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# Accounting Information Quality, Financing Constraints, and Company Innovation Investment Efficiency by Big Data Analysis

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## ABSTRACT

This paper takes the listed companies in China from 2008 to 2017 as the research sample to study the relationship between accounting information quality (AIQ) and company innovation investment efficiency. The results show that AIQ is negatively correlated with both the underinvestment and overinvestment of corporate innovation. Further, AIQ can alleviate financing constraints and reduce the lack of innovation investment. At the same time, AIQ can also alleviate the agency conflict and reduce the excessive investment in innovation. Finally, AIQ can promote the innovation investment efficiency of companies with low information environment.

## KEYWORDS

Accounting Information Quality, Agency Conflicts, Financing Constraints, Information Environments, Innovation Investment Efficiency

## INTRODUCTION

The economic effect of accounting information quality (AIQ) is a classic theme in the accounting field. A large amount of the previous literature examines the impact of AIQ on corporate investment efficiency and reports that high-quality accounting information can promote corporate investment efficiency. Examples include work by Healy and Palepu (2001), Biddle and Hilary (2006), Biddle et al. (2009), Chen et al. (2011), Ramalingegowda et al. (2013), and Dou et al. (2019). However, there is little literature on the impact of AIQ on the efficiency of corporate innovation investment. Corporate innovation investment is a special type of investment. Compared with general physical capital investment, corporate innovation investment is characterized by a large investment amount, a long cycle, high risk, an uncertain cash flow, and other characteristics (Holmström, 1989), as well as natural confidentiality. Whether AIQ has an effect on the efficiency of corporate innovation investment needs further study.

This paper examines the relationship between AIQ and the efficiency of company investment in innovation. We study this problem mainly for the following reasons. First, the capital market is an important place for allocating company innovation resources as well as an important factor influencing company investment in innovation. The existing literature suggests that company innovation is a source of relative power helping to ensure a country's economic growth (Romer, 1990) as well as

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its competitive advantage (Solow, 1957). Innovation also serves as a driving force behind industrial transformation and modernization, which fuel core competitiveness to help maintain a company's sustainable and healthy development (Rosenberg, 2004). However, it has also been shown that innovation is difficult for companies to stimulate and cultivate (He et al., 2021; Hsu et al., 2014). The innovation process is not only time-consuming, specific, and unpredictable, but it is also prone to failure (Holmström, 1989). However, the uncertainty inherent to innovation activities, information asymmetry, large required amounts of investment, and other company characteristics can easily lead to a lack of innovation capital (Acharya & Xu, 2017), leaving industry experts and researchers unsure about how to better promote corporate innovation. Some scholars have found that capital markets play an important role in promoting innovation; they can boost the efficiency of firms' investments in innovation in four ways: (1) serve as a source of finance (Brown et al., 2012; Rajan, 2012), (2) evaluate and screen innovative investment projects (Hsu et al., 2014), (3) share risk (Levine, 2005), and (4) alleviate agency problems and motivate and supervise managers (Hall & Lerner, 2010). In this body of existing research, the capital market is an important unifying mechanism that affects corporate innovation. Second, information asymmetry exists in the capital market. Information asymmetry can and often will lead directly to the problems of adverse selection and moral hazards. Adverse selection increases financing costs, which ultimately imposes financing constraints on the company, which in turn result in company underinvestment in innovation. Moral hazards produce agency problems, affecting the selection of innovation projects, which leads to company overinvestment in innovation. Therefore, information asymmetry can cause investment in innovation to deviate from the optimal level, creating innovation investment inefficiency for the company. Accordingly, inefficient innovation investment is mainly divided into two forms: underinvestment and overinvestment in innovation, both of which result in a suboptimal level of innovation investment expenditure. Both scenarios negatively impact corporate innovation and create further disruptions in the capital market's ability to optimize the allocation of innovative resources. Therefore, information asymmetry in the capital market negatively affects the efficiency of company investment in innovation. Finally, high-quality accounting information can help alleviate information asymmetry in the capital market. Specifically, improved accounting information can alleviate information asymmetry between the company and external investors, reducing the company's financing constraints and investment shortages. It can also alleviate the information asymmetry between shareholders and managers, reducing agency costs and overinvestment (Chen et al., 2011; Houcine, 2017; Verdi, 2006).

The key concepts of this paper are company innovation investment efficiency and AIQ. Following the work of Verdi (2006), this study defines innovation investment efficiency as the condition when a company invests optimally in all innovation projects with a positive net present value, assuming no agency conflicts or financing constraints. If the company gives up an innovation investment project with a positive net present value, the company's innovation investment is, according to this definition, lower than the optimal innovation investment and therefore designated as an underinvestment in innovation. On the contrary, it designated as an overinvestment in innovation. We use an established model (Gunny, 2010) to estimate the best innovation investment and the residual term to represent the company's innovation investment efficiency. A residual error greater than zero indicates an overinvestment in innovation; otherwise, it is an underinvestment in innovation. The term 'accounting information quality' refers to the information listed on a listed company's financial report. This report contains the company's production and operation information, financial situation, cash flow, operating results, and other pertinent financial information (Biddle et al., 2009).Previous studies have measured AIQ using three main methods. The first method (Dechow et al., 1995) is an adopted and modified Jones model of performance adjustment. The second method (Kothari et al., 2005) uses the Jones model of performance adjustment to measure AIQ. The third method (Dechow & Dichev, 2002) uses the Dechow and Dichev model to measure AIQ. In order to prevent the errors of various models, this study uses the average value of various models to measure the quality of corporate accounting information.

This paper uses the big data analysis method to empirically test the relationship between AIQ and company innovation investment efficiency. The results show that AIQ is significantly negatively correlated with company underinvestment and overinvestment in innovation. Further, AIQ can alleviate financing constraints and reduce the lack of innovation investment. At the same time, it can also alleviate agency conflict and reduce excessive investment in innovation. Finally, AIQ can promote the innovation investment efficiency of companies with a low-information environment.

This study makes some innovative contributions to the field. First, it enriches the economic effect of AIQ literature. The economic effect of the AIQ is a classical subject in the accounting field. Extensive existing literature examines the influence of AIQ on stock prices and contracts (Ball & Brown, 1968; Beaver, 1968; Watts & Zimmerman, 1986), financing cost (Beyer et al., 2010; Healy & Palepu, 2001; Verrecchia, 2001), corporate governance (Bushman & Smith, 2001), investment efficiency (Biddle & Hilary, 2006; Biddle et al., 2009; Chen et al., 2011; Dou et al., 2019; Ramalingegowda et al., 2013), and company innovation (Simpson & Tamayo, 2020). However, unlike general corporate investment, corporate innovation investment is an important strategic investment activity and features inherent confidentiality information asymmetry. Therefore, further study should be done to determine whether AIQ affects the efficiency of corporate innovation investment. Focusing on the corporate innovation investment activities, this paper studies the internal mechanism of the influence of the AIQ on the efficiency of corporate innovation investment. As the study results show, in the process of corporate innovation investment, satisfactory accounting information can give full play to the function of governance, monitor managers to lower their ethical risk, minimize overinvestment in the corporate innovation investment, and improve the efficiency of corporate innovation investment. Apart from that, it can serve as a signal to reduce the innovation information risk faced by external investors, help corporation raise more funds for innovation, and increase the efficiency of corporate innovation investment. This conclusion not only expands the study of the economic consequences of the AIQ but also academically makes a breakthrough in the classic accounting study architecture. Second, the research on the influencing factors of innovation investment efficiency is extended. The efficiency of corporate innovation investment is an important issue in the field of corporate investment. The existing literature reveals that financing constraints (Saidani et al., 2017), agent costs (Francis & Smith, 1995), AIQ (Brown & Martinsson, 2019; Park, 2018), highly developed financial markets (Hsu et al., 2014), firms with higher institutional ownership (Aghion et al., 2013), and corporate venture capital-backed firms (Chemmanur et al., 2014) and Competitive advantages of export enterprises (Wang et al., 2021) are the critical factors influencing corporate innovation investment, but little of it focuses on the influence of AIQ on the efficiency of corporate innovation investment. This paper uses 5,143 sample data points of Chinese listed companies from 2008 to 2017 to prove that the AIQ is one of the determinants for the efficiency of corporate innovation investment. The authors find that AIQ affects the efficiency of corporate innovation investment through financing constraints, agent costs, and other intermediary factors, enriching the study content of the efficiency of corporate innovation investment and making up for the deficiencies of the study in this field.Third, this paper reveals how the AIQ affects the efficiency of corporate innovation investment. As the study results show, financing constraints, agent costs, and the external information environment serve as the significant paths for AIQ to affect the efficiency of corporate innovation investment. Consequently, the conclusion furthers the understanding with respect to the influence of AIQ on the efficiency of corporate innovation investment.

The structure of this paper is as follows: section 2 discusses the theoretical mechanism and research hypothesis. Section 3 discusses research design and descriptive statistics. Section 4 reviews empirical analysis. Finally, Section 5 provides the discussion and policy recommendations.

# THEORETICAL MECHANISM AND RESEARCH HYPOTHESIS

## Determinants of Company Innovation Investment Efficiency

Financial constraint is a key determinant that often causes a company to underinvest in innovation. Compared with other investment activities, investment in innovation is characterized by relatively large investment amounts, longer term horizons, higher risk, and higher capital costs. These specific characteristics often prevent companies from investing in innovation solely from internal funding, instead driving them to seek external sources of financial support, usually in the capital market. Some scholars have found that while the capital market does play an important supporting role in financing corporate innovation, present information asymmetries also lead to problematic decision-making, such as adverse selection. This kind of behavior may lead to capital mismatching among companies, which leads to an extra cost premium for external financing. This premium results in significantly higher costs of external financing compared to internal financing (Hubbard, 1997). For example, if a company has a good investment opportunity, an innovation project with a net present value greater than zero but high external financing costs and insufficient internal funds, the company will be forced to forgo the project, resulting in an underinvestment in innovation (Simpson & Tamayo, 2020).

Agency conflict is the key determinant influencing company overinvestment in innovation. Compared with other types of investment, innovation investment is characterized by high R&D risk and credit risk (He et al., 2014). High credit risk mainly arises from information asymmetry between innovation investors and innovation managers; managers hold company innovation information, while the external innovation investors know little about the company's internal innovation activities. This information asymmetry also leads to moral hazards (Jensen & Meckling, 1976). In the absence of proper incentives and supervision, managers may choose innovation projects with a negative net present value in order to fulfill their own private interests, which may result in overinvestment in innovation (Stein, 2003).

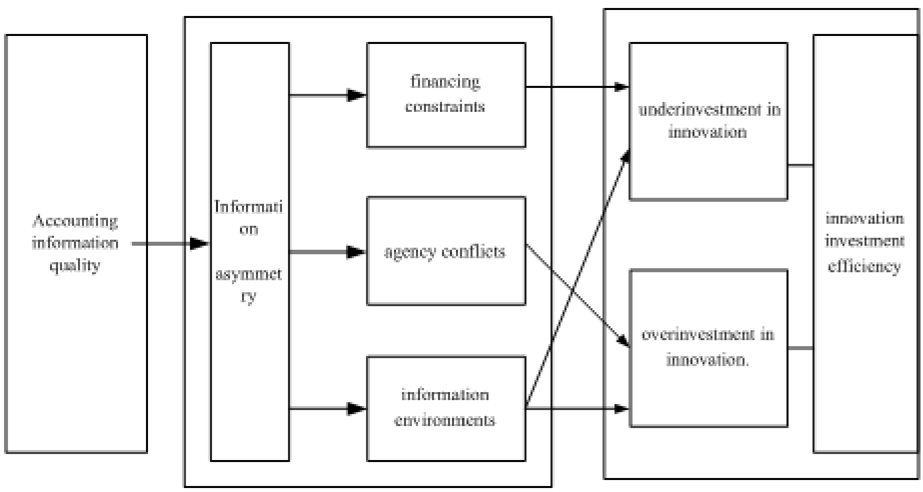
Information asymmetry affects company innovation investment efficiency. First, asymmetric information between a company and external innovation investors produces adverse selection and increases the company's financing costs, thus leading to financing constraints, which affect innovation investment. For example, Myers and Majluf (1984) and Biddle et al. (2009) found that information asymmetry affects financing constraints and inadequate investment. Second, information asymmetry between innovation manager and shareholders can lead to moral hazards, agency costs, poor innovation project selection, and excessive investment. Jensen and Meckling (1976), moreover, found that information asymmetry between shareholders and managers in company innovation can produce moral hazards and agency conflicts, which can influence innovation investment project selection and produce excessive investment (Biddle et al., 2009; Qin & Shao, 2019, Tian et al., 2020). Therefore, information asymmetry, by producing financing constraints and affecting project choices, influences the efficiency of company investments.

## AIQ and Company Innovation Investment Efficiency

Existing literature finds that high AIQ can reduce information asymmetry between companies and external investors (Kanodia & Lee, 1998) and also between company managers and shareholders (Bushman & Smith, 2001). Its influence on stock prices and contracts (Ball & Brown, 1968; Beaver, 1968; Watts & Zimmerman, 1986), financing cost (Beyer et al., 2010; Healy & Palepu, 2001; Verrecchia, 2001), corporate governance (Bushman & Smith, 2001) and investment efficiency (Biddle & Hilary, 2006; Biddle et al., 2009; Chen et al., 2011; Dou et al., 2019; Ramalingegowda et al., 2013), and company innovation (Simpson & Tamayo, 2020). The capital market is an important platform for innovative capital allocation. Rajan and Zingales (2000) observed that "to function properly, a financial system requires clear laws and rapid enforcement, an accounting and disclosure system that promotes transparency, and a regulatory infrastructure that protects consumers and controls risk." Thus, high AIQ may serve to enhance company's innovation investment efficiency by mitigating these frictions.

AIQ is another key determinant of innovation investment efficiency. It mainly has three influencing paths. First, it reduces the uncertainty of investment decisions for external innovation investors and managers. High AIQ can help innovation investors and management identify investment opportunities and promote innovation investment efficiency. Second, it reduces moral hazards and supervises the innovation behavior of managers. High AIQ can alleviate information asymmetry between innovation investors and management and help innovation investors supervise, evaluate, and control managers, thus reducing the moral hazards of managers and improving the efficiency of innovation investment. Finally, adverse selection is reduced, and innovation funding is alleviated. High AIQ can alleviate the financing constraint of a company by alleviating information asymmetry between the company and external innovation investors, reducing the inadequacy of innovation investment of the company through financing constraint, and improving the efficiency of the company's innovation investment.

**Figure 1. Accounting information quality and innovation investment efficiency**




## Research Hypotheses

Based on the above theories, we speculate that high AIQ can promote the efficiency of the company's investment in innovation (underinvestment in innovation and overinvestment in innovation), by reducing information asymmetry. Therefore, we assume the following:

**Hypothesis One:** AIQ is significantly negatively correlated with both underinvestment in innovation and overinvestment in innovation.

In addition, we study the impact of AIQ and the efficiency of the corporate innovation investment mechanism. First, financing constraints affect the company's insufficient investment in innovation, the information asymmetry in the capital market affects financial constraints, and accounting information alleviates the information asymmetry in the capital market. Therefore, AIQ can alleviate the lack of innovation investment through financing constraints. We assume that compared with non-financing-constrained companies, the quality of accounting information of financing-constrained companies alleviates the inadequacy of corporate innovation investment more significantly. This is mainly because AIQ can alleviate financing constraints.

**Hypothesis Two:** The relation between AIQ and underinvestment in innovation is stronger in companies facing financing constraints.

Second, AIQ can alleviate agency conflict and reduce excessive investment in innovation. The reasons are as follows: first, companies with high agency conflict have high cash flow and free cash flow. Second, high-cash-flow and free-cash-flow company managers have more opportunities to use the company's innovative investment projects to gain personal benefits at the expense of the company. Finally, AIQ can alleviate information asymmetry and play an important role in corporate governance to reduce agency conflicts.

**Hypothesis Three:** The relation between AIQ and overinvestment in innovation is stronger in companies that hold large amounts of cash.

Finally, this paper studies how AIQ affects the company's lack of innovation investment through the company's information environment. AIQ is an important source of information for external innovation investment to understand the company's innovation investment activities. For example, when the information environment of a company is high, the external innovation investors may know the company through the capital market analysts, thus reducing the dependence on the company's accounting information. We hypothesize that compared with the company high information environment, low information quality of accounting information on the company's innovation underinvestment is more prominent. This is mainly because AIQ can alleviate the information asymmetry of companies in a low-information environment and reduce the lack of innovation investment.

**Hypothesis Four:** The relation between AIQ and innovation investment efficiency is stronger in companies with low-quality information environments.

## RESEARCH DESIGN AND DESCRIPTIVE STATISTICS

### Data Sources

The initial sample consists of a-share companies listed on the Shanghai and Shenzhen stock exchanges from 2008 to 2017. Excluding ST companies, listed companies in the financial industry, and companies with zero R&D investment leaves a total of 5,143 samples. The data are from the CSMAR database. To minimize the impact of outliers, the upper and lower 1% of all of the continuous variables are winsorized.

### Measuring Company Innovation Investment Efficiency

To measure the efficiency of a company's investment in innovation, the authors first estimate a model that will predict a firm's level of innovation investment and then use residuals from this model as for company innovation investment efficiency. The idea of measuring the efficiency of investment in innovation derives from models developed by Richardson (2006). However, in view of the differences between general investment and innovation investment, the factors affecting innovation investment are different. Therefore, the authors estimate a model for investment in innovation efficiency following Gunny (2010). This model is based on the idea that size, growth opportunities, and internal cash flow lagging by one investment in the innovation period should explain company investment in innovation when markets are perfect.

$$\frac{II_{i,t}}{A_{i,t\text{-}1}} = \alpha_0 + \alpha_1 \frac{1}{A_{i,t\text{-}1}} + \beta_1 MV_{i,t} + \beta_2 Q_{i,t} + \beta_3 \frac{INT_{i,t}}{A_{i,t\text{-}1}} + \beta_4 \frac{II_{i,t\text{-}1}}{A_{i,t\text{-}1}} . \\ + \sum \text{Year} + \sum \text{Industry} + \varepsilon^{II}_{i,t} \tag{1}$$

We only for industry and annual data sets with at least 20 samples. $II_{i,\ t}$ is the measure of R&D expense. $A_{i,\ t-1}$ is the total assets at the end of the period. $MV_{i,\ t}$ is a measure of the company size, which is measured by the natural log of the market value. $Q_{i,\ t}$ is a measure of investment opportunity, which is calculated as the ratio of the market value of total assets to the book value of total assets. $INT_{i,\ t}$ is a measure of the internal cash flow of the company, which is calculated as income before extraordinary items, R&D, and depreciation divided by sales, following Berger (1993). $II_{i,\ t-1}$ is R&D expenses with a leg of one period. i represents the company, and t is time, the control industry, and the time variable. $\varepsilon^{II}$ is the residual, which indicates the investment effect.

The sample consists of 9,782 a-share companies listed on the Shanghai and Shenzhen stock markets with available data, which are used to estimate $II_{i,\ t}/A_{i,\ t-1}$, $1/A_{i,\ t-1}$, $MV_{i,\ t}$, $Q_{i,\ t}$, $INT_{i,\ t}$, and $II_{i,\ t-1}/A_{i,\ t-1}$ during the sample period, 2008–2017. We use the residual of Equation (1) to measure the efficiency of a company's investment in innovation. When the residual of Equation (1) is positive, it represents the company's overinvestment in innovation. When the residual of equation (1) is negative, this represents a company's underinvestment in innovation. Both the underinvestment in innovation and the overinvestment in innovation reduce the level of investment in innovation.

Table 1 reports the results of the investment in innovation model in Equation (1) and the descriptive statistics for the innovation investment residual, overinvestment in innovation, and underinvestment in innovation. The mean of variable $II_{i,\ t}/A_{i,\ t-1}$ is 2.60%, the minimum is 0.00%, and the maximum is 12.20%. $Q_{i,\ t}$ has a mean value of 2.43, ranging from 0.22 to 10.39. The mean of variable $INT_{i,\ t}$ is 11.10%, the minimum is −10.30%, and the maximum is 42.30%. The mean of variable $MV_{i,\ t}$ is 22.7, the minimum is 20.895, and the maximum is 25.416. There are 9,782 annual observations of companies in this article. The average of innovation investment residual is 0, the minimum is −6.90%, and the maximum is 9%. There are 4,460 (5,322) firms classified as overinvesting (underinvesting) in innovation. The mean value is 0.50% for overinvestment in innovation −0.40% for underinvestment in innovation.

### AIQ Measurement

AIQ records the company's operating information and can predict the company's unearned cash flow, which is an important basis for investors to make decisions (Verdi, 2006). This definition is consistent with China's accounting standards for business enterprises, No. 30 (2014). There are many classical models of AIQ measurement. Referring to Francis et al. (2005) and other related literature, the authors select 'accruals quality' to represent AIQ. Because accounting surplus is the most typical and the most important, it is also the information about which investors are the most interested. Past studies have shown that in China's capital market, the estimated total accruals by industry and by year can effectively reveal a company's earnings' management degree. In order to prevent the measurement bias of a single model, the average values of the modified Jones model (Dechow et al., 1995), the performance-adjusted Jones model (Kothari et al., 2005), and the DD model (Dechow & Dichev, 2002) are measured and denoted as $DA_{i,\ t-1}$. The modified Jones model is denoted as $DA_{1i,\ t-1}$, the modified Jones model of performance adjustment is denoted as $DA_{2i,\ t-1}$, and the DD model is denoted as $DA_{3i,\ t-1}$.

### Model Specification

To test the research hypothesis, we construct the following model:

**Table 1. Innovation investment description statistics of companies**

| Variables | Obs | Mean | STD | Min | Max |
|---|---|---|---|---|---|
| $II_{i,t}/A_{i,t-1}$ | 9782 | 0.026 | 0.022 | 0.000 | 0.122 |
| $1/A_{i,t-1}$ | 9782 | 0.000 | 0.000 | 0.000 | 0.000 |
| $MV_{i,t}$ | 9782 | 22.700 | 0.907 | 20.895 | 25.416 |
| $Q_{i,t}$ | 9782 | 2.434 | 1.916 | 0.220 | 10.391 |
| $INT_{i,t}$ | 9782 | 0.111 | 0.084 | −0.103 | 0.423 |
| $II_{i,t-1}/A_{i,t-1}$ | 9782 | 0.022 | 0.018 | 0.000 | 0.096 |
| $II\_fe_{i,t}$ | 9782 | 0.000 | 0.008 | −0.069 | 0.090 |
| $II\_U_{i,t}$ | 5322 | −0.004 | 0.005 | −0.069 | −0.000 |
| $II\_O_{i,t}$ | 4460 | 0.005 | 0.007 | −0.000 | 0.090 |

$$II\_fe_{i,t+1} = \alpha + \beta_{DA} AIQ_{i,t} + \beta_{cv} \cdot \text{Control} + \text{Industry}_j + \text{Year}_t + \varepsilon_{i,t}\,. \quad (2)$$

In Equation (2), $II\_fe_{i,t+1}$ is the efficiency of enterprises' investment in innovation, which is Equation (1) for residuals investment in the innovation model taking the absolute value. Overinvestment in corporate innovation is the positive residuals of Equation (1), and underinvestment in corporate innovation is the negative residuals of the Equation (1) multiplied by '−1'. $AIQ_{i,t}$ is the quality of accounting information with a lag of one period, calculated by $DA_{i,t-1}$, $DA1_{i,t-1}$, $DA2_{i,t-1}$, or$DA3_{i,t-1}$. Following prior studies of the determinants of innovation efficiency (Biddle et al., 2009; Chen et al., 2011), the authors include a number of control variables: $1/A_{i,t-1}$, $MV_{i,t}$, $INT_{i,t}$, $II_{i,t-1}/A_{i,t-1}$, $Q_{i,t}$, $Lev_{i,t}$ Year, Industry. $Lev_{i,t}$ is measured by the ratio of total liabilities to total assets. $1/A_{i,t-1}$, $MV_{i,t}$, $INT_{i,t}$, $II_{i,t-1}/A_{i,t-1}$, $Q_{i,t}$, are defined in the same way as Equation (1).

Table 2 presents the descriptive statistics for a smaller sample than reported in Table 1 owing to the data availability for $DA_{i,t}$, $DA1_{i,t}$, $DA2_{i,t}$, and $DA3_{i,t}$. The sample includes 7,342 annual observations of companies. The authors winsorize continuous variables at the 1% and 99% levels. In this sample, there are 3,979 (3,363) companies classified as innovation-underinvesting (overinvesting) companies. The mean value for underinvestment in innovation is 0.40%, and for overinvestment in innovation, it is 0.50%. $DA_{i,t}$ has a mean (median) value of −4.90% (−3.60%). $DA1_{i,t}$ has a mean (median) value of −5.10% (−3.70%). $DA2_{i,t}$ has a mean (median) value of −5.0% (−3.60%). $DA3_{i,t}$ has a mean (median) value of −4.5% (−3.40%). Finally, the authors include descriptive statistics for the mean, standard deviation, 100th, median, and 99th percentiles of the subsample on $1/A_{i,t-1}$, $MV_{i,t}$, $Q_{i,t}$, $INT_{i,t}$, $II_{i,t-1}/A_{i,t-1}$, Lev, and age.

$II\_U_{i,t}$ is negatively correlated with $DA_{i,t}$ (the correlation coefficient is −0.07); the same is true for $II\_O_{i,t}$ (the correlation coefficient is −0.12). These results present preliminary evidence for the relation between AIQ and company innovation investment efficiency, as proposed in Hypotheses 1.

## EMPIRICAL ANALYSIS

### Basic Regression Results

Because this paper is interested in how AIQ affects innovation investment efficiency, the authors investigate Hypotheses 1 by regressing the measure of innovation investment efficiency in year *t* + 1 on the measures of AIQ in year *t*. Similar to Biddle et al. (2009), the authors also estimate Equation (2) separately for underinvestment in innovation and overinvestment in innovation. The

**Table 2. Description and statistics of the efficiency model of corporate innovation investment**

| Variables | Obs | Mean | STD | P1 | Median | P99 |
|---|---|---|---|---|---|---|
| (1) Total sample descriptive statistics | | | | | | |
| $II\_fe_{i,t}$ | 7342 | 0.005 | 0.005 | 0.000 | 0.003 | 0.029 |
| $Residuals_{i,t}$ | 7342 | 0.000 | 0.007 | −0.020 | 0.000 | 0.025 |
| $DA_{i,t}$ | 7342 | −0.049 | 0.043 | −0.231 | −0.036 | −0.003 |
| $DA1_{i,t}$ | 7342 | −0.051 | 0.048 | −0.251 | −0.037 | −0.001 |
| $DA2_{i,t}$ | 7342 | −0.050 | 0.047 | −0.248 | −0.036 | −0.001 |
| $DA3_{i,t}$ | 7342 | −0.045 | 0.042 | −0.215 | −0.034 | −0.001 |
| $1/A_{i,t-1}$ | 7342 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $MV_{i,t}$ | 7342 | 22.670 | 0.905 | 20.90 | 22.61 | 25.32 |
| $Q_{i,t}$ | 7342 | 2.504 | 1.984 | 0.220 | 1.961 | 10.39 |
| $INT_{i,t}$ | 7342 | 0.109 | 0.083 | −0.099 | 0.097 | 0.420 |
| $II_{i,t-1}/A_{i,t-1}$ | 7342 | 0.022 | 0.018 | 0.000 | 0.018 | 0.095 |
| $Lev_{i,t}$ | 7342 | 0.408 | 0.204 | 0.046 | 0.395 | 0.887 |
| (2) Innovation underinvestment description statistics | | | | | | |
| $II\_U_{i,t}$ | 3979 | 0.004 | 0.005 | 0.000 | 0.003 | 0.023 |
| $Residuals_{i,t}$ | 3979 | −0.004 | 0.004 | −0.020 | −0.003 | 0.000 |
| $DA_{i,t}$ | 3979 | −0.047 | 0.042 | −0.231 | −0.035 | −0.003 |
| $DA1_{i,t}$ | 3979 | −0.050 | 0.047 | −0.251 | −0.036 | −0.001 |
| $DA2_{i,t}$ | 3979 | −0.049 | 0.046 | −0.248 | −0.035 | −0.001 |
| $DA3_{i,t}$ | 3979 | −0.044 | 0.041 | −0.212 | −0.033 | −0.001 |
| $1/A_{i,t-1}$ | 3979 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $MV_{i,t}$ | 3979 | 22.680 | 0.920 | 20.900 | 22.600 | 25.320 |
| $Q_{i,t}$ | 3979 | 2.462 | 1.909 | 0.220 | 1.954 | 10.180 |
| $INT_{i,t}$ | 3979 | 0.112 | 0.078 | −0.059 | 0.099 | 0.393 |
| $II_{i,t-1}/A_{i,t-1}$ | 3979 | 0.021 | 0.017 | 0.000 | 0.018 | 0.094 |
| $Lev_{i,t}$ | 3979 | 0.399 | 0.204 | 0.047 | 0.382 | 0.870 |
| (3) Innovation overinvestment describes statistics | | | | | | |
| $II\_O_{i,t}$ | 3363 | 0.005 | 0.006 | 0.000 | 0.003 | 0.029 |
| $Residuals_{i,t}$ | 3363 | 0.005 | 0.006 | 0.000 | 0.003 | 0.025 |
| $DA_{i,t}$ | 3363 | −0.050 | 0.044 | −0.225 | −0.037 | −0.003 |
| $DA1_{i,t}$ | 3363 | −0.052 | 0.049 | −0.244 | −0.038 | −0.001 |
| $DA2_{i,t}$ | 3363 | −0.051 | 0.048 | −0.239 | −0.037 | −0.001 |
| $DA3_{i,t}$ | 3363 | −0.046 | 0.042 | −0.215 | −0.034 | −0.001 |
| $1/A_{i,t-1}$ | 3363 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $MV_{i,t}$ | 3363 | 22.66 | 0.887 | 20.900 | 22.620 | 25.110 |
| $Q_{i,t}$ | 3363 | 2.554 | 2.069 | 0.229 | 1.974 | 10.390 |
| $INT_{i,t}$ | 3363 | 0.106 | 0.089 | −0.099 | 0.096 | 0.420 |
| $II_{i,t-1}/A_{i,t-1}$ | 3363 | 0.022 | 0.019 | 0.000 | 0.018 | 0.095 |
| $Lev_{i,t}$ | 3363 | 0.420 | 0.204 | 0.046 | 0.408 | 0.887 |

data of underinvestment and overinvestment are a mixed sample of positive values; using ordinary least-square regression produces inconsistent parameter estimates, a primary reason for adopting the Tobit model. The results are shown in Table 3.

**Table 3. Determinants of company innovation investment efficiency**

| | $II\_U_{i,t+1}$ | | | | $II\_O_{i,t+1}$ | | | |
|---|---|---|---|---|---|---|---|---|
| $DA_{i,t}$ | −0.009*** (−4.328) | | | | −0.007** (−2.498) | | | |
| $DA1_{i,t}$ | | −0.007*** (−3.739) | | | | −0.006** (−2.412) | | |
| $DA2_{i,t}$ | | | −0.007*** (−3.971) | | | | −0.006** (−2.278) | |
| $DA3_{i,t}$ | | | | −0.009*** (−4.386) | | | | −0.007** (−2.501) |
| $1/A_{i,t-1}$ | 0.000** (2.374) | 0.000** (2.373) | 0.000** (2.429) | 0.000** (2.315) | 0.000* (1.902) | 0.000* (1.912) | 0.000* (1.903) | 0.000* (1.890) |
| $MV_{i,t}$ | 0.000 (0.193) | 0.000 (0.231) | 0.000 (0.263) | 0.000 (0.017) | 0.000 (0.737) | 0.000 (0.719) | 0.000 (0.733) | 0.000 (0.721) |
| $Q_{i,t}$ | −0.000 (−1.424) | −0.000 (−1.381) | −0.000 (−1.354) | −0.000 (−1.338) | 0.000*** (3.955) | 0.000*** (3.982) | 0.000*** (3.983) | 0.000*** (3.990) |
| $INT_{i,t}$ | 0.009*** (7.612) | 0.009*** (7.592) | 0.009*** (7.607) | 0.009*** (7.700) | 0.009*** (6.350) | 0.009*** (6.355) | 0.009*** (6.346) | 0.009*** (6.391) |
| $II_{i,t-1}/A_{i,t-1}$ | 0.066*** (12.800) | 0.066*** (12.810) | 0.066*** (12.799) | 0.065*** (12.749) | 0.025*** (3.719) | 0.025*** (3.719) | 0.025*** (3.717) | 0.025*** (3.672) |
| $Lev_{i,t}$ | −0.000 (−0.129) | −0.000 (−0.126) | −0.000 (−0.050) | 0.000 (0.076) | 0.003*** (5.467) | 0.003*** (5.501) | 0.003*** (5.498) | 0.003*** (5.539) |
| Year/ Industry | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| _cons | −0.001 (−0.474) | −0.002 (−0.505) | −0.002 (−0.543) | −0.001 (−0.298) | −0.002 (−0.342) | −0.002 (−0.335) | −0.002 (−0.337) | −0.002 (−0.312) |
| N | 2813 | 2813 | 2813 | 2813 | 2330 | 2330 | 2330 | 2330 |

Table 3 presents the results for the tests of H1. The estimated model is a Tobit model regression of innovation investment efficiency on accounting information quality, company characteristics ($1/A_{i,t-1}$, $MV_{i,t}$, $Q_{i,t}$, $INT_{i,t}$, $II_{i,t-1}/A_{i,t-1}$, $Lev_{i,t}$), and industry and year fixed effects. The dependent variable is underinvestment in innovation in the first four columns and overinvestment in innovation in the last columns. The results show that $II\_U_{i,t+1}$ is negatively related to $DA_{i,t}$, $DA1_{i,t}$, $DA2_{i,t}$, and $DA3_{i,t}$ (coefficients are significant at the 1% level), and the estimated coefficients are also negative and significant for $II\_O_{i,t+1}$, supporting H1. The estimated coefficients suggest that increasing $DA_{i,t}$ ($DA1_{i,t}$, $DA2_{i,t}$, $DA3_{i,t}$) by one standard deviation is associated with a reduction of $II_{i,u}$ of 0.9% (0.7%, 0.7%, 0.9%), and of $II_{i,o}$ of 0.7% (0.6%, 0.6%, 0.7%). Across all eight of the test specifications, the conclusion is the same: AIQ enhances innovation investment efficiency.

## Controls for Potential Endogeneity

This section discusses a causal relationship between the quality of accounting information and the efficiency of innovation investment. For example, suppose that low-performing managers are more likely to invest inefficiently in innovation and report poor-quality accounting information to conceal their bad performance (Verdi, 2006). Thus, the authors observe the quality of accounting information affecting innovation investment efficiency and vice versa. To address this concern, the authors adopt the instrumental variable method. First, the authors repeat the analysis using the AIQ proxies lagging by two periods. Second, they explicitly control for past innovation investment efficiency in the model. In this test, if past innovation investment efficiency drives AIQ, there should be no relation between AIQ and future innovation investment efficiency after controlling for past innovation investment efficiency.

**Table 4. Endogenous: Instrumental variable**

| | $II\_U_{i,t+1}$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| L. $DA_{i,t}$ | −0.006** (−2.330) | | | | −0.005** (−2.060) | | | |
| L. $DA1_{i,t}$ | | −0.004* (−1.930) | | | | −0.004* (−1.692) | | |
| L. $DA2_{i,t}$ | | | −0.005** (−2.131) | | | | −0.004* (−1.884) | |
| L. $DA3_{i,t}$ | | | | −0.006** (−2.281) | | | | −0.005** (−2.022) |
| L. $II\_U_{i,t+1}$ | | | | | 0.106*** (4.412) | 0.107*** (4.448) | 0.106*** (4.434) | 0.106*** (4.420) |
| $1/A_{i,t-1}$ | 0.000 (0.752) | 0.000 (0.743) | 0.000 (0.770) | 0.000 (0.775) | 0.000 (0.639) | 0.000 (0.631) | 0.000 (0.655) | 0.000 (0.659) |
| $MV_{i,t}$ | 0.000 (0.880) | 0.000 (0.889) | 0.000 (0.908) | 0.000 (0.876) | 0.000 (0.764) | 0.000 (0.772) | 0.000 (0.789) | 0.000 (0.761) |
| $Q_{i,t}$ | −0.000 (−0.841) | −0.000 (−0.817) | −0.000 (−0.809) | −0.000 (−0.797) | −0.000 (−0.871) | −0.000 (−0.849) | −0.000 (−0.843) | −0.000 (−0.833) |
| $INT_{i,t}$ | 0.013*** (7.705) | 0.013*** (7.692) | 0.013*** (7.687) | 0.013*** (7.729) | 0.012*** (7.188) | 0.012*** (7.174) | 0.012*** (7.170) | 0.012*** (7.208) |
| $II_{i,t-1}/A_{i,t-1}$ | 0.039*** (4.178) | 0.039*** (4.177) | 0.039*** (4.181) | 0.039*** (4.137) | 0.042*** (4.516) | 0.042*** (4.517) | 0.042*** (4.520) | 0.042*** (4.480) |
| $Lev_{i,t-1}$ | −0.000 (−0.356) | −0.000 (−0.344) | −0.000 (−0.310) | −0.000 (−0.261) | −0.000 (−0.037) | −0.000 (−0.022) | 0.000 (0.005) | 0.000 (0.048) |
| Year/ Industry | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| _cons | −0.006 (−1.178) | −0.006 (−1.198) | −0.006 (−1.209) | −0.006 (−1.149) | −0.005 (−1.040) | −0.005 (−1.057) | −0.005 (−1.067) | −0.005 (−1.014) |
| N | 1569 | 1569 | 1569 | 1569 | 1569 | 1569 | 1569 | 1569 |

Table 4 reports the results of the eight sensitivity analyses when $II\_U_{i,t+1}$ is used as the dependent variable. In the first four columns, when $DA_{i,t}$ (column I), $DA1_{i,t}$ (column II), $DA2_{i,t}$ (column III) and $DA3_{i,t}$ (column IV) lag by two periods, the inferences are unchanged. The estimated coefficients are statistically negative at conventional levels. In the last four columns, the authors include past $II\_U_{i,}$

$_{t+1}$ in the model. In this case, the estimated coefficients of $DA_{i,t}$ (column V), $DA1_{i,t}$ (column VI), $DA2_{i,t}$ (column VII), and $DA3_{i,t}$ (column VIII) are still negative and significant.

Table 5 presents the results of the eight sensitivity analyses when $II\_O_{i,t+1}$ is used as the dependent variable. The estimated coefficients of $DA_{i,t}$, $DA1_{i,t}$, $DA2_{i,t}$, and $DA3_{i,t}$ are positive and not significant. All of the inferences are changed.

**Table 5. Endogenous: Instrumental variable**

| | $II\_O_{i,t+1}$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** | **(8)** |
| L. $DA_{i,t}$ | 0.005<br>(1.153) | | | | 0.006<br>(1.447) | | | |
| L. $DA1_{i,t}$ | | 0.004<br>(1.069) | | | | 0.005<br>(1.368) | | |
| L. $DA2_{i,t}$ | | | 0.005<br>(1.366) | | | | 0.007*<br>(1.658) | |
| L. $DA3_{i,t}$ | | | | 0.003<br>(0.809) | | | | 0.005<br>(1.058) |
| L. $II\_O_{i,t+1}$ | | | | | 0.143***<br>(3.933) | 0.143***<br>(3.929) | 0.143***<br>(3.949) | 0.141***<br>(3.895) |
| $1/A_{i,t-1}$ | 0.000<br>(1.172) | 0.000<br>(1.165) | 0.000<br>(1.171) | 0.000<br>(1.197) | 0.000<br>(1.075) | 0.000<br>(1.065) | 0.000<br>(1.106) | 0.000<br>(1.107) |
| $MV_{i,t}$ | 0.000<br>(1.087) | 0.000<br>(1.089) | 0.000<br>(1.072) | 0.000<br>(1.106) | 0.000<br>(0.819) | 0.000<br>(0.820) | 0.0005<br>(1.076) | 0.000<br>(0.845) |
| $Q_{i,t}$ | 0.000***<br>(2.821) | 0.000***<br>(2.815) | 0.000***<br>(2.841) | 0.000***<br>(2.781) | 0.000**<br>(2.522) | 0.000**<br>(2.518) | 0.000**<br>(2.542) | 0.000**<br>(2.476) |
| $INT_{i,t}$ | 0.010***<br>(3.862) | 0.010***<br>(3.867) | 0.010***<br>(3.870) | 0.010***<br>(3.838) | 0.011***<br>(4.196) | 0.011***<br>(4.204) | 0.011***<br>(4.206) | 0.011***<br>(4.164) |
| $II_{i,t-1}/A_{i,t-1}$ | 0.015<br>(1.283) | 0.015<br>(1.283) | 0.015<br>(1.270) | 0.015<br>(1.318) | −0.003<br>(−0.226) | −0.003<br>(−0.226) | −0.003<br>(−0.243) | −0.002<br>(−0.174) |
| $Lev_{i,t-1}$ | 0.003***<br>(2.929) | 0.003***<br>(2.925) | 0.003***<br>(2.955) | 0.003***<br>(2.894) | 0.003**<br>(2.342) | 0.003**<br>(2.340) | 0.003**<br>(2.370) | 0.003**<br>(2.304) |
| Year/ Industry | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| _cons | −0.005<br>(−0.473) | −0.004<br>(−0.470) | −0.004<br>(−0.454) | −0.005<br>(−0.506) | −0.004<br>(−0.390) | −0.004<br>(−0.385) | −0.003<br>(−0.368) | −0.004<br>(−0.431) |
| N | 1078 | 1078 | 1078 | 1078 | 1078 | 1078 | 1078 | 1078 |

Overall, the results in Tables 4 and 5 support H1; namely, AIQ is negatively associated with both innovation underinvestment and overinvestment.

## Cross-Sectional Partitions

The authors empirically test hypotheses 2, 3 and 4. These hypotheses involve grouping tests under different conditions of financing constraints, cash flow, and information environment. In order to be able to test these hypotheses, model (3) is built by referring to Verdi (2006).

$$II\_fe_{i,t} = \alpha + \beta_1 \cdot \text{Partition}_{i,t} + \beta_2 \text{AIQ}_{i,t\text{-}1} + \beta_3 \text{AIQ} \cdot \text{Partition}_{i,t} \\ + \beta_{cv} \text{ControlVariables}_{i,t} + \text{Industry}_j + \text{Year}_t + \varepsilon_{i,t}, \quad (3)$$

where $\text{II\_fe}_{i,\ t}$ is either corporate innovation underinvestment or corporate innovation overinvestment. $\text{AIQ}_{i,\ t-1}$ is either $\text{DA}_{i,\ t-1}$, $\text{DA1}_{i,\ t-1}$, $\text{DA2}_{i,\ t-1}$, or $\text{DA3}_{i,\ t-1}$. $\text{Partition}_{i,\ t}$ is an indicator variable, mainly representing financing constraints, high cash flow, and information environment. Section 3 provides the coefficient of AIQ's interaction with the classification variable. If the coefficient of $\beta_3$ is negative, the effect of AIQ on the innovation investment efficiency of the company is more obvious in companies with financing constraints, high cash flow, and a low-information environment.

### *Financing Constraints*

In this section, the authors test Hypothesis Two. That is, when a company faces financing constraints, the relationship between the AIQ and the lack of innovation investment is stronger. This is because financing-constrained firms face greater limits on how much they can raise. The authors follow the approach in Verdi (2006) to classify companies into financially-constrained and unconstrained categories. In particular, the authors adopt five different criteria considering the lack of consensus about which approach provides the best classification (Hadlock & Pierce, 2010; Kaplan & Zingales, 1997; Whited & Wu, 2006).

First, the authors measure the WW index following Whited and Wu (2006). According to the order of the company's interest-protection multiples from small to large, companies with less-than-average values are labeled as high-financing-constraint companies, and those with a higher-than-average values are labeled as low-financing-constraint companies. The logit regression model is established with the variable WFC (1 is a high-financing-constraint company, 0 is a low-financing-constraint company). WFC = β0 + β1 AP + β2 FR + β3 Lev + β4 ROE + β5 QUA. Logit regression is conducted for each industry and year, and the estimated value of each coefficient is calculated; the comprehensive financing constraint index of each company is calculated with the estimated value of the coefficient. The smaller the WFC index, the smaller the degree of corporate financing constraint. According to the WFC index value, the first 33% of samples are labeled as non-financing constrained companies, and the last 33% of samples are labeled as financing-constrained companies. Second, the authors measure the SA index following Hadlock and Pierce (2010). SA = −0.737 × size + 0.043 × size2 − 0.04 × age, where size represents the size of the company, which is measured by the total ending assets of the company. Age indicates the company's listing age. The larger the SA index, the smaller the degree of corporate financing constraints. Then, according to the SA index values, the top 33% of samples are labeled as financing-constrained companies, and the bottom 33% of samples are labeled as non-financing-constrained companies. Third, we measured the KZ index following Kaplan and Zingales (1997). KZ = −1.001909 × OCF / Asset + 3.139193 × Lev − 39.3678 × Dividends / Asset1 − 314759 × Cash / Asset + 0.2826389 × Tobin's Q, where OCF, dividends, and cash are net operating cash flow, dividends, and cash holding, and asset, lev, and Tobin's Q are total assets at the beginning, asset-liability ratio, and Tobin's Q value. The smaller the KZ index, the less financing constraints the company faces. Then, according to the KZ index value, the top 33% of samples are labeled as non-financing-constrained companies, and the bottom 33% of samples are labeled as financing-constrained companies. Fourth, the authors rank the total assets of the company by industry and year from low to high, marking the sample of the top 33% as financing-constrained companies and the samples of the bottom 33% as non-financing-constrained companies. Finally, the authors sort by company age. Younger companies are more likely to face financing constraints, and older companies have more ways to deal with them. Therefore, the authors rank the top 50% of the samples as non-financing-constrained companies and the bottom 50% as financing-constrained companies by industry, from low to high.

Table 6 shows the test results of Hypothesis Two. $1/A_{i,t-1}$, $MV_{i,t}$, $Q_{i,t}$, $INT_{i,t}$, $II_{i,t-1}/A_{i,t-1}$, $Lev_{i,t}$, and industry and year fixed effects are controlled in the model. The coefficients of the control variables are similar to the estimated coefficients reported in Table 3. Table 5 lists the regression results of proxy variables DA, DA1, DA2, and DA3 and the efficiency of innovation investment in financing-constrained companies. When the authors use DA to measure AIQ and SA (WW, KZ, size, and age) index as the classification index of financing constraint, the coefficient of interaction between DA and financing constraint is −0.007 (−0.007, 0.008, −0.007, and 0.006), which is significant at the level of 5% (5%, 5%, 5%, and 10%). When the authors use DA1, DA2 and DA3 to measure the quality of accounting information, the results are stable. This shows that the relationship between AIQ and the underinvestment of corporate innovation is stronger in financing-constrained companies. Therefore, the results support Hypothesis Two.

**Table 6. Underinvestment regressions-partitions by financing constraint**

| **Accounting information quality: DA1** | | | | **Accounting information quality: DA2** | | |
|---|---|---|---|---|---|---|
| Partition criteria | Partition | AIQ | DA* partition | Partition | AIQ | DA* partition |
| SA | −0.000 (−1.325) | −0.002 (−1.141) | −0.008*** (−2.580) | −0.000 (−0.996) | −0.004* (−1.694) | −0.006** (−2.046) |
| WW | −0.001*** (−2.763) | −0.005** (−2.413) | −0.005* (−1.741) | −0.001*** (−2.819) | −0.005** (−2.530) | −0.006* (−1.850) |
| KZ | 0.000 (1.585) | −0.009*** (−4.770) | 0.007** (2.304) | 0.000 (1.605) | −0.010*** (−4.957) | 0.007** (2.304) |
| Size | −0.000 (−1.325) | −0.002 (−1.141) | −0.008*** (−2.580) | −0.000 (−0.996) | −0.004* (−1.694) | −0.006** (−2.046) |
| Age | 0.000 (0.002) | −0.008*** (−4.236) | 0.004 (1.393) | 0.000 (0.332) | −0.009*** (−4.686) | 0.005* (1.827) |
| **Accounting information quality: DA3** | | | | **Accounting information quality: DA** | | |
| Partition criteria | Partition | AIQ | DA* partition | Partition | AIQ | DA* partition |
| SA | −0.000 (−1.263) | −0.003 −1.391) | −0.008** (−2.386) | −0.000 (−1.178) | −0.004 (−1.626) | −0.007** (−2.191) |
| WW | −0.001*** (−2.626) | −0.006*** (−2.687) | −0.006* (−1.675) | −0.001*** (−2.925) | −0.006*** (−2.680) | −0.007** (−1.999) |
| KZ | 0.000 (1.525) | −0.011*** (−4.849) | 0.007** (2.182) | 0.000* (1.747) | −0.011*** (−5.214) | 0.008** (2.425) |
| Size | −0.000 (−1.263) | −0.003 (−1.391) | −0.008** (−2.386) | −0.000 (−1.178) | −0.004 (−1.626) | −0.007** (−2.191) |
| Age | 0.000 (0.801) | −0.011*** (−5.080) | 0.008** (2.468) | 0.000 (0.463) | −0.011*** (−4.937) | 0.006* (1.929) |

### *Cash Balances*

In this section, the authors tested Hypothesis Three. In high-cash companies, AIQ can reduce the excessive investment in innovation. This is because AIQ can alleviate information asymmetry between shareholders and managers, reduce corporate moral hazards, and ease corporate agency conflicts (Simpson & Tamayo, 2020). The authors use cash holdings and free cash flow to measure corporate agency conflicts. First, the authors build a classification variable High Cash, which is coded as ‘1’if the firm is above the median in the distribution of cash balances deflated by total assets in a given year and '0' otherwise. Second, following Richardson (2006), Free Cash Flow is equal to cash flow from operations plus R&D expenses minus depreciation; the predicted investment for the firm as estimated in Table 1. Free Cash Flow is recoded as an indicator variable and coded as '1' if the computation of free cash flow is positive and '0' otherwise.

Table 7 lists the test results of Hypothesis Three. $1/A_{i,\,t-1}$, $MV_{i,\,t}$, $Q_{i,\,t}$, $INT_{i,\,t}$, $II_{i,\,t-1}/A_{i,\,t-1}$, $Lev_{i,\,t}$, and industry and year fixed effects are controlled in the model. The coefficients of the control variables are similar to the estimated coefficients reported in Table 4. Table 6 lists the regression results of the proxy variables DA, DA1, DA2, and DA3 of the quality of accounting information and the excessive investment of corporate innovation in high-cash companies, respectively. When the authors use DA as the agent variable of accounting information quality and High Cash (Free Cash Flow) index as the classification index of agent conflict, the interaction coefficient between DA and agent conflict is −0.011 (−0.013), which is significant at the level of 5% (5%). When the authors use DA3 to measure the quality of accounting information, the result is robust. When the authors use DA1 and DA2 to measure the quality of accounting information, and use High Cash index as the classification index of agency conflict, the interaction coefficient between DA1 (DA2) and agency conflict is −0.011 (−0.009), which is significant at the level of 1% (5%). However, when Free Cash Flow is used as the classification index of proxy conflict, the interaction coefficient between DA1 (DA2) and proxy conflict is −0.009 (−0.009), but it is not significant at the level of 10% (10%). These results indicate that the relationship between AIQ and excessive investment in corporate innovation is stronger in high-cash companies. Therefore, the results support Hypothesis Three.

**Table 7. Company innovation overinvestment regression partitions by cash holdings**

| **Accounting information quality: DA1** | | | | **Accounting information quality: DA2** | | |
|---|---|---|---|---|---|---|
| Partition criteria | Partition | AIQ | DA* partition | Partition | AIQ | DA* partition |
| High cash | −0.001*** (−3.254) | 0.001 (0.323) | −0.011*** (−2.603) | −0.001*** (−2.993) | 0.000 (0.032) | −0.009** (−2.172) |
| Free cash flow | −0.000 (−0.047) | −0.001 (−0.249) | −0.009 (−1.639) | −0.000 (−0.046) | −0.001 (−0.215) | −0.009 (−1.636) |
| **Accounting information quality: DA3** | | | | **Accounting information quality: DA** | | |
| Partition criteria | Partition | AIQ | DA* partition | Partition | AIQ | DA* partition |
| High cash | −0.001*** (−2.866) | −0.002 (−0.536) | −0.009** (−2.001) | −0.001*** (−3.162) | −0.000 (−0.052) | −0.011** (−2.428) |
| Free cash flow | −0.000 (−0.911) | −0.000 (−0.098) | −0.017*** (−2.834) | −0.000 (−0.468) | −0.001 (−0.205) | −0.013** (−2.121) |

### *Information Environment*

In this section, the authors test Hypothesis Four. In companies with a low-information environment, AIQ plays a stronger role in promoting the efficiency of corporate innovation investment. This is because innovative investors in low-information-environment companies rely more on the quality of corporate accounting information to predict corporate management. Analysts and report attention are two proxy variables used to measure the external information environment of the company.

This paper uses Verdi (2006) as a reference to measure the information environment using two proxy variables: analysts and research journal attention. First, analysts are the main source of information for innovative investors in listed companies. The stocks recommended by analysts, the problems predicted, and the research reports published are important sources of investment decision information. The analysts' data come from the CSMAR database and are measured by the number of analysts the company tracks. The more analysts the company tracks, the better its external information environment; conversely, the external information environment is low. Low analyst count is an indicator variable and is coded as '1' if the firm is in the bottom three quartiles of the analyst following the index in a given year and '0' otherwise.

Second, the attention of the research paper is used to measure the external information environment of the company. The company research report is an important source of investor information, which can alleviate the information asymmetry between the company and market participants. The data of the research paper's attention mainly come from the CSMAR database and are measured by the number of the company's annual report. The greater the number of the company's research reports, the better the company's external information environment; otherwise, the company's external information environment is lower. The authors consider a firm as Low report attention if the firm is in the bottom three quartiles in a given year (coded as '1' and '0' otherwise).

Table 8 lists the test results of Hypothesis Four. $1/A_{i,\,t-1}$, $MV_{i,\,t}$, $Q_{i,\,t}$, $INT_{i,\,t}$, $II_{i,\,t-1}/A_{i,\,t-1}$, $Lev_{i,\,t}$, and industry and year fixed effects are controlled in the model. The coefficients of the control variables are similar to the estimated coefficients reported in Table 4. Table 8 lists the regression results of proxy variables DA, DA1, DA2, and DA3 of AIQ and the efficiency of corporate innovation investment (underinvestment in corporate innovation and overinvestment in corporate innovation in companies with a low-information environment. Table 8 lists the regression results of proxy variables DA, DA1, DA2, and DA3 of AIQ and the efficiency of corporate innovation investment (underinvestment in corporate innovation and overinvestment in corporate innovation) in companies with a low-information environment. When the company's innovation investment efficiency is measured by the company's innovation investment shortage, AIQ is measured by DA, and the classification variable of information environment is measured by Low Ana Attention, then the coefficient of interaction between DA and information environment is −0.011 (−0.012), which is significant at the level of 1% (1%). When corporate innovation investment efficiency is measured by excessive investment in corporate innovation, AIQ is measured by DA, and the classification variable of information environment is measured by Low Ana Attention, then the coefficient of interaction between DA and information environment is 0.005 (−0.012), which is significant at the level of 5%. When the authors use DA1, DA2, and DA3 to measure the quality of accounting information, the authors get similar results. This shows that the relationship between the quality of accounting information and the efficiency of innovation investment is stronger in companies with a low-information environment. Therefore, the results support Hypothesis Four.

### *Robustness Test*

In order to ensure the robustness of the research conclusion, the authors use four methods to test. First, they use the fixed-effect model for the empirical test. The advantage of this model is that it controls the unobservable individual effects of the firm. Untabulated analyses show that the fixed-effect model estimates support Hypotheses 1, 2, 3, and 4.

Second, the authors repeat the analysis use capital expenditures as a means to ensure investment. Capital expenditure includes fixed investment and research and development. The empirical results show that the quality of accounting information is negatively correlated with the efficiency of investment. This conclusion is consistent with the research hypothesis.

Third, the authors repeat the analysis using a manufacturing sample. For sensitivity testing, the authors repeat the analysis using a sample of manufacturing industries. Untabulated analyses show that the results for H1, H2, H3, and H4 are similar to those reported.

Finally, alternative measures of AIQ are considered. The results obtained in the previous sections may be biased by variables' measures, especially those related to AIQ. To solve this problem, the authors conduct a set of sensitivity checks. They investigate the sensitivity of the results to alternative

**Table 8. Innovation investment efficiency regressions-partitions by information environment**

| Accounting information quality: DA1 | | | | Accounting information quality: DA2 | | |
|---|---|---|---|---|---|---|
| Partition criteria | Partition | AIQ | DA* partition | Partition | AIQ | DA* partition |
| Underinvest innovation | | | | | | |
| Low Ana attention | −0.000 (−0.041) | −0.002 (−1.087) | −0.010*** (−3.576) | 0.000 (0.155) | −0.003 (−1.471) | −0.009*** (−3.234) |
| Low report attention | 0.000 (0.286) | −0.002 (−1.019) | −0.011*** (−3.839) | 0.000 (0.357) | −0.002 (−1.301) | −0.011*** (−3.662) |
| Overinvest innovation | | | | | | |
| Low Ana attention | 0.000 (0.580) | −0.007** (−2.525) | 0.005** (1.137) | 0.000 (0.537) | −0.007** (−2.474) | 0.005** (1.087) |
| Low report attention | 0.001** (2.078) | −0.008*** (−3.187) | 0.009** (2.197) | 0.001** (2.183) | −0.009*** (−3.270) | 0.010** (2.374) |
| **Accounting information quality: DA3** | | | | **Accounting information quality: DA** | | |
| Partition criteria | partition | AIQ | DA* partition | partition | AIQ | DA* partition |
| Underinvest innovation | | | | | | |
| Low Ana attention | 0.000 (0.168) | −0.003 (−1.453) | −0.011*** (−3.244) | −0.000 (−0.041) | −0.003 (−1.503) | −0.011*** (−3.325) |
| Low report attention | 0.000 (0.392) | −0.003 (−1.254) | −0.012*** (−3.681) | 0.000 (0.171) | −0.003 (−1.343) | −0.012*** (−3.731) |
| Overinvest innovation | | | | | | |
| Low Ana attention | 0.000 (0.353) | −0.009*** (−2.814) | 0.004** (0.879) | 0.000 (0.609) | −0.008*** (−2.794) | 0.005** (1.169) |
| Low report attention | 0.001** (2.195) | −0.011*** (−3.759) | 0.012** (2.405) | 0.001** (2.315) | −0.011*** (−3.631) | 0.012** (2.515) |

measures of AIQ, such as the DD model in Dechow and Dichev (2002); the Jones model in Dechow et al. (1995); and the Jones model of performance adjustment in work by Kothari et al. (2005). The results are similar to results for H1, H2, H3, and H4.

## DISCUSSION AND POLICY RECOMMENDATIONS

In recent years, with the development and improvement of China's capital market, AIQ is playing an increasingly important role in the allocation of resources in the capital market. Although previous literature reports that AIQ can promote corporate investment efficiency (Biddle et al., 2009; Chen et al., 2011), there is little literature that examines the relationship between AIQ and the efficiency of corporate innovation investment. Thus, this study investigates the relationship between AIQ and innovation investment efficiency.

Proxies for AIQ are negatively associated with both underinvestment in innovation and overinvestment in innovation. In financing-constrained companies, AIQ has a stronger relationship with insufficient investment in innovation, which is consistent with the view that accounting information can reduce information asymmetry between companies and innovative investors and thus reduce the financing costs of companies. Similarly, for companies with high agency costs, AIQ has a stronger relationship with excessive investment in innovation, which indicates that AIQ can reduce information asymmetry between principals and agents, thus reducing the cost of supervision of managers by shareholders and improving project selection. Finally, the authors find that AIQ has a stronger relationship with innovation investment efficiency in a low-information environment.

These conclusions have important policy significance as well. First, in view of the importance of corporate innovation investment efficiency to the increase of corporate value and national economic growth, it is helpful to understand the importance of innovation investment efficiency at the corporate level. Second, the quality of accounting information is a key factor in the capital market, which helps innovation investors make scientific investment decisions and provides new evidence for the capital market to promote the efficiency of corporate innovation investment. Finally, this paper studies the mechanism of influencing factors on the efficiency of corporate innovation investment and finds that improving the quality of accounting information can likewise improve the efficiency of corporate innovation investment by reducing information asymmetry in the capital market. This helps shed light on a new idea for the relevant departments to draft policies that can improve innovation investment efficiency.

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