



Measuring and analyzing the information entropy value of key Audit matters (KAMs) disclosure at the system and reporting scale

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ABSTRACT

Drawing upon information entropy theory, this study deduces a measurement formula for the information entropy for key audit matters (KAMs) disclosure, considering both system scale and audit report scale. The information entropy of an audit report within a specific system is calculated as the weighted average logarithm value of the continuous product of KAM disclosure frequencies. Subsequently, a systematic calculation of KAM disclosure information entropy is conducted using 14,837 financial statement audit reports from listed companies traded on the Shanghai and Shenzhen Stock Exchanges, covering the FY 2017-20 period. The findings indicate that: (1) The information entropy of KAM disclosure has decreased from 2017 to 2020, while the homogenization degree of KAM disclosure has increased. (2) The information entropy and evenness of KAM disclosure on the main board are significantly higher than those of the ChiNext and the STAR Market. (3) The transportation, storage and postal services, manufacturing, finance, power supply, heating, gas and water supply industries exhibit the highest overall information entropy of KAM disclosure, indicating good quality. (4) The information entropy and evenness of KAM disclosure are higher for the big 4 accounting firms compared to domestic accounting firms and big 8 accounting firms. (5) The KAMs disclosed when the Certified Public Accountant (CPA) provides unqualified opinions, emphasizing that matter paragraphs possess higher information value, and are more disorderly and balanced. The measurement method and related results of information entropy offer reference and comparative value for future research on the quality of KAMs disclosure.

1. Introduction

Following the global financial crisis, there has been a growing demand from financial statement users and potential investors for auditors to enhance the quality of audit, increase the information content of audit reports and improve the validity of decision support [1]. In January 2015, the IAASB issued *ISA 701, entitled Communicating Key Audit Matters in the Independent Auditor's Report* [2,3]. This standard mandates auditors to communicate and disclose KAMs in the audit report for the listed companies' financial statements, thereby enhancing the value of information conveyed in the reports [4,5].

In 2016, in line with the international convergence requirements of audit standards and the prevailing national conditions, the Ministry of Finance issued the *Auditing Standard No. 1504 for Certified Public Accountants of China - Communication on Key Audit Matters in Audit Reports* (hereinafter referred to as the "Standard No. 1504"). This set of standards governs the communication of KAMs in the audit reports for listed companies traded on the Shanghai Stock Exchange and the Shenzhen Stock Exchange, effective from January 1,

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2018 [6].

The KAMs disclosure represents a fundamental change in the new audit report, and is often regarded as the “Crown Jewels” of the audit report. However, currently, there is no established scientific method to evaluate and compare the quality of KAMs disclosure or measure the valuable information contained within audit reports. Therefore, the key research goal of this paper is to seek a kind of parameter index or technical method that can reasonably measure the KAMs disclosure quality and calculate the information value of audit report, to provide solutions for evaluating the effect of KAMs disclosure reform. This paper makes two primary contributions. Firstly, it derives a method for measuring the information entropy of KAMs disclosure on the scale of the system and derives the report from the entropy theory. This method effectively addresses the agency problem associated with the quality of KAMs disclosure and the information quantity of key audit matters in empirical research. Secondly, by utilizing data from 14,837 new-style audit reports of listed companies traded on the Shanghai and Shenzhen Stock Exchange, this study measures and analyzes the information entropy value of KAMs disclosure. It sheds light on the quality characteristics of KAMs disclosure since the implementation of the new audit report reform, employing an entropy-based quantification approach. This research further enhances and complements the existing body of knowledge on the reform’s impact on KAMs disclosure.

In the following sections, a literature review was conducted on existing research in the second section; the third section will derive the calculation equation for the information entropy of KAMs disclosure in a single audit report to solve the above-mentioned measurement problem, based on the theory of information entropy and employing logical analysis and hypothetical calculus. Subsequently, the information entropy of KAMs disclosure will be empirically calculated from 2017 to 2020 for longitudinal comparison analysis in the fourth part. Furthermore, the information entropy of KAMs disclosure will be calculated for different years, industries, accounting firms and types of audit opinions to enable horizontal comparison analysis. These empirical results are not only the case application of the derived equations, but also the first quantitative measurement and comparative analysis of the KAMs disclosure quality in successive years. The fifth part of this study will summarize the main findings and discuss the research gaps and prospects.

2. Literature review

During the initial phase of the implementing the new auditing report standards, scholars have shown great interest in the features and issues surrounding KAM disclosure. Liu and Dong [7], as well as Lu and Zhang [8] have extensively analyzed the characteristics of KAMs disclosed in the audit reports of listed companies. They examined the disclosure modes, distribution of quantities, detailed classifications, industry characteristics and firm characteristics. Additionally, they tested the impact of policy implementation based on these characteristic insights [9]. Zhang et al. [10] proposed adopting a specific form of disclosure, increasing the amount of disclosure considering industry characteristics and customer risks, and utilizing a more detailed perspective to determine the type of KAMs. Furthermore, they recommended enhancing the specific provisions regarding the disclosure of KAMs.

As the new auditing report standards were implemented, it has become a significant concern in both practical and theoretical circles whether the disclosure of the KAMs can achieve the expected reform effect of increasing the information content of the audit report. Yin and Li [11] used a cosine algorithm-based text similarity computing tool to explore whether KAMs provided continuous information increment and identified factors influencing this increment. They found strong homogeneity between pre- and post-implementation years, with limited continuous information increment. Han and Liu [12] employed empirical methods, including regression analysis, to examine whether KAMs disclosure in audit reports increased the information content of the reports, and acted as an investment risk signal to the stock market. Liu et al. [13] demonstrated the information value of KAMs disclosure from the perspective of stock liquidity, arguing that audit report reform has achieved its intended purpose of improving the efficiency of the securities market. Zhang et al. [14] discovered that KAMs conveyed incremental risk information to investors in IPO companies and significantly increased IPO underpricing. However, the addition of KAMs only served as a supplement to the disclosure of small companies with limited alternative sources of information, without providing additional information for larger companies that already had relatively comprehensive disclosure channels [15]. Consequently, investors should rationally interpret the information conveyed by key audit items when making investment decisions.

In recent years, relevant research has focused on two main areas: aspects of research, KAMs disclosure factors, and the interaction of KAMs disclosure. Scholars have examined various factors that influence Certified Public Accountant’s decision-making regarding KAMs disclosure. These factors include auditor gender [16], firm size [17], alumni relationships [18], information technology background of the signing accountant [19], auditor changes [20], informal audit team size [21], auditor fraud detection [22], negative media coverage [23], etc. Regarding the relevance of KAMs disclosure, the focus lies in understanding the relationship or impact of KAMs disclosure on audit quality [24,25], audit costs [26], internal control [27], investment efficiency [28,29], enterprise innovation [30], earnings management [31], accounting robustness [32], risk disclosure [33,34], and other related areas. One of the primary challenges faced by researchers is finding suitable proxy indicators that effectively capture KAMs disclosure. A common approach is to use the logarithmic value of the number of disclosed items. However, it is evident that such proxy indicators offer a relatively rough representation of KAMs disclosure quality and the amount of information conveyed.

In addition, the entropy theory used for reference in this paper has been widely applied in many fields and themes, such as literature communication [35], information science [36], stock market [37], and rural tourism [38]. Entropy weight method is widely used in all kinds of evaluation activities [39,40]. However, except for audit evaluation, the application of entropy theory in the study of disclosure quality and information value of KAMs in audit reports has hardly been reported.

In summary, previous research on KAMs disclosure quality has focused on understanding the characteristics and influencing factors of KAMs disclosure. Additionally, empirical studies have examined the effectiveness of KAMs disclosure based on the information content and interaction relationships involved. To study the quality and effectiveness of KAMs disclosure, it is crucial to adopt effective

methods for measuring the information quantity of KAMs disclosure in a scientific and accurate way. The conventional approach of using the number of disclosure items in an audit report as a logarithmic measure is not reasonable or accurate for assessing the quality or information content of KAMs. Therefore, in this study, we aim to expand KAM-related research by calculating the information entropy of KAM disclosure using information entropy theory, providing a more comprehensive analysis.

The quality and information content of KAMs disclosure are closely related to their homogeneity. However, homogeneity is a characteristic that requires comparison and definition within a system, such as a cluster of audit reports over a specific period of time, within an industry, or within an accounting association. If the KAMs disclosed in the audit report within the system are concentrated in one or a few categories, the homogeneity is higher, indicating an “Order” characteristic of the system. Conversely, if the disclosed KAMs are diverse, scattered, and do not exhibit the characteristics of clustering, then the homogeneity is low, indicating a “Disorder” characteristic of the system. Therefore, we can refer to the idea that “Entropy decrease” and “Entropy increase” meant “Order and disorder” respectively in the theory of Entropy Theory. By calculating the entropy value of KAMs disclosure, we can gauge the level of homogeneity and infer the quality or information content of KAMs disclosure.

3. Calculation method for deriving the information entropy of KAM disclosure

This part is divided into three sections. The basic concepts and formulas of entropy theory are described in section 3.1, and as a reference, the system-scale formula of information entropy value of KAMs disclosure is deduced in section 3.2. Based on this, the formula of reporting scale is put forward through the further shift and derivation in section 3.3.

3.1. Concept of information entropy

The concept of entropy in information theory, which originated from the thermodynamics, a branch of physics, is closely related to the thermodynamic entropy [41]. In thermodynamics, entropy, also known as thermal entropy, is defined as the logarithm of the number of possible states of a system. It is a physical quantity that quantifies the disorder of molecular states [42]. The concept of entropy in information theory is inspired by this.

Claude Elwood Shannon, often referred to as the “father of information theory” [43], played a pivotal role in the development of information theory. Information theory considers the transmission of information as a statistical phenomenon. His groundbreaking paper *A Mathematical Theory of Communication* [44], published in the Bell System Technical Journal in October 1948, is considered the starting point of modern information theory. In this paper, Shannon introduces the concept of information entropy to measure the amount of information contained in a message. Table 1 lists the meanings of the symbols that appear in the following description or derivation of this chapter.

First, let the random variable X have values of X_1, X_2, \dots, X_N , $P(X_i)$ is the probability of the event X_i , and $\sum_{i=1}^N P(X_i) = 1$.

Second, let the information contained in the event X_i be the negative logarithm of its occurrence probability, which is denoted by $I(X_i)$, then Eq. (1) is:

$$I(X_i) = -\log(P(X_i)) \tag{1}$$

Then, let the average information contained in the random variable X be $H(X)$, i.e., the expected value. It is equal to the synthesis of each possible outcome in a trial multiplied by the probability of its outcome. Thus, the information entropy is calculated by Eq. (2):

$$H(X) = E[I(X_i)] = E[-\log(P(X_i))] = -\sum_{i=1}^N P(X_i)\log(P(X_i)) \tag{2}$$

Based on Shannon’s definition and mathematical equation, we can see that information entropy is actually a mathematical expectation of the information contained in a random variable. Information entropy is a quantifiable measure that relates to information. The unit of information entropy is related to the logarithm base, most commonly using 2 (unit: Bit). In theoretical derivations, the natural constant e is often used as the logarithm base (unit: nat). Other bases and units can also be used interchangeably.

Table 1
The interpretation of formula notations.

Notations	Entropy theory formula	Entropy formula of KAMs
X_i	represent a random event or situation	represent a KAM
$P(X_i)$	represent the probability that a random event will occur	represent the frequency of occurrence of a KAM
$I(X_i)$	the negative logarithm of a random event’s occurrence probability	/
$H(X)$	the average information contained in the random variable	the entropy value of KAMs disclosure
Q	/	the total number of KAMs disclosed by audit reports within a system
N	/	the type number of KAMs disclosed by audit reports within a system
$Q(X_i)$	/	corresponding number of a certain KAM disclosed
J	/	represent the Pielou’s evenness index
$AR_{(X_i)}^j$	/	represent a KAM named X_i is disclosed in No. j audit report
T	/	represent the number of KAMs disclosed in an individual audit report

3.2. System-scale inference of information entropy value of KAM disclosure

Information entropy serves a dual purpose. Firstly, it enables the evaluation of the equilibrium and complexity levels within a system, providing a measure of its disorderliness. If a system is orderly, its information entropy is low; if a system is disorderly, its information entropy is high [45]. From the perspective of information transmission, information entropy represents the value of information itself. It allows for further insights and inferences regarding information transmission processes and the circulation of knowledge [46–49].

Secondly, KAM disclosure fundamentally involves information transmission. To enhance the communicative value of audit reports, it is essential to conduct scientific and quantitative analysis of the information value contained in the disclosed KAMs. However, variations in audit subjects' practices and preferences, industry attributes, macro-institutional environment can lead to differences in KAM disclosure [50,51]. In other words, the disclosure of KAMs can exhibit both "Order" or "Disorder" within the information transmission system.

Therefore, this study considers the cluster of audit reports sharing common characteristics as an information transmission system. This can refer to audit reports within a specific time frame, within an industry, or on a regional scale. Each audit report within the system serves as an independent unit of information, and each disclosed KAM can be seen as an event. To capture the spatiotemporal distribution patterns of changes and types of KAM disclosure, this study incorporates the concept of "entropy" from thermodynamics and applies the information entropy theory.

Suppose that within a certain period of time, there are a total of Q KAMs disclosed and a total of N KAM types within a certain industry, or region, or other system scale, which are denoted by X_1, X_2, \dots, X_N , respectively. Their corresponding number of KAMs disclosed is denoted by $Q(X_1), Q(X_2), \dots, Q(X_N)$, respectively. The proportion of the number of KAMs disclosed to the total number of KAMs disclosed is denoted by $P(X_1), P(X_2), \dots, P(X_N)$, respectively. Where $P(X_i) = Q(X_i) \div Q$, which satisfies $\sum_{i=1}^N P(X_i) = 1$ and $Q(X_i) \neq 0$. Then the information entropy of KAM disclosure is expressed in Eq. (3).

$$H(X) = - \sum_{i=1}^N P(X_i) \ln P(X_i) = - \sum_{i=1}^N \frac{Q(X_i)}{Q} \ln \frac{Q(X_i)}{Q} \quad (3)$$

In the above equation, the information entropy is measured in Nat, and serves as an indicator of the balance of KAM disclosure. A larger information entropy value reflects a more balanced the KAM disclosure. When the frequencies of all types of KAM disclosures are equal, they are considered to be in a state of balance. During this time, the KAM disclosure is characterized as the most disorderly, and the information entropy reaches its maximum value, denoted as, $H(X)_{MAX} = \ln N$. Conversely, a smaller information entropy signifies a more unbalanced KAM disclosure, indicating a higher frequency of a specific type of KAM disclosure and a greater degree of homogeneity.

However, due to the subjective nature of KAM disclosure, there is no standardized classification system. The types of KAMs can vary, resulting in a lack of comparability in the information entropy of KAM disclosure. To address this issue, the Pielou's evenness index [52–54] has been introduced as a solution. Its formulation is shown in Eq. (4).

$$J = \frac{H(X)}{H(X)_{MAX}} = \frac{- \sum_{i=1}^N P(X_i) \ln P(X_i)}{\ln N} \quad (4)$$

Where: J is the Pielou's evenness index;

$H(X)_{MAX}$ is the maximum information entropy of KAM disclosure;

N is the number of KAM types.

The Pielou's evenness index is proportional to the information entropy. A higher Pielou's evenness index indicates a weaker advantage in the disclosure of a specific type of KAM during the KAM disclosure process. It also suggests a better balance in KAM disclosure, resulting in a lower degree of homogenization in KAM disclosure.

3.3. Deriving the information entropy of KAM disclosure at the audit report scale

It is important to note that the calculation of the information entropy of audit reports using Eq. (3) is based on the entropy of a certain scale system, rather than the information entropy of an individual audit report itself. The determination of whether the disclosure of KAMs enhances the information and communication value of audit reports relies on whether it improves the information and communication value of each individual audit report. Therefore, the measurement of the information entropy of an individual audit report and its relationship with audit quality are the central focus of this study. In order to reasonably calculate the information entropy of an individual audit report, the following derivations are further conducted:

Suppose that within a certain time period, there are a total of Q KAM disclosures and a total of N KAM types within a certain scale system, which are denoted by X_1, X_2, \dots, X_N , respectively. Their corresponding number of KAMs disclosed is denoted by $Q(X_1), Q(X_2), \dots, Q(X_N)$, respectively. The proportion of the number of KAMs disclosed to the total number of KAMs disclosed is denoted by $P(X_1), P(X_2), \dots, P(X_N)$, respectively. Where $P(X_i) = Q(X_i) \div Q$, which satisfies $\sum_{i=1}^N P(X_i) = 1$ and $Q(X_i) \neq 0$.

Also, suppose that a certain KAM type is disclosed in k audit reports, and each disclosure is represented by $AR_{(X_i)}^j$, where $j =$

1, 2, 3, ..., k , which means that the KAM X_i is disclosed in No. j audit report. Since the same KAM type will only be disclosed once in an audit report, that is, $AR_{(X_i)}^j = 1$, then: $Q(X_1) = \sum_{j=1}^k AR_{(X_1)}^j = AR_{(X_1)}^1 + AR_{(X_1)}^2 + \dots + AR_{(X_1)}^k = k \times 1 = k$.

Likewise: $Q(X_2) = \sum_{j=1}^m AR_{(X_2)}^j = AR_{(X_2)}^1 + AR_{(X_2)}^2 + \dots + AR_{(X_2)}^m = m \times 1 = m$; $Q(X_N) = \sum_{j=1}^t AR_{(X_N)}^j = AR_{(X_N)}^1 + AR_{(X_N)}^2 + \dots + AR_{(X_N)}^t = t \times 1 = t$.

Finally, suppose that a total of T_j KAMs are disclosed in No. j audit report, then: $T_j = AR_{(X_1)}^j + AR_{(X_2)}^j + \dots$.

Eq. (3) is rewritten as Eq. (5):

$$H(X) = - \sum_{i=1}^N \frac{Q(X_i)}{Q} \ln \frac{Q(X_i)}{Q} = - \left(\frac{Q(X_1)}{Q} \ln P(X_1) + \frac{Q(X_2)}{Q} \ln P(X_2) + \dots + \frac{Q(X_N)}{Q} \ln P(X_N) \right). \quad (5)$$

Then, $Q(X_1)$, $Q(X_2)$, ..., $Q(X_N)$ are substituted into the above equation respectively, and the above equation is further rewritten as Eq. (6):

$$H(X) = - \left(\left(\frac{AR_{(X_1)}^1 + AR_{(X_1)}^2 + \dots + AR_{(X_1)}^k}{Q} \right) \ln P(X_1) + \left(\frac{AR_{(X_2)}^1 + AR_{(X_2)}^2 + \dots + AR_{(X_2)}^m}{Q} \right) \ln P(X_2) + \dots \right). \quad (6)$$

According to the principle of merging KAMs in the same audit report, the above equation is transposed to Eq. (7):

$$H(X) = - \left(\left(\frac{AR_{(X_1)}^1}{Q} \ln P(X_1) + \frac{AR_{(X_2)}^1}{Q} \ln P(X_2) + \dots \right) + \left(\frac{AR_{(X_1)}^2}{Q} \ln P(X_1) + \frac{AR_{(X_2)}^2}{Q} \ln P(X_2) + \dots \right) + \dots \right). \quad (7)$$

As $AR_{(X_1)}^j = AR_{(X_2)}^j = \dots = AR_{(X_N)}^j = 1$, the above equation is rewritten as Eq. (8):

$$H(X) = - \left(\left(\frac{AR_{(X_1)}^1 + AR_{(X_2)}^1 + \dots}{Q} (\ln P(X_1) + \ln P(X_2) + \dots) \right) + \left(\frac{AR_{(X_1)}^2 + AR_{(X_2)}^2 + \dots}{Q} (\ln P(X_1) + \ln P(X_2) + \dots) \right) + \dots \right). \quad (8)$$

Put $T_j = AR_{(X_1)}^j + AR_{(X_2)}^j + \dots$ into the above formula, and it is simplified as Eq. (9):

$$H(X) = - \left(\left(\frac{T_1}{Q} (\ln P(X_1) P(X_2) \dots) \right) + \left(\frac{T_2}{Q} (\ln P(X_1) P(X_2) \dots) \right) + \dots \right). \quad (9)$$

Based on the equation mentioned above, the definition is made as follows: The information entropy of KAM in a certain scale system refers to the weighted average logarithm value obtained by multiplying the disclosure frequency of KAMs in each audit report that comprises the system. The weights are determined by the proportion of the number of KAMs disclosed in each audit report to the total number of KAMs disclosed in the entire system. Consequently, the information entropy of an individual audit report within the system can be calculated using Eq. (10):

$$H(X) = - \frac{T}{Q} \ln \prod_{i=1}^T P(X_i) \quad (10)$$

Where: $H(X)$ is the information entropy of an individual audit report;

T is the number of KAMs disclosed in an individual audit report;

Q is the total number of KAMs disclosed in all audit reports within a system;

$P(X_i)$ is the disclosure frequency of KAM X_i in the system.

4. Analysis of the results

The below section 4.1 provides a detailed breakdown of the data used in the empirical study. Then, the entropy of KAMs disclosure on a system scale of year, stock sector, industry sector, accounting firms, and type of audit opinion are calculated and compared in sections 4.2 through 4.6 accordingly. In this chapter, the change rules of KAMs disclosure entropy are analyzed and the disclosure quality are evaluated in different systems.

4.1. Data source and processing

In this study, we collected audit reports from listed companies traded on the Shanghai Stock Exchange and the Shenzhen Stock Exchange for the fiscal years 2017–2020. The samples include companies listed on the Shanghai main board, Shenzhen main board, ChiNext, and STAR Market. The processing of the audit report samples involved the following steps: (1) excluding audit reports of listed companies that were issued but did not express their opinions; (2) excluding the audit reports of listed companies that did not explicitly disclose KAMs; (3) excluding the audit reports of listed companies with incomplete information. Finally, we obtained a total of 14,837 audit reports from 4159 listed companies, and their distribution is presented in Table 2.

As shown in Table 2, the audit reports from 2017 are 3,468, accounting for 23.37 % of the total samples and 98.75 % of the total audit reports (3,512) in 2017. The audit reports from 2018 are 3,541, accounting for 23.87 % of the total samples and 98.17 % of the total audit reports (3,607) in 2018. The audit reports from 2019 are 3,747, accounting for 25.25 % of the total samples and 98.27 % of the total audit reports (3,813) in 2019; the audit reports from 2020 are 4,081, accounting for 27.51 % of the total samples and 94.93 % of the total audit reports (4,299) in 2020. These figures indicate a balanced distribution of samples across the years, with each year accounting for approximately 25 % of the total. Except for slightly less than 95 % in 2020, the audit report samples from the other years accounted for more than 98 % of the total audit reports for their respective years. This indicates that the study samples are well-distributed and representative across the years.

Among the 14,837 study samples, 11,407 (76.88 %) were audit reports from the main board (Shenzhen main board, Shanghai main board, SME board), representing 97.77 % of the total audit reports (11,667) from the main board. The audit reports of the ChiNext are 3,124, accounting for 21.06 % of the total samples and 97.44 % of the total audit reports (3,206) of the ChiNext; the audit reports of the STAR Market are 306, accounting for 2.06 % of the total samples and 85.47 % of the total audit reports (358) of the STAR Market. These findings indicate the main board market is the primary focus of the capital market, with a concentration of study samples in this market, followed by the ChiNext; With the exception of around 85 % of the STAR Market, the audit report samples from the main board and the ChiNext account for more than 97 % of the total audit reports for their respective boards. This indicates that the study samples are well-distributed and representative across the different boards.

Among the 14,837 study samples, 1036 (6.98 %) audit reports were issued by the international Big Four firms, while 13,801 (93.02 %) were issued by domestic accounting networks and associations. Among these samples, there were 14,113 audit reports with standard unqualified opinions (95.12 %) and 387 unqualified audit reports with an emphasis of matter (2.61 %). The number of qualified audit reports was 337 (2.27 %).

Referring to the categorization of KAMs by Liu and Dong [7], and considering the latest KAM disclosures and the requirements of this study, we divided the KAMs into 30 categories and 66 items [55]. Due to space limitations, the detailed list of these categories and items is not provided here.

4.2. Comparison of the information entropy of KAM disclosure of different years

If we consider the KAM disclosure of different years as independent systems, we can compare the information entropy of KAM disclosure for each year (as shown in Fig. 1) using Equation (3). The analysis leads to the following conclusions.

First, the information entropy of KAM disclosure decreases almost linearly from 2017 to 2020 by either category or subcategory. This suggests that KAM disclosure has evolved towards greater “orderliness” and an increasing dominance of a single KAM disclosure. In other words, there is an increasing homogenization degree in KAM disclosure over time.

Second, the information entropy is influenced by the degree of classification of KAMs. The information entropy of KAM disclosure of different years calculated by category is lower than that calculated by subcategory. In practice, a general classification of KAMs underestimates the information entropy of KAM disclosure, while a detailed classification accurately reflects the information entropy of KAM disclosure.

Third, the change in information entropy of KAM disclosure does not appear to be closely related to the degree of classification of KAMs. The change trends in information entropy of KAM disclosure for different years, calculated by either category or subcategory, are almost parallel, indicating good agreement. Therefore, it is possible to assess the change trends in information entropy of KAM disclosure without requiring the detailed classification of KAMs.

The comparison of the evenness of KAM disclosure across different years (as illustrated in Fig. 2) is determined using Eq. (4). The analysis leads to the following conclusions. First, the evenness of KAM disclosure demonstrates a linear decrease, providing further evidence that KAM disclosure is uneven and gradually moving towards a state of “orderliness”. Second, the evenness of KAM disclosure

Table 2

Year and board distribution of the audit report samples.

Fiscal year	Main board		ChiNext		STAR Market		Annual total
	Report (pcs.)	Proportion (%)	Report (pcs.)	Proportion (%)	Report (pcs.)	Proportion (%)	Report (pcs.)
2017	2754	79.41 %	714	20.59 %	0	0	3468
2018	2804	79.19 %	737	20.81 %	0	0	3541
2019	2865	76.46 %	790	21.08 %	92	2.46 %	3747
2020	2984	73.12 %	883	21.64 %	214	5.24 %	4081
Total	11407	76.88 %	3124	21.06 %	306	2.06 %	14837

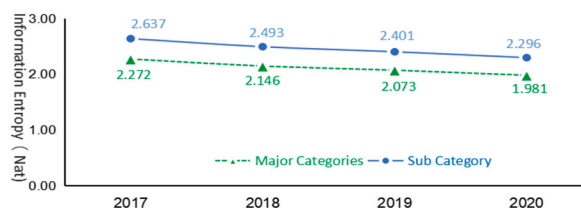


Fig. 1. Comparison of the information entropy of KAM disclosure of different years.

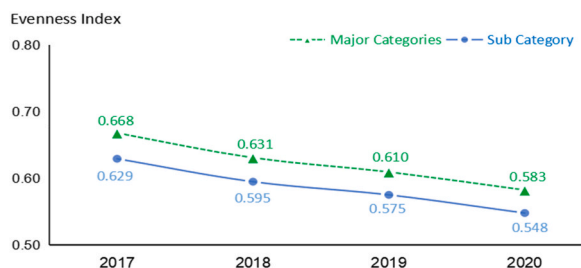


Fig. 2. Comparison of the evenness of KAM disclosure of different years.

is associated with the degree of classification of KAMs.

In practice, the broad classification of KAMs results in the falsely high evenness of KAM disclosure, as it reduces the disparity in the disclosure frequency among different KAM types. On the other hand, a detailed classification of KAMs offers a more objective evaluation of the evenness in KAM disclosure.

To sum up, the KAM disclosure does not adhere to the “principle of entropy increase”, where suggests a transition from low entropy (order) to high entropy (disorder) [56]. Instead, it evolves in the opposite direction. This implies that accounting firms and CPAs tend to homogenize KAM disclosure in audit reports [57,58].

4.3. Comparison of the information entropy of KAM disclosure of different boards

If we consider the KAM disclosure of different boards as independent systems, we can calculate the information entropy and evenness of KAM disclosure for each board (as shown in Figs. 3 and 4) using Eqs. (3) and (4). Upon analysis, the following conclusions are drawn. The information entropy and evenness of KAM disclosure follow a decreasing order from the main board to the ChiNext and STAR Market. The main board exhibits significantly higher information entropy and evenness in KAM disclosure compared to the ChiNext and STAR Market.

This indicates that KAM disclosure on the main board is characterized by higher disorderliness and balance, with a lower degree of homogenization and higher quality. These findings suggest that enhancing the information and communication value of KAMs disclosed in the audit reports of companies listed on the ChiNext and STAR Market is necessary to improve the overall quality of KAM disclosure.

4.4. Comparison of the information entropy of KAM disclosure of different industries

If we consider the KAM disclosure of different industries as independent systems, we can determine the information entropy and evenness of KAM disclosure for each industry (as shown in Figs. 5 and 6) using Eqs. (3) and (4). The analysis leads to the following conclusions.

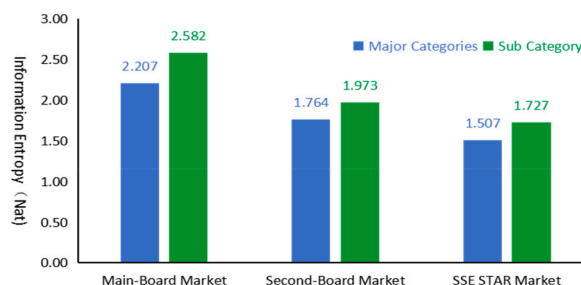


Fig. 3. Comparison of the information entropy of KAM disclosure of different boards.

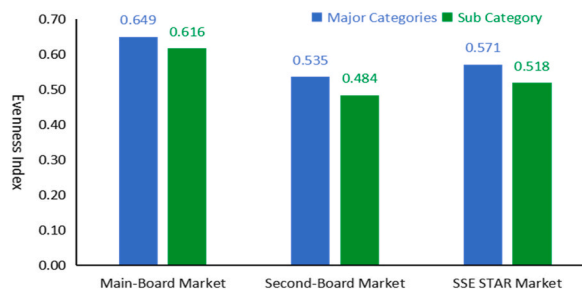


Fig. 4. Comparison of the evenness of KAM disclosure of different boards.

First, the overall information entropy of KAM disclosure in the five industries of transportation, storage and postal services, mining, finance, power supply, heating, gas and water supply rank among the top five, indicating these industries have high entropy in KAM disclosure. Additionally, the evenness of KAM disclosure in the five industries ranks at the top. This indicates that the KAM disclosure of the five industries is both disorderly and balanced, suggesting that the disclosed KAMs hold effective information value.

Second, the information entropy of KAM disclosure in the residential services, repair and other services, health and social work, scientific research and technology service. Construction and education industries ranks among the bottom five, indicating these industries have low entropy in KAM disclosures.

Furthermore, the evenness of KAM disclosure in the health and social work, scientific research and technology services, and construction industries ranks at the bottom. This implies that the KAM disclosure in these industries is orderly and unbalanced, with a dominance of a single KAM, resulting in a high degree of homogenization in KAM disclosure and information redundancy.

Third, the information entropy and evenness of KAM disclosure of the manufacturing industry are generally in the middle range. Since the manufacturing industry accounts for over 60 % of both audit reports and KAMs, it has a significant impact on the entire KAM disclosure system and its information value. This suggests that we should pay close attention to KAM disclosure in the manufacturing industry and strive to improve the information entropy and evenness of KAM disclosure, enhancing the information value of KAMs disclosed.

4.5. Comparison of the information entropy of KAM disclosure of different accounting firms

If we consider the KAM disclosure of different accounting firms (including big 4 accounting firms, big 8 accounting firms and

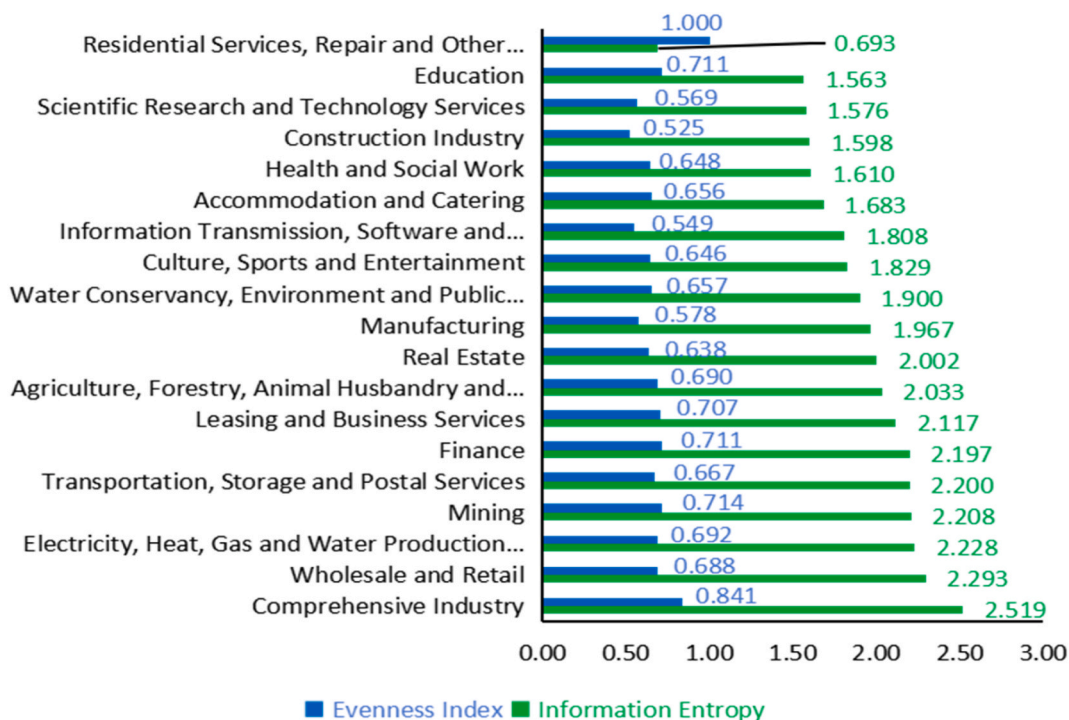


Fig. 5. Comparison of the information entropy and evenness of KAM disclosure of different industries (by category).

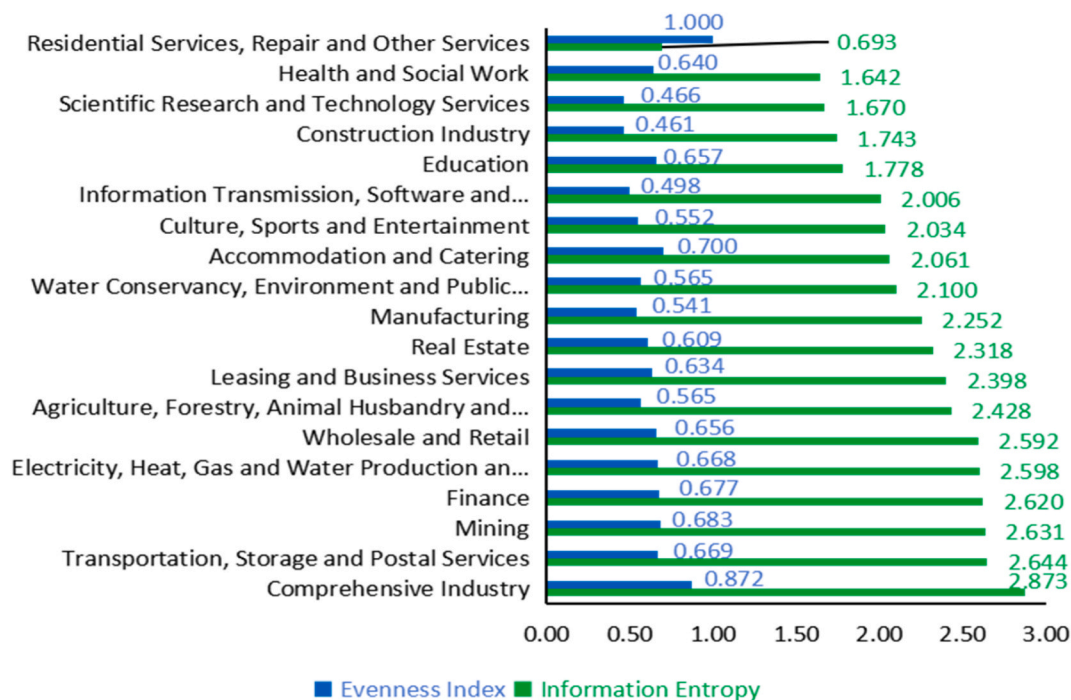


Fig. 6. Comparison of the information entropy and evenness of KAM disclosure of different industries (by subcategory).

domestic accounting firms) as independent systems, we can determine the information entropy and evenness of KAM disclosure for each firm (as shown in Figs. 7 and 8) using Eqs. (3) and (4). The analysis leads to the following conclusions.

The information entropy and evenness of KAM disclosure decrease in the following order: big 4 accounting firms, domestic accounting firms and big 8 accounting firms. Specifically, the information entropy and evenness of KAM disclosure of the big 4 accounting firms are higher compared to those in domestic accounting firms and big 8 accounting firms. The KAM disclosure of Big Four accounting firms exhibits more disorderliness and balance, indicating a lower degree of homogenization and higher quality of KAM disclosure [59,60]. Overall, there is indeed a gap in practice quality and audit reports between domestic accounting firms, big 8 accounting firms and the big 4 accounting firms. At the same time, it is important to note that the information entropy and evenness of KAM disclosure in the big 8 accounting firms are worse than those in other domestic accounting firms, indicating a relatively low overall quality of KAM disclosure.

The above findings clearly demonstrate that domestic accounting firms, especially the big 8 accounting firms, should place significant emphasis on the quality of KAM disclosure and its information value, avoiding a mere formality. It is crucial to effectively enhance the quality and communicative value of audit reports, which will further improve the practice quality and professional reputation of domestic accounting firms and narrow the gap with Big Four accounting firms.

4.6. Comparison of the information entropy of KAM disclosure of different audit opinion types

If we consider the KAM disclosure of different audit opinion types as independent systems, we can determine the information

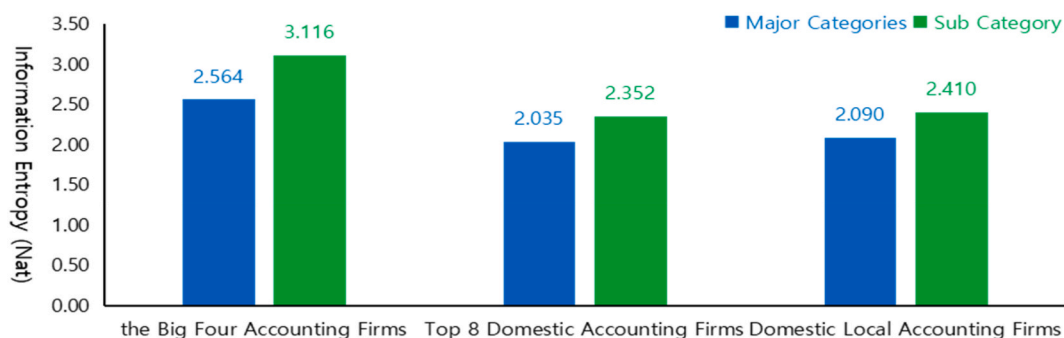


Fig. 7. Comparison of the information entropy of KAM disclosure of different accounting firms.

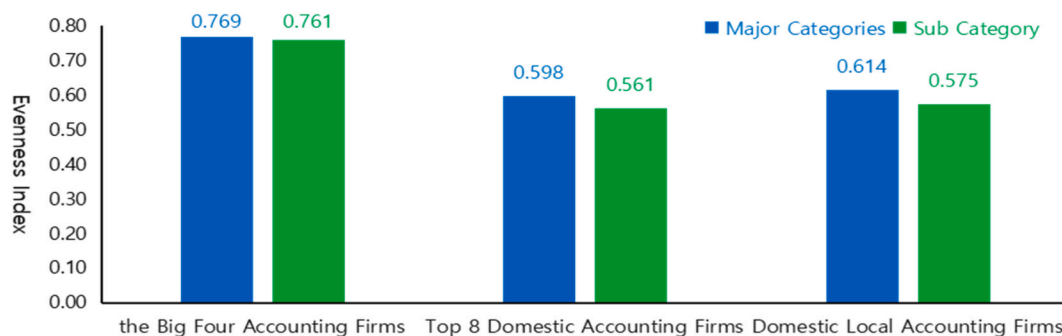


Fig. 8. Comparison of the evenness of KAM disclosure of different accounting firms.

entropy and evenness of KAM disclosure for each type (as shown in Figs. 9 and 10) using Eqs. (3) and (4). The analysis leads to the following conclusions.

The information entropy and evenness of KAM disclosure in audit reports with unqualified opinions accompanied by emphasis of matter paragraphs are higher compared to those with standard unqualified opinions and qualified opinions. This indicates that the KAMs disclosed when the CPA provides unqualified opinions with emphasis of matter paragraphs hold greater information value, and they are more disorderly and balanced. This observation may be directly related to the nature and issuance requirements of different audit opinion types [61].

An unqualified audit opinion signifies that the auditor found no significant violations or misstatement in a company's financial statements, which are accurate, complete, explicit and without material omissions. The KAM disclosure in the audit reports with unqualified opinions lacks substantial content [62]. In practice, most CPAs and accounting firms tend to be perfunctory in their KAM disclosure efforts, resulting in the uniform or untargeted KAM disclosure. As a result, the information entropy and evenness of KAM disclosure are not high.

An unqualified opinion suggests that the auditor identified issues in a company's financial statements, such as substantial doubts or uncertainties regarding the company's ability to continue as a going concern. In such cases, most companies have significant matters that impact the audit of the current financial statements, requiring the CPA to exercise professional judgment in identifying and disclosing these matters as KAMs. Consequently, the information entropy and evenness of KAM disclosure in the audit reports with unqualified opinions with emphasis of matter paragraphs are expected to be high, indicating a high level of communicative value in the KAMs.

A qualified opinion indicates that the auditor identified significant material misstatements in the financial information, although the financial statements are fairly presented in all material respects. In these instances, most companies also have important matters affecting the audit of their financial statements. Some of these matters will be listed as the basis for forming reservations and cannot be repeatedly disclosed as KAMs according to relevant regulations.

Therefore, in audit reports with qualified opinions, the primary communicative value may lie in the matters listed as the basis for forming reservations, followed by the KAMs disclosed. In terms of the information entropy and evenness of KAM disclosure, the audit reports with qualified opinions fall between the audit reports with standard unqualified opinions and the audit reports with unqualified opinions with emphasis of matter paragraphs in terms of information entropy and evenness of KAM disclosure.

5. Conclusions and enlightenment

5.1. Research summary

The research in this paper presents an innovative approach by integrating information entropy theory with the practical communication of KAMs. The paper derives an equation for calculating the information entropy of an individual audit report. The information entropy of an audit report within a specific system is determined by the weighted average logarithm value of the continuous product of KAM disclosure frequencies. The equation can be applied to calculate the information entropy of audit reports from different years, boards, industries, accounting firms and audit opinion types. By doing so, it effectively addresses the agency problem associated with the quality of disclosure and the quantity of information related to key audit matters in empirical research.

The findings indicate that from 2017 to 2020, KAM disclosure has been moving towards "orderliness", with a growing dominance of individual KAMs and an increasing level of homogenization. Moreover, the information entropy and evenness of KAM disclosure on the main board are significantly higher compared to the ChiNext and the STAR Market; Among the five industries analyzed (transportation, storage and postal services, manufacturing, finance, power supply, heating, gas and water supply), the overall KAM disclosure quality ranks among the top five; The Big 4 accounting firms exhibit higher information entropy and evenness in KAM disclosure compared to domestic and Big 8 accounting firms. Additionally, KAMs disclosed in audit reports with unqualified opinions and emphasis of matter paragraphs offer greater information value, displaying a more disorderly and balanced pattern. These findings make a valuable contribution to the research on the impact of key audit matters disclosure reform.

In practice, individual certified public accountants can utilize the information entropy measurement formula proposed in this paper

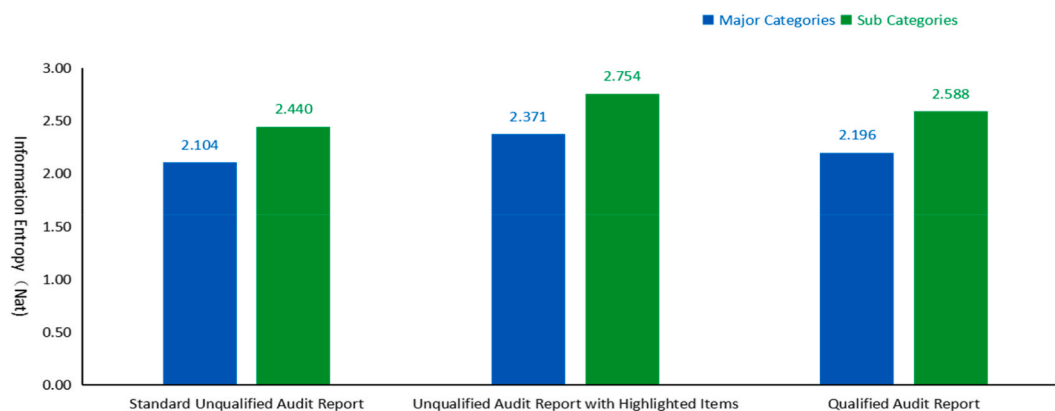


Fig. 9. Comparison of the information entropy of KAM disclosure of different audit opinion types.

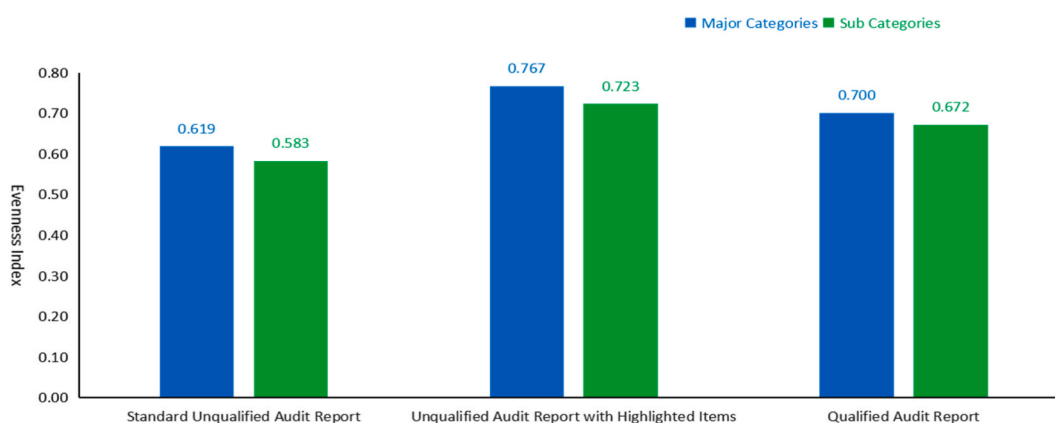


Fig. 10. Comparison of the evenness of KAM disclosure of different audit opinion types.

to calculate the information entropy of a signed report within a specific time frame. This enables the quantification of the information content and value of the audit report, facilitating report review and improving the disclosure level of key audit matters. The Accounting networks and associations can employ the audit report information entropy measurement tool for subsequent analysis and comparative evaluation within their firm's system, thereby enhancing the overall standard of audit practice through quality control and internal governance. Furthermore, industry associations can leverage the information entropy data from audit reports at the system and reporting scale, serving as an objective basis for industry supervision and quality inspection of practices.

5.2. Research limitations

In previous studies, the calculation of information entropy for audit reports often relied on the logarithmic value of the number of KAMs disclosed. In contrast, this paper takes a progressive approach by employing the theory of information entropy. However, the information contained in KAM disclosures is not solely determined by the number of KAMs, but also by factors such as paragraph number, length, text content of each KAM disclosure and alignment with the actual circumstances. A large amount of disclosure or lengthy disclosures may result in information redundancy, reducing the effectiveness of valuable information. Conversely, a small amount of disclosure or concise disclosures may contain highly valuable content.

Although the method proposed in this paper measures the entropy of KAM disclosure by considering the frequency of disclosure rather than the direct number of items, it still does not fully address the essence of the disclosure text. This diminishes our focus on the "effective information" or "value information" within key audit matters.

5.3. Future research

Under the new audit reporting standard, CPAs are required to adhere to specific guidelines when describing KAMs. The objective is to provide a concise and impartial explanation that allows prospective users to comprehend why a matter was deemed significant enough to be classified as a key audit matter, as well as how it was addressed during the audit process.

It is evident that KAM disclosure is a systematic project, involving prescribed operations, professional implementation by relevant

parties, clear objectives, and targeted audiences. To improve the quality of KAM disclosure and achieve the desired outcomes of the new audit report reform necessitates collaborative efforts from policy-makers, and regulators, accounting firms and auditors, listed companies, the general public and report users, rather than solely relying on CPAs.

Testing the relationship between audit quality and the entropy value of KAM disclosure could be an important avenue for future research. This investigation can be approached from various angles. Firstly, exploring the relationship between the two can be based on factors such as the number of disclosure paragraphs, length and textual content, which serves as key indicators for further analysis. Second, examining the incremental entropy calculation of KAM disclosure in audit reports can provide a more accurate reflection of the effective information contained within KAM disclosure. Lastly, it is crucial to assess whether or not KAM disclosure can continue to provide valuable information for investors to make decisions.

Ethics approval

Not applicable.

Informed consent

Not applicable.

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Data availability statement

Question: Has data associated with your study been deposited into a publicly available repository?

Response: No.

Question: Please select why. Please note that this statement will be available alongside your article upon publication.

Response: Data will be made available on request.

Additional information

No additional information is available for this paper.

CRediT authorship contribution statement

Jintian Lin: Writing - review & editing, Writing - original draft, Visualization, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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