access to internal and external equity finance levels had an impact on R&D, especially for firms with binding financing constraints. This effect could be attributed to the fact that "firms facing financing frictions have strong incentives to build and utilize costly stocks of liquidity to keep the flow of R&D spending relatively smooth compared to transitory finance shocks, avoiding the very large adjustment costs associated with R&D" (Brown et al., 2012) p 1527.

Considering firms listed at NYSE, AMEX, or NASDAQ exchange over the period 1980 to 2011, Zhang (2015) find, firms that are more financially constrained or during economic downturns show a stronger relationship between R&D and distress risk, while firms with high analyst coverage or firms that have been successful in their R&D can mitigate the risk of distress. That is, firms which are financially secure have sufficient internal resources or are more likely to survive the uncertainty of this type of risky investment. In China research found that financial constraints and higher financing costs result from information asymmetry between borrowers and lenders in the capital market. Managers' superior private information about the progress and potential for success of R&D projects intensifies information asymmetry, moral hazard and adverse selection, leading to the firms' difficulty to obtain external financing. Consequently, firms can only rely on self-funding which is insufficient to meet the huge capital demand of R&D projects. This 'financing gap greatly inhibits firms' innovative capacity and R&D spending (Beladi et al., 2021).While this line of research suggest financial constrains to restrict or even diminish R&D activities, empirical evidence found somehow contradicting results:

Chinese R&D-intensive A-share listed firms have strong incentives to maintain constant R&D investments due to high R&D adjustment costs. Chinese R&D-intensive firms (for the period 2009 to 2016 of the study) sell their operating and financial assets to retain their value-enhancing R&D investments. While financial constraints have an adverse impact on R&D smoothing with asset sales, except for firms with high innovation efficiency. Therefore, innovation efficiency, measured as research output (application of patents for either invention or utility mode or design) over R&D spending, allows R&D-intensive firms independent of their financial constraints to use the proceeds from asset sales to retain their R&D inputs while avoiding more costly adjustment costs. Therefore, asset sales diminishes the role of financial constraints (Liu et al., 2021). Prior research into financial constraints has

implications for R&D cost stickiness. High ability management is able to attract more bank loans are lower costs and reduces information asymmetry that the financial constraints could be more easily overcome compared to low ability management. Therefore, enhancing R&D cost stickiness. However, in China banks external financing might be limited that management with either high or low ability has to rely on internal financing (from operating cashflows generated through revenue) which in turn implies that R&D activities have to remain or even diminish when sales declines.

Consequently, in the presence of high financial constraints, managers will be driven to consider resources adjustment costs to dimmish R&D activities. During sales declines and heightened financial constrains low ability management will decline R&D spending. In contrast, high ability management will try its best to retain R&D activities considering the high adjustment costs and implications for firm's future innovation output. To test this hypothesis below section 5.6.2.1 SA and 5.6.2.2 KZ index will introduce, explain and test for Hypothesis 3 for different measure of financial constraints.

5.6.2.1 SA Index

The SA index of a firm is calculated using the Size (S) and Age (A) of the firm. Taking the estimated values from Hadlock et al., (2010), the equation is as follows:

$$SA = -0.737 * Size + 0.043 * Size^{\wedge}2 - 0.040 * Age \quad (2)$$

Whereas: *Size* is the natural logarithm of total assets of enterprises. *Age* is Business Year equals the Observation Year (Current Accounting Period) minus the Enterprise Establishment Date (Year). If either size or age is missing for an observation, the index is not calculated. Firms within the financial industry were removed, firms with missing data for S and A are removed. The data was then winsorized by year, with the top and bottom 1% removed.

Our findings in Table 81 below are consistent with the prediction in Hypothesis 3 that stronger R&D stickiness should be observed under more capable managers.

Table 81Managerial ability and R&D cost stickiness for the sample partitioned by high and low financial constraint (Hadlock et al 2010).

	H3	
Model	3	
	Low SA (High financial constraint)	High SA (Low financial constraint)
β_1ΔLn(IncomeR)	0.643***	0.578***
	(0.030)	(0.024)
β_2ΔLn(IncomeR)*D	-0.327***	-0.284***
	(0.120)	(0.108)
β_3ΔLn(IncomeR)*D*MA	**0.175**	**-1.629*** **
	(0.313)	**(0.301)**
β_5FCF*ΔLn(IncomeR)*D	-0.739***	-0.107
	(0.214)	(0.168)
β_6Assets Intensity*ΔLn(IncomeR)*D	-0.096*	-0.162***
	(0.057)	(0.058)
β_7D_twoyear*ΔLn(IncomeR)*D	0.079	0.136
	(0.113)	(0.097)
$\beta_8$da*ΔLn(IncomeR)*D	0.998***	0.381
	(0.375)	(0.330)
β_9REM*ΔLn(IncomeR)*D	0.601	-0.176
	(0.376)	(0.316)
β_{11}MA	-0.137*	-0.219***
	(0.073)	(0.055)
β_{12}Assets Intensity	-0.016	-0.036***
	(0.015)	(0.012)
β_{13}D_twoyear	-0.063**	-0.074***
	(0.031)	(0.024)
β_{14}FCF	-0.173**	-0.082
	(0.071)	(0.056)
β_{15}da	0.234***	0.191***
	(0.089)	(0.067)
β_{16}REM	0.114*	0.045
	(0.058)	(0.043)
Constant	0.323***	0.215***
	(0.075)	(0.061)
	P=0.042 (Significant difference between groups)	
Obs	7,963	8,316
Adj-R2	0.1237	0.1220
F value	28.40	29.18

5.6.2.2 Kaplan and Zingales (1997) Index to measure financial constraints

While the Kaplan and Zingales (1997) Index (KZ method) to measure financial constraints is widely used there has been sever concerns about the its validity (Hadlock and Pierce, 2010). The KZ (1997) approach is to gather detailed qualitative information on financial constraints from annual report made by managers in these financial filings. The derived financial constraint categories are then used by employing an ordered logit models to predict a firm's constraint level as a function of a variety of different qualitative factors. The study by Hadlock and Pierce, (2010) concludes "that the principal problem underlying the

original KZ index is a modeling flaw in which the same quantitative information is incorporated into both the dependent and the independent variables" (p. 1938). The researchers advise for future studies to use alternative measures of financial constraints.

Therefore, results using the KZ index must be viewed with caution. Similarly, the findings using the KZ index are not supported by prior literature, while the significance for β_3ΔLn(IncomeR)*D*MA is inverse to the test using Hadlock and Pierce, (2010).

KZ index reflects the degree of financing constraint faced by companies relative to other firms by year. The higher it is, the stronger financing constraints are faced by a given company. The KZ Index used here is constructed by CSMAR, the data provider, following the same method applied in Kaplan & Zingales (1997), Tan Yue, Xia Fang (2011) and Wei Zhihua et al. (2014). The data used were taken from firms listed on Shanghai Stock Exchange and Shenzhen Stock Exchange. A three-step method is applied.

Step one. For each year, create five dummy variables as follows:

- KZ1: Calculate *Net Operating Cash Flow* divided by *Total Assets* for each firm, using beginning of year figures. Set KZ1 equals to 1 if this value is lower than the median, 0 otherwise.
- KZ2: Calculate Cash Dividend of Current Year divided by *Assets of the Previous Year* ($\frac{\mathrm{DIV_{it}}}{\mathrm{ASSET_{it-1}}}$). Set KZ2 equals to 1 if this value is lower than the median, 0 otherwise.
- KZ3: Calculate *Cash Holdings of Current Year* divided by *Total Assets of the Previous Year* ($\frac{\mathrm{CASH_{it}}}{\mathrm{ASSET_{it-1}}}$). Set KZ3 equals to 1 if this value is lower than the median, 0 otherwise.
- KZ4: Take *Debt to Assets Ratio* (LEV_{it}), set KZ4 equals to 1 if this value is higher than the median, 0 otherwise.
- KZ5: Take *Tobin's Q* ($\mathrm{Q_{it}}$), set KZ5 equals to 1 if this value is higher than the median, 0 otherwise.

Step two.

Take these five values and add them up to arrive at KZ, this index takes on discrete values that runs from 0 to 5. Use Ordered Next Ordered Logistic Regression, taking the latent variable approach and estimate the following model:

$$KZ^*_{it} = \hat{a}_1 \times \left(\frac{\mathrm{CF_{it}}}{\mathrm{ASSET_{it-1}}}\right) + \hat{a}_2 \mathrm{LEV_{it}} + \hat{a}_3 \frac{\mathrm{DIV_{it}}}{\mathrm{ASSET_{it-1}}} + \hat{a}_4 \frac{\mathrm{CASH_{it}}}{\mathrm{ASSET_{it-1}}} + \hat{a}_5 \mathrm{Q_{it}} \qquad (1)$$

Where,

$$KZ_{it} = \begin{cases} 0 & if\ KZ^* \le \theta_1 \\ 1 & if\ \theta_1 \le KZ^* \le \theta_2 \\ 2 & if\ \theta_2 \le KZ^* \le \theta_3 \\ 3 & if\ \theta_3 \le KZ^* \le \theta_4 \\ 4 & if\ \theta_4 \le KZ^* \le \theta_5 \\ 5 & if\ \theta_5 \le KZ^* \end{cases}$$

Step three.

Firms within the financial industry were removed, firms with missing data are removed. The estimated KZ^* was winsorized by year, with the top and bottom 1% removed.

Table 82R&D Stickiness and management ability under financial constraints measured by KZ (Kaplan &Zingales, 1997) index and partitioned sample by high vs low financial constraint-the higher KZ, the higher financial constraint.

	H3	
Model	3	
	Low KZ (Low financial constraint)	High KZ (High financial constraint)
β_1ΔLn(IncomeR)	0.630***	0.588***
	(0.024)	(0.030)
β_2ΔLn(IncomeR)*D	-0.137	-0.195*
	(0.154)	(0.105)
β_3ΔLn(IncomeR)*D*MA	**-1.889*** **	**0.015**
	(0.394)	**(0.279)**
β_5FCF*ΔLn(IncomeR)*D	0.499	-0.447***
	(0.380)	(0.169)
β_6Assets Intensity*ΔLn(IncomeR)*D	-0.173*	-0.116**
	(0.091)	(0.050)
β_7D_twoyear*ΔLn(IncomeR)*D	-0.147	0.097
	(0.141)	(0.097)
$\beta_8$da*ΔLn(IncomeR)*D	0.705	0.482
	(0.596)	(0.314)
β_9REM*ΔLn(IncomeR)*D	-0.825*	0.154
	(0.462)	(0.319)
β_{11}MA	-0.186***	-0.160**
	(0.053)	(0.075)
β_{12}Assets Intensity	-0.013	-0.038**
	(0.012)	(0.015)
β_{13}D_twoyear	-0.062**	-0.086***
	(0.026)	(0.029)
β_{14}FCF	-0.131**	-0.132*
	(0.055)	(0.073)
β_{15}da	0.214***	0.229***
	(0.073)	(0.084)
β_{16}REM	0.162***	-0.079
	(0.040)	(0.064)
Constant	0.314***	0.250***
	(0.063)	(0.073)
	P=0.024 (Significant difference between groups)	
Obs	7,868	8,411
Adj-R2	0.1427	0.1127
F value	31.76	27.05

In line with Kaplan and Zingales (2000) we argue that "financial distress is a form of being financially constrained" (p 710). This is underpinned by the finding that "firms KZ classify as possibly financially constrained (PFC), which exhibit the lowest sensitivity of all, are in fact distressed." Furthermore, Lamont, Polk, and Requejo (2001) state that they do not

equate financial constraint with distress, although distress is significantly and positively correlated with financial constraint. Whited and Wu (2006) claim that it is difficult to distinguish between financial distress and financial constraint. They view distressed firms close to default, whereas constrained firms are of young age and restrained from growing due to the difficulty in financing. These papers eventually control for distress by dropping observations that have negative sales growth.

5.6.3 Managerial ability and Financial Risks

In line with Kaplan and Zingales (2000) we argue that "financial distress is a form of being financially constrained" (p 710). This is underpinned by the finding that " firms KZ classify as possibly financially constrained (PFC), which exhibit the lowest sensitivity of all, are in fact distressed." Furthermore, Lamont, Polk, and Requejo (2001) state that they do not equate financial constraint with distress, although distress is significantly and positively correlated with financial constraint. Whited and Wu (2006) claim that it is difficult to distinguish between financial distress and financial constraint. They view distressed firms close to default, whereas constrained firms are of young age and restrained from growing due to the difficulty in financing. These papers eventually control for distress by dropping observations that have negative sales growth.

Section 5.6.3.1. Altman Z-score and 5.6.3.2. Value O & Risk Coefficient use different measure of financial risk to explain and test for Hypothesis 3.

5.6.3.1 Altman Z-score

The Z-score is a linear combination of five business ratios, weighted by coefficients. Altman (1968) estimates the coefficients by identifying a set of firms which had declared bankruptcy and then collecting a matched sample of firms which had survived, with matching by industry and approximate size (assets).Altman applied discriminant analysis to a dataset of publicly held manufacturers. The estimation was originally based on data from publicly held manufacturers.

$$Z=1.2X_1+1.4X_2+3.3X_3+0.6X_4+0.999X_5$$

Of which:

$X1$=Working Capital / Total Assets; reflects the liquidity and scale characteristics of assets.

$X2$=Retained Earnings / Total Assets; reflects the cumulative profitability of the company.

$X3$=EBIT / Total Asset; Reflects the profitability of the asset.

$X4$=Market Value of Equity /Book Value of Total Liabilities; it is a ratio that measures the financial structure of a company, shows the relative relationship between owners' equity and creditors' equity, and can reflect the solvency of a company.

$X5$=Operating Revenue/ Total Assets; reflects the turnover of corporate assets and is used to measure the efficiency of assets utilization of the company.

Firms within the financial industry were removed; for them a Z-score with different

coefficients applies. Firms with missing data for X1-X5 are removed. The data was then winsorized by year, with the top and bottom 1% removed.

Altman (2002) suggests following 'zones of discrimination':

$Z > 2.99$ – "safe" zone

$1.81 < Z < 2.99$ – "grey" zone

$Z < 1.81$ – "distress" zone

Table 83 R&D Stickiness and management ability under financial riskiness measured by Altman (2002) index and partitioned sample by high vs low financial risk

	H3	
Model	3	
	Low Zscore	High Zscore
β_1ΔLn(IncomeR)	0.623***	0.586***
	(0.027)	(0.028)
β_2ΔLn(IncomeR)*D	-0.274**	-0.273**
	(0.116)	(0.118)
β_3ΔLn(IncomeR)*D*MA	**0.028**	**-1.352*****
	(0.308)	**(0.324)**
β_5FCF*ΔLn(IncomeR)*D	-0.407**	-0.521***
	(0.207)	(0.182)
β_6Assets Intensity*ΔLn(IncomeR)*D	-0.144**	-0.038
	(0.057)	(0.072)
β_7D_twoyear*ΔLn(IncomeR)*D	0.176*	-0.140
	(0.107)	(0.119)
$\beta_8$da*ΔLn(IncomeR)*D	0.203	1.213***
	(0.367)	(0.389)
β_9REM*ΔLn(IncomeR)*D	0.401	-0.247
	(0.353)	(0.364)
β_{11}MA	-0.154*	-0.145***
	(0.079)	(0.053)
β_{12}Assets Intensity	-0.051***	-0.010
	(0.016)	(0.011)
β_{13}D_twoyear	-0.081***	-0.079***
	(0.030)	(0.025)
β_{14}FCF	-0.120*	-0.156***
	(0.073)	(0.056)
β_{15}da	0.226**	0.175**
	(0.089)	(0.069)
β_{16}REM	0.056	0.095**
	(0.070)	(0.039)
Constant	0.186**	0.334***
	(0.079)	(0.060)
	P=0.036 (Significant difference between groups)	
Obs	7,672	8,607
Adj-R2	0.1247	0.1058
F value	27.66	25.82

5.6.3.2 Value O & Risk Coefficient

Ohlson (1980) O-score was derived from a sample of just over 2000 companies, whereas by comparison its predecessor the Altman Z-score considered just 66 companies. As a result,

the O-score is significantly more accurate predictor of bankruptcy within a 2-year period. The original Z-score was estimated to be over 70% accurate with its later variants reaching as high as 90% accuracy. The O-score is more accurate.

The Ohlson (1980) O-score results from a linear combination of 9 factors which are coefficient-weighted ratios derived from common figures found in firms' annual reports. Two factors are dummies: Firstly, *OENEG* when equity is negative and therefore *Total liabilities* is bigger than *Total Assets* returning 1 otherwise 0. or if the firm made a loss in 2 consecutive years returning1, otherwise 0. Therefore, their impact upon the formula typically is 0. When using an O-score to evaluate the probability of company's failure, then exp(O-score) is divided by 1 + exp(O-score).

The calculation for Ohlson O-score is as follows:

$$O\text{−Score} = -1.32 - 0.407SIZE + 6.03TLTA - 1.43WCTA + 0.0757CLCA - 2.37NITA - 1.83FUTL + 0.285INTWO - 1.72OENEG - 0.521CHIN$$

Of which:

SIZE=Ln(Total Assets);

TLTA=Total Liabilities / Total Assets;

WCTA=Working Capital /Total Assets;

CLCA=Current Liabilities / Current Assets;

NITA=Net Profit/Total Assets; FUTL=Net Operating Cash Flow/Total Liabilities;

INTWO=If the net profit in the past two years is negative, it is 1; otherwise, it is 0;

OENEG=If Total Liabilities>Total Assets, it is 1; otherwise, it is 0;

$CHIN=(NI_t - NI_{t-1})/(|NI_t| + |NI_{t-1}|)$,

NI = Net Profit.

Risk Coefficient=$eO-S$core/(1+$eO-S$core)

Firms within the financial industry were removed. Firms with missing data for above variables are removed. The data was then winsorized by year, with the top and bottom 1% removed. O-score larger than 0.5 suggests that the firm will default within two years.

Table 84R&D Stickiness and management ability under financial riskiness measured by Ohlson (1980) O-score and partitioned sample by high vs low financial risk

	H3	
Model	3	
	Low Oscore	High Oscore
β_1ΔLn(IncomeR)	0.622***	0.588***
	(0.023)	(0.032)
β_2ΔLn(IncomeR)*D	-0.232	-0.230**
	(0.144)	(0.111)
β_3ΔLn(IncomeR)*D*MA	**-1.889*** **	**-0.068**
	(0.384)	**(0.284)**
β_5FCF*ΔLn(IncomeR)*D	-0.621***	-0.272
	(0.209)	(0.199)
β_6Assets Intensity*ΔLn(IncomeR)*D	-0.137	-0.111**
	(0.087)	(0.051)
β_7D_twoyear*ΔLn(IncomeR)*D	-0.047	0.093
	(0.125)	(0.102)
$\beta_8$da*ΔLn(IncomeR)*D	1.858***	0.253
	(0.529)	(0.340)
β_9REM*ΔLn(IncomeR)*D	-0.491	0.199
	(0.419)	(0.339)
β_{11}MA	-0.202***	-0.117
	(0.052)	(0.082)
β_{12}Assets Intensity	-0.023**	-0.030*
	(0.011)	(0.016)
β_{13}D_twoyear	-0.064***	-0.085***
	(0.024)	(0.031)
β_{14}FCF	-0.262***	-0.007
	(0.055)	(0.075)
β_{15}da	0.283***	0.119
	(0.072)	(0.088)
β_{16}REM	0.128***	-0.020
	(0.040)	(0.070)
Constant	0.298***	0.250***
	(0.059)	(0.082)
	P=0.030 (Significant difference between groups)	
Obs	8,994	7,285
Adj-R2	0.1316	0.1086
F value	34.25	22.65

5.7 Robustness checks

We perform several robustness checks; our results are confirmed by those checks (see Table 85).

Table 85 Robustness test for H2 and H3

<table>
<tr><td></td><td>Hypothesis2</td><td colspan="2">Hypothesis3</td></tr>
<tr><td></td><td>H2 holds: β3<0
H2 rejected: β3>0</td><td colspan="2">H3 holds: β3<0 in high product market competition sub-sample
H3 rejected: β3>0 in high product market competition sub-sample</td></tr>
<tr><td colspan="4">Robustness test for Hypothesis2 and Hypothesis3:</td></tr>
<tr><td rowspan="3">1) Fixed effects model</td><td rowspan="3">β3=-0.974*
β3<0, H2 holds</td><td>High product market competition</td><td>Low product market competition</td></tr>
<tr><td>β3=-2.311*</td><td>β3=0.302</td></tr>
<tr><td colspan="2">P=0.000 (Groups are significantly different)</td></tr>
<tr><td rowspan="2">2) Replace operating revenue with total revenue</td><td rowspan="2">β3=-0.591***</td><td>β3=-1.714***</td><td>β3=0.053</td></tr>
<tr><td colspan="2">P=0.055 (Groups are significantly different)</td></tr>
<tr><td rowspan="2">3) Combat corruption policy 2013</td><td rowspan="2">β3=-0.607***</td><td>β3=-1.755***</td><td>β3=0.071</td></tr>
<tr><td colspan="2">P=0.055 (Groups are significantly different)</td></tr>
<tr><td rowspan="2">4) Add more control variable to models-Dual</td><td rowspan="2">β3=-0.570***</td><td>β3=-1.734***</td><td>β3=0.125</td></tr>
<tr><td colspan="2">P=0.048 (Groups are significantly different)</td></tr>
<tr><td rowspan="2">5) Add earnings management from Ch.3 and ownership concentration from Ch.4 to our baseline model</td><td rowspan="2">β3=-0.606***</td><td>β3=-1.732***</td><td>β3=0.049</td></tr>
<tr><td colspan="2">P=0.059 (Groups are significantly different)</td></tr>
<tr><td colspan="4">Robustness test for Hypothesis2:</td></tr>
<tr><td>6) MA delays one year</td><td>β3=-0.545***</td><td colspan="2"></td></tr>
<tr><td>7) Measure managerial ability measure - CEO tenure</td><td>β3=-0.088***</td><td colspan="2"></td></tr>
<tr><td colspan="4">Robustness test for Hypothesis3:</td></tr>
<tr><td rowspan="2">8) Use Herfindahl-Hirschman Index (HHI) to measure product market competition</td><td rowspan="2"></td><td>β3=-0.972***</td><td>β3=0.976**</td></tr>
<tr><td colspan="2">P=0.072 (Groups are significantly different)</td></tr>
<tr><td>Interpretation</td><td>Company with capable managers keep on doing R&D investment when company is in downturn</td><td colspan="2">Firms with capable managers would further keep on doing R&D costs when the degree of product market competition increases</td></tr>
</table>

5.7.1 Fixed effects model

The empirical results based on OLS are likely to be biased due to the omission of variables correlated with both R&D stickiness and managerial ability. The fixed effects model have been adopted to mitigate the concern about the unobserved time-invariant firm characteristics that may affect research results. Column 1 in Table 86 shows that β3<0 and significant at the 10% level, which indicates that managerial ability positively influences R&D cost stickiness (capable managers keep on doing R&D investment when the company is in downturn); column 2 in Table 86 shows that managerial ability has a negative effect on R&D stickiness (capable managers keep on doing R&D investment when the company is in downturn) when competition in product markets is high (β3=-2.311*); column 3 in Table 86 shows that, in the low competition sub-sample, managerial ability has no impact on R&D stickiness (β3=0.302). The difference between these two groups is statistically significant (P value=0.000). Therefore, we find evidence consistent with our main results.

Table 86 Individual fixed effects model

	H2	***H3***	
Model	3	3	
		Low Lerner index (strong competition)	High Lerner index (weak competition)
β_1ΔLn(IncomeR)	0.620***	0.654***	0.563***
	(0.039)	(0.052)	(0.065)
β_2ΔLn(IncomeR)*D	-0.368***	-0.416**	-0.162
	(0.140)	(0.201)	(0.221)
β_3ΔLn(IncomeR)*D*MA	**-0.974***	**-2.311***	**0.302**
	(0.579)	**(1.315)**	**(0.382)**
β_5FCF*ΔLn(IncomeR)*D	-0.566***	-0.829***	0.036
	(0.176)	(0.318)	(0.304)
β_6Assets Intensity*ΔLn(IncomeR)*D	-0.152**	-0.302**	-0.100
	(0.069)	(0.135)	(0.109)
β_7D_twoyear*ΔLn(IncomeR)*D	0.044	0.031	0.087
	(0.136)	(0.191)	(0.158)
$\beta_8$da*ΔLn(IncomeR)*D	0.587	1.200	0.096
	(0.378)	(0.791)	(0.558)
β_9REM*ΔLn(IncomeR)*D	0.342	0.481	0.008
	(0.421)	(0.484)	(0.835)
β_{11}MA	-0.401***	-0.498**	-0.390***
	(0.105)	(0.194)	(0.122)
β_{12}Assets Intensity	-0.040	-0.086**	-0013
	(0.027)	(0.042)	(0.037)
β_{13}D_twoyear	-0.094***	-0.078**	-0.130***
	(0.026)	(0.035)	(0.034)
β_{14}FCF	-0.160***	-0.143*	-0.071
	(0.056)	(0.087)	(0.081)
β_{15}da	0.191***	0.246***	0.054
	(0.067)	(0.094)	(0.121)
β_{16}REM	0.140**	0.125	0.145*
	(0.057)	(0.084)	(0.088)
Constant	0.254***	0.317***	0.206**
	(0.051)	(0.068)	(0.081)
YEAR	Control	Control	Control
		P=0.000 (Significant diff. between groups)	
Obs	16,279	8,615	7,664
Fvalue	33.77	17.09	17.82

Notes: The table reports the coefficients based on Anderson et al. (2003) model. The sample period is 2010-2019. The sample consists of 16,279 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. All models include year- and industry-fixed effects. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Following Sheikh (2018) and Philoppe Aghion et al. (2013), we used Lerner index as the primary measure of product market competition. The higher the Lerner index the lower the competition. The sample were split to high product market competition and low product market competition samples using the 50th percentile. If Lerner index is higher than median, that is low product market competition. While if Lerner index is lower than median, that is high product market competition.

5.7.2 Replace operating revenue with total revenue

In our main results, we run our tests using operating revenue. Following Bradbury and Scott (2018) as a robustness test, we use total revenue to replace operating revenue and run the models again. Column 1 in Table 87 shows that β_3=-0.591<0and significant at a 1% level, which indicates that managerial ability positively influences R&D cost stickiness (capable managers keep on doing R&D investment when the company is in downturn); column 2 in Table 87 shows that β_3=-1.714<0and significant at a 1% level, which shows that high product market competition would lead capable managers to keep on investing in R&D when the company is in downturn. However, $\beta_3$in weak product market competition sub-sample is 0.053 but not significant, which indicate that capable managers do not significantly influence R&D stickiness when market product competition is low. The difference between those two groups is statistically significant (P value=0.055). Therefore, we find evidence consistent with our main results.

Table 87Use Total revenue to replace operating revenue

	H2	H3	
Model	3	3	
		Low Lerner index (strong competition)	High Lerner index (weak competition)
β_1ΔLn(IncomeR)	0.609***	0.635***	0.583***
	(0.019)	(0.029)	(0.025)
β_2ΔLn(IncomeR)*D	-0.284***	-0.352***	-0.164
	(0.081)	(0.115)	(0.115)
β_3ΔLn(IncomeR)*D*MA	**-0.591*** **	**-1.714*** **	**0.053**
	(0.210)	**(0.374)**	**(0.253)**
β_5FCF*ΔLn(IncomeR)*D	-0.465***	-0.871***	-0.170
	(0.040)	(0.226)	(0.168)
β_6Assets Intensity*ΔLn(IncomeR)*D	-0.102**	-0.215***	-0.098*
	(0.040)	(0.070)	(0.051)
β_7D_twoyear*ΔLn(IncomeR)*D	0.040	0.116	0.030
	(0.074)	(0.117)	(0.098)
$\beta_8$da*ΔLn(IncomeR)*D	0.599**	1.125***	0.257
	(0.249)	(0.422)	(0.313)
β_9REM*ΔLn(IncomeR)*D	0.118	0.260	-0.133
	(0.244)	(0.358)	(0.344)
β_{11}MA	-0.158***	-0.225***	-0.139**
	(0.045)	(0.074)	(0.055)
β_{12}Assets Intensity	-0.027***	-0.051***	-0.009
	(0.009)	(0.014)	(0.013)
β_{13}D_twoyear	-0.080***	-0.058**	-0.095***
	(0.019)	(0.027)	(0.028)
β_{14}FCF	-0.145***	-0.194***	-0.101*
	(0.045)	(0.067)	(0.060)
β_{15}da	0.188***	0.254***	0.137*
	(0.055)	(0.079)	(0.078)
β_{16}REM	0.066*	0.070	0.054
	(0.036)	(0.055)	(0.047)
Constant	0.269***	0.307***	0.227**
	(0.049)	(0.062)	(0.097)
		P=0.055 (Significant diff. between groups)	
Obs	16,279	8,615	7,664
Adj-R2	0.1154	0.1167	0.1176
F value	52.78	30.96	26.53

Notes: The table reports the coefficients based on Anderson et al. (2003) model. The sample period is 2010-2019. The sample consists of 16,279 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Following Sheikh (2018) and Philoppe Aghion et al. (2013), we used Lerner index as the primary measure of product market competition. The higher the Lerner index the lower the competition. The sample were split to high product market competition and low product market competition samples using the 50th percentile. If Lerner index is higher than median, that is low product market competition. While if Lerner index is lower than median, that is high product market competition.

5.7.3 Combat corruption policy of 2013

Corruption could influence innovation. Corruption shifts firms' ethical norms (Lyon & Maher, 2005) and is one of the factors which influence investment and economic growth (Porta et al., 1999). Based on the survey data from Central and Eastern Europe (CCEs), Chadee et al. (2021) find that there is a negative relationship between corruption and innovation. In December 2012, the Chinese Government issued an important policy "Eight-Point Regulation", which has been recognized as a forceful anti-corruption movement since Xi Jinping assumed power (Chen et al., 2020). The anti-corruption movement could influence our research, so the dummy variable *Post* (1 if it is after the 2013 anti-corruption movement, 0 otherwise) has been added to our model and we run the model again. We find evidence consistent with our main results.

Column 1 in Table 88 shows that $\beta_3<0$and significant at a 1% level, which indicates that managerial ability positively influences R&D cost stickiness (capable managers keep on doing R&D investment when the company is in downturn); column 2 in Table 88 shows that $\beta_3<0$and significant at a 1% level, which shows that high product market competition would lead capable managers to keep on investing in R&D when the company is experiencing downturn. However, column 3 in Table 88 show that $\boldsymbol{\beta_3}>0$ but not significant, which indicates that capable managers do not significantly influence R&D stickiness when market product competition is low. The difference between those two groups is statistically significant (P value=0.055). Therefore, we find evidence consistent with our main results.

Table 88Combat corruption policy of 2013

	H2	H3	
Model	3	3	
		Low Lerner index (strong competition)	High Lerner index (weak competition)
β_1ΔLn(IncomeR)	0.674***	1.037***	0.260***
	(0.053)	(0.078)	(0.071)
β_2ΔLn(IncomeR)*D	-0.466***	-1.164***	0.275
	(0.155)	(0.233)	(0.204)
β_3ΔLn(IncomeR)*D*MA	**-0.607*** **	**-1.755*** **	**0.071**
	(0.212)	**(0.376)**	**(0.254)**
β_5FCF*ΔLn(IncomeR)*D	-0.460***	-0.861***	-0.170
	(0.135)	(0.226)	(0.167)
β_6Assets Intensity*ΔLn(IncomeR)*D	-0.105***	-0.213***	-0.101**
	(0.040)	(0.070)	(0.051)
β_7D_twoyear*ΔLn(IncomeR)*D	0.031	0.100	0.029
	(0.074)	(0.117)	(0.098)
$\beta_8$da*ΔLn(IncomeR)*D	0.616**	1.140***	0.253
	(0.250)	(0.423)	(0.315)
β_9REM*ΔLn(IncomeR)*D	0.114	0.291	-0.110
	(0.245)	(0.359)	(0.347)
β_{11}MA	-0.159***	-0.228***	-0.139**
	(0.045)	(0.074)	(0.055)
β_{12}Assets Intensity	-0.027***	-0.052***	-0.009
	(0.009)	(0.014)	(0.013)
β_{13}D_twoyear	-0.082***	-0.063**	-0.093***
	(0.019)	(0.027)	(0.028)
β_{14}FCF	-0.143***	-0.186***	-0.101*
	(0.045)	(0.067)	(0.060)
β_{15}da	0.189***	0.260***	0.140*
	(0.055)	(0.079)	(0.077)
β_{16}REM	0.065*	0.062	0.056
	(0.036)	(0.055)	(0.047)
β_{17}Post	**-0.100*** **	**-0.043**	**-0.142*** **
	(0.034)	**(0.052)**	**(0.045)**
β_{18}L_revenue*post	**-0.074**	**-0.458*** **	**0.363*** **
	(0.056)	**(0.082)**	**(0.075)**
β_{19}D_oneyear* L_revenue*post	**0.209**	**0.902*** **	**-0.486** **
	(0.149)	**(0.222)**	**(0.197)**
Constant	0.250***	0.187***	0.308***
	(0.051)	(0.066)	(0.098)
		P=0.055 (Significant diff. between groups)	
Obs	16,279	8,615	7,664
Adj-R2	0.1152	0.1198	0.1198
F value	50.31	30.32	25.84

5.7.4 Add more control variable to models-Dual

The OLS are likely to be biased due to the omission of variables correlated with both managerial ability and R&D stickiness. For example, our controls for R&D stickiness may be imperfect. Chen et al. (2012) find that corporate governance is one of the factors which

influence cost stickiness. To address this potential problem of endogeneity, following Bugeja et al. (2015), we add the dummy variable of whether board chair and CEO are occupied by one person (*Dual*) as control variable to models. *Dual*is a Dummy variable, equal to 1 if the positions of board chair and CEO are occupied by one person, and 0 otherwise.

Column 1 in Table 89 shows that β3=-0.570<0 and significant at a 1% level, which indicates that managerial ability positively influences R&D cost stickiness (capable managers keep on doing R&D investment when the company is in downturn); column 2 in Table 89 shows that β_3=-1.734<0and significant at a 1% level, which shows that high product market competition would lead capable managers to keep on investing in R&D when the company is in downturn. However, column 3 in Table 89 show that $\boldsymbol{\beta_3}$>0 but not significant (0.125), which indicates that capable managers do not significantly influence R&D stickiness when market product competition is low. The difference between those two groups is statistically significant (P value=0.048). Therefore, we find evidence consistent with our main results.

Table 89Add more control variables to models-Dual

	H2(3)	*H3(3)*	
		Low Lerner index (strong competition)	High Lerner index (weak competition)
β_1ΔLn(IncomeR)	0.613***	0.645***	0.587***
	(0.023)	(0.036)	(0.029)
β_2ΔLn(IncomeR)*D	-0.306***	-0.350***	-0.210*
	(0.085)	(0.124)	(0.119)
β_3ΔLn(IncomeR)*D*MA	**-0.570*** **	**-1.734*** **	**0.125**
	(0.211)	**(0.375)**	**(0.254)**
β_5FCF*ΔLn(IncomeR)*D	-0.466***	-0.873***	-0.193
	(0.136)	(0.226)	(0.168)
β_6Assets Intensity*ΔLn(IncomeR)*D	-0.099**	-0.218***	-0.085*
	(0.040)	(0.070)	(0.052)
β_7D_twoyear*ΔLn(IncomeR)*D	0.044	0.113	0.034
	(0.074)	(0.117)	(0.098)
$\beta_8$da*ΔLn(IncomeR)*D	0.619**	1.136***	0.363
	(0.250)	(0.424)	(0.317)
β_9REM*ΔLn(IncomeR)*D	0.078	0.268	-0.250
	(0.247)	(0.359)	(0.348)
β_{11}MA	-0.157***	-0.232***	-0.134**
	(0.045)	(0.074)	(0.055)
β_{12}Assets Intensity	-0.026***	-0.052***	-0.006
	(0.009)	(0.014)	(0.013)
β_{13}D_twoyear	-0.080***	-0.059**	-0.094***
	(0.019)	(0.027)	(0.028)
β_{14}FCF	-0.144***	-0.194***	-0.102*
	(0.045)	(0.067)	(0.060)
β_{15}da	0.189***	0.257***	0.138*
	(0.055)	(0.079)	(0.078)
β_{16}REM	0.066*	0.070	0.052
	(0.036)	(0.055)	(0.047)
β_{17}Dual *ΔLn(IncomeR)*D	0.098	-0.019	0.228*
	(0.094)	(0.146)	(0.121)
β_{18}Dual	-0.008	-0.018	0.005
	(0.013)	(0.020)	(0.018)
β_{19}Dual *ΔLn(IncomeR)	-0.012	-0.022	-0.020
	(0.039)	(0.056)	(0.054)
Constant	0.267***	0.309***	0.221**
	(0.049)	(0.062)	(0.097)
		P=0.048 (Significant diff. between groups)	
Obs	16,279	8,615	7,664
Adj-R2	0.1209	0.1159	0.1176
F value	28.75	48.43	24.75

Notes: The table reports the coefficients based on Anderson et al. (2003) model. The sample period is 2010-2019. The sample consists of 16,279 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Following Sheikh (2018) and Philoppe Aghion et al. (2013), we used Lerner index as the primary measure of product market competition. The higher the Lerner index the lower the competition. The sample were split to high product market competition and low product market competition samples using the 50th percentile. If Lerner index is higher than median, that is low product market competition. While if Lerner index is lower than median, that is high product market competition.

5.7.5 Add earnings management from Chapter 3 and ownership concentration from Chapter 4 to models

To test H2, stronger R&D stickiness should be observed under more capable managers, earnings management based on Chapter 3 as well as ownership concentration based on Chapter 4 has been included in our baseline regression models. After adding earnings management and ownership concentration to models, our research results still show that managerial ability could strengthen the level of R&D expenditure stickiness. The empirical result shows that the value of β_3 (-0.591, -0.600and -0.606) is negative and statistically significant at the 1% level, indicating that capable managers strengthen the stickiness of R&D (Table 90).

Test 1- Add factor "avoid revenue decrease or avoid loss" from Chapter 3 as control variable – *Loss* (column 1)

Test 2- Add factor "ownership concentration" from Chapter 4 as control variable–- *Concern* (column 2)

Test 3- Add factor "ownership concentration" from Chapter 4 and factor "avoid revenue decrease or avoid loss" from Chapter 3 as control variable: *Concern* and *Loss* (column 3)

Table 90Results of H2 after add earnings management from Chapter3 and ownership concentration from Chpater4 to models

	H2		
	1	2	3
Model		3	
β_1ΔLn(IncomeR)	0.605***	0.608***	0.606***
	(0.019)	(0.019)	(0.019)
β_2ΔLn(IncomeR)*D	-0.277***	-0.207**	-0.204**
	(0.082)	(0.097)	(0.098)
β_3ΔLn(IncomeR)*D*MA	**-0.591*** **	**-0.600*** **	**-0.606*** **
	(0.210)	**(0.210)**	**(0.211)**
β_5FCF*ΔLn(IncomeR)*D	-0.466***	-0.438***	-0.443***
	(0.136)	(0.137)	(0.137)
β_6Assets Intensity*ΔLn(IncomeR)*D	-0.104***	-0.115***	-0.115***
	(0.040)	(0.041)	(0.041)
β_7D_twoyear*ΔLn(IncomeR)*D	0.034	0.035	0.031
	(0.074)	(0.074)	(0.074)
$\beta_8$da*ΔLn(IncomeR)*D	0.592**	0.602**	0.597**
	(0.250)	(0.249)	(0.250)
β_9REM*ΔLn(IncomeR)*D	0.123	0.118	0.124
	(0.245)	(0.245)	(0.245)
β_{11}MA	-0.160***	-0.159***	-0.159***
	(0.045)	(0.045)	(0.045)
β_{12}Assets Intensity	-0.027***	-0.028***	-0.028***
	(0.009)	(0.009)	(0.009)
β_{13}D_twoyear	-0.081***	-0.082***	-0.083***
	(0.019)	(0.019)	(0.019)
β_{14}FCF	-0.144***	-0.142***	-0.142***
	(0.045)	(0.045)	(0.045)
β_{15}da	0.188***	0.186***	0.186***
	(0.055)	(0.055)	(0.055)
β_{16}REM	0.064*	0.066*	0.064*
	(0.036)	(0.036)	(0.036)
β_{17}Loss *ΔLn(IncomeR)*D	**0.052**		**0.060**
	(0.110)		**(0.110)**
β_{18}Loss	**-0.014**		**-0.013**
	(0.012)		**(0.012)**
β_{19}Concen *ΔLn(IncomeR)*D		**-0.466**	**-0.472**
		(0.341)	**(0.342)**
β_{20}Concen		**-0.023**	**-0.022**
		(0.046)	**(0.046)**
Constant	0.273***	0.273***	0.276***
	(0.049)	(0.049)	(0.049)
Adj-R2	0.1152	0.1152	0.1152
F value	50.31	50.30	48.11

Notes: The table reports the coefficients based on Anderson et al. (2003) model to test to what extend managerial ability influences R&D stickiness. The sample period is 2010-2019. The sample consists of 16,279 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively.

To test H3, R&D stickiness maintains or increases under capable managers under a competitive environment, after adding earnings management based on Chapter 3 and ownership concentration based on Chapter 4 to our baseline models, our research results still show that high product market competition could strengthen the positive relationship between managerial ability and R&D stickiness relative to those companies with low product market competition (Table 91). Column 1 in Table92 below shows that higher competition in products markets strengthens the negative relationship between managerial ability and R&D stickiness (capable managers maintain R&D investment when the company is in downturn) (β_3=-1.732***); column 2 in Table92 below shows that capable managers have no impact on R&D stickiness in the low competition group (β3=0.049). The difference between those two groups is statistically significant (P value=0.059).

Table 91Results of H3 add EM Ch.3 &ownership concentration Ch.4

	H3 (model 3)			
	Low Lerner index (strong competition)	High Lerner index (weak competition)	Low Lerner index (strong competition)	High Lerner index (weak competition)
	Add EM from Ch.3 to model		Add ownership concen. Ch.4	
β_1ΔLn(IncomeR)	0.630***	0.582***	0.635***	0.583***
	(0.029)	(0.025)	(0.029)	(0.025)
β_2ΔLn(IncomeR)*D	-0.351***	-0.149	-0.332**	-0.016
	(0.119)	(0.116)	(0.141)	(0.135)
β_3ΔLn(IncomeR)*D*MA	**-1.728*** **	**0.074**	**-1.726*** **	**0.045**
	(0.375)	**(0.253)**	**(0.375)**	**(0.253)**
β_5FCF*ΔLn(IncomeR)*D	-0.883***	-0.158	-0.868***	-0.108
	(0.227)	(0.168)	(0.227)	(0.170)
β_6Assets Intensity*ΔLn(IncomeR)*D	-0.217***	-0.101**	-0.219***	-0.126**
	(0.070)	(0.051)	(0.071)	(0.053)
β_7D_twoyear*ΔLn(IncomeR)*D	0.111	0.028	0.116	0.018
	(0.117)	(0.098)	(0.117)	(0.098)
$\beta_8$da*ΔLn(IncomeR)*D	1.130***	0.257	1.134***	0.227
	(0.423)	(0.313)	(0.425)	(0.313)
β_9REM*ΔLn(IncomeR)*D	0.276	-0.142	0.257	-0.117
	(0.359)	(0.345)	(0.358)	(0.344)
β_{11}MA	-0.229***	-0.137**	-0.232***	-0.134**
	(0.074)	(0.055)	(0.074)	(0.055)
β_{12}Assets Intensity	-0.052***	-0.008	-0.053***	-0.008
	(0.014)	(0.013)	(0.014)	(0.013)
β_{13}D_twoyear	-0.060**	-0.096***	-0.058**	-0.099***
	(0.027)	(0.028)	(0.027)	(0.028)
β_{14}FCF	-0.195***	-0.099	-0.194***	-0.097
	(0.067)	(0.060)	(0.067)	(0.061)
β_{15}da	0.255***	0.136*	0.255***	0.130*
	(0.079)	(0.078)	(0.079)	(0.078)
β_{16}REM	0.065	0.054	0.069	0.055
	(0.055)	(0.047)	(0.055)	(0.047)
β_{17}Loss *ΔLn(IncomeR)*D	**0.117**	**-0.054**		
	(0.155)	**(0.155)**		
β_{18}Loss	**-0.026**	**0.000**		
	(0.017)	**(0.015)**		
β_{19}Concen *ΔLn(IncomeR)*D			**-0.125**	**-0.862****
			(0.524)	**(0.437)**
β_{20}Concen			**-0.022**	**-0.039**
			(0.067)	**(0.061)**
Constant	0.317***	0.227**	0.313***	0.232**
	(0.062)	(0.097)	(0.063)	(0.097)
	P=0.050 (Significant diff. between groups)		P=0.062 (Significant diff. between groups)	
Obs	8,615	7,664	8,615	7,664
Adj-R2	0.1170	0.1172	0.1166	0.1176
F value	29.53	25.21	29.42	25.32

Notes: The table reports the coefficients based on Anderson et al. (2003) model to test how product market competitioninfluences the relationship between managerial ability and R&D stickiness. The sample period is 2010-2019. The sample consists of 16,279 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Following Sheikh (2018) and Philoppe Aghion et al. (2013), we used Lerner index as the primary measure of product market competition. The higher the Lerner index the lower the competition. The sample were split to high product market competition and low product market competition samples using the 50th percentile. If Lerner index is higher than median, that is low product market competition. While if Lerner index is lower than median, that is high product market competition.

Table 92Results of H3 adding EM Ch.3 & ownership concentration Ch.4

	H3 (model 3)	
	Low Lerner index (strong competition)	High Lerner index (weak competition)
	Add EM Chapter3 &ownership concentration from Chpater4 to model	
β_1ΔLn(IncomeR)	0.630***	0.583***
	(0.029)	(0.025)
β_2ΔLn(IncomeR)*D	-0.332**	-0.014
	(0.143)	(0.135)
β_3ΔLn(IncomeR)*D*MA	**-1.732*** **	**0.049**
	(0.375)	**(0.254)**
β_5FCF*ΔLn(IncomeR)*D	-0.878***	-0.106
	(0.227)	(0.170)
β_6Assets Intensity*ΔLn(IncomeR)*D	-0.220***	-0.126**
	(0.071)	(0.053)
β_7D_twoyear*ΔLn(IncomeR)*D	0.112	0.020
	(0.117)	(0.098)
$\beta_8$da*ΔLn(IncomeR)*D	1.137***	0.230
	(0.425)	(0.314)
β_9REM*ΔLn(IncomeR)*D	0.272	-0.120
	(0.359)	(0.345)
β_{11}MA	-0.230***	-0.134**
	(0.074)	(0.055)
β_{12}Assets Intensity	-0.052***	-0.008
	(0.014)	(0.013)
β_{13}D_twoyear	-0.060**	-0.099***
	(0.027)	(0.028)
β_{14}FCF	-0.194***	-0.097
	(0.067)	(0.061)
β_{15}da	0.255***	0.130*
	(0.079)	(0.078)
β_{16}REM	0.065	0.055
	(0.055)	(0.047)
β_{17}Loss *ΔLn(IncomeR)*D	**0.119**	**-0.029**
	(0.155)	**(0.156)**
β_{18}Loss	**-0.026**	**0.001**
	(0.017)	**(0.015)**
β_{19}Concen *ΔLn(IncomeR)*D	**-0.125**	**-0.855***
	(0.525)	**(0.439)**
β_{20}Concen	**-0.020**	**-0.039**
	(0.067)	**(0.061)**
Constant	**0.320*** **	**0.232*** **
	(0.063)	**(0.097)**
	P=0.059 (Significant diff. between groups)	
Obs	8,615	7,664
Adj-R2	0.1168	0.1174
F value	28.12	24.16

Notes: The table reports the coefficients based on Anderson et al. (2003) model to test how product market competition influences the relationship between managerial ability and R&D stickiness. The sample period is 2010-2019. The sample consists of 16,279 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Following Sheikh (2018) and Philoppe Aghion et al. (2013), we used Lerner index as the primary measure of product market competition. The higher the Lerner index the lower the competition. The sample were split to high product market competition and low product market competition samples using the 50th percentile. If Lerner index is higher than median, that is low product market competition. While if Lerner index is lower than median, that is high product market competition.

5.7.6 Managerial ability delayed by one year

The empirical results based on OLS are likely to be biased due to reverse causality between managerial ability and R&D investment decision. R&D stickiness is both a cause and an effect of managerial ability. It is possible that high-ability managers are attracted to firms that have high R&D investment even when the company is experiencing downturn, because R&D investment leads to a company's long-term development. Conversely, it is also possible that high-ability managers are the key driver to keep on investing in R&D even when the company is experiencing downturn, because existing research shows a positive relationship between high-ability managers and the company's performance. To address this potential problem of endogeneity, we delay managerial ability for one year and run the model again and we find evidence consistent with our main results.

Regression result in Table 93 shows that β_3 is negative (-0.545^{***}) and significant at a 1% level, which indicates that managerial ability positively influences R&D cost stickiness (capable managers maintain R&D investment when the company is in downturn). Therefore, we find evidence consistent with our main results.

Table 93Managerial ability delayed by one year

	H2
Model	3
β_1ΔLn(IncomeR)	0.546***
	(0.019)
β_2ΔLn(IncomeR)*D	-0.019
	(0.085)
β_3ΔLn(IncomeR)*D*MA	**-0.545*** **
	(0.211)
β_5FCF*ΔLn(IncomeR)*D	-0.136
	(0.161)
β_6Assets Intensity*ΔLn(IncomeR)*D	-0.099**
	(0.042)
β_7D_twoyear*ΔLn(IncomeR)*D	0.043
	(0.074)
$\beta_8$da*ΔLn(IncomeR)*D	0.538**
	(0.248)
β_9REM*ΔLn(IncomeR)*D	-0.144
	(0.262)
β_{10}MA	0.311***
	(0.046)
β_{11}Assets Intensity	0.010
	(0.009)
β_{12}D_twoyear	-0.070***
	(0.020)
β_{13}FCF	-0.087*
	(0.045)
β_{14}da	0.102*
	(0.056)
β_{15}REM	0.025
	(0.037)
Constant	0.149***
	(0.048)
Obs	12,937
Adj-R2	0.1258
F value	47.52

Notes: The table reports the coefficients based on Anderson et al. (2003) model. The sample period is 2010-2019. The sample consists of 12,937 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively.

5.7.7 Use alternative measure of managerial ability–- CEO tenure

Following Walters et al. (2007), we also use managers' tenure to measure managerial ability; if the matching between the CEO and the company is good then they carry on. The empirical results show that the value of β_3 is negative and significant. Regression result in Table 94 shows that the value of β_3 is positive and significant. Therefore, we find evidence consistent with our main results.

Table 94Measure managerial ability using CEO tenure

	H2 (3)	H3 (3)	
		Low Lerner index (strong competition)	High Lerner index (weak competition)
β1ΔLn(IncomeR)	0.604***	0.635***	0.574***
	(0.019)	(0.029)	(0.025)
β2ΔLn(IncomeR)*D	0.012	0.169	-0.063
	(0.126)	(0.192)	(0.167)
β3ΔLn(IncomeR)*D*MA	**-0.088*** **	**-0.156*** **	**-0.041**
	(0.029)	**(0.047)**	**(0.037)**
β5FCF*ΔLn(IncomeR)*D	-0.296**	-0.612***	-0.053
	(0.136)	(0.225)	(0.172)
β6Assets Intensity*ΔLn(IncomeR)*D	-0.057	-0.103	-0.046
	(0.042)	(0.066)	(0.056)
β7D_twoyear*ΔLn(IncomeR)*D	0.023	0.062	0.012
	(0.075)	(0.121)	(0.098)
β8da*ΔLn(IncomeR)*D	0.550**	0.769*	0.324
	(0.250)	(0.427)	(0.312)
β9REM*ΔLn(IncomeR)*D	0.016	0.043	-0.126
	(0.245)	(0.358)	(0.345)
β11MA	-0.009*	-0.011	-0.009
	(0.005)	(0.007)	(0.006)
β12Assets Intensity	-0.017*	-0.039***	0.005
	(0.009)	(0.013)	(0.013)
β13D_twoyear	-0.085***	-0.076***	-0.095***
	(0.019)	(0.027)	(0.028)
β14FCF	-0.134***	-0.182***	-0.094
	(0.046)	(0.067)	(0.061)
β15da	0.157***	0.214***	0.103
	(0.055)	(0.079)	(0.078)
β16REM	0.040	0.013	0.051
	(0.036)	(0.055)	(0.046)
Constant	0.293***	0.347***	0.228**
	(0.051)	(0.066)	(0.102)
YEAR	Control	Control	Control
INDUSTRY	Control	Control	Control
		P=0.082 (Significant diff. between groups)	
Obs	15,943	8,452	7,491
Adj-R2	0.1122	0.1151	0.1188
F value	70.48	29.92	26.25

Notes: The table reports the coefficients based on Anderson et al. (2003) model. The sample period is 2010-2019. The sample consists of 15,943 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Following Sheikh (2018) and Philoppe Aghion et al. (2013), we used Lerner index as the primary measure of product market competition. The higher the Lerner index the lower the competition. The sample were split to high product market competition and low product market competition samples using the 50th percentile. If Lerner index is higher than median, that is low product market competition. While if Lerner index is lower than median, that is high product market competition.

5.7.8 Herfindahl-Hirschman Index (HHI) as a measure of product market competition

We have divided product market competition into high and low product market competition, following the Herfindahl-Hirschman Index. Managerial ability has a negative effect on R&D stickiness (capable managers maintain R&D investment when the company is in downturn) when competition in product markets is high. When competition is low, managerial ability has no impact on R&D stickiness.

Table 95 Descriptive statistic of *Herfindahl-Hirschman Index (HHI)*

The descriptive statistic of *HHI* is for a sample of 16,279 firm-year observations from 2,923 firms following Bradbury and Scott (2018). On average *HHI* was 0.05 (median: 0.02, standard deviation: 0.09) with a minimum of 0.01 and maximum of 0.49.

	Obs.	Mean	Standard Deviation	Median	Minimum	Maximum
HHI	16,279	0.05	0.09	0.02	0.01	0.49
D_HHI	16,279	0.45	0.50	0.00	0.00	1.00

Column 1 in Table 96 shows that managerial ability has a negative effect on R&D stickiness (capable managers maintain R&D investment when the company is in downturn) when competition in product markets is high (β_3=-1.311***); column 2 in Table 96 shows that, in the low competition sub-sample, managerial ability has positive but not significant impact on R&D stickiness (β_3=0.575). The difference between these two groups is statistically significant (P value=0.022). Therefore, we find evidence consistent with our main results.

Table 96 Herfindahl-Hirschman Index (HHI) product market competition measure

	H3	
	1 Low HHI (strong competition)	2 High HHI (weak competition)
β1ΔLn(IncomeR)	0.644***	0.565***
	(0.022)	(0.033)
β2ΔLn(IncomeR)*D	-0.303***	-0.225
	(0.095)	(0.139)
β3ΔLn(IncomeR)*D*MA	-1.311***	0.575
	(0.224)	(0.413)
β5FCF*ΔLn(IncomeR)*D	-0.362**	-0.638***
	(0.161)	(0.234)
β6Assets Intensity*ΔLn(IncomeR)*D	-0.115**	-0.031
	(0.048)	(0.073)
β7D_twoyear*ΔLn(IncomeR)*D	-0.103	0.155
	(0.080)	(0.145)
β8da*ΔLn(IncomeR)*D	0.784***	0.417
	(0.273)	(0.490)
β9REM*ΔLn(IncomeR)*D	-0.296	0.180
	(0.286)	(0.421)
β11MA	-0.157***	-0.154**
	(0.058)	(0.070)
β12Assets Intensity	-0.008	-0.045***
	(0.011)	(0.016)
β13D_twoyear	-0.104***	-0.054
	(0.021)	(0.035)
β14FCF	-0.054	-0.279***
	(0.049)	(0.083)
β15da	0.184***	0.204**
	(0.060)	(0.101)
β16REM	0.057	0.055
	(0.042)	(0.062)
Constant	0.215***	0.264***
	(0.045)	(0.065)
	P=0.022 (Significant diff. between groups)	
Obs	9,030	7,249
Adj-R2	0.1498	0.0933
F value	67.28	19.65

Notes: The table reports the coefficients based on Anderson et al. (2003) model. The sample period is 2010-2019. The sample consists of 16,279 firm year observations. For the definitions of variables see Appendix 1. All continuous variables are winsorised at the 1st and 99th percentiles. Standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Year and industry fixed effects are included in the model to control for common effects across all firms in each year and each industry, respectively. Following Kao and Chen (2013), we also use Herfindahl-Hirschman Index (HHI) to measure product market competition. The higher the HHI the lower the competition. The sample were split to high product market competition and low product market competition samples using the 50th percentile.

5.8 Conclusion

The possession of resources is as important as resource utilization. This study draws on the Resource Based View (RBV) to investigate the relationship between the important resources of managerial ability and R&D during times when managers face operating cash constraints, paying particular attention to the degree of product market competition. The importance of resource allocation is pronounced when sales revenue and cash resources are limited and managerial ability gains even more importance. Existing research shows ambiguous results with respect to the relationship between managerial ability and company long term performance (Demerjian et al., 2013; Gul et al., 2018). In this paper, we study the relationship between managerial ability and the retention of R&D resources (R&D stickiness) when firms face declining sales revenues. Using a panel dataset of Chinese companies listed in Shanghai and Shenzhen Stock Exchanges in our empirical analysis, we found that capable managers retain R&D resources when their firm is in downturn. In addition, product market competition forces companies to allocate resources efficiently. Bloom and Reenen (2007) find that poor management practices are more prevalent when product market competition is weak. This study further examines the impact of product market competition on the relationship between managerial ability and R&D stickiness. Empirical results indicate that managerial ability is negatively associated with R&D stickiness. However, this association is driven by product market competition. Specifically, managerial ability has a negative effect on R&D stickiness only when product market competition is high. When product market competition is low, managerial ability has no impact on R&D stickiness. The findings indicate that high-ability managers are more rational in their R&D resource allocation, can use their firm- and industry-knowledge to enhance the firm's efficiency to retain long-term innovation. The mechanism tests reveal that managerial ability taking into account financial constraints has a pronounced positive effect on R&D stickiness. High ability management is able to manage resources more effectively to avoid high R&D adjustment costs.

The empirical results remain robust when CEO tenure is used as an alternative way to measure managerial ability. Results also remain the same when 2013 data is dropped due to the combat corruption policy being adopted in that year. Moreover, the results do not change when total revenue is used to replace operating revenue in models. Results also remain similar when the dummy variable of whether the board chair and CEO are the same people is added to the models.

This research is not without limitations. Future research could take into account networks of companies and companies' foreign subsidiaries as additional driving factors or R&D resource allocation. Similarly, in the Chinese context, state ownership and corporate governance features could be considered.

6 Conclusion

6.1 Introduction

This chapter draws on theories and empirical data from the previous three papers to conclude this thesis. Section 6.2 briefly summarizes this study's motivation and scope, followed by the theories on which this thesis draws (Section 6.3), and the research design employed in this study (Section 6.4). The subsequent sections illustrate the findings (Section 6.5), key contributions in regard to theory, and empirical findings and their synthesis (Section 6.6). The implications of this thesis are outlined (Section 6.7), as are its limitations (Section 6.8) and opportunities for future research (Section 6.9). The last section (Section 6.10) sums up this thesis.

6.2 Motivation and scope

Traditional cost behaviour models identify costs as either fixed or variable. For the latter there is a linear relationship to sales units (Noreen, 1991). Anderson et al. (2003) point out that cost increases following sales revenue increases were steeper than the cost decreases following sales decrease. They named this asymmetric cost behaviour 'cost stickiness'. A significant amount of academic research explores the non-linear relationship between cost increases vs. decreases when sales revenue increased or decreased (Ibrahim et al., 2022). Different from previous research which only focuses on the behaviour of five cost categories (SG&A, operating costs, Cost of Goods Sold, total cost, and labour costs), this research investigates R&D expense behaviour. There are various reasons to consider R&D expenses. First, R&D activities are important for a company's long term and sustainable development (Schuster et al., 2018). Secondly, there is an ongoing debate about whether assets constitute investments which need constant maintenance through additional annual R&D expenses, otherwise the knowledge base would erode. Thirdly, China has put considerable resources into R&D activities, encouraging SOEs and POEs (Privately Owned Enterprises) to spend more on R&D to achieve more innovation. The features of China's business landscape are considered, especially the importance of SOEs and government impact as well as the relatively weak investor protection, with high blockholding and institutional ownership.

This research responds to Ibrahim et al.'s (2022) call to examine cost stickiness in developing countries. This research examines company resource allocation decisions on R&D through the lens of cost stickiness for Chinese listed firms. More specifically, it investigates the impact of ownership structure and managerial ability on company resource allocation decisions on R&D based on Chinese firm data.

1. Firstly**,** we argue that, during financial downturns, the adjustment cost to cut R&D influences changes in R&D costs. The costs that business entities need to incur to retire slack resources when sales decrease are the adjustment costs (Anderson et al., 2003). When the adjustment costs to retire unused resources are higher than to keep them, managers are more

willing to retain unused resources to avoid adjustment costs. Our findings show that R&D is sticky. This prediction is in line with the view that the adjustment cost to cut R&D is higher than to keep them (Venieris et al., 2015).

2. Secondly following agency theory, we argue that ownership structure is associated with a company's resource allocation decision on R&D when sales decrease. We separately investigate how type one agency problems (conflict of interest between managers and shareholders) and type two agency problems (conflict of interests between controlling shareholders and minority shareholders) influence a company's R&D investment decisions when sales decrease.

3. Lastly we argue that managerial ability plays a role on a company's R&D resource allocation decision when sales decrease. Our findings show that there is a positive relationship between managerial ability and R&D stickiness, which means capable managers allocate resources to R&D even when sales decrease. This prediction is in line with the view of the upper echelons theory that managers are unique and their decisions influence company outcomes (Hambrick, 2007). Based on the upper echelons theory, managers make decisions according to the situation they face (Hambrick & Mason, 1984). Our findings show that, under the situation of product market competition, high product market competition will force capable managers to continue to invest in R&D even when sales decrease in order to maintain a competitive advantage with their peers. These findings to some extent show that managers are unique, and managers make their own decisions based on the situations they face.

6.3 Theory

This study draws on agency theory, the principal-agent and principal-principal conflicts of interest to explain either management's motivation to manipulate earnings, given managerial ability or ownership concentration, and managerial ability on R&D stickiness. Thereby, the literature on stickiness is extended by investigating factors beyond the initial probabilistic and adjustment cost-based view brought forward by Anderson et al. (2003). Our findings extend the discussion of agency problems into the realm of R&D stickiness and into the Chinese institutional setting of high ownership concentration and relatively weak (minority) shareholder protection.

6.4 Research design

This study draws on firm-year data of firms listed at Shanghai and Shenzhen Stock Exchanges. After applying commonly used selection criteria, data was analyzed using OLS and FE models. Robustness tests include alternative measures of independent variables, adding more control variables to models, and dropping data because of event shocks to our research.

Variables are commonly tested without interaction terms and with interaction terms for changes in sales revenue and decline in sales revenue to determine the relative impact of

variables on sales revenue increase versus sales revenue decreases to measure the impact on R&D expenses and the existence or absence of stickiness and anti-stickiness.

Variable definitions follow existing research and were selected according to the research question and underlying theory. In order to check findings for robustness, alternate variable definitions are chosen based on the suggestions in prior studies.

6.5 Findings

6.5.1 Motivation to manipulate earnings, managerial ability and R&D stickiness

Looking at the type one agency problem, because of the separation of ownership from control and information asymmetry between managers and shareholders, Jensen and Meckling (1976) posit that there are conflicts of interest between managers and shareholders and managers are looking to their self-interests at the expense of shareholder interests. Our findings show that R&D stickiness decreases when managers are motivated to avoid revenue decrease or to avoid loss, which means managers cut R&D investment in order to manipulate earnings upwards when sales decrease. This prediction is in line with the view of agency theory that managers are self-serving and looking to self-interest at the expense of shareholder interests (Jensen & Meckling, 1976). Existing research shows mixed results on whether managers forego company long-term development and cut R&D to manipulate earnings upwards (Roychowdhury, 2006b; Venieris et al., 2015). Our findings show that R&D and other costs play the same role as a tool to manipulate earnings when managers are motivated by earnings management.

Furthermore, our findings also confirm that agency theory applies to capable managers. Jensen and Meckling (1976) posit that there are conflicting interests between managers and shareholders and managers are looking for their self-interests at the expense of shareholders' interests. The first research of the thesis shows that capable managers strengthen the negative relationship between earnings management motivation and R&D stickiness, which means that when managers are motivated to avoid revenue decrease or avoid loss, even capable managers seek short-term profits at the expense of the company's long-term development and will cut R&D to manipulate earnings upwards. The first research of the thesis confirmed Jensen and Meckling's (1976) agency theory that there are conflicting interests between managers and shareholders.

6.5.2 Ownership concentration, managerial ability, and R&D stickiness

Looking at the type two agency problem, Jensen and Meckling (1976) point out that controlling shareholders have the ability to benefit themselves at the expense of minority shareholders, which leads to a conflict of interests between larger shareholders and minority shareholders. In that, controlling shareholders and minority shareholders may have conflicting views on company resource allocation decisions on R&D when sales decrease because R&D has a low chance of success (Carpenter & Petersen, 2002). Controlling shareholders cannot

diversify their risk to others, while minority shareholders are less risk-averse because one decline will not influence the overall value of minority shareholder portfolios. Firms controlled by diversified shareholders invest more in risky projects than firms controlled by non-diversified shareholders (Faccio et al., 2011). Due to the risk-taking difference between controlling shareholders and minority shareholders, controlling shareholders are risk averse so they are likely to cut R&D when sales decrease to avoid risk. However, minority shareholder may be keen to take on risk and keep investing in R&D even when sales decrease. Existing research shows mixed results about the relationship between ownership concentration and the R&D investment decision (Lee & O'Neill, 2003; Minetti et al., 2015b; Vito et al., 2010; Yafeh & Yosha, 2003).

What will controlling shareholders do to R&D when sales decrease? Our findings show that there is a positive relationship between ownership concentration and R&D stickiness, which means that controlling shareholders are taking on risk to keep investing in R&D even when sales decrease. This prediction is in line with the view that controlling shareholders take some risks for the company's long-term development (Francis & Smith, 1995; Lee & O'Neill, 2003). In this regard, we do not see conflicting views on R&D investment when sales decrease between controlling shareholders and minority shareholders. Even controlling shareholders are keen to take on risk to keep investing in R&D for the company's long-term development even when sales decrease.

Jensen and Meckling (1976) posit that ownership concentration aligns the conflict of interests between managers and shareholders. The second research of the thesis shows that capable managers strengthen the positive relationship between ownership concentration and R&D stickiness, which means capable managers stay on the controlling shareholders' side to keep investing in R&D even when sales decrease. Controlling shareholders are strongly motivated (Lee, 2021) and have lower costs (Yafeh & Yosha, 2003) to monitor management compared with other shareholders, so ownership concentration could align the conflicts of interest between managers and shareholders. Because of the monitoring effect of controlling shareholders, capable managers stay on the controlling shareholders' side to keep investing in R&D even when sales decrease. Our findings show that even capable managers are self-serving when they are motivated by earnings management and ownership concentration aligns the conflict of interest between capable managers and shareholders.

6.5.3 Managerial ability, R&D stickiness under product market competition

The third paper adopts the RBV and finds that managerial ability and R&D expenses are important resources when product market competition is present.

The possession of resources is as important as resource utilization and this study draws on the Resource Based View (RBV) to investigate the relationship between the important resources of managerial ability and R&D during times when managers face operating cash constraints, while paying particular attention to the degree of product market competition. The

importance of resource allocation is pronounced when sales revenue and cash resources are limited. This means managerial ability gains even more importance. Existing research shows ambiguous results with respect to the relationship between managerial ability and company long term performance (Demerjian et al., 2013; Gul et al., 2018). In this paper, we study the relationship between managerial ability and retention of R&D resources (R&D stickiness) when firms face declining sales revenues. We found that capable managers retain R&D resources when their firm is experiencing downturn. In addition, product market competition forces companies to allocate resources efficiently. Bloom and Reenen (2007) find that poor management practices are more prevalent when product market competition is weak. This study further examines the impact of product market competition on the relationship between managerial ability and R&D stickiness. Empirical results indicate that managerial ability is positively associated with R&D stickiness. Furthermore, this association is driven by product market competition. Specifically, managerial ability has a positive effect on R&D stickiness only when product market competition is high. When product market competition is low, managerial ability has no impact on R&D stickiness. These findings indicate that high-ability managers are more rational in their R&D resource allocation and can use their firm- and industry-knowledge to enhance the firm's efficiency to retain long-term innovation. The empirical results remain robust across a battery of different tests.

6.6 Key contributions

This study contributes to our understanding of R&D expense allocation under different conditions including managements' motivation for earnings management, corporate governance features of blockholding and institutional investor shareholding, and product market competition. The findings to each of these fields make the following contributions.

6.6.1 Motivation to manipulate earning, managerial ability and R&D stickiness

Expanding agency theory allows for understanding pathways for management's behaviour that priorities self-interest over R&D expenses and shareholder value. Prior research did not consider management's motivation to earnings management on the asymmetric behaviour of R&D expenses.

The consideration that managerial ability is conflated into agency provides an additional explanation of management's motivation to retain or retire R&D expenses in times of declining sales revenue.

6.6.2 Blockholders, managerial ability and R&D stickiness

The second paper adds to our understanding of the interplay between blockholding or institutional investors' shareholding on R&D expenses (stickiness) in China, extending the principal-principal consideration of agency theory. Management's ability further contributes to our understanding.

This research contributes to the literature by adding more evidence to the debate on whether controlling or institutional shareholders expatriate resources to maximize self-interest at the expense of minority shareholders' interests or to support R&D activities. Our study extends the scope of agency theory by examining the effect of principal-principal conflicts between majority and minority shareholders on R&D investment decisions in the setting of cost stickiness. Our findings suggest that firms have to sustain dividends to minority shareholders to compensate for potential governance shortcomings associated with blockholding. Blockholders encourage R&D stickiness, and this effect is even more pronounced for high-ability management who can allocate resources more rationally, especially during times of sales revenue declines.

Our study also contributes to the literature by providing evidence on ownership concentration and institutional ownership, managerial ability and R&D stickiness, to gain an in-depth understanding of R&D cost stickiness under various governance factors. Managerial ability strengthens R&D cost stickiness under ownership concentration and institutional blockholding, while accrual earnings management remains a critical factor. Concentrated and institutional ownership do not limit earnings management activities during sales revenue increases and during sales revenue declines; when accrual earnings management is exhausted, R&D expenses may even diminish.

6.6.3 Managerial ability, R&D stickiness under product market competition

Overall, these papers extend the original idea of Anderson et al. (2003) to show that cost stickiness is not merely based on management's probabilistic assessment of future sales revenue changes, nor merely on the firm specific adjustment costs of R&D expense increases or decreases, but an array of other (management specific, motivational, ownership and even firm external PMC) factors. Managers use their tacit knowledge to contribute to a firm's competitive advantage by retaining R&D resources despite the shortage of cash under high market competition.

6.7 Implication of results

The first paper provides evidence that the agency problem between management and principal impacts on R&D expense asymmetry, particularly for those firms with low-ability management. This study makes several contributions to the literature. First, prior studies on cost stickiness ignore the impact of managerial incentives on R&D expenses. We show that beyond economic factors, agency factors also motivate managers' R&D expense adjustment decisions and help to explain R&D expense behaviour. We show that the agency problem shifts R&D expense stickiness away from its optimal level. Secondly, we document a strong positive association between free cash flow and R&D expense asymmetry. R&D activities are not just dependent on the change in sales revenue but are also dependent on free cash flows.

The second paper has implications for investors and auditors. While sustained R&D expenses send a signal of investments in a firm's future and innovative power, they might merely support blockholders' intention to comply with the China Government's macro-economic policy of higher R&D spending. When prevailing earnings management scope is exhausted or free cashflow declines, firms will diminish R&D expenses. Therefore, at first glance the previously found principal-principal conflict between blockholder and minority shareholder is kept latent, but it still prevails under conditions of profit decline or cash shortage. However, high capability management can mitigate this issue by using their tacit and industry specific knowledge to act more rationally and use resources more efficiently to retain R&D expenses during sales revenue declines.

The third paper emphasizes that managerial ability is a crucial resource when PMC is high. That is, high-ability management faced with PMC are able to orchestrate the use of scarce resources to more efficient use which in turn allows firms to retain their R&D resource allocation. This paper goes beyond economic factors demonstrated in prior literature to explain asymmetric cost behaviour and show that product market competition as well as managerial ability have implications on R&D resource allocation.

6.8 Limitations

*6.8.1 ST and *ST company could influence research results*

To protect investors, on April 22, 1998, the Shanghai and Shenzhen Stock Exchanges announced that companies whose audit results show negative net profit and the negative net profit lasts for two fiscal years will be referred to as Special Treatment (ST) companies. The *ST companies are those companies who have delist risks warnings issued by a stock exchange and the negative net profit lasts for three years.

In this research, we investigate how ownership structure and managerial ability (MA) influence company resource allocation on R&D under the particular setting that the company is experiencing downturn. ST companies and *ST companies are important observations in our research. Following existing Chinese based cost stickiness research (Bu et al., 2015a; He & He, 2022; Xu & Sim, 2017; Xue & Hong, 2016), those ST companies and *ST companies are included in our research. However, we realized that ST and *ST companies are more likely to manipulate earnings (Chen et al., 2009), which to some extent influences research results.

6.8.2 Industry difference and geographic location could influence research results

In this research, all A share companies listed at Shanghai and Shenzhen Stock Exchanges are included in the research. Although we have controlled the industry dummy in our research, we still realized that the industry difference on the issue of R&D investment could influence research results.

There is an imbalance in development between different regions in China. Eastern provinces are developing much faster than Western provinces. However, all A share

companies, wherever those companies are located, are included in the research. Due to the imbalanced development of difference provinces, geographic location could influence a company's R&D investment decision. Zeng et al. (2021) point out that imperfect marketization usually leads to weak awareness of protection of property rights, which negatively influences a company's innovation decision. The imbalanced development between different regions could influence research results.

6.9 Future research

First, this research follows the viewpoint that R&D input and innovation output are two different concepts (Ortega-Argiles et al., 2005). Zhou et al. (2017) investigate the relationship between R&D investment and innovation output based on Chinese data. Their findings indicate that state ownership is inefficient in transferring R&D input into innovation output. Based on Zhou et al. (2017), we cannot simply equal R&D input with innovation output. The effect of how R&D stickiness influences innovation output will be the subject of further research.

Secondly, future research could also take into account the networks of companies and foreign subsidiaries as additional driving factors for R&D resource allocation. Similarly, in the Chinese context state ownership and corporate governance features could be considered.

Lastly, qualitative research will be adopted for setting the problem properly. We may miss important points if we do not work on it in real practice. We may gain important insights if we could talk to capable managers directly. Aside from a data analysis as we have done in this thesis, qualitative research based, for example, on semi structured interviews will be adopted in further research.

6.10 Concluding comments

This thesis has shed light on the relationship between changes in R&D expenses and sales revenue increase and declines given various conditions. This insight contributes to agency theory and the principal-agent and principal-principal conflicts among Chinese investors and firms in particular. The effect of product market competition on R&D stickiness, given management's ability, adds further evidence and insights to external factors impacting on management's R&D expense allocation decisions. Overall, we provide grounds for further studies to better understand R&D expense allocations when firms face sales revenue declines. Our study is limited by data availability, and common shortcomings for statistical, as opposed to other means of inquiry.

7 Bibliography

Abad, D., Cutillas-Gomariz, M. F., Sanchez-Ballesta, J. P., & Yague, J. (2016). Real Earnings Management and Information Asymmetry in the Equity Market. *European Accounting Review*, DOI:10.1080/09638180.1261720.

Abernathy, J. L., Beyer, B., & Rapley, E. T. (2014). Earnings Management Constraints and Classification Shifting. *Journal of Business Finance & Accounting*, 41(5-6), 600-626. https://doi.org/https://doi.org/10.1111/jbfa.12076

Acemoglu, D., & Linn, J. (2004). Market Size in Innovation: Theory and Evidence from the Pharmaceutical Industry. *The Quarterly Journal of Economics*, 119(3), 43.

Acharya, V., & Xu, Z. (2017). Financial dependence and innovation: The case of public versus private firms. *Journal of Financial Economics*, 124(2017), 21.

Acheson, J., & Malone, R. (2020). Respect your elders: Evidence from Ireland's R&D tax credit reform. *Economic and Social Research Institute*, 51(1), 28.

Adams, R. B., Almeida, H., & Ferreira, D. (2005). Powerful CEOs and Their Impact on Corporate Performance. *The Review of Financial Studies*, 18(4), 31.

Adhikari, B. K., & Agrawal, A. (2016). Religion, gambling attitudes and corporate innovation. *Journal of Corporate Finance*, 37(2016), 20.

Aghion, P., Bloom, N., Blundell, R., Griffith, R., & Howitt, P. (2005). Competition and innovation: An inverted-U relationship. *The Quarterly Journal of Economics*, 120(2005), 29.

Aghion, P., Reenen, J. V., & Zingales, L. (2013). Innovation and Institutional Ownership. *American Economic Review*, 103(1), 29.

Aghion, P., Van Reenen, J., & Zingales, L. (2013). Innovation and Institutional Ownership. *American Economic Review*, 103(1), 277-304. https://doi.org/10.1257/aer.103.1.277

Agrawal, A. & Chadha, S., 2005. Corporate Governance and Accounting Scandals. *The Journal of Law & Economics*, 48, 371-406. 10.1086/430808

Alimov, A. (2014). Product market competition and the value of corporate cash: Evidence from trade liberalization. *Journal of Corporate Finance*, 25(2014), 18.

Altman, E. I. (1968). Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *Journal of Finance*, 23(4), 189-209.

Alzugaiby, B. (2022). Managerial ability and corporate risk-taking in an emerging economy. Managerial Finance, 48(910), 1544-1557.

Amore, M. D., & Failla, V. (2020). Pay Dispersion and Executive Behaviour: Evidence from Innovation. *British Journal of Management*, 31(2020), 18.

Anderson, M. C., Banker, R. D., & Janakiraman, S. N. (2003). Are selling, general, and administrative costs "Sticky"? *Journal of Accounting Research*, 41(1).

Anderson, R., & Reeb, D. (2004). Board composition: balancing family influence in S&P 500 firms. *Administrative Science Quarterly*, 49(2), 209-327.

Anderson, S. W., & Lanen, W. N. (2007). Understanding cost management: what can we learn from the evidence on 'stickycosts'? Available at SSRN 975135.

Andreou, P. C., Philip, D., &Robejsek, P. P. (2016). Bank liquidity creation and risk-taking: does managerial ability matter? *Journal of business finance and accounting*, 43(1-2), 42.

Anggraini, P. G. &Sholihin, M., (2023). What do we know about managerial ability? A systematic literature review. *Management Review Quarterly*, 73, 1-30. 10.1007/s11301-021-00229-6

AsianDevelopmentBankInstitute. (2019). Asian development outlook 2019: strengthening disaster resilience. Manila: Asian Development Bank Institute.

Atanassov, J. (2013). Do hostile takeovers stifle innovation? Evidence from antitakeover legislation and corporate patenting. *The Journal of Finance*, LXVIII(3), 35.

Baber, W. R., Fairfield, P. M., & Haggard, J. A. (1991). The effect of concern about reported income on discretionary spending decisions: The case of research and development. *The Accounting Review*, 66(4), 12.

Badertscher, B., Collins, D., & Lys, T. (2011). Discretionary accounting choices and the predictive ability of accruals with respect to future cash flows. *Journal of Accounting and Economics*, 53, 330-352.

Bae, K., Kang, J., & Kim, J. (2002). Tunneling or Value Added? Evidence from Mergers by Korean Business Groups. *The Journal of Finance*, LVII(6), 2695-2739.

Baggs, J., &Bettignies, J.-E. D. (2007). Product market competition and agency costs. *The Journal of Industrial Economics*, LV(2), 36.

Bah, R., & Dumontier, P. (2001). R&D intensity and corporate financial policy: Some international evidence. *Journal of business finance and accounting*, 28(5), 22.

Baik, B., Choi, S., & Farber, D. B. (2020). Managerial Ability and Income Smoothing [Article]. *The Accounting Review*, 95(4), 1-22. https://doi.org/10.2308/accr-52600

Balakrishnan, R., & Gruca, T. S. (2008). Cost Stickiness and Core Competency: A Note*. *Contemporary Accounting Research*, 25(4), 993-1006. https://doi.org/https://doi.org/10.1506/car.25.4.2

Balakrishnan, R., Petersen, M. J., & Soderstrom, N. S. (2004). Does Capacity Utilization Affect the "Stickiness" of Cost? *Journal of Accounting, Auditing & Finance*, 19(3), 283-300. https://doi.org/10.1177/0148558X0401900303

Balsmeier, B., &Czarnitzki, D. (2017). Ownership concentration, institutional development and firm performance in Central and Eastern Europe. *MANAGERIAL AND DECISION ECONOMICS*, 38(2017), 15.

Baik, B., Brockman, P. A., Farber, D. B. & Lee, S., (2018). Managerial Ability and the Quality of Firms' Information Environment. *Journal of Accounting, Auditing & Finance*, 33, 506-527. 10.1177/0148558x17742820

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management,* 17(1), 22.

Banker, V. L. & MUELLER, G. C. 2002. CEO Characteristics and Firm R&D Spending. Management Science, 48, 782-801.

Banker, R. D., &Byzalov, D. (2014). Asymmetric Cost Behavior. *Journal of Management Accounting Research*, 26(2), 38.

Banker, R. D., Byzalov, D., & Chen, L. (2013). Employment protection legislation, adjustment costs and cross-country differences in cost behavior. *Journal of Accounting and Economics*, 55(1), 111-127. https://doi.org/https://doi.org/10.1016/j.jacceco.2012.08.003

Banker, R. D., Byzalov, D., Ciftci, M., &Mashruwala, R. (2014). The moderating effect of prior sales changes on asymmetric cost behavior. *Journal of Management Accounting Research*, 26(2), 23.

Banker, R. D., Byzalov, D., Fang, S., & Liang, Y. (2018). Cost management research. *Journal of Management Accounting Research*, 30(3), 187-209.

Barclay, M. J., & Holderness, C. G. (1989). Private benefits from control of public corporations. *Journal of Financial Economics*, 25(2), 371-395.

Barker, V. L., & Mueller, G. C. (2002). CEO Characteristics and Firm R&D Spending. *MANAGEMENT SCIENCE*, 48(6), 20.

Bartten, B., Payne, J. L., & Thomas, W. B. (2016). Earnings Management: Do Firms Play "Follow the Leader"? *Contemporary Accounting Research*, 33(2), 616-643.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management,* 17(1), 22.

Bartov, E., & Mohanram, P. S. (2014). Does Income Statement Placement Matter to Investors? The Case of Gains/Losses from Early Debt Extinguishment. *The Accounting Review*, 89(6), 2021-2055. http://www.jstor.org.ezproxy.nottingham.edu.cn/stable/24467284

Baysinger, B. D., Kosnik, R. D., & Turk, T. A. (1991). Effects of board and ownership structure on corporate R&D strategy. *Academy of Management Journal*, 34(1), 11.

Beasley, M. S., 1996. An Empirical Analysis of the Relation between the Board of Director Composition and Financial Statement Fraud. *The Accounting Review,* 71**,** 443-465.

Beladi, H., Deng, J. & Hu, M., (2021). Cash flow uncertainty, financial constraints and R&D investment. *International Review of Financial Analysis*, 76, 101785. https://doi.org/10.1016/j.irfa.2021.101785

Belloc, F. (2012). Corporate governance and innovation: A survey. *Journal of Economic Surveys*, 26(5), 835-864.

Belloc, F., Laurenza, E. & Alessandra Rossi, M., 2016. Corporate governance effects on innovation when both agency costs and asset specificity matter. *Industrial and Corporate Change*, 25, 977-999. 10.1093/icc/dtw009

Bereskin, F. L., Hsu, P.-H., & Rotenberg, W. (2018). The Real Effects of Real Earnings Management: Evidence from Innovation [https://doi.org/10.1111/1911-3846.12376]. *Contemporary Accounting Research*, 35(1), 525-557. https://doi.org/https://doi.org/10.1111/1911-3846.12376

Berk, J. B., & Stanton, R. (2007). Managerial ability, Compensation, and the Closed-End fund discount. The Journal of Finance, LXII(2), 28.Bernile, G., Bhagwat, V., & Yonker, S. (2018). Board diversity, firm risk, and corporate policies. *Journal of Financial Economics*, 127(2018), 25.

Berkman, H., Cole, R. A., & Fu, L. J. (2009). Expropriation through loan guarantees to related parties: Evidence from China. *Journal of Banking & Finance*, 33(2009), 141-156.

Bertrand, M., Mehta, P., & Mullainathan, S. (2002). Ferreting Out Tunneling: An Application to Indian Business Groups. *The Quarterly Journal of Economics*, 117(1), 121-148.

Bertrand, M., &Schoar, A. (2003). Managing with style: The effect of managers on firm policies. *The Quarterly Journal of Economics*, CXVIII(4), 40.

Bloch, C. (2005). R&D investment and internal finance: The cash flow effect. *Economics of innovation and new technology*, 14(3), 12.

Block, J. H. (2012). D&D investments in family and founder firms: An agency perspective. *Journal of Business Venturing*, 27(2012), 248.

Bloom, N. (2007). Uncertainty and the Dynamics of R&D. *The American Economic Review*, 97(2), 250-255. http://www.jstor.org/stable/30034455

Bloom, N., Bond, S., & Reenen, J. v. (2007). Uncertainty and Investment Dynamics. *The Review of Economic Studies*, 74(2), 26.

Bloom, N., Draca, M., & Reenen, J. V. (2016). Trade induced technical change? The impact of Chinese imports on innovation, IT and productivity. *Review of Economic Studies*, 83(2016), 32.

Bloom, N., & Reenen, J. V. (2007). Measuring and explaining management practices across firms and countries. *The Quarterly Journal of Economics*, CXXII(4), 59.

Bogliacino, F., Prato, G. D., &Nepelski, D. (2013). Ownership structure and R&D orientation in ICT groups. *Eurasian Business Review*, 3(2), 15.

Bolton, P., & Von Thadden, E. L. (1998). Blocks, liquidity, and corporate control. *The Journal of Finance*,

53(1), 1-25.
Bonsall IV, S. B., Holzman, E. R., & Miller, B. P. (2017). Managerial Ability and Credit Risk Assessment. *Management Science*, 63(5), 1425-1449. https://doi.org/10.1287/mnsc.2015.2403
Bougheas, S., Gorg, H., & Strobl, E. (2003). Is R&D financially constrained? Theory and evidence from Irish manufacturing. *Review of industrial organization*, 22(2003), 16.
Bouvatier, V., Lepetit, L., & Strobel, F. (2014). Bank income smoothing, ownership concentration and the regulatory environment. *Journal of Banking & Finance*, 41(2014), 253-270.
Bradbury, M. E., & Scott, T. (2018). Do managers forecast asymmetric cost behaviour? *Australian Journal of Management*, 43(4), 17.
Bradley, D., Kim, I., & Tian, X. (2017). Do Unions Affect Innovation? *MANAGEMENT SCIENCE*, 63(7), 21.
Brossard, O., Lavigne, S., &Sakinc, M. C. (2013). Ownership structures and R&D in Europe: the good institutional investors, the bad and ugly impatient shareholders. *Industrial and corporate change*. 22(4), 1031-1068.
Brous, P. A. & Kini, O., 1994. The Valuation Effects of Equity Issues and the Level of Institutional Ownership: Evidence from Analysts' Earnings Forecasts. *Financial Management*, 23, 33-46. 10.2307/3666054
Brown, J. R., Fazzari, S. M., & Petersen, B. C. (2009). Financing Innovation and Growth: Cash flow, External Equity, and the 1990s R&D boom. *The Journal of Finance*, LXIV(1), 36.
Brown, J. R., & Martinsson, G. (2019). Does transparency stifle or facilitate innovation? *MANAGEMENT SCIENCE*, 65(4), 24.
Brown, J. R., Martinsson, G. & Petersen, B. C., (2012). Do financing constraints matter for R&D? *European Economic Review*, 56, 1512-1529. https://doi.org/10.1016/j.euroecorev.2012.07.007
Brown, J. R., & Petersen, B. C. (2011). Cash holdings and R&D smoothing. *Journal of Corporate Finance*, 17(2011), 16.
Bu, D., Wen, C., & Banker, R. D. (2015). Implications of asymmetric cost behaviour for analysing financial reports of companies in China. *China Journal of Accounting Studies*, 3(3), 181-208. https://doi.org/10.1080/21697213.2015.1062343
Bugeja, M., Lu, M., & Shan, Y. (2015). Cost stickiness in Australia: Characteristics and Determinants. *Australian Accounting Review*, 25(3).
Burgstahler, D., &Dichev, I. (1997). Earnings management to avoid earnings decreases and losses. *Journal of Accounting and Economics*, 24(1997), 28.
Burkart, M., Gromb, D., &Panunzi, F. (1997). Large shareholders, monitoring, and the value of the firm. *Quarterly Journal of Economics*, 1997(112), 693-728.
Burkart, M., Panunzi, F., & Shleifer, A. (2003). Family firms. *Journal of Finance*, 58, 2167-2202.
Bushee, B. J. (1998). The influence of institutional investors on myopic R&D investment behavior. *The Accounting Review*, 73(3), 29.
Bushee, B. J. (1998). The influence of institutional investors on myopic R&D investment behavior. *The Accounting Review*, 305-333.
Cai, H., & Liu, Q. (2009). Competition and corporate tax avoidance: Evidence from Chinese industrial firms. *The Economic Journal*, 119(April), 32.
Calleja, K., Steliaros, M., & Thomas, D. C. (2006). A note on cost stickiness: Some international comparisons. *Management Accounting Research*, 17(2), 127-140. https://doi.org/https://doi.org/10.1016/j.mar.2006.02.001

Cannon, J. N. (2014). Determinants of "Sticky Costs": An Analysis of Cost Behavior using United States Air Transportation Industry Data. *The Accounting Review*, 89(5), 29.

Carnes, C. M., Xu, K., Sirmon, D. G., & Karadag, R. (2019). How competitive action mediates the resources slack-performance relationship: A meta-analytic approach. *Journal of Management Studies*, 56, 34.

Carpenter, R. E., & Petersen, B. C. (2002). CAPTIAL MARKET IMPERFECTIONS, HIGH-TECH INVESTMENT, AND NEW EQUITY FINANCING. *The Economic Journal*, 112(February), 19.

Chadee, D., Roxas, B., & Kouznetsov, A. (2021). Corruption, Bribery and Innovation in CEE: Where is the link? *Journal of Business Ethics*, 174(2021), 17.

Chan, L. K. C., Lakonishok, J., &Sougiannis, T. (2001). The stock market valuation of research and development expenditures. *The Journal of Finance*, LVI(6), 26.

Chan, S. H., Martin, J. D., & Kensinger, J. W. (1990). Corporate research and development expenditures and share value. *Journal of Financial Economics*, 26(2), 255-276. https://doi.org/https://doi.org/10.1016/0304-405X(90)90005-K

Chang, C.-H., Chang, C.-H., Hsu, P.-K., & Yang, S.-Y. (2018). The catalytic effect of internationalization on innovation. *European Financial Management*, 25(4), 36.

Chang, C.-H., & Wu, Q. (2021). Board Networks and Corporate Innovation. *MANAGEMENT SCIENCE*, 67(6), 37.

Chang, S.-J., Chung, C.-N., & Mahmood, I. P. (2006). When and how does business group affiliation promote firm innovation? A tale of two emerging economies. *Organization Science*, 17(5), 637-656.

Chang, S. J., & Hong, J. (2000). Economic performance of group-affiliated companies in Korea: Intragroup resource sharing and internal business transactions. *Academy of Management journal*, 43(3), 429-448.

Chen, C., Lu, H. and Sougiannis, T., 2008. Managerial Empire Building. *Corporate Governance, and the Asymmetrical Behavior of Selling, General, and Administrative Costs. Working Paper, University of Illinois at Urbana-Champaign*.

Chen, C. X., Lu, H., &Sougiannis, T. (2012). The agency problem, Corporate governance, and the Asymmetrical behavior of Selling, General, and Administrative costs. *Contemporary Accounting Research*, 29(1), 31.

Chen, C. X., Nasev, J., & Wu, S. Y.-C. (2021). CFO Overconfidence and Cost Behavior. *Journal of Management Accounting Research*. https://doi.org/10.2308/jmar-18-055

Chen, J., Leung, W. S., & Evans, K. P. (2016). Are employee-friendly workplaces conducive to innovation? *Journal of Corporate Finance*, 40(2016), 19.

Chen, S., Wang, Y., & Zhao, Z. (2009). Regulatory incentives for earnings management through asset impairment reversals in China. *Journal of Accounting, Auditing & Finance*, 24(4), 32.

Chen, T., Harford, J. & Lin, C., 2015. Do analysts matter for governance? Evidence from natural experiments. *Journal of Financial Economics*, 115, 383-410. https://doi.org/10.1016/j.jfineco.2014.10.002

Chen, V. Z., Li, J., Shapiro, D. M. & Zhang, X., 2014. Ownership structure and innovation: An emerging market perspective. *Asia Pacific Journal of Management,* 31**,** 1-24. 10.1007/s10490-013-9357-5

Chen, X., Jiang, X., Lu, L. Y., & Yu, Y. (2021). Local political corruption and Firm's non-GAAP reporting. Journal of Corporate Finance, 70(2021), 102071

Chen, Y.-F., Lin, F.-L., & Yang, S.-Y. (2015). Does institutional short-termism matter with managerial myopia? *Journal of Business Research*, 68(2015), 6.

Chen, Y., Che, L., Zheng, D., & You, H. (2020). Corruption culture and accounting quality. *J. Account.*

Public Policy, 39(2020), 22.

Chen, Y., Podolski, E. J., & Veeraraghavan, M. (2015). Does managerial ability facilitate corporate innovative success? *Journal of Empirical Finance*, 34, 313-326. https://doi.org/https://doi.org/10.1016/j.jempfin.2015.08.002

Cheng, S., 2008. Board size and the variability of corporate performance. *Journal of Financial Economics,* 87**,** 157-176. https://doi.org/10.1016/j.jfineco.2006.10.006

Cheng, S., Jiang, W., & Zeng, Y. (2018). Does access to capital affect cost stickiness? Evidence from China. *Asia-Pacific Journal of Accounting & Economics*, 25(1-2), 177-198. https://doi.org/10.1080/16081625.2016.1253483

Cheung, Y., Rau, P. R., & Stouraitis, A. (2006). Tunneling, propping, and expropriation: evidence from connected party transactions in Hong Kong. *Journal of Financial Economics*, 82(2006), 343-386.

ChinaPowerProject. (2022). Is China a Global Leader in Research and Development? Retrieved 16th August from https://chinapower.csis.org/china-research-and-development-rnd/

ChinaStatisticsPress. (2020). CHINA STATISTICAL YEARBOOK 2020. Retrieved 15th August from http://www.stats.gov.cn/tjsj/ndsj/2020/indexeh.htm

Cho, C., Halford, J. T., Hsu, S., & Ng, L. (2016). Do managers matter for corporate innovation? *Journal of Corporate Finance*, 36(2016), 24.

Choi, I. (2001). Unit root tests for panel data. Journal of International Money and Finance, 20, 249-272.

Choi, S. B., Lee, S. H., & Williams, C. (2011). Ownership and firm innovation in a transition economy: Evidence from China. *Research Policy*, 40(2011), 12.

Christensen, T. E., Huffman, A., Lewis-Western, M. F., & Scott, R. (2021). Accrual earnings management proxies: Prudent business decisions or earnings manipulation? *Journal of Business Finance & Accounting*, 2022(49), 536-587.

Claessens, S., &Djankov, S. (1999). Ownership concentration and corporate performance in the Czech Republic. *Journal of comparative economics*, 27(3), 498-513.

Coad, A. (2019). Persistent heterogeneity of R&D intensities within sectors: Evidence and policy implications. *Research Policy*, 48(1), 37-50. https://doi.org/https://doi.org/10.1016/j.respol.2018.07.018

Cohen, D. A., Dey, A., & Lys, T. Z. (2008). Real and Accrual-Based Earnings Management in the Pre- and Post-Sarbanes-Oxley Periods. *The Accounting Review*, 83(3), 757-787.

Cohen, D. A., &Zarowin, P. (2010). Accrual-based and real earnings management activities around seasoned equity offerings. *Journal of Accounting and Economics*, 50(2010), 18.

Cohen, D., Pandit, S., Wasley, C. E., & Zach, T. (2020). Measuring real activity management. *Contemporary Accounting Research*, 37, 1172-1198.

Commerford, B. P., Hermanson, D. R., Houston, R. W., & Peters, M. F. (2019). Auditor sensitivity to real earnings management: The importance of ambiguity and earnings context. *Contemporary Accounting Research*, 36(2), 1055-1076.

Connelly, B. L., Hoskisson, R. E., Tihanyi, L. & Certo, S. T., 2010. Ownership as a Form of Corporate Governance. *Journal of Management Studies,* 47**,** 1561-1589. https://doi.org/10.1111/j.1467-6486.2010.00929.x

Cook, D. O., Kieschnick, R., & Moussawi, R. (2019). Operating leases, operating leverage, operational inflexibility and sticky costs. *Finance Research Letters*, 31(2019), 5.

Cooper, J. C., &Selto, F. H. (1991). An experimental examination of the effects of SFAS No.2 on R&D investment decisions. *Accounting Organizations and Society*, 16(3), 16.

Cooper, R.W. and Haltiwanger, J.C., 2006. On the nature of capital adjustment costs. *The Review of Economic Studies*, *73*(3), pp.611-633.

Cornaggia, K. J., Krishnan, G. V., & Wang, C. (2017). Managerial ability and Credit ratings. *Contemporary Accounting Research*, 34(4), 29.

Correa, J. A., & Ornaghi, C. (2014). Competition & Innovation: Evidence from U.S. patent and productivity data. *The Journal of Industrial Economics*, LXII(29), 258.

Costa, M. D., & Habib, A. (2021). Trade credit and cost stickiness. *Accounting & Finance*, 61(2021), 41.

Cui, H., Chen, C., Zhang, Y. & Zhu, X., (2019). Managerial ability and stock price crash risk. Asia-Pacific *Journal of Accounting & Economics*, 26, 532-554. 10.1080/16081625.2019.1636662

Curi, G., & Lozano-Vivas, A. (2020). Managerial ability as a tool for prudential regulation. *Journal of Economic Behavior and Organization*, 174(2020), 87-107.

Czarnitzki, D., & Toole, A. A. (2007). Business R&D and the interplay of R&D subsidies and product market uncertainty. *Review of industrial organization*, 31(3), 13.

Dahya, J. & McConnell, J. J., 2005. Outside directors and corporate board decisions. *Journal of Corporate Finance*, 11, 37-60. https://doi.org/10.1016/j.jcorpfin.2003.10.001

Dai, Y., Kong, D. & Wang, L., 2013. Information asymmetry, mutual funds and earnings management: Evidence from China. China *Journal of Accounting Research*, 6, 187-209. https://doi.org/10.1016/j.cjar.2013.03.001

Dalziel, T., Gentry, R. J., & Bowerman, M. (2011). An Integrated Agency–Resource Dependence View of the Influence of Directors' Human and Relational Capital on Firms' R&D Spending. *Journal of Management Studies*, 48(6), 1217-1242. https://doi.org/https://doi.org/10.1111/j.1467-6486.2010.01003.x

Daradheh, H., Shams, S., Bose, S., & Gunasekarage, A. (2022). Does managerial ability matter for corporate climate change disclosures? *Corporate Governance-An International Review*, 31(2023), 83-104.

David, P., Hitt, M., & Gimeno, J. (2001). The role of institutional investors in influencing R&D. *Academy of Management journal*, 44(1), 144-157.

David, P., Yoshikawa, T., Chari, M. D. R., & Rasheed, A. A. (2006). Strategic investments in Japanese corporations: do foreign portfolio owners foster underinvestment or appropriate investment? *Strategic Management Journal*, 27(6), 591-600. https://doi.org/https://doi.org/10.1002/smj.523

Davis, J., Schoorman, D., & Donaldson, L. (1997). Toward a stewardship theory of management. *Emerald Management Reviews*, 22, 20-47.

Dechow, P. M., & Sloan, R. G. (1991). Executive incentives and the horizon problem. *Journal of Accounting and Economics*, 14(1991), 39.

DeFond, M. L., & Park, C. W. (1999). The effect of competition on CEO turnover. *Journal of Accounting and Economics*, 27(1999), 22.

De Franco, G., Hope, O.-K. & Lu, H., (2017). Managerial ability and bank-loan pricing. *Journal of Business Finance & Accounting*, 44, 1315-1337. https://doi.org/10.1111/jbfa.12267

Degeorge, F., Ding, Y., Jeanjean, T. &Stolowy, H., 2013. Analyst coverage, earnings management and financial development: An international study. *Journal of Accounting and Public Policy,* 32, 1-25. https://doi.org/10.1016/j.jaccpubpol.2012.10.003

Degeorge, F., Patel, J., & Zeckhauser, R. (1999). Earnings Management to Exceed Thresholds. *The Journal of Business*, 72(1), 35.

Del Guercio, D., & Hawkins, J. (1999). The motivation and impact of pension fund activism. *Journal of*

Financial Economics, 52(3), 293-340.
Demerjian, P. (2012). Quantifying Managerial Ability: A New Measure and Validity Tests. *MANAGEMENT SCIENCE*, 58(7), 19.
Demerjian, P., Lev, B., & McVay, S. (2012). Quantifying managerial ability: A new measure and validity tests. *MANAGEMENT SCIENCE*, 58(7), 21.
Demerjian, P., Lewis-Western, M., & McVay, S. (2020). How Does Intentional Earnings Smoothing Vary With Managerial Ability? *Journal of Accounting, Auditing & Finance*, 35(2), 406-437. https://doi.org/10.1177/0148558x17748405
Demerjian, P. R., Lev, B., Lewis, M. F., & McVay, S. E. (2013). Managerial Ability and Earnings Quality. *The Accounting Review*, 88(2), 37.
Demsetz, H., & Lehn, K. (1985). The structure of corporate ownership: Causes and consequences. *Journal of political economy*, 93(6), 1155-1177.
Ding, X., Guo, M., Kuai, Y. & Niu, G., 2023. Social trust and firm innovation: Evidence from China. *International Review of Economics & Finance,* 84**,** 474-493. https://doi.org/10.1016/j.iref.2022.12.007
DIERYNCK, B., LANDSMAN, W. R. & RENDERS, A. 2012. Do managerial incentives drive cost behaviour? Evidence about the role of the zero earnings benchmark for labor cost behaviour in private Belgian firms. *The Accounting Review*, 84, 1219.
Dong, N., Wang, F., Zhang, J. & Zhou, J., 2020. Ownership structure and real earnings management: Evidence from China. *Journal of Accounting and Public Policy,* 39, 106733. https://doi.org/10.1016/j.jaccpubpol.2020.106733
Dosi, G., & Marengo, L. (2007). Perspective—on the evolutionary and behavioral theories of organizations: a tentative roadmap. *Organization Science*, 18(3), 491-502.
Driouchi, T., Chen, M., Lyu, Z., Bennett, D. J., & So, Raymond, H. Y. (2022). Ambiguity, Managerial ability, and Growth options. *British Journal of Management*, 33(2022), 1323-1345.
DYCK, A., MORSE, A. & ZINGALES, L., 2010. Who Blows the Whistle on Corporate Fraud? *The Journal of Finance*, 65, 2213-2253. https://doi.org/10.1111/j.1540-6261.2010.01614.x
Easterbrook, F.H. (1984). Two agency-cost explanations of dividend. *American Economic Review*, 74(4), 650-659.
Eberhart, A. C., Maxwell, W. F., & Siddique, A. R. (2004). An Examination of Long-Term Abnormal Stock Returns and Operating Performance Following R&D Increases. *The Journal of Finance*, 59(2), 623-650. https://doi.org/https://doi.org/10.1111/j.1540-6261.2004.00644.x
Eisfeldt, A. L., & Kuhnen, C. M. (2013). CEO turnover in a competitive assignment framework. *Journal of Financial Economics*, 109(2013), 22.
Eng, L. L., & Shackell, M. (2001). The implications of long-term performance plans and institutional ownership for firms' research and development (R&D) investments. *Journal of Accounting, Auditing & Finance*, 16(2), 117-139.
Ettredge, M., Scholz, S., Smith, K., & Sun, L. (2010). How do restatements begin? Evidence of earnings management preceding restated financial reports. *Journal of Business Finance and Accounting*, 37(3-4), 332-355.
Faccio, M., Marchica, M.-T., & Mura, R. (2011). Large Shareholder Diversification and Corporate Risk-Taking. *The Review of Financial Studies*, 24(11), 42.
Fama, E. F., & Jensen, M. C. (1983). Separation of Ownership and Control. *The Journal of Law & Economics*, 26(2), 26.
Fang, V. W., Tian, X., & Tice, S. (2014). Does Stock Liquidity Enhance or Impede Firm Innovation? *The*

Journal of Finance, LXIX(5), 42.

Feng, S., & Ho, C.-Y. (2016). The real option approach to adoption or discontinuation of a management accounting innovation: the case of activity-based costing. *Review of Quantitative Finance and Accounting*, 47(3), 835-856.

Eisfeldt, A. L., & Kuhnen, C. M. (2013). CEO turnover in a competitive assignment framework. *Journal of Financial Economics*, 109(2013), 22.

Fishman, A., & Rob, R. (1999). The size of firms and R&D investment. *International Economic Review*, 40(4), 17.

Fluck, Z., 1998. Optimal financial contracts: debt versus outside equity. *Review of Financial Studies*, 11, 383-418.

Fluck Z., 1999. The dynamics of the management-shareholder conflict. *Review of Financial Studies*, 11, 347-377.

Francis, B. B., Kim, I., Wang, B., & Zhang, Z. (2018). Labor low and innovation revisited. *Journal of Banking & Finance*, 94(2018), 15.

Francis, B., Hasan, I., & Li, L. (2016). A cross-country study of legal-system strength and real earnings management. *Journal of Accounting and Public Policy*, 35(2016), 477-512.

Francis, J., Huang, A. H., Rajgopal, S., & Zang, A. Y. (2008). CEO Reputation and Earnings Quality. *Contemporary Accounting Research*, 25(38), 109.

Francis, J., & Smith, A. (1995). Agency costs and innovation Some empirical evidence. *Journal of Accounting and Economics*, 19(1995), 27.

Fu, R., Kraft, A., Tian, X., Zhang, H., & Zuo, L. (2020). Financial Reporting Frequency and Corporate Innovation. *Journal of Law and Economics*, 63(August 2020), 30.

Fu, X., & Mu, R. (2014). Enhancing China's Innovation Performance: The Policy Choices. *China & World Economy*, 22(2), 19.

Galasso, A., & Simcoe, T. S. (2011). CEO Overconfidence and Innovation. *MANAGEMENT SCIENCE*, 57(8), 16.

Gan, H. (2019). Does CEO managerial ability matter? Evidence from corporate investment efficiency. *Review of Quantitative Finance and Accounting*, 52(4), 1085-1118. https://doi.org/10.1007/s11156-018-0737-2

Gao, H., Hsu, P.-H., & Li, K. (2018). Innovation Strategy of Private Firms. *Journal of Financial and Quantitative analysis*, 53(1), 32.

Garcia-Meca, E., & Garcia-Sanchez, I. (2018). Does managerial ability influence the quality of financial reporting? *European Management Journal*, 36(2018), 544-557.

Geroski, P., Machin, S., & Reenen, J. V. (1993). The profitability of innovating firms. RAND *Journal of Economics*, 24(2), 14.

Gillan, S. L., & Starks, L. T. (2000). Corporate governance proposals and shareholder activism: The role of institutional investors. *Journal of Financial Economics*, 57(2), 275-305.

Gong, M., Wang, Y. & Yang, X., 2021. Do independent directors restrain controlling shareholders' tunneling? Evidence from a natural experiment in China. *Economic Modelling*, 94, 548-559. https://doi.org/10.1016/j.econmod.2020.01.023

Gordon, E. A., Hsu, H.-T., & Huang, H. (2020). Peer R&D disclosure and corporate innovation: Evidence from American depositary receipt firms. *Advances in Accounting*, 49(2020), 13.

Gorodnichenko, Y., Svejnar, J., & Terrell, K. (2010). Globalization and innovation in emerging markets. *American economic journal. Macroeconomics*, 2(2), 35.

Goux, D., Maurin, E. and Pauchet, M., 2001. Fixed-term contracts and the dynamics of labour demand. *European Economic Review*, *45*(3), pp.533-552.

Graham, J. R., Harvey, C. R. &Rajgopal, S., 2005. The economic implications of corporate financial reporting. *Journal of Accounting and Economics*, 40, 3-73. https://doi.org/10.1016/j.jacceco.2005.01.002

Graham, J. R., Harvey, C. R., & Puri, M. (2013). Managerial attitudes and corporate actions. *Journal of Financial Economics*, 109(2013), 19.

Greenwald, B. C., & Stiglitz, J. E. (1990). Asymmetric Information and the New Theory of the Firm: Financial Constraints and Risk Behavior. *The American Economic Review*, 80(2), 160-165. http://www.jstor.org/stable/2006562

Grossman, S. J., & Hart, O. D. (1980). Takeover Bids, The Free-Rider Problem, and the Theory of the Corporation. *The Bell Journal of Economics*, 11(1), 42-64. https://doi.org/10.2307/3003400

Groysberg, B., McLean, A. N., & Nohria, N. (2006). Is management talent portable? *Harvard Business Review*, May(2006), 10.

Guenther, T. W., Riehl, A., & Rößler, R. (2014). Cost stickiness: state of the art of research and implications. *Journal of Management Control*, 24(4), 301-318.

Gul, F. A., Khedmati, M., Lim, E. K., &Navissi, F. (2018). Managerial Ability, Financial Distress, and Audit Fees. *Accounting Horizons*, 32(1), 24.

Gul, F. A., Kim, J.-B., & Qiu, A. A. (2010). Ownership concentration, foreign shareholding, audit quality, and stock price synchronicity: Evidence from China. *Journal of Financial Economics*, 95(2010), 18.

Gunny, K. A. (2010). The relation between earnings management using real activities manipulation and future performance: Evidence from meeting earnings benchmarks. *Contemporary Accounting Research*, 27(3), 34.

Hadlock, C. J. & Pierce, J. R., (2010). New Evidence on Measuring Financial Constraints: Moving Beyond the KZ Index. *The Review of Financial Studies*, 23, 1909-1940.

Haider, I., Singh, H., & Sultana, N. (2021). Managerial ability and accounting conservatism. *Journal of Contemporary Accounting and Economics*, 17(2021), 20.

Hall, B. H. (1993). The stock market's valuation of R&D investment during the 1980's. *The American Economic Review*, 83(2), 259-264.

Hall, B. H. (2002). The financing of research and development. *Oxford review of economic policy*, 18(1), 35.

Hall, B. H., & Hayashi, F. (1989). Research and Development as an Investment. In: National Bureau of Economic Research Cambridge, Mass., USA.

Hambrick, D. C. (2007). Upper echelons theory: An update. *Academy of Management Review*, 32(2), 11.

Hambrick, D. C., & Mason, P. A. (1984). Upper Echelons: The organization as a reflection of its top managers. *Academy of Management Review*, 9(2), 14.

Handfield-Jones, H., Michaels, E., & Axelrod, B. (1999). The War for Talent. Harvard Business School Press.

Harhoff, D. (1998). Are there financing constraints for R&D and investment in German manufacturing firms? *ANNALES DECONOMIE ET DE STATISTIQUE*, 49-50(49/50), 37.

Harris, M. & Raviv, A., 2008. A Theory of Board Control and Size. *The Review of Financial Studies*, 21, 1797-1832.

Hasan, I., Hoi, C.-K. S., Wu, Q., & Zhang, H. (2020). Is social capital associated with corporate innovation? Evidence from publicly listed firms in the U.S. *Journal of Corporate Finance*, 62(2020), 27.

Hashmi, A. R. (2013). Competition and innovation: The inverted-U relationship revisited. *The Review of Economics and Statistics*, 95(5), 17.

Haushalter, D., Klasa, S., & Maxwell, W. F. (2007). The influence of product market dynamics on a firm's cash holdings and hedging behavior. *Journal of Financial Economics*, 84(2007), 29.

He, J., & He, L. (2022). Saving or spending? Military CEOs and cost stickiness. *Asia-Pacific Journal of Accounting & Economics*, 2022(09), 20.

He, J., & Tian, X. (2018). Finance and Corporate Innovation: A Survey. *Asia-Pacific Journal of Financial Studies*, 2018(47), 165.

Healy, P. M., & Wahlen, J. M. (1999). A review of the earnings management literature and its implications for standard setting. *Accounting Horizons*, 3, 365-383.

Heider, F., & Ljungqvist, A. (2015). As certain as debt and taxes: Estimating the tax sensitivity of leverage from state tax changes. *Journal of Financial Economics*, 118(2015), 29.

Helfat, C. E., &Peteraf, M. A. (2003). The dynamic resource‐based view: Capability lifecycles. *Strategic Management Journal*, 24(10), 997-1010.

Hess, M. F., & Hess, A. M. (2020). The Consequences of Accounting Failure for Innovation: A Multi-Level Analysis. *Accounting Horizons*, 34(2), 17.

Hill, C. W. L., & Snell, S. A. (1988). External control, corporate strategy, and firm performance in research-intensive industries. *Strategic Management Journal*, 9(1988), 14.

Himmelberg, C. P., & Petersen, B. C. (1994). R&D and internal finance: A panel study of small firms in high-tech industries. *The Review of Economics and Statistics*, 76(1), 15.

Hoberg, G., Phillips, G., &Prabhala, N. (2014). Product market threats, Payouts, and Financial flexibility. *The Journal of Finance*, LXIX(1), 33.

Holcomb, T. R., Holmes Jr, R. M., & Connelly, B. L. (2009). Making the most of what you have: Managerial ability as a source of resource value creation. *Strategic Management Journal*, 30(5), 457-485.

Holmstrom, B. (1982). Moral Hazard in Teams. *The Bell Journal of Economics*, 13(2), 18.

Holmstrom, B. (1989). AGENCY COSTS AND INNOVATION. *Journal of Economic Behavior and Organization*, 12(1989), 23.

Holzhacker, M., Krishnan, R., & Mahlendorf, M. D. (2015). The Impact of Changes in Regulation on Cost Behavior. *Contemporary Accounting Research*, 32(2), 534-566. https://doi.org/https://doi.org/10.1111/1911-3846.12082

Hope, O.-K., & Thomas, W. B. (2008). Managerial Empire Building and Firm Disclosure. *Journal of Accounting Research*, 46(3), 36.

Hoskisson, R. E., Hitt, M. A., Johnson, R. A. & Grossman, W., 2002. Conflicting voices: The effects of institutional ownership heterogeneity and internal governance on corporate innovation strategies. *Academy of Management journal,* 45**,** 697-716.

Hribar, P., & Jenkins, N. T. (2004). The Effect of Accounting Restatements on Earnings Revisions and the Estimated Cost of Capital. *Review Accounting Studies*, 9(2004), 20.

Hsu, C., Wang, R., Whipple, B. C. (2022). Non-GAAP earnings and stock price crash risk. Journal of Accounting and Economics, 73(2022), 101473

Hsu, P.-H., Tian, X., & Xu, Y. (2014). Financial development and innovation: Cross-country evidence. *Journal of Financial Economics*, 112(2014), 20.

Huang, H. J., Habib, A., Sun, S. L., Liu, Y., & Guo, H. (2021). Financial reporting and corporate innovation: a review of the international literature. *Accounting & Finance*, 61(2021), 61.

Huang, X., & Sun, L. (2017). Managerial ability and real earnings management. *Advances in Accounting*, 39, 91-104. https://doi.org/https://doi.org/10.1016/j.adiac.2017.08.003

Huang, Y. S. & Wang, C.-J., 2015. Corporate governance and risk-taking of Chinese firms: The role of board size. *International Review of Economics & Finance*, 37, 96-113. https://doi.org/10.1016/j.iref.2014.11.016

Ibrahim, A. E. A. (2018). Board characteristics and asymmetric cost behavior: evidence from Egypt. *Accounting Research Journal*, 31(2), 301-322. https://doi.org/10.1108/ARJ-11-2015-0148

Ibrahim, A. E. A., Ali, H., &Aboelkheir, H. (2022). Cost stickiness: A systematic literature review of 27 years of research and a future research agenda. *Journal of International Accounting, Auditing and Taxation*, 46(2022), 1.

Iqbal, A., Rao, Z.-u.-R., Tauni, M. Z., &Jebarn, K. (2016). Modeling product market competition and reporting quality: the transitional economy of China. *Managerial Finance*, 43(2), 14.

Iqbal, A., Zhang, X., Tauni, M. Z., & Jebran, K. (2020). Principal-principal agency conflicts, product market competition and corporate payout policy in China. *Journal of Asia Business Studies*, 14(3), 16.

Irani, R. M. & Oesch, D., 2013. Monitoring and corporate disclosure: Evidence from a natural experiment. *Journal of Financial Economics*, 109, 398-418. https://doi.org/10.1016/j.jfineco.2013.02.021

Iturriage, F. J. L., & Lopez-Millan, E. J. (2016). Institutional framework corporate ownership structure, and R&D investment: an international analysis. *R&D MANAGEMENT*, 47(2017), 18.

Jagannathan, R., & Srinivasan, S. B. (1999). Does product market competition reduce agency costs? *North American Journal of Economics and Finance*, 10(1999), 13.

Jaramillo, F., Schiantarelli, F. and Sembenelli, A., 1993. Are adjustment costs for labor asymmetric? An econometric test on panel data for Italy. *The Review of Economics and Statistics*, pp.640-648

Jankensgård, H., & Vilhelmsson, A. (2018). The Shareholder Base Hypothesis of Stock Return Volatility: Empirical Evidence. *Financial Management*, *47*(1), 55–79. http://www.jstor.org/stable/45091092

Jensen, M. C. (1986). Agency Costs of Free Cash Flow, Corporate Finance, and Takeovers. *The American Economic Review*, 76(2), 8.

JENSEN, M. C., 1993. The Modern Industrial Revolution, Exit, and the Failure of Internal Control Systems. *The Journal of Finance*, 48, 831-880. https://doi.org/10.1111/j.1540-6261.1993.tb04022.x

Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: ManagerialBehavior, Agency Costs and Ownership Structure. *Journal of Financial Economics*, 3(1976), 56.

Jia, N. (2017). Should Directors Have Term Limits? - Evidence from Corporate Innovation. *European Accounting Review*, 26(4), 32.

Jia, N. (2019). The impact of accounting restatements on corporate innovation strategy. *J. Account. Public Policy*, 38(2019), 19.

Jiang, F., Ma, F., & Shi, B. (2017). Stock liquidity and dividend payouts. *Journal of Corporate Finance*, 42, 295-314.

Jiang, W., Yao, W., & Hu, Y. (2016). The enforcement of the Minimum Wage Policy in China and firm cost stickiness. *China Journal of Accounting Studies*, 4(3), 339-355. https://doi.org/10.1080/21697213.2016.1218631

Jiang, X., & Yuan, Q. (2018). Institutional investors' corporate site visits and corporate innovation. *Journal of Corporate Finance*, 48(2018), 21.

Jin, X., Xu, L., Xin, Y., & Adhikari, A. (2022). Political governance in China's state-owned enterprises. *China Journal of Accounting Research*, 15(2), 100236. https://doi.org/https://doi.org/10.1016/j.cjar.2022.100236

Jiraporn, P., Leelalai, V., & Tong, S. (2016). The effect of managerial ability on dividend policy: how do teaented managers view dividend payouts? *Applied Economics Letters*, 32(12), 857-862.

Johnson, S., Rafael, L. P., Florencio, L., & Andrei, S. (2000). Tunneling. *American Economic Review*, 90, 22-27.

Ju, X., Lu, D., & Yu, Y. (2013). Financing Constraints, Working Capital Management and the Persistence of Firm Innovation. *Economic Research*, 2013(01, 5-17.)

Kama, I., & Weiss, D. (2013). Do earnings targets and managerial incentives affect sticky costs? *Journal of Accounting Research*, 51(1), 24.

Kama, I., & Weiss, D. A. N. (2013). Do Earnings Targets and Managerial Incentives Affect Sticky Costs? *Journal of Accounting Research*, 51(1), 201-224. http://www.jstor.org.ezproxy.nottingham.edu.cn/stable/23473283

Kamien, M. I., & Schwartz, N. L. (1975). Market structure and Innovation: A survey. *Journal of Economic Literature*, 13(1), 38.

Kang, Y.-S., & Kim, B.-Y. (2012). Ownership structure and firm performance: Evidence from the Chinese corporate reform. *China Economic Review*, 23(2), 471-481. https://doi.org/https://doi.org/10.1016/j.chieco.2012.03.006

Kang, E., & Kim, R. (2021). Product market competition, reputation, and dividend policy. *Applied Economics*, 53(29), 14.

Kao, L., & Chen, A. (2013). How product market competition affects dividend payments in a weak investor protection economy: Evidence from Taiwan. *Pacific-Basin Finance Journal*, 25(2013), 19.

Kang, H. C., Anderson, R. M., Eom, K. S., & Kang, S. K. (2017). Controlling shareholders' value, long-run value and short-term performance. *Journal of Corporate Finance*, 43(2017), 340-353.

Ke, B. & Petroni, K., (2004). How Informed Are Actively Trading Institutional Investors? Evidence from Their Trading Behavior before a Break in a String of Consecutive Earnings Increases. *Journal of Accounting Research*, 42, 895-927.

Khanna, T., & Krishna, P. (1997). Why focused strategies may be wrong for emerging markets. *Harvard Business Review*, July-August, 41-51.

Khanna, T., & Krishna, P. (2000). Is group affiliation profitable in emerging markets: An analysis of diversified Indian business groups. *Journal of Finance*, 55, 867-891.

Kharpal, A. (2021). China to boost research and development spend in push for tech breakthroughs. Retrieved 5th August from https://www.cnbc.com/2021/03/05/china-to-boost-research-and-development-spend-in-push-for-tech-breakthroughs.html

Kim, H., Kim, H., & Lee, P. M. (2008). Ownership structure and the relationship between financial slack and R&D investments: Evidence from Korean Firms. *Organization Science*, 19(3), 16.

Kim, H., & Park, S.-Y. (2012). The relation between cash holdings and R&D expenditures according to ownership structure. *Eurasian Business Review*, 2(2), 18.

Klein, A., (2002). Economic Determinants of Audit Committee Independence. *The Accounting Review*, 77, 435-452.

Koh, P.-S., (2007). Institutional investor type, earnings management and benchmark beaters. *Journal of Accounting and Public Policy*, 26, 267-299. https://doi.org/10.1016/j.jaccpubpol.2006.10.001

Kothari, S., Laguerre, T. E., & Leone, A. J. (2002). Capitalization versus expensing: Evidence on the uncertainty of future earnings from capital expenditures versus R&D outlays. *Review of accounting Studies*, 7(4), 355-382.

Kothari, S., Shu, S. & Wysocki, P., (2006). DoManagersWithholdBadNews? *JournalofAccountingResearch*.

Kubota, K., & Takehara, H. (2019). Firm-level innovation by Japanese family firms: Empirical analysis using multidimensional innovation-measures. *Pacific-Basin Finance Journal*, 57(2019), 11.

Kummar, S., &Zbib, L. (2022). Firm performance during the Covid-19 crisis: Does managerial ability matter? *Finance Research Letters*, 47(2022), 102720.

Lacetera, N., 2001. Corporate Governance and the Governance of Innovation: The Case of Pharmaceutical Industry. *Journal of Management and Governance,* 5**,** 29-59. 10.1023/A:1017907119114

Lach, S. (2002). Do R&D subsidies stimulate or displace private R&D? Evidence from Israel. *The Journal of Industrial Economics*, L(4), 22.

Lamont, O., C. Polk, and J. Saa-Requejo (2001). Financial constraints and stock returns, *Review of Financial Studies*, 14, pp. 529-554

Larcker, D. F., Richardson, S. A., & Tuna, I. (2007). Corporate Governance, Accounting Outcomes, and Organizational Performance. *The Accounting Review*, 82(4), 963-1008.

Larrain, B., & Urzua I. F. (2013). Controlling shareholders and market timing in share issuance. *Journal of Financial Economics*, 109(2013), 661-681.

Le, D. V., Le, H. T. T., & Vo, L. V. (2021). The bright side of product market threats: The case of innovation. *International Review of Economics and Finance*, 71(2021), 16.

Lee, J. H., Byun, H. S., & Park, K. S. (2018). Product market competition and corporate social responsibility activities: Perspectives from an emerging economy. *Pacific-Basin Finance Journal*, 49(2018), 21.

Lee, K.-J., Shyu, D. S., & Dai, M.-L. (2009). The valuation of information technology investments by real options analysis. *Review of Pacific Basin Financial Markets and Policies*, 12(04), 611-628.

Lee, P. M., & O'Neill, H. M. (2003). Ownership structures and R&D investments of U.S. and Japanese firms: Agency and stewardship perspectives. *Academy of Management Journal*, 46(2), 14.

Lee, S. (2012). Financial determinants of corporate R&D investment in Korea. *Asian Economic Journal*, 26(2), 18.

Lee, S. (2021). Does corporate ownership matter for innovation? *Journal of the Asia Pacific Economy*, 95, 17.

Lee, W.-J., Pittman, J., & Saffar, W. (2020). Political Uncertainty and Cost Stickiness: Evidence from National Elections around the World. *Contemporary Accounting Research*, 37(2), 1107-1139. https://doi.org/https://doi.org/10.1111/1911-3846.12547

Lev, B., & Thiagarajan, S. R. (1993). Fundamental Information Analysis. *Journal of Accounting Research*, 31(2), 27.

Li, J., & Luo, Z. (2021). Product market competition and cost stickiness: Evidence from China. *Manage Decis Econ*, 42(2021), 14.

Li, P., Shu, W., Tang, Q., & Zheng, Y. (2017). Internal control and corporate innovation: evidence from China. Asia-Pacific *Journal of Accounting & Economics*, 26, 22.

Li, Q., Ma, M., & Shevlin, T. (2021). The effect of tax avoidance crackdown on corporate innovation. *Journal of Accounting and Economics*, 71(2021), 26.

Li, S., Quan, Y., Tian, G. G., Wang, K. T., & Wu, S. H. (2022). Academy fellow independent directors and innovation. *Asia Pacific Journal of Management*, 39(2022), 46.

Li, T., & Sun, X. (2023). Is controlling shareholders' credit risk contagious to firms?-Evidence from China. *Pacific-Basin Finance Journal*, 77(203), 1-20.

Li, W.-l., & Zheng, K. (2017). Product market competition and cost stickiness. *Review of Quantitative Finance and Accounting*, 49(2), 283-313. https://doi.org/http://dx.doi.org/10.1007/s11156-016-0591-z

Li, W., Zhou, J., Yan, Z., & Zhang, H. (2020). Controlling shareholder share pledging and firm cash dividends. *Emerging Markets Review*, 42(2020), 1-25.

Li, Z., Li, X., & Xie, A. (2020). Independent technical directors and their effect on corporate innovation in China. *China Journal of Accounting Research*, XXX(2020), 25.

Li, Z., Ying, Q., Chen, Y., & Zhang, X. (2020). Managerial risk appetite and asymmetry cost behavior: evidence from China. *Accounting & Finance*, 60(5), 4651-4692. https://doi.org/https://doi.org/10.1111/acfi.12692

Liang, S., Chen, D., & Hu, X. (2014). External auditor types and the cost stickiness of listed companies. *China Journal of Accounting Studies*, 2(4), 294-322. https://doi.org/10.1080/21697213.2014.982004

Liang Tang, Yiyang Huang, Jiali Liu &Xiangyu Wan (2022) Cost Stickiness and Stock Price Crash Risk: Evidence from China, Emerging Markets Finance and Trade, 58:2, 544-569, . https://doi.org/10.1080/1540496X.2020.1787148

Lin, C., Liu, S., & Manso, G. (2021). Shareholder litigation and corporate innovation. *MANAGEMENT SCIENCE*, 67(6), 21.

Lin, J. Y., & Tan, G. (1999). Policy Burdens, Accountability, and the Soft Budget Constraint. *The American Economic Review*, 89(2), 7.

Lipton, M. & Lorsch, J. W., (1992). A Modest Proposal for Improved Corporate Governance. *The Business Lawyer*, 48, 59-77.

Liu, C., Uchida, K., & Yang, Y. (2014). Controlling shareholder, split-share structure reform and cash dividend payments in China. *International Review of Economics and Finance*, 29(2014), 339-357.

Liu, D., Li, Z., He, H. & Hou, W., (2021). The determinants of R&D smoothing with asset sales: Evidence from R&D-intensive firms in China. *International Review of Economics & Finance*, 75, 76-93. https://doi.org/10.1016/j.iref.2021.03.013

Liu, Q. & Lu, Z., (2007). Corporate governance and earnings management in the Chinese listed companies: A tunneling perspective. *Journal of Corporate Finance*, 13, 881-906. https://doi.org/10.1016/j.jcorpfin.2007.07.003

Liu, X., Liu, X. & Reid, C. D., (2019). Stakeholder Orientations and Cost Management. *Contemporary Accounting Research*, 36, 486-512. https://doi.org/10.1111/1911-3846.12389

Lo, A. W. Y., Wong, R. M. K. & Firth, M., (2010). Can corporate governance deter management from manipulating earnings? Evidence from related-party sales transactions in China. *Journal of Corporate Finance*, 16, 225-235. https://doi.org/10.1016/j.jcorpfin.2009.11.002

Lo, K., Ramos, F., & Rogo, R. (2017). Earnings management and annual report readability. *Journal of Accounting and Economics*, 63(2017), 1-25.

Lu, C.-W., Chen, T.-K. & Liao, H.-H., (2010). Information uncertainty, information asymmetry and corporate bond yield spreads. *Journal of Banking & Finance*, 34, 2265-2279. https://doi.org/10.1016/j.jbankfin.2010.02.013

Lyon, J. D., & Maher, M. W. (2005). The importance of business risk in setting audit fees: Evidence from cases of client misconduct. *Journal of Accounting Research*, 43(1), 19.

Madden, G., & Savage, S. J. (1999). Telecommunications productivity, catch-up and innovation. *Telecommunications Policy*, 23(1999), 17.

Magerakis, E. (2022). The importance of managerial discretion on managerial ability-firm cash holding nexus. *Managerial Decision*, 60(12), 3275-3303.

Mahmood, I. P., & Mitchell, W. (2004). Two faces: Effects of business groups on innovation in emerging economies. *Management Science*, 50(10), 1348-1365.

Mankiw, N. G. (2017) Principles of Economics, 8th edition. Cengage Learning.

MÁÑEZ, J. A., ROCHINA-BARRACHINA, M. E., SANCHIS, A., & SANCHIS, J. A. (2009). THE ROLE OF SUNK COSTS IN THE DECISION TO INVEST IN R&D*. *The Journal of Industrial Economics*, 57(4), 712-735. https://doi.org/https://doi.org/10.1111/j.1467-6451.2009.00398.x

Manso, G. (2011). Motivating innovation. *The Journal of Finance*, 66(5), 1823-1860.

Marcus, A. A., & Goodman, R. S. (1986). AIRLINE DEREGULATION FACTORS AFFECTING THE CHOICE OF FIRM POLITICAL STRATEGY. *Policy Studies Journal*, 15(2), 17.

Marques, P., Presas, P., & Simon, A. (2014). The heterogeneity of family firms in CSR engagement: The role of values. *Family Business Review*, 27(3), 22.

Martzoukos, S. H. (2001). Hysteresis models of investment with multiple uncertainties and exchange rate risk. *Review of Quantitative Finance and Accounting*, 16(3), 251-268.

Masulis, R. W., Wang, C., & Xie, F. (2007). Corporate Governance and Acquirer Return. *The Journal of Finance*, LXII(4), 39.

Mayer, C., (1997). Corporate Governance, Competition, and Performance. *Journal of Law and Society,* 24**,** 152-176.

Mazzi, F., Slack, R., Tsalavoutas, I., &Tsoligkas, F. (2019). Country-level corruption and accounting choice: Research & development capitalization under IFRS. *The British Accounting Review*, 51(2019), 25.

McDonald, R., & Siegel, D. (1986). The value of waiting to invest. *The quarterly journal of economics*, 101(4), 707-727.

McVay, S. E. (2006). Earnings Management Using Classification Shifting: An Examination of Core Earnings and Special Items. *The Accounting Review*, 81(3), 501-531.

Meng, X. H., Zeng, S. X., Xie, X. M., & Qi, G. Y. (2016). The impact of product market competition on corporate environmental responsibility. *Asia Pac J Manag*, 33(2016), 26.

Michaels, E., Handfield-Jones, H., & Axelrod, B. (2001). The war for talent. Harvard Business Press.

Minetti, R., Murro, P., &Paiella, M. (2015a). Ownership structure, governance, and innovation. *European Economic Review*, 80, 165-193. https://doi.org/https://doi.org/10.1016/j.euroecorev.2015.09.007

Minetti, R., Murro, P., &Paiella, M. (2015b). Ownership structure, governance, and innovation. *European Economic Review*, 80(2015), 29.

Mirrlees, J. A. (1999). The Theory of Moral Hazard and Unobservable Behaviour: Part I. *The Review of Economic Studies*, 66(1), 3-21. https://doi.org/10.1111/1467-937x.00075

Mukherjee, A., Singh, M., & Zaldokas, A. (2017). Do corporate taxes hinder innovation? *Journal of Financial Economics*, 124(2017), 27.

Munari, F., Oriani, R., & Sobrero, M. (2010). The effects of owner identity and external governance systems on R&D investments: A study of Western European firms. *Research Policy*, 39(2010), 12.

Mutlu, C. C., Van Essen, M., Peng, M. W., Saleh, S. F., & Duran, P. (2018). Corporate Governance in China: A Meta-Analysis. *Journal of Management Studies*, 55(6), 943-979. https://doi.org/https://doi.org/10.1111/joms.12331

Noreen, E. (1991). Conditions Under Which Activity-Based Cost Systems Provide Relevant Costs. *Journal of Management Accounting Research*, 3(4), 11.

O'Callaghan, S., Ashton, J. & Hodgkinson, L., (2018). Earnings management and managerial ownership in private firms. *Journal of Applied Accounting Research*, 19, 648-668. 10.1108/JAAR-11-2017-0124

OECD. (2015). OECD innovation strategy 2015: An agenda for policy action. OECD Publishing.

OECD. (2022). Main Science and Technology Indicators. Retrieved 15th August from https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB

Ogawa, K. (2007). Debt, R&D investment and technological progress: A panel study of Japanese manufacturing firms' behavior during the 1990s. *J. Japanese Int. Economies*, 21(2007), 21.

Opler, T. C., &Sokobin, J. S. (1995). Does coordinated institutional activism work? An analysis of the activities of the council of institutional investors.

Oranzlin, N., &Akhmetzhanov, R. (2019). Earnings management, audit quality, and cost of debt: evidence from a Central Asian economy. *Managerial Auditing Journal*, 34(6), 696-721.

Oriani, R., & Sobrero, M. (2008). Uncertainty and the market valuation of R&D within a real options logic. *Strategic Management Journal*, 29(4), 343-361.

Ortega-Argiles, R., Moreno, R., &Caralt, J. S. (2005). Ownership structure and innovation: is there a real link? *Annals of regional science*, 39(4), 27.

Oskouei, Z. H., &Sureshjani, Z. H. (2020). Studying the relationship between managerial ability and real earnings management in economic and financial crisis conditions. *International Journal of Finance & Economics*, 26(2021), 4574-4589.

Osma, B. G. (2008). Board independence and real earnings management: The case of R&D expenditure. *CORPORATE GOVERNANCE*, 16(2), 16.

Oswald, D. R., &Zarowin, P. (2007). Capitalization of R&D and the informativeness of stock prices. *The European accounting review*, 16(4), 39.

Pan, Y., Wang, T. Y. & Weisbach, M. S., (2015). Learning About CEO Ability and Stock Return Volatility. *The Review of Financial Studies*, 28, 1623-1666. 10.1093/rfs/hhv014

Pappas, K., Walsh, E., & Xu, A. L. (2019). Real earnings management and loan contract terms. *The British Accounting Review*, 51(2019), 373-401.

Peasnell, K. V., Pope, P. F. & Young, S., (2000). ACCRUAL MANAGEMENT TO MEET EARNINGS TARGETS: UK EVIDENCE PRE- AND POST-CADBURY. *The British Accounting Review*, 32, 415-445. https://doi.org/10.1006/bare.2000.0134

Petkevich, A. & Prevost, A., (2018). Managerial ability, information quality, and the design and pricing of corporate debt. *Review of Quantitative Finance and Accounting*, 51, 1033-1069. 10.1007/s11156-017-0696-z

Pfann, G.A. and Palm, F.C., (1993). Asymmetric adjustment costs in non-linear labour demand models for the Netherlands and UK manufacturing sectors. *The Review of Economic Studies*, *60*(2), pp.397-412.

Pfeffer, J., (1972). Size and Composition of Corporate Boards of Directors: The Organization and its Environment. *Administrative Science Quarterly*, 17, 218-228. 10.2307/239395

Pham, H.-y., Chung, R., Bao, B.-H., & Min, B.-S. (2021). Corporate payout policy: does product market competition matter? Evidence from Australia. International *Journal of Managerial Finance*, 17(2), 16.

Pindyck, R. S. (1986). Irreversible investment, capacity choice, and the value of the firm. In: National Bureau of Economic Research Cambridge, Mass., USA.

Poonawala, S. H., & Nagar, N. (2019). Gross profit manipulation through classification shifting. *Journal of Business Research*, 94, 81-88. https://doi.org/https://doi.org/10.1016/j.jbusres.2018.09.013

Porta, R. L., Lopez-de-Silanes, F., Shleifer, A., &Vishny, R. (1999). The quality of government. *Journal of Law, Economics, and Organization*, 15(1), 58.

Porter, W. L., (1992). Architecture and Culture: Lessons from the Past? *Journal of Architectural Education* (1984-), 46, 46-48. 10.2307/1425240

Pound, J., (1992). Beyond takeovers: politics comes to corporate control. *Harvard business review,* 70**,**

83-93.
Prabowo, R., Hooghiemstra, R., & Van Veen-Dirks, P. (2018). State Ownership, Socio-political Factors, and Labor Cost Stickiness. *European Accounting Review*, 27(4), 771-796. https://doi.org/10.1080/09638180.2017.1329659
Prowse, S. D., (1990). Institutional investment patterns and corporate financial behavior in the United States and Japan. *Journal of Financial Economics,* 27, 43-66. https://doi.org/10.1016/0304-405X(90)90020-Z
Qin, X., & Zhang, X. (2019). De-politicization and innovation: Evidence from China. *J. Account. Public Policy*, 38(2019), 22.
Rogers, W. 1993. Regression standard errors in clustered samples. State Technical Bulletin, 13, 19-23.
Rong, Z., Wu, X., & Boeing, P. (2017). The effect of institutional ownership on firm innovation: Evidence from Chinese listed firms. *Research Policy*, 46(9), 1533-1551. https://doi.org/https://doi.org/10.1016/j.respol.2017.05.013
Roychowdhury, S. (2006). Earnings management through real activities manipulation. *Journal of Accounting and Economics*, 42(2006), 36.
Ryan, H. E., & Wiggins, R. A. (2002). The interactions between R&D investment decisions compensation policy. *Financial Management*, 31(1), 25.
Schelleman, C., & Knechel, W. R. (2010). Short-term accruals and the pricing and production of audit services. *Auditing: A Journal of Practice & Theory*, 29(1), 221-250.
Schmidt, K. M. (1997). Managerial Incentives and Product market competition. *Review of Economic Studies*, 64(1997), 24.
Schumpeter, J. A. (1942). Capitalism, Socialism and Democracy. Harper.
Schuster, C. L., Nicolai, A. T., & Covin, J. G. (2018). Are Founder-Led Firms Less Susceptible to Managerial Myopia? *Entrepreneurship Theory and Practice*, 00(0), 31.
Seybert, N. (2010). R&D Capitalization and Reputation-Driven Real Earnings Management (Partially Retracted). *The Accounting Review*, 85(2), 671-693. https://doi.org/10.2308/accr.2010.85.2.671
Sharma, A. (1997). Professional as Agent: Knowledge Asymmetry in Agency Exchange. *Academy of Management Review*, 22(3), 758-798. https://doi.org/10.5465/amr.1997.9708210725
Shehzad, C. T., Haan, J. d., & Scholtens, B. (2010). The impact of bank ownership concentration on impaired loans and capital adequacy. *Journal of Banking & Finance*, 34(2010), 399-408.
Sheikh, S. (2012). Do CEO compensation incentives affect firm innovation? *Review of Accounting and Finance*, 11(1), 36.
Sheikh, S. (2018). Corporate social responsibility, product market competition, and firm value. *Journal of Economics and Business*, 98(2018), 19.
Shen, Y., Yang, X., & Zhu, B. (2021). Multiple large shareholders and controlling shareholders' related-party M&As. *Applied Economics Letters*, 30(3), 397-403.
Shi, C. (2003). On the trade-off between the future benefits and riskiness of R&D: a bondholders' perspective. *Journal of Accounting and Economics*, 35(2003), 28.
Shleifer, A., &Vishny, R. W. (1986). Large shareholders and corporate control. *Journal of political economy*, 94(3), 461-488.
Shleifer, A., &Vishny, R. W. (1997). A survey of corporate governance. *The Journal of Finance*, LII(2), 47.
Simamora, A. J. (2021). Crime rate, real earnings management and managerial ability. *Corporate Governance*, 22(2), 405-423.
Smith, M. P., (1996). Shareholder Activism by Institutional Investors: Evidence from CalPERS. *The*

Journal of Finance, 51**,** 227-252. https://doi.org/10.1111/j.1540-6261.1996.tb05208.x

Sohn, B. C. (2016). The effect of accounting comparability on the accrual-based and real earnings management. *Journal of Accounting and Public Policy*, 35, 513-539.

Sougiannis, T. (1994). The Accounting Based Valuation of Corporate R&D. *The Accounting Review*, 69(1), 44-68. http://www.jstor.org/stable/248260

Srivastava, A. (2019). Improving the measures of real earnings management. *Review of Accounting Studies*, 24, 1277-1316.

Stein, J. C. (1988). Takeover threats and managerial myopia. *Journal of Political Economy*, 96(1), 20.

Stulz, R. M. (1990). Managerial discretion and optimal financing policies. *Journal of Financial Economics*, 26(1990), 25.

Subramaniam, C., & Watson, M. W. (2016). Additional Evidence on the Sticky Behavior of Costs. In Advances in Management Accounting (Vol. 26, pp. 275-305). Emerald Group Publishing Limited. https://doi.org/10.1108/S1474-787120150000026006

Sun, E. Y. (2020). The differential role of R&D and SG&A for earnings management and stock price manipulation. *Contemporary Accounting Research*, 38(1), 34.

Sundaramurthy, C. & Lyon, D. W., 1998. Shareholder Governance Proposals And Conflict Of Interests Between Inside And Outside Shareholders.*Journal of Managerial Issues,* 10**,** 30-44.

Tang, L., Huang, Y., Liu, J., & Wan, X. (2020). Cost Stickiness and Stock Price Crash Risk: Evidence from China. *Emerging Markets Finance and Trade*, 1-26. https://doi.org/10.1080/1540496X.2020.1787148

Testoni, M. (2022). The market value spillovers of technological acquisitions: Evidence from patent-text analysis. *Strategic Management Journal*, 43(5), 964-985. https://doi.org/https://doi.org/10.1002/smj.3355

Tian, X. & Wang, T., 2014. Tolerance for failure and corporate innovation. *Review of Financial Studies,* 27**,** 211-255.

Tihanyi, L., Johnson, R. A., Hoskisson, R. E., & Hitt, M. A. (2003). Institutional ownership differences and international diversification: The effects of boards of directors and technological opportunity. *Academy of Management journal*, 46(2), 195-211.

Tribo, J. A., Berrone, P., &Surroca, J. (2007). Do the type and number of blockholders influence R&D investments? New evidence from Spain. *CORPORATE GOVERNANCE*, 15(5), 15.

Trueman, B. (1986). Why do managers voluntarily release earnings forecasts? *Journal of Accounting and Economics*, 8, 53-71.

Ughetto, E. (2008). Does internal finance matter for R&D? New evidence from a panel of Italian firms. *Cambridge Journal of Economics*, 32(2008), 19.

Ujah, N. U., Tarkom, A., & Okafor, C. E. (2021). Working capital management and managerial talent. *International journal of managerial finance*, 17(3), 455-477.

Vafeas, N., (2005). Audit Committees, Boards, and the Quality of Reported Earnings*. *Contemporary Accounting Research*, 22, 1093-1122. https://doi.org/10.1506/1QYN-2RFQ-FKYX-XP84

Ven, B. v. d., & Jeurissen, R. (2005). Competing Responsibly. *Business ethics quarterly*, 15(2), 19.

Venieris, G., Naoum, V. C., & Vlismas, O. (2015). Organisation capital and sticky behaviour of selling, general and administrative expenses. *Management Accounting Research*, 26(2015), 29.

Vito, J. D., Laurin, C., &Bozec, Y. (2010). R&D Activity in Canada: Does Corporate Ownership Structure Matter? *Canadian Journal of Administrative Sciences*, 27, 15.

Wang, D., Wu, Z., & Zhu, B. (2022). Controlling Shareholder Characteristics and Corporate Debt Default Risk: Evidence Based on Machine Learning. *Emerging Markets Finance and Trade*, 58(12), 3324-3339.

Wang, K., & Xiao, X. (2011). Controlling shareholders' tunneling and executive compensation: Evidence from China. *Journal of Accounting and Public Policy*, 30(2011), 89-100.

Wally, S., & Baum, J. R. (1994). Personal and structural determinants of the pace of strategic decision making. *Academy of Management Journal*, 37(4), 25.

Walters, B. A., Kroll, M. J., & Wright, P. (2007). CEO tenure, boards of directors, and acquisition performance. *Journal of Business Research*, 60(2007), 8.

Wan, L., Ou, J., & Lin, B. (2021). Does religion affect cost stickiness? Evidence from China. *Applied Economics*, 53(32), 3730-3743. https://doi.org/10.1080/00036846.2021.1885612

Wan, S.Y. and Wang, H.J., 2011. Managerial self-interest, board governance and cost stickiness. *Econ. Manage*, *5*, pp.26-32.

Wang, I. Y. (2007). Private Earnings Guidance and Its Implications for Disclosure Regulation. *The Accounting Review*, 82(5), 1299-1332.

Wang, Q., Qiu, M., & Tan, W. (2020). Does insiders share pledging stifle innovation? Evidence from China. *International Review of Economics and Finance*, 72(2020), 23.

Wang, Z., Chen, M.-H., Chin, C. L., & Zheng, Q. (2017). Managerial ability, political connections, and fraudulent financial reporting in China. *J. Account. Public Policy*, 36(2017), 22.

Weiss, D. (2010). Cost Behavior and Analysts' Earnings Forecasts. *The Accounting Review*, 85(4), 1441-1471.

Wen, H., & Xia, K. (2016). Venture capital, Ownership concentration and Enterprise R&D investment. *Information Technology and Quantitative Management*, 91(2016), 7.

Wernerfelt, B. (1984). A resource‐based view of the firm. Strategic *Management Journal*, 5(2), 171-180.

Xie, B., Davidson, W. N. & DaDalt, P. J., (2003). Earnings management and corporate governance: the role of the board and the audit committee. *Journal of Corporate Finance*, 9, 295-316. https://doi.org/10.1016/S0929-1199(02)00006-8

Xu, J. (2012). Profitability and capital structure: Evidence from import penetration. *Journal of Financial Economics*, 106(2012), 20.

Xu J., & Huang, H. (2021). Pay more or pay less? The impact of controlling shareholders' share pledging on firms' dividend payouts. *Pacific-Basin Finance Journal*, 65(2021), 1-20.

Xu, J., & Sim, J. W. (2017). Are costs really sticky and biased? Evidence from manufacturing listed companies in China. *Applied Economics*, 49(55), 14.

Xue, S., & Hong, Y. (2016). Earnings management, corporate governance and expense stickiness. *China Journal of Accounting Research*, 2016(9), 18.

Yafeh, Y., & Yosha, O. (2003). Large shareholders and banks: Who monitors and how? *The Economic Journal*, 113(January), 19.

Yang, C. Y., Lai, H. N. &Leing Tan, B., (2008). Managerial Ownership Structure and Earnings Management. *Journal of Financial Reporting and Accounting*, 6, 35-53. 10.1108/19852510880000634

Yang, Y. (2019). Do accruals earnings management constraints and intellectual capital efficiency trigger asymmetric cost behaviour? Evidence from Australia. *Australian Accounting Review*, 29(1), 16.

Young, M. N., Peng, M. W., Ahlstrom, D., Bruton, G. D., & Jiang, Y. (2008). Corporate Governance in Emerging Economies: A Review of the Principal–Principal Perspective. *Journal of Management Studies*, 45(1), 196-220. https://doi.org/https://doi.org/10.1111/j.1467-6486.2007.00752.x

Yu, F., (2008). Analyst coverage and earnings management. *Journal of Financial Economics*, 88, 245-271. https://doi.org/10.1016/j.jfineco.2007.05.008

Yuan, R., & Wen, W. (2018). Managerial foreign experience and corporate innovation. *Journal of*

Corporate Finance, 48(2018), 19.

Yung, K., & Chen, C. (2018). Managerial ability and firm risk-taking behavior. *Review of Quantitative Finance and Accounting*, 51(4), 1005-1032. https://doi.org/10.1007/s11156-017-0695-0

Yung, K., & Nguyen, T. (2020). Managerial ability, product market competition, and firm behavior. *International Review of Economics and Finance*, 70(2020), 15.

Zeng, T., & Lin, H. C. (2011). Ownership structure and R&D spending: evidence from China's listed firms. *Chinese Management Studies*, 5(1), 82-93. https://doi.org/10.1108/17506141111118471

Zeng, W., Li, L., & Huang, Y. (2021). Industrial collaborative agglomeration, marketization, and green innovation: Evidence from China's provincial panel data. *Journal of Cleaner Production*, 279(2021), 10.

Zhang, L., Li, J., & Wang, H. (2021). IPO over-funding and cost stickiness. *Asia-Pacific Journal of Accounting & Economics*, 28(4), 411-426. https://doi.org/10.1080/16081625.2019.1601024

Zhang, M., Gao, S., Guan, X., & Jiang, F. (2014). Controlling shareholder-Manager collusion and tunneling: Evidence from China. *Corporate Governance: An International Review*, 22(6), 440-459.

Zhang, W., (2015). R&D investment and distress risk. *Journal of Empirical Finance*, 32, 94-114. https://doi.org/10.1016/j.jempfin.2015.03.009

Zhang, X., Yu, M., & Chen, G. (2020). Does mixed-ownership reform improve SOEs' innovation? Evidence from state ownership. *China Economic Review*, 61(2020), 22.

Zheng, G., Wang, S., & Xu, Y. (2018). Monetary stimulation, bank relationship and innovation: Evidence from China. *Journal of Banking & Finance*, 89(2018), 12.

Zhong, R. (2018). Transparency and firm innovation. *Journal of Accounting and Economics*, 66(2018), 27.

Zhou, K. Z., Gao, G. Y., & Zhao, H. (2017). State Ownership and Firm Innovation in China: An Integrated View of Institutional and Efficiency Logics. *Administrative Science Quarterly*, 62(2), 31.

8 Appendix 1– Variable definition

$\Delta ln(R\&Dcosts_{it})$ (Anderson et al., 2003)	Log-change: R&D in year t	$ln(R\&D\ costs_{it}) - ln(R\&D\ costs_{it-1})$
$\Delta ln(IncomeR_{it})$ (Anderson et al., 2003)	Log-change: sales in year t	$ln(Sales_{it}) - ln(Sales_{it-1})$
D_{it} (Anderson et al., 2003)	Whether sales decreased	1 if sales decreased from year t–1 to year t, 0 otherwise.
D_twoyear (Anderson et al., 2003)	Successive Decrease	1 if sales decreased in both year t-1 and year t, and 0 otherwise.
Assets (Anderson et al., 2003)	Asset Intensity	$ln\left(\frac{Total\ Assets_{it}}{Sales_{it}}\right)$
FCF (Chen et al., 2012)	Free Cash Flow	(EBIAT + Depreciation and Amortization - Additional Working Capital - Capital Expenditure)/total assets
da (Chen et al., 2012); (I. Kama & D. Weiss, 2013)	Accrual Earnings Management	Discretionary accruals based on modified Jones model
REM (Chen et al., 2012); (I. Kama & D. Weiss, 2013)	Real Earnings Management	Real earnings management based on Roychowdhury (2006b)
MA (Demerjian et al., 2012)	Managerial Ability	Using DEA optimization approach
Com (Huang & Sun, 2017)	Lerner index	(Operating Revenue-Operating costs-Sales Costs-Admin Costs)/Operating Revenue
Com (Huang & Sun, 2017)	Herfindahl-Hirschman Index	The HHI equals the sum of an industry's squared market share (in %)
Lev (Yang, 2015)	Leverage	Total liabilities divided by total assets
Loss (Kama & Weiss, 2013)	Company's management wants to avoid loss and wants to avoid sales decrease	Dummy variable that equals 1 if "avoid loss=1" (0<ROA<1%) or "avoid earnings decrease=1" (0<change in annual earnings deflated by total assets at prior year end<1%), and 0 otherwise.
Concern (Chen et al. 2005)	Ownership Concentration	Top five ownership percentage of $firm_{i,t}$ to measure ownership concentration
Nature (Bu, Wen & Banker, 2015)	Ownership Structure	1 if the firm is controlled by state, otherwise 0
Instshareholding (Bushee, 1998)	Institutional Shareholding	Shares held by institutional investors over total shares