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Role of ALTMAN Z SCORE MODEL for Checking financial health and detection of financial frauds of top ten public sector banks in India.

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Abstract:

Most of the frauds occurred by corporate and key managerial personnel using the loophole /absence of rules and regulations connected with the bookkeeping / accounting for their personal gain. There are new methods or models developed and used in finding fraudulent practices i.e., The fraud triangle, fraud Diamond, Altman z score and Benford's Law. Benford's Law is widely used for Detection of financial Fraud and crime and known as digit probability. In this study, we use Benford's Law in Detection of financial Fraud or crime of selected public sector banks. We took a sample of top five public sector bank of India. Outcomes of study investigate that the Frequency of first digit to fourth digit of SBI, PNB, BOB, BOI and Canara bank were slightly less than or more than the normal frequency of Benford's law and it is not exact same as Benford's law frequency. This study concludes that if any investor wants to check or collect the evidence then he or she can use Benford's Law in Detection of financial Fraud or crime.

Key words: Financial Fraud or Crime, Digit Probability and Benford's Law.

1. Introduction:

Meaning of frauds: It is defined as an unlawful act which is performed for personal gain. Any unlawful act which contains monetary aspects or finance is called financial frauds. When the frauds are in the terms of manipulation in financial statements then it is known as financial statements frauds. There are multiples types of frauds like: Mail related Fraud, Healthcare Fraud, Debit and Credit Card related Fraud, Bank Account Fraud, Internet Fraud, banking frauds, SMS frauds, etc. Financial fraud occurs when someone harms financial health of corporate through deceptive, misleading, or other illegal practices for personal gain. It can be through a variety of methods such as identity theft or investment fraud. There are multiple types of techniques through which we can check or identify the frauds. i.e., Ratio analysis, The fraud triangle, fraud Diamond, Altman z score and Benford's Law.

Benford's law: It is called as the law of anomalous numbers, Newcomb Benford law and the first-digit law. Benford's law is the observation of many actual sets of numerical data, the first digit is likely to be small. Observation in many sets obey the law, the digit 1 comes as the leading significant digit as 30% times in the data sets, while last digit 9 appears as the leading significant digit less than 5% times in the data sets. If each digit were distributed consistently, they occur about 11.1% times in the data sets. Benford's law also predict about the frequency of second digits, third digits, fourth digit combinations.

2. Review of literature:

Wahyuni et al. (2018) This study examines the elements of fraud diamond theory based on local wisdom on fraud behavior. The study was conducted by taking a sample of 40 finance department employees of all the universities of Buleleng Regency, Bali. Quantitative Research was conducted to address the objective. The outcome of this study is before moderating variable namely the philosophy of social contact harmony presents, all independent variables i.e., pressure, opportunity, rationalization and capacity positively impact on fraud behavior. But when entering the moderating variable in the study, pressure and capacity have a negatively impact while another two variables opportunity and rationalization values are decreasing.

Mateja (2019) This study uses the mathematical tool of determining whether financial statements have a chance of unintentional errors or fraud. According to the standard law bogus numbers have a different pattern than valid or random numbers. It is an effective technique and analytical method to help in detection of accounting fraud. Motives and causes

for fraud was explained by the fraud triangle, which includes perceived pressure, perceived opportunities and their actions. It is just one of the possible number frequency tools used to detect irregularities/abnormality, which can be used in the various projects of data verification in financial statements.

3. Research Methodology

1. Research Design

This study adopts a **quantitative research design** using **forensic accounting techniques** to evaluate the effectiveness of **Benford's Law** in identifying anomalies that may indicate financial fraud in public sector banks in India. The research will be **exploratory and analytical** in nature.

Problems statement: There was a big list of frauds that happened in last decades and it is very difficult to collect evidence that will be helpful in court of law. So, there are multiple techniques which we can use for collecting evidence for presenting in court of case namely, Fraud Triangle, The Fraud Diamond Theory, Altman z score and Benford's Law. In this paper or study, we want to find out the efficiency of Benford's law.

2. Objectives of the Study

1. To assess whether financial data from selected public sector banks follow Benford's Law.
2. To detect any anomalies or deviations from Benford's Law that may suggest manipulation or fraud.
3. To analyze the reliability of Benford's Law as a fraud detection tool in the Indian banking sector.

3. Hypothesis Testing

Null Hypothesis (H_0): The financial data of the selected public sector banks follow to Benford's Law.

Alternative Hypothesis (H_1): The financial data of the selected public sector banks significantly deviate from Benford's Law, indicating possible fraud or manipulation.

4. Target Population is all Public Sector Banks (PSBs) operated in India.

5. Sample Banks: State Bank of India, Punjab National Bank, Bank of Baroda, Bank of India and Canara Bank are the major public sector banks selected purposively based on availability and size.

6. Time Frame: Data for the **last 10 financial years** from 2013–2023 are considered to ensure comprehensive analysis. Time periods is from 2013 to 2022. (10 years)

7. Data Collection Methods: **Secondary Data** will be collected from Annual reports of the selected banks, financial statements (Balance Sheet, Profit & Loss Accounts), Public disclosures on bank websites and RBI reports and banking statistics. Data are collected with the help of CMIE Prowess IQ software for analysis and apply the Benford's law. It includes all the component of Profit and loss a/c, Balance Sheet and Cash Flow Statement

8. Tools and Techniques for Data Analysis: **Benford's Law Application:** Analyze the **distribution of first digits to fourth** of all the selected financial datasets and compare observed frequency distributions with expected distributions based on Benford's Law.

9. Limitations of the Study

Benford's Law is not a conclusive fraud detection tool it only points to anomalies. Possible misinterpretation of anomalies as fraud without corroborating evidence.

4. Data analysis:

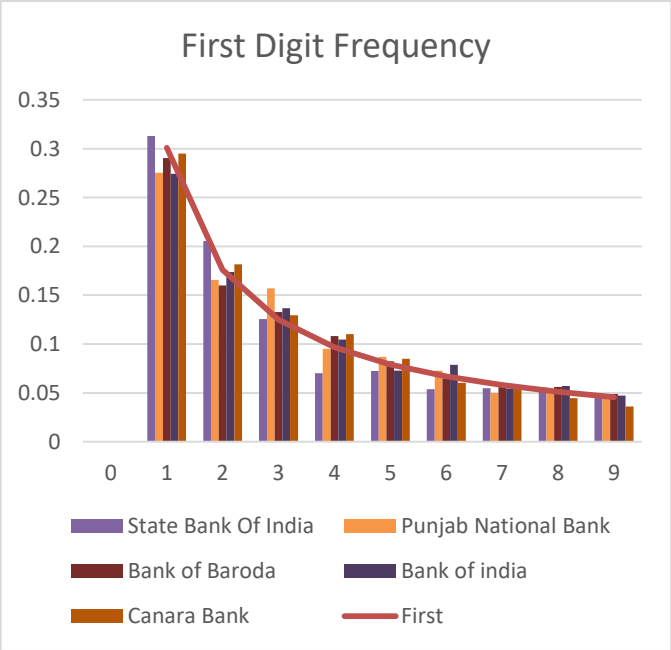
in this study, Benford's law or digit frequency of first four digit of any number or amount is taken into consideration and table of probability of first digit to fourth digits of number and graph was shown given below.

Table:1 Present the First Digit Frequency Count Table:

First Digit	B- First digit frequency	State Bank of India	Punjab National Bank	Bank of Baroda	Bank of India	Canara Bank
0	-	-	-	-	-	-
1	0.30103	0.313081	0.275309	0.290257	0.274409	0.294858

2	0.17609	0.205511	0.16572	0.160014	0.17369	0.181532
3	0.12494	0.125498	0.157033	0.13295	0.136691	0.129416
4	0.09691	0.070053	0.095222	0.108254	0.104488	0.110178
5	0.07918	0.072377	0.086869	0.082206	0.07297	0.084995
6	0.06695	0.053785	0.072837	0.064953	0.078794	0.060511
7	0.05799	0.054781	0.049783	0.056157	0.054471	0.057712
8	0.05115	0.055445	0.051453	0.056157	0.057211	0.044771
9	0.04576	0.049469	0.045773	0.049053	0.047276	0.036027
Total		1	1	1	1	1

Graph-1 shows the First Digit Frequency Count



Analysis of Table:1

Objective 1: To assess whether financial data from selected public sector banks follow Benford's Law.

Benford's Law predicts a specific distribution for the leading digits in naturally occurring datasets, with the digit '1' expected to appear about 30.1% of the time, and subsequent digits appearing with progressively lower frequencies. Comparing the first digit frequencies from the selected public sector banks State Bank of India, Punjab National Bank, Bank of Baroda,

Bank of India, and Canara Bank against Benford's expected values, we observe a generally similar pattern. For instance, the digit '1' is the most frequent first digit in all banks, with values ranging from 27.44% (Bank of India) to 31.31% (State Bank of India), which closely aligns with Benford's expected 30.1%. Other digits follow the decreasing trend, though with some variation. These patterns suggest that, overall, the financial data of these banks exhibit a distribution that is reasonably consistent with Benford's Law.

Objective 2: To detect any anomalies or deviations from Benford's Law that may suggest manipulation or fraud.

While general conformity to Benford's Law is noted, certain deviations can be observed. For example, Punjab National Bank shows a relatively lower frequency for the digit '1' (27.53%) and a higher value for the digit '3' (15.70%) compared to the expected 12.49%. Similarly, Bank of India shows a higher-than-expected frequency for the digit '4' (10.83%) and a slightly elevated count for digit '2' (17.37%). These variances, although not conclusively indicative of fraud, could warrant further statistical testing or scrutiny to rule out possible data manipulation, especially if consistent patterns of deviation appear across several years or account types.

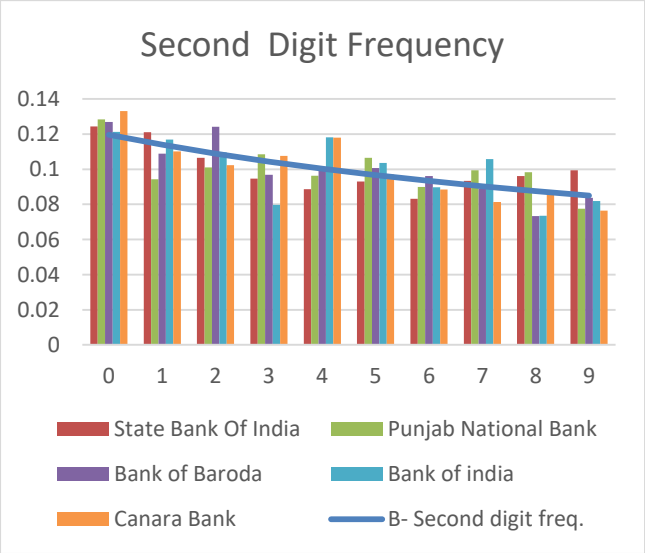
Objective 3: To analyze the reliability of Benford's Law as a fraud detection tool in the Indian banking sector.

The results indicate that while Benford's Law can serve as a useful preliminary screening tool to identify unusual patterns in financial data, its reliability is influenced by the nature and size of the dataset. Minor deviations, such as those observed in Canara Bank and Bank of Baroda, could stem from operational factors or specific financial reporting practices rather than manipulation. Therefore, Benford's Law should be used in conjunction with other forensic accounting techniques and context-specific knowledge to improve its effectiveness in detecting fraud in the Indian banking sector. The observed conformity in most cases supports the method's general applicability, but the anomalies suggest that caution must be exercised in interpreting results.

Table:2 Present the Second Digit Frequency Count Table

Second Digit	B- Second digit freq.	State Bank of India	Punjab National Bank	Bank of Baroda	Bank of India	Canara Bank
0	0.11968	0.124408	0.128275	0.126858	0.121317	0.133168
1	0.11389	0.121028	0.09425	0.108884	0.116811	0.110085
2	0.10882	0.106491	0.101055	0.124093	0.109532	0.102273
3	0.10433	0.094659	0.10854	0.096785	0.079723	0.107599
4	0.10031	0.088573	0.096291	0.100933	0.118198	0.117898
5	0.09668	0.092968	0.106499	0.100588	0.10364	0.096946
6	0.09337	0.083164	0.089826	0.096094	0.089775	0.088423
7	0.09035	0.093306	0.099354	0.088835	0.105719	0.081321
8	0.08757	0.096011	0.098333	0.07328	0.073484	0.085938
9	0.085	0.099391	0.077577	0.08365	0.081802	0.076349
Total	**1**	1	1	1	1	1

Graph-2 shows the second Digit Frequency Count



Objective 1: To assess whether financial data from selected public sector banks follow Benford's Law.

Benford's Law also provides expected frequencies for the second digit, which follow a less steep but still predictable decreasing pattern from 11.97% for the digit '0' to 8.50% for the

digit '9'. When comparing the second digit frequencies of the selected banks with Benford's expected values, we observe both similarities and inconsistencies. For example, the frequency of the digit '0' is slightly higher than expected across all banks, with Canara Bank (13.32%) and Bank of Baroda (12.69%) showing noticeable increases. The digit '1' also exceeds the expected 11.39% in most cases except Bank of Baroda (9.42%), where it falls significantly short. While some digits, such as '5' and '6', align closely with expected frequencies, others show substantial deviation. This mixed conformity suggests partial adherence to Benford's Law in the second-digit distributions.

Objective 2: To detect any anomalies or deviations from Benford's Law that may suggest manipulation or fraud.

Certain deviations in second-digit frequencies raise red flags that could merit further investigation. For instance, Canara Bank reports a much higher-than-expected frequency for '0' (13.32%) and '4' (11.79%). Punjab National Bank shows higher frequencies for '1' (12.10%), '8' (9.60%), and '9' (9.94%) compared to Benford's Law, which may suggest rounding practices, data structuring issues, or potential manipulation. Similarly, Bank of Baroda exhibits a notable drop in '1' (9.42%) and spike in '5' (10.65%) and '7' (9.94%). While not definitive proof of fraud, these patterns highlight irregularities that deviate from natural expectations, suggesting the need for closer scrutiny of these accounts or datasets.

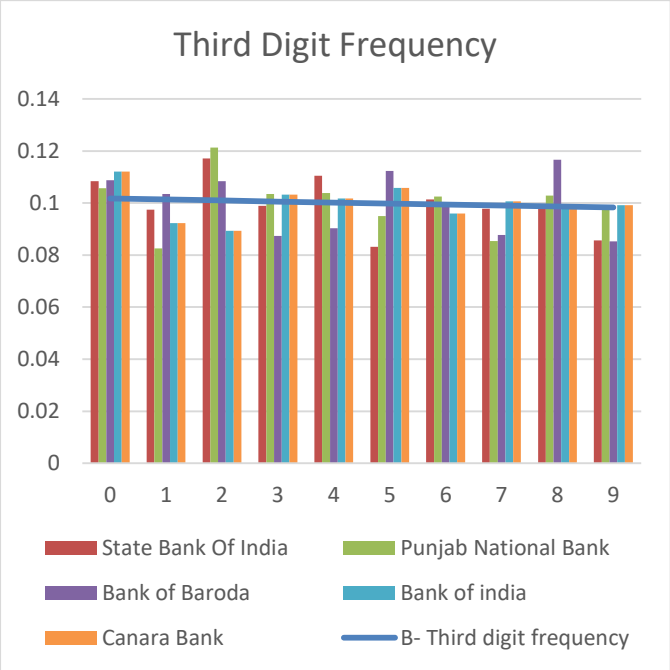
Objective 3: To analyze the reliability of Benford's Law as a fraud detection tool in the Indian banking sector.

The analysis of second-digit frequencies underscores the limited but useful applicability of Benford's Law in fraud detection. While some conformity exists particularly for certain digits like '5', '6', and '7' numerous inconsistencies and fluctuations suggest that second-digit analysis alone may not be a highly reliable fraud indicator in isolation. The second-digit distribution is inherently more sensitive to variations in transaction rounding, data grouping, and systemic accounting practices. Therefore, although Benford's Law offers a useful red flag system, especially in first-digit analysis, its reliability in second-digit detection is comparatively lower. In the Indian banking sector, it should thus be supplemented with additional forensic tools and context-based assessments for more robust fraud detection.

Table:3 Present the Third Digit Frequency Count Table

Third Digit	B- Third digit frequency	State Bank of India	Punjab National Bank	Bank of Baroda	Bank of India	Canara Bank
0	0.10178	0.108383	0.105656	0.108812	0.112047	0.112047
1	0.10138	0.09751	0.082533	0.103461	0.092274	0.092274
2	0.10097	0.117152	0.121309	0.108455	0.089345	0.089345
3	0.10057	0.098913	0.103522	0.087406	0.103259	0.103259
4	0.10018	0.110488	0.103878	0.09026	0.101794	0.101794
5	0.09979	0.083129	0.094984	0.11238	0.105822	0.105822
6	0.0994	0.101368	0.102455	0.099536	0.095936	0.095936
7	0.09902	0.09786	0.085379	0.087763	0.100696	0.100696
8	0.09864	0.099614	0.10281	0.116661	0.099597	0.099597
9	0.09827	0.085584	0.097474	0.085266	0.099231	0.099231
Total	**1**	**1**	**1**	**1**	**1**	**1**

Graph-3 shows the third Digit Frequency Count



Objective 1: To assess whether financial data from selected public sector banks follow Benford's Law.

Benford's Law also outlines expected frequencies for the third digit, though these are more uniform compared to the first and second digits. The expected frequencies range from 10.18% (for digit '0') to 9.83% (for digit '9'), with very slight differences across all digits. In the data for the selected public sector banks State Bank of India, Punjab National Bank, Bank of Baroda, Bank of India, and Canara Bank the observed third-digit frequencies generally align with the expected uniformity. For example, digits like '0', '4', '6', and '8' in most banks fall close to the expected Benford frequencies. However, slight variations are visible. Canara Bank and Bank of India show higher frequencies for '0' (11.20% and 11.28%, respectively) than expected, while Punjab National Bank and Bank of Baroda show a slightly lower frequency for '1'. Overall, the data follows Benford's Law fairly closely, with only minor variances, suggesting natural distribution.

Objective 2: To detect any anomalies or deviations from Benford's Law that may suggest manipulation or fraud.

Though the third digit is less sensitive than the first digit to manipulation, some anomalies in the data are worth noting. For example, Punjab National Bank exhibits an unusually high frequency for digit '2' 11.71% as expected 10.10% and digit '4' 11.05% as 10.01%, while reporting a notably low frequency for digit '5' 8.31% as expected 9.98%. Bank of Baroda also shows elevated values for digit '2' (12.13%) and lower values for digit '1' (8.25%) and '7' (8.53%). While these differences are not extremely large, they suggest areas where transaction patterns or data processing might not follow expected natural trends. These deviations may not directly indicate fraud but could highlight irregularities that deserve further attention or a more detailed forensic review.

Objective 3: To analyze the reliability of Benford's Law as a fraud detection tool in the Indian banking sector.

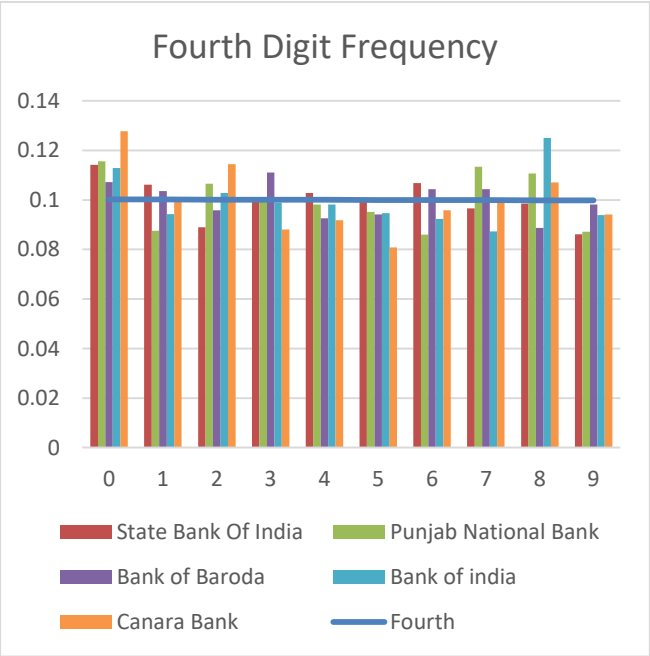
From the third-digit analysis, it becomes evident that Benford's Law retains some degree of reliability in identifying irregularities but is inherently less sensitive when applied to third digits. The frequency variations are typically smaller and can be influenced by numerous benign factors such as rounding, reporting conventions, or operational constraints. That said, repeated or consistent deviations in specific digits such as those seen in Punjab National Bank and Bank of Baroda may help flag patterns for further investigation when combined with first- and second-digit analyses. Hence, while Benford's Law can still serve as a supportive

fraud detection tool in the Indian banking sector, third-digit analysis should only be used as a supplementary indicator, not as a primary diagnostic method.

Table: 4 Present the Fourth Digit Frequency Count Table

fourth Digit	B- fourth digit frequency	State Bank of India	Punjab National Bank	Bank of Baroda	Bank of India	Canara Bank
0	0.10018	0.11415	0.115618	0.107143	0.112928	0.127728
1	0.10014	0.106127	0.087566	0.103611	0.094237	0.100647
2	0.1001	0.088986	0.10652	0.095761	0.102804	0.11439
3	0.10006	0.099562	0.099697	0.111068	0.09891	0.088116
4	0.10002	0.102845	0.09818	0.092622	0.098131	0.091754
5	0.09998	0.100292	0.095148	0.094192	0.094626	0.080841
6	0.09994	0.106856	0.08605	0.104396	0.09229	0.095796
7	0.0999	0.096645	0.113343	0.104396	0.087227	0.099434
8	0.09986	0.098468	0.11069	0.088697	0.125	0.107114
9	0.09982	0.086069	0.087187	0.098116	0.093847	0.094179
Total		1	1	1	1	1

Graph-4 shows the third Digit Frequency Count



Objective 1: To assess whether financial data from selected public sector banks follow Benford's Law.

Benford's Law also provides expected frequencies for the **fourth digit,** though at this level the distribution becomes nearly uniform, with all digits expected to appear approximately 10% of the time. The theoretical frequencies range narrowly from 9.982% to 10.018%. In comparing this with the actual data from the selected public sector banks State Bank of India, Punjab National Bank, Bank of Baroda, Bank of India, and Canara Bank we see some general conformity, especially in banks like State Bank of India and Bank of India, where digit frequencies hover near the 10% expected mark. However, Canara Bank and Punjab National Bank show more noticeable deviations. For instance, Canara Bank has a significantly higher frequency for digit '0' (12.77%) and '2' (11.44%), while Punjab National Bank shows elevated occurrences of '0' (11.42%) and '6' (10.69%). Despite these deviations, the general trend still reflects a relatively balanced distribution, indicating that the fourth-digit data mostly aligns with Benford's Law, though with more variation than earlier digits.

Objective 2: To detect any anomalies or deviations from Benford's Law that may suggest manipulation or fraud.

In terms of detecting anomalies, the fourth-digit analysis reveals some outliers that could be suggestive of either manipulation, rounding practices, or systemic biases. Canara Bank stands out, showing a significantly higher frequency for digit '0' (12.77%), which is more than 2.7% above the expected 10%. It also shows an above-average frequency for digit '2' (11.44%) and digit '8' (10.71%), while underreporting digit '5' (8.08%). Punjab National Bank also shows some inconsistencies, such as low occurrences of digit '9' (8.61%) and high occurrences of digit '6' (10.69%). Such anomalies are subtle, given the close proximity of expected values, but consistent deviations across multiple digits could be indicative of patterns worth further investigation. While these deviations are not sufficient to prove manipulation or fraud, they highlight areas that could benefit from deeper audit or forensic scrutiny.

Objective 3: To analyze the reliability of Benford's Law as a fraud detection tool in the Indian banking sector.

The fourth-digit analysis shows that as we move deeper into digit positions, Benford's Law becomes less sensitive and therefore less reliable for fraud detection. The frequency differences are smaller and more easily influenced by legitimate factors such as transaction rounding, account structuring, or standard formatting conventions in financial systems. While the first and second digits provide stronger indicators for irregularities, the fourth-digit data serves more as a supplementary check. In the Indian banking sector, the fourth digit can still offer insight when used alongside first- and second-digit analysis, especially when similar anomalies are observed across digit levels. However, its standalone utility in fraud detection is limited, and should be considered part of a broader forensic accounting toolkit rather than a primary investigative tool.

5. Conclusion and suggestions:

Across the four digit-position analyses, the results suggest **partial conformity** to Benford's Law. Here's a summary of what the data indicates for each objective:

- **First Digit:** Most banks closely follow Benford's Law. Minor deviations (e.g., in Punjab National Bank and Bank of India) are observed but not severe, **supporting H_0** overall.
- **Second Digit:** While there is moderate conformity, notable anomalies (e.g., high frequencies in digits like 2 and 4) are observed, particularly in Punjab National Bank and Canara Bank. This provides **some support for H_1,** depending on statistical significance.
- **Third Digit:** Deviations are relatively small and consistent with natural fluctuations. The distribution is fairly uniform, **supporting H_0** in most cases.
- **Fourth Digit:** Here, the deviations are more noticeable in banks like Canara Bank and Punjab National Bank, especially for digits 0, 2, and 5. These may indicate **potential red flags,** giving **limited support to H_1.**

Based on the descriptive analysis of digit frequencies, The **first and third digits** generally follow Benford's Law, supporting the null hypothesis (H_0). The **second and fourth digits** show more noticeable deviations in certain banks (e.g., Canara Bank and Punjab National

Bank), which **may indicate areas for further investigation** and lend partial support to the alternative hypothesis (H_1).

Therefore, without statistical testing, we can say that The financial data of the selected public sector banks **largely conform** to Benford's Law, but **certain deviations** especially in later digits **warrant deeper analysis** to rule out manipulation or structural irregularities.

Suggestions:

- Continue using Benford's Law as a **regular monitoring tool** for financial records.
- Integrate Benford's analysis into **internal audit protocols** to proactively detect irregularities.
- Use first-digit and third-digit analyses as **baseline indicators** for data authenticity due to their higher conformity levels.

- Conduct **in-depth forensic audits** on specific banks or transaction types where deviations are concentrated.
- Apply **statistical hypothesis testing** (e.g., chi-square test) to confirm whether these deviations are statistically significant.
- Implement **digital accounting checks** to detect repeated or structured entries that might cause non-random patterns.

- Combine Benford's Law with other **fraud detection techniques** such as ratio analysis, trend analysis, or AI-based anomaly detection.
- Use it as part of a **multi-layered audit system**, where deviations trigger more detailed investigations.
- Train audit staff and compliance officers in **data analytics and digital forensics** to enhance their interpretation of Benford-based patterns.

in all the banks i.e., SBI, PNB, BOB, BOI and Canara bank, the Frequency of first digit to fourth digit was slightly less than or more than the normal frequency of Benford's law and it is not exact same as Benford's law frequency. In this study, we can conclude that there may be or may not be the chance of financial frauds in above given banks. if any investor wants to check the frauds, then he or she may be using this method for checking the financial frauds or for deciding to go for forensic audit or accountant service or not. The Overall suggestion is

that Forensic accountants and auditors should consider these deviations as part of their due diligence to assess the accuracy and reliability of financial statements and analysing these patterns helps in identifying discrepancies and ensuring the integrity of financial reporting.

References

[1] Edy Sujana, I Nyoman Putra Yasa, Made Arie Wahyuni., (2018) Testing of Fraud Diamond Theory Based on Local Wisdom on Fraud Behavior, Advances in Economics, Business and Management Research, volume 69, 3rd International Conference on Tourism, Economics, Accounting, Management, and Social Science (TEAMS 2018)

[2] Mateja Gorenc., Benford's Law As a Useful Tool to Determine Fraud in Financial Statements, International School of Social and Business Studies and Management, Slovenia, 14 (1): 19–31

[3] Lawless, Christopher J., and Robin Williams. "Helping with Inquiries or Helping with Profits? The Trials and Tribulations of a Technology of Forensic Reasoning." *Social Studies of Science*, vol. 40, no. 5, 2010, pp. 731–55. *JSTOR*, http://www.jstor.org/stable/25746361. Accessed 28 Apr. 2023.

[4] Caplan, Dennis. "Internal Controls and the Detection of Management Fraud." *Journal of Accounting Research*, vol. 37, no. 1, 1999, pp. 101–17. *JSTOR*, https://doi.org/10.2307/2491398. Accessed 28 Apr. 2023.

[5] Misiewicz, Kevin M. "The Normative Impact of CPA Firms, Professional Organizations, and State Boards on Accounting Ethics Education." *Journal of Business Ethics*, vol. 70, no. 1, 2007, pp. 15–21. *JSTOR*, http://www.jstor.org/stable/25075267. Accessed 28 Apr. 2023