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Applying Benford's Law to Detect Accounting Data Manipulation: An Empirical Study of Non-Performing Loans (NPL) Scenario in Banking Industry of Bangladesh

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Abstract- **Non-performing loans (NPLs) in Bangladesh's banking sector have almost tripled during 2023-2025 period, which points to an impending crisis since increased NPLs reduce a bank's interest income and depletes its capital bases. The economy of Bangladesh is highly dependent on the banking industry as such an increased NPL level not only makes the banks vulnerable, but also erodes the nation's economic stability. It has been alleged that the manipulation of accounting data in the banking industry exacerbates the scenario by painting a seemingly rosy picture where the banks' liabilities are understated and assets are overstated. In this context, this study applies Benford's law in order to detect possible manipulation of banks' loan data, especially the different types of NPLs such as special mention account (SMA), substandard (SS), doubtful (DF), and bad loans (BL). Benford's Law describes the frequency distribution of the leading digits in many naturally occurring datasets and it has been applied to analyze data related to non-performing loans (NPLs) in major commercial banks. A number of statistical tests including chi-squared test and Kolmogorov-Smirnov (K-S) test have been conducted to check conformity of leading digit distribution to Benford's law. A significant deviation from Benford's Law in NPL data has been noticed which indicates potential manipulation or fraudulent activities.**

Keywords - **Non-performing loans (NPLs), accounting data manipulation, Benford's law**

I.INTRODUCTION

In recent times, non-performing loans (NPLs) have turned out to be a critical challenge for banking sectors worldwide, especially in developing economies. These defaulted loans not only undermine the profitability of financial institutions but also endanger the stability of entire financial systems. While the global financial crisis of 2007–2009 revealed flawed accounting reporting in U.S. banks, similar patterns have been witnessed in Bangladesh, albeit under a different set of regulatory and institutional frameworks. Bangladesh's fast-developing banking sector has experienced a notable surge in non-performing loans - with the magnitude of NPLs nearly tripling during the period from 2023 to 2025 [6]. This sparks serious concerns regarding governance framework, regulatory effectiveness, and the transparency of financial disclosures.

Bangladesh's non-performing loan (NPL) crisis emerges from a combination of poor internal controls, political interference, and inadequate risk evaluation practices, especially within state-run banks where the NPL ratios remain persistently higher than in private institutions [3]. The problem got fueled by the prevalence of financial misreporting and audit failures as illustrated by the Hallmark group scandal and BASIC Bank loan scam [2]. A holistic strategy is required to combat the challenge of non-performing loans. Key ideas include strengthening regulatory frameworks, applying strict standards for loan classification and provisioning and fostering greater transparency in financial reporting. Reformation of audit practices to uphold independence and accountability and alignment with global best practices should also be prioritized. Without these reforms, there is heightened risk of further decline in the banking sector, which can hamper inclusive finance initiatives and sustainable economic growth.

This paper applies Benford's law, which predicts the frequency distribution of leading digits in naturally occurring datasets, to detect accounting data manipulation in the NPL scenario in the banking industry of Bangladesh. Its application to analyze loan portfolios, and specifically to classified NPL categories such as Special Mention Account (SMA), Substandard (SS), Doubtful (DF), and Bad Loans (BL), acts as an effective approach to uncover discrepancies in the reported figures.

This paper investigates the conformity of NPL data from major commercial banks in Bangladesh to Benford's Law, utilizing secondary loan data covering the period 2000 to 2024. Through robust statistical measures including the chi-squared, Kolmogorov-Smirnov tests, Mantissa Arc Test and Mean Absolute Deviation (MAD), the study identifies potential anomalies that suggest data manipulation. The insights aim to support regulators, policymakers, and financial stakeholders in enhancing transparency and governance within Bangladesh's banking sector.

II.LITERATURE REVIEW

- *Theoretical Background: Benford's Law and Manipulation Detection*

The estimated frequency of initial (and other) digits in naturally occurring numerical datasets is expressed by Benford's Law. This distribution is appropriate for a range of accounting and economic datasets since it is unit-independent and scale-invariant [1]. Finding deviations from expected patterns is one of its strengths in forensic accounting. It has been used by academics and auditors to

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study banking data [5] taxation [19], corporate earnings [8]; [23], and macroeconomic indicators [12]. The first to detect it was Newcomb [15], and redefined by [3]. It states that the leading digit d (1-9) will appear with the probability
$f(d) = \log_{10}(1 + 1/d)$
(Nigrini, 2012).
For example, approximately 30% of numbers should start with "1," but only ~5% with "9." Benford's methodology does not require predictive models; instead, it assesses whether the digit frequencies in reported numbers match the theoretical distribution [10]. Because manipulation frequently results in unusual digit distributions, anomalies serve as warning signs of inaccurate reporting [15].

- *Non-Performing Loans (NPL) Trends in Bangladesh*

Historical NPL Trends
NPL levels in Bangladesh's banking industry have been consistently high. Systemic flaws in state-owned commercial banks (SCBs) and development financial institutions (DFIs) were reflected in the overall non-performing loan (NPL) percentage of about 34.9% in 2000 (Bangladesh Bank, 2019). The percentage decreased to about 7.3% by 2010 after reforms in the 2000s (Bangladesh Bank, 2019). Nonetheless, SCBs and DFIs continued to exhibit disproportionately large non-performing loans (NPLs), which are frequently associated with lending that is driven by politics [24].
Ratios increased once more after 2010; in 2012, the NPL ratio was 10%, and it varied between 8 and 10% for the next ten years [4]. Although provisions covered only roughly 55% of reported non-performing loans (NPLs), official data by 2023 indicated a 9% percentage [24]. Significant understatement is suggested by independent reviews. For example, an Asset Quality Review (AQR) conducted in 2025 discovered that six significant Islamic banks' actual non-performing loans (NPLs) were over four times greater than their stated amounts, with some banks underreporting by over 70 percentage points [18]. Comparably, a forensic investigation of Global Islami Bank revealed that it underreported non-performing loans (NPLs) in 2023, concealing losses of Tk 2,259 crore, which were later shown to account for 25% of the bank's loan book rather than the 2.6% reported [22].

Loan Classification and Provisioning Framework in Bangladesh
According to Bangladesh Bank regulations, loans are classified into five categories based mostly on days past due: standard, sub-standard, doubtful, bad/loss, and special mention account (SMA) [22]. 1% for standard, 5% for SMA, 20% for sub-standard, 50% for dubious, and 100% for bad/loss are the corresponding provisioning needs (Master Circular on Loan Classification and Provisioning (BRPD Circular No. 15), 2024). The goal of these regulations is to guarantee that credit risk is identified.
Misclassification, however, compromises this structure. In order to keep their "standard" status, banks have been "evergreening" by rolling over delinquent loans [2]. In order to postpone the recognition of defaults, some also capitalized interest that remained unpaid [7]. Such actions reduce the efficacy of provisions and decrease openness.
Bangladesh Bank has tightened oversight in order to address these issues. To get ready for the switch to IFRS 9 by 2027, it tightened classification thresholds, cut the loan write-off duration from three years to two, and released a new Master Circular on Loan Classification and Provisioning in 2024 (Master Circular on Loan Classification and Provisioning (BRPD Circular No. 15), 2024). In instance, among Islamic institutions, the Bank Resolution Ordinance 2025 gave regulators further authority to reorganize or consolidate troubled banks [17]. These actions show an effort to rebuild credibility and acknowledge widespread deception.

- *Upsides of applying Benford's Law*

While there are few direct applications of Benford's Law to the banking industry in Bangladesh, similar research conducted in other developing nations offers pertinent information. Following the implementation of International Financial Reporting Standards (IFRS), Russian banks' financial statements were more Benford-conforming, indicating more openness, according to [8]. [11] used extensive datasets from both developed and emerging economies to show that emerging markets had more departures from Benford's distribution, which is in line with more opportunistic reporting. These results suggest that Benford's Law can successfully draw attention to anomalies in situations where regulatory enforcement is not strong.
Benford analysis and other forensic techniques are flourishing in Bangladesh as a result of the recent revelation of widespread loan misclassification. In the context of the United States, [12] showed that manipulating loan loss provisions and non-performing loan (NPL) numbers downward frequently results in noticeable departures from predicted digit patterns. Similar techniques applied to loan classification data from Bangladesh might uncover systematic distortions, offering a quantitative foundation for identifying institutions that need more investigation.

III.METHODOLOGY

Data Collection
This study is based on secondary data on different categories of classified loans over a twenty five-year period from 2000 to 2024 (although, not all data were obtainable or pertinent to

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the analysis). The sample encompasses loan classifications including Special Mention Account (SMA), Substandard (SS), Doubtful (DF), and Bad Loans (BL) for 49 leading commercial banks operating in Bangladesh. The sample selection covers a broad spectrum of banking institutions including Islamic and conventional banks, state-owned and private banks to ensure a representative dataset. The data are obtained from official financial disclosures, and annual reports of individual banks. According to Benford's Law, in many naturally occurring datasets, the distribution of the first digits follows a logarithmic scale. Here, the digit '1' appears as the leading digit about 30.1% of the time, while the frequencies decline for the subsequent higher digits. Assuming that authentic financial data should conform to Benford's expected frequency distribution of digits (1 through 9), deviations from the pattern may imply potential irregularities such as data fabrication or fraud.

In this study, the leading digit of each loan amount within the classified NPL categories is considered and its frequency distribution compared against the expected frequencies predicted by Benford's Law.

Statistical Tests

To assess whether the distribution of leading digits in the classified loan amounts align with Benford's Law, this study applies four widely accepted statistical measures: Chi-Squared (χ^2) Test, Kolmogorov-Smirnov (K-S) Test, Mantissa Arc Test (MAT) and Mean Absolute Deviation (MAD).

The Chi-Squared (χ^2) Test measures the goodness-of-fit between the observed leading digit frequencies and the expected digit frequencies as mentioned by Benford's Law. A significant Chi-Square (χ^2) value indicates deviation from expected frequencies and is suggestive of data manipulation. The Chi-Square (χ^2) value is gauged as:

$$\chi^2_{(10)} = n\sum_{i=0}^{10} \frac{\left(\hat{\theta}_i - f(i)\right)^2}{f(i)}$$

(Grammatikos & Papanikolaou, 2021).

Kolmogorov-Smirnov (K-S) Test is a non-parametric statistical tool that checks whether the cumulative pattern of observed digits matches what's expected. It's particularly useful in uncovering differences in the shape of the distributions. A significant difference, indicated by a low p-value, suggests that the data does not conform to the law, potentially signaling anomalies or fraud in datasets used in forensic accounting and auditing.

The Mantissa Arc Test (MAT) is a statistical test used to assess data quality and detect potential fraud by comparing the observed mantissa (the fractional part of a logarithm) distribution against Benford's Law. It works by treating the mantissae as points on a unit circle and calculating the "center of mass" of these points to see if the data deviates significantly from the expected circular distribution predicted by the law. A high p-value or a center of mass close to the center of the unit circle indicates conformity to Benford's Law, while low p-values suggest potential data manipulation, however there's no such threshold value prescribed in the literature.

In the context of Benford's Law, Mean Absolute Deviation (MAD) is a statistical measure used to quantify the deviation of a dataset's observed digit frequencies from the expected frequencies predicted by Benford's Law. A higher MAD value, i.e., greater than 0.015 indicates a greater difference from the expected logarithmic distribution, suggesting potential non-conformity with the law, which can be a sign of fraud in areas like financial data analysis.

IV.RESULTS

The different categories of loan data corresponding to the commercial banks in Bangladesh across 2000-2024 were collected for analysis. It should be noted, a number of commercial banks such as Sonali Bank and State Bank of India's data were excluded due to inconsistency in reporting. Besides, a number of banks' data before 2010 were hardly available. Accordingly, those were not considered in the analysis.

Bad Loan:

The bad loan data or bad/loss data corresponding to 623 observations were considered for leading digit analysis with respect to Benford's law. Following are the test results summarized -

- Pearson's Chi-squared test conducted via R-package resulted in the following output:
  $\chi^2 = 35.12$, p-value = 0.000025
- Kolmogorov-Smirnov Test (K-S Test) for Benford's law when conducted yielded the following output:
  D = 1.97, p-value = 0.0004
- Mantissa Arc Test conducted via R-package resulted in the following output:
  L2 = 0.018, p-value = 0.000013
- Mean Absolute Deviation (MAD): 0.004

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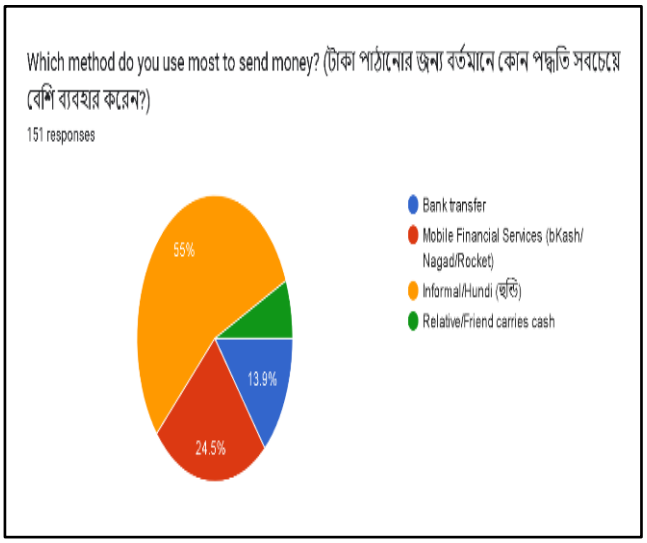

Figure 1: Output from test on 'bad loans' data

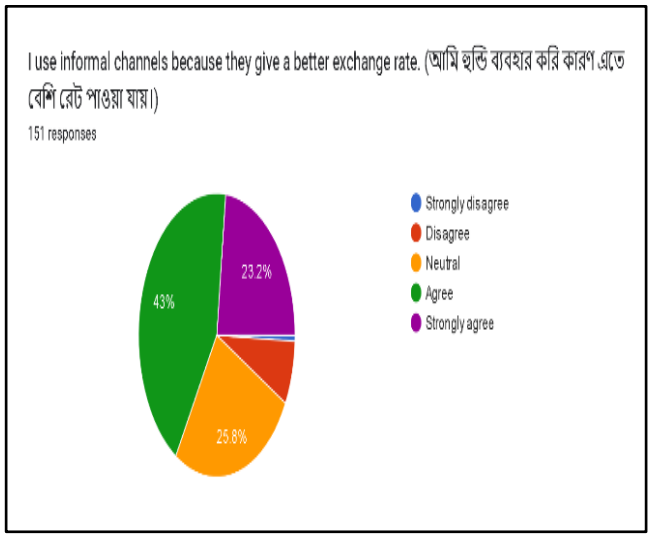

Figure 2: Output from test on 'doubtful loan' data

The results presented above as well as Figure 1 indicate that there were significant deviations from expected distribution of leading digits. One may conclude under the purview of Benford's that such a nonconformity is indicative of manipulation of reported bad loan data.

Doubtful Loan:
The doubtful loan data from 609 valid observations were considered for leading digit analysis with respect to Benford's law. Following are the test results summarized -

- Pearson's Chi-squared test conducted via R-package resulted in the following output:
  $\chi^2 = 20.3$, p-value = 0.009
- Kolmogorov-Smirnov Test (K-S Test) for Benford's law when conducted yielded the following output:
  D = 1.52, p-value = 0.005
- Mantissa Arc Test conducted via R-package resulted in the following output:
  L2 = 0.0103, p-value = 0.0020
- Mean Absolute Deviation (MAD): 0.016

The results presented above followed by Figure 2 indicate that there were significant deviations from expected distribution of leading digits. This conclusion matches with the conclusion from bad loan data analysis and one may conclude under the purview of Benford's that such a nonconformity is indicative of manipulation of reported doubtful loan data.

Sub-standard Loan:
The sub-standard loan data from 612 valid observations were considered for leading digit analysis with respect to Benford's law. Following are the test results summarized -
Following are the test results summarized -

- Pearson's Chi-squared test conducted via R-package resulted in the following output:
  $\chi^2 = 4.59$, p-value = 0.71
- Kolmogorov-Smirnov Test (K-S Test) for Benford's law when conducted yielded the following output:
  D = 1.97, p-value = 0.0004
- Mantissa Arc Test conducted via R-package resulted in the following output:
  L2 = 0.000225, p-value = 0.87
- Mean Absolute Deviation (MAD): 0.008

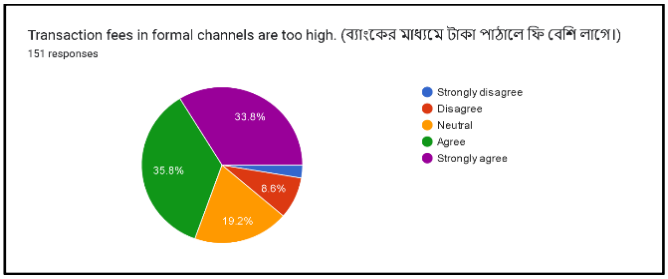

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Figure 3: Output from test on 'sub-standard loans' data

The results presented above followed by Figure 3 does not necessarily indicate that there were significant deviations from expected distribution of leading digits. Only the K-S test may indicate the presence of data manipulations. Therefore, one may not conclude there is nonconformity in the distribution of leading digits as such the report sub-standard loans during the period may not have been misreported.

Special Mention Account Loan:

The special mention account (SMA) loan data corresponding to 591 observations were considered for leading digit analysis with respect to Benford's law. Following are the test results summarized –

- Pearson's Chi-squared test conducted via R-package resulted in the following output:
  $\chi^2 = 14.69$, p-value = 0.0655
- Kolmogorov-Smirnov Test (K-S Test) for Benford's law when conducted yielded the following output:
  D = 0.935, p-value = 0.15
- Mantissa Arc Test conducted via R-package resulted in the following output:
  L2 = 0.0027, p-value = 0.20
- Mean Absolute Deviation (MAD): 0.009

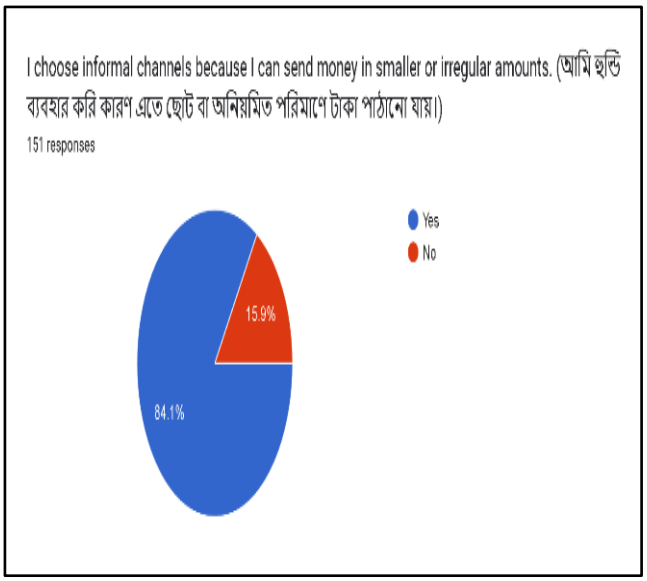

Figure 4: Output from test on 'SMA loans' data

The results presented above followed by Figure 4 does not necessarily indicate that there were significant deviations from expected distribution of leading digits. Only the chi-squared test may indicate the presence of data manipulations. This lack of non-conformity and possible case of fair reporting are intuitive and a bit logical, too. The commercial banks have incentive to misreport the bad loan and doubtful loan data since these two are likely to be reported in the media and scrutinized by most stakeholders.

Unclassified/Standard Loan:

Finally, the standard or unclassified loan corresponding to 662 observations were considered for leading digit analysis with respect to Benford's law. Following are the test results summarized –

- Pearson's Chi-squared test conducted via R-package resulted in the following output:
  X-squared = 14.92, p-value = 0.061
- Kolmogorov-Smirnov Test (K-S Test) for Benford's law when conducted yielded the following output:
  D = 1.49, p-value = 0.007
- Mantissa Arc Test conducted via R-package resulted in the following output:
  L2 = 0.0114, p-value = 0.0005
- Mean Absolute Deviation (MAD): 0.013

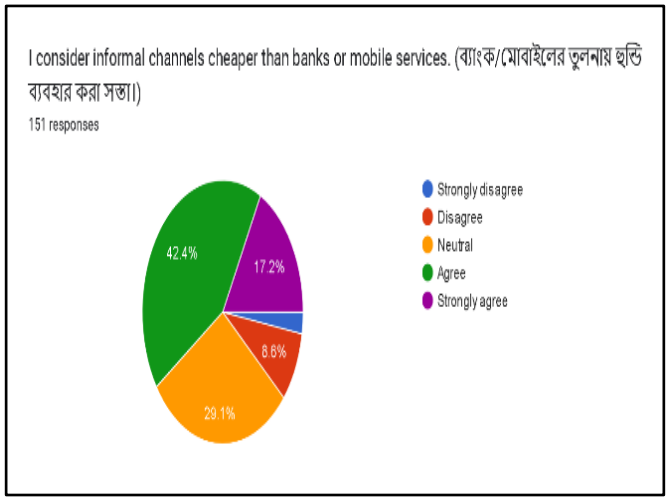

Figure 5: Output from test on 'standard loans' data

The results presented above as well as Figure 5 indicate that there were significant deviations from expected distribution of leading digits. One may conclude under the purview of Benford's that such a nonconformity is indicative of manipulation of reported standard loan data.

V.DISCUSSIONS

The following table summarizes the findings:

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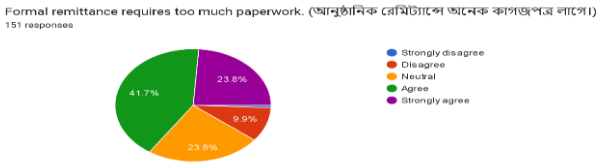

Figure 6: Findings Summary

The analysis of the test results reveals potential signs of data manipulation in certain types of loans. Specifically, the standard (STD), doubtful (DF), and bad loans (BL) loan categories show significant anomalies across multiple tests. For UC/STD loans, the low p-values in the K-S test (0.007), and MAT test (0.0005) suggest deviations from expected patterns, indicating possible data manipulations. Similarly, DF loans exhibit very low p-values across the χ^2 (0.009), K-S (0.005), and MAT tests (0.002) alongside a relatively higher MAD (0.016), pointing to substantial deviation that may reflect manipulative behavior. The BL category shows an even stronger indication of manipulation, with extremely low p-values in all three tests—χ^2 (0.000025), K-S (0.0004), and MAT (0.000013) that clearly displays a significant deviation from expected distribution pattern, which strongly suggests fraudulent data inputs.

Conversely, the SMA and SS loans do not exhibit conclusive signs of manipulation based on the statistical tests. For SMA loans, all p-values are relatively high—χ^2 (0.0655), K-S (0.15), and MAT (0.2)—accompanied by a low MAD (0.009), indicating that the data conforms closely to expected distributions. While SS loans have a low p-value for the K-S test (0.0004), the χ^2 (0.71) and MAT (0.87) tests show no significant deviations, and the MAD value is low (0.008). These mixed results suggest that while some irregularities might exist, there is no strong, consistent evidence of manipulation. Overall, the data for SMA and SS loans appear to be more trustworthy and aligned with natural patterns, contrasting with other loan types where manipulation signs are evident.

VI.CONCLUSION

Considering the recent hike in non-performing loans in Bangladesh's banking industry, this study was motivated to address growing concerns regarding the accuracy of reported loan statistics. An empirical method of determining if reported loan figures match estimated natural trends is to apply Benford's Law. Significant variances for the bad loans and doubtful loan categories are shown in the results, suggesting that the reported data may have been manipulated. The substandard and special mention account categories, on the other hand, are generally consistent with expected digit distributions and do not exhibit any overt indications of manipulation. The study's shortcomings include the fact that Benford's Law is only a screening technique and not a definitive fraud detection tool, and that the dataset employed was aggregate in nature, which reduced precision (Nigrini, 2012). Due to these circumstances, anomalies cannot be used as independent proof, even though they may indicate manipulation. To investigate differences in reporting practices, future study could compare state-owned and private banks or Islamic and conventional banks. For a more thorough evaluation, future research might potentially incorporate transaction-level data or combine forensic auditing with Benford analysis.

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