Part III - Forensic Accounting

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- Disciplines: statistics, epidemiology, health care finance and economics

- Epidemiologist: "HealthLink Wellness" program

  A CDC funded healthy aging program

  Web Site: www.NewEnglandSenior.com

- Statistical and analytical advisor

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Text and Materials

- Audimetrics - AI v6.3 Software Recommended.
- Textbook: Statistical Audit - AI

  Applying Artificial Intelligence techniques

- Slide Presentation
  - Part I Basic Principles
  - Part II the Statistical Audit

BENFORD'S LAW

- History
- What is Benford's Law
- Types of Data That Conform
- Uses in Fraud Investigations
- Examples
- Other uses of Benford's Law
- Cautions When Using Benford's Law

HISTORY

- Simon Newcomb – 1881
- Frank Benford – 1938
- Roger Pinkham – 1961
- Benford's Law was first used by accountants in late 1980
- Theodore Hill – 1995

WHAT IS BENFORD'S LAW

- BENFORD'S LAW FORMULA

The probability of any number "d" from 1 through 9 being the first digit is….

$$\text{Log}_{10}(1 + 1/d)$$

WHAT IS BENFORD'S LAW?

- Benford's law gives the probability of obtaining digits 1 through 9 in each position of a number.
- For example, 3879
  - 3 - first digit
  - 8 - second digit
  - 7 - third digit
  - 9 – fourth digit

WHAT IS BENFORD'S LAW

- Most people assume the probability is 1/9 that the first digit will be 1 - 9
- This would mean digits are equally likely to occur, but this is not the case
- According to Benford's Law the probability of obtaining a 1 in the first digit position is 30.1%

Expected Frequencies Based on Benford's Law

Digit	1st Place	2nd Place	3rd Place	4th Place
0		0.11968	0.10178	0.10018
1	0.30103	0.11389	0.10138	0.10014
2	0.17609	0.19882	0.10097	0.1001
3	0.12494	0.10433	0.10057	0.10006
4	0.09691	0.10031	0.10018	0.10002
5	0.07918	0.09668	0.09979	0.09998
6	0.06695	0.09337	0.0994	0.09994
7	0.05799	0.0935	0.09902	0.0999
8	0.05115	0.08757	0.09864	0.09986
9	0.04576	0.085	0.09827	0.09982

Source: Nigrini, 1996

Logic Behind Benford's Law

- If a data entry begins with the digit 1 it has to double in size (100%)before it begins with the digit 2

- If a data entry begins with the digit 9 it only has to be increased by 11% in order for the first digit to be a 1

Types of Data That Conform

When Benford Analysis Is Likely Used	Examples
Sets of numbers that result from mathematical combination of numbers – Result comes from two distributions	Accounts receivable (number sold x price), Accounts payable (number bought x price)
Transaction-level data – Large data sets	Disbursements, sales, expenses
On large data sets – The more observations, the better	Full year's transactions
Accounts that appear to conform – When the mean of a set of numbers is greater than the median and the skewness is positive	Most sets of accounting numbers

Examples of where it should apply
(cont.)

- Electricity bills
- Street addresses
- Stock prices
- Population numbers
- Death rates
- Lengths of rivers
- Accounts payable invoice and payment values
- General Ledger balances
- Customer Loan and Deposit account balances
- Land Valuations

Examples of where it should apply
(cont.)

- Accounts receivable data
- Estimations in the general ledger
- Relative size of inventory unit prices among locations
- New combinations of selling prices
- Customer refunds
- Duplicate payments

What “types” of data should it apply?

- Balances or totals of numbers resulting from aggregation (e.g. General Ledger Balances, supplier accounts payable balances, data warehouse aggregates)
- The more stages of calculations to obtain each member of a series of numbers, conform to the predictions of Benford’s Law
- Numbers resulting from the mathematical combination of numbers (e.g. price times quantity)
- Transaction-level data (e.g. payments, sales, purchases)
- Numbers that describe the ‘count’ or ‘value’ of the elements of a dataset

Types of Data That Do Not Conform

When Benford Analysis Is *Not* Likely Used	**Examples**
Data set is comprised of assigned numbers	Check numbers, invoice numbers, zip codes
Numbers that are influenced by human thought	Prices set at psychological thresholds ($1.99, ATM withdrawals
Accounts with a large number of firm-specific numbers	An account specifically set up to record $100 refunds
Accounts with a built in minimum or maximum	Set of assets that must meet a threshold to be recorded
Where no transaction is recorded	Thefts, kickbacks, contract rigging

Types not to conform (cont.)

- Numbers which conform to other distributions (e.g. normal distribution, lotteries)
- Items/numbers with built-in minimum or maximum values, e.g. 1st digit of heights (in metres) of a group of humans is most likely to be a 1 or a 2
- 'Price Effect' e.g. Sales receipts where one product (with a specific price) forms a large part of the population of sales made, or individual staff members' payroll totals for a pay period (predominance of similar hours times similar rates per hour
- When selecting small sample sizes
- Non-naturally occurring numbers (e.g. telephone numbers)

Uses in Fraud Investigations

- Invented or altered numbers are not likely to follow Benford's Law
  - Human choices are not random

- 1993, State of Arizona vs. Wayne James Nelson

Benford Link With Data Quality

- Duplicate payments (accounts payable)
- Fraudulent payments
- Fraudulent expense claims
- Tax return fraud
- Biased estimation in General Ledger balances
- Arbitrarily invented numbers in forecasting (forecasts should conform to the expected distributions of their related 'actuals')
- Biased estimates in bad debt provisions
- Systemic error (e.g. through incorrect ETL logic, resulting in accidentally duplicated or repeated values)
- Processing inefficiencies (e.g. high quantity/low $ transactions)

Examples of Benford's Law

- Benford's Law was used to analyze the first 2 digits of accounts payable data for a NASDAQ-listed software company
- Bank audit

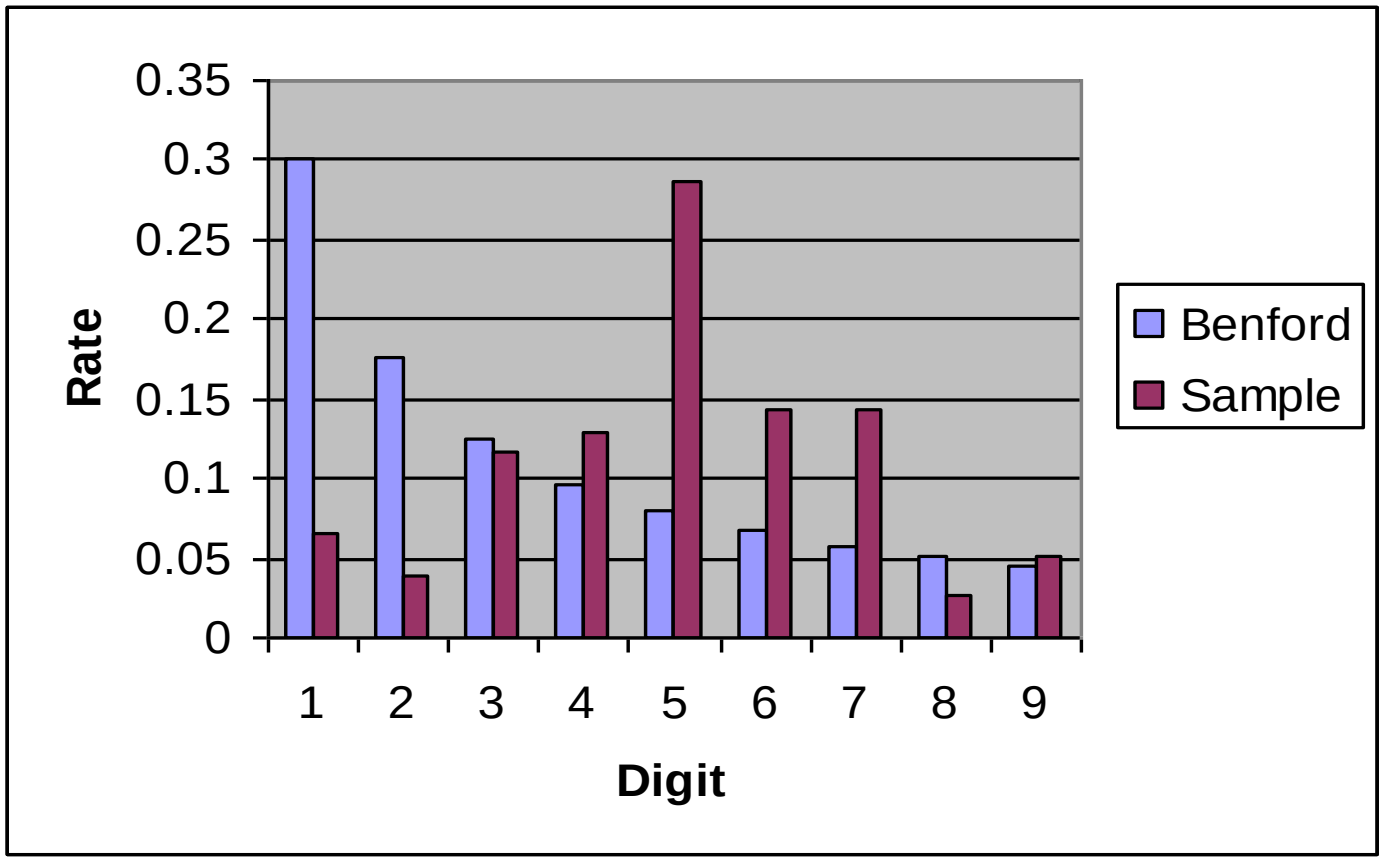
Small Business Owner Example

- Small business owner expanded his one-store family-owned business into a four-store chain
- Had to relinquish some hands-on control with the expansion
- Concerned about bookkeeping errors or possibility of fraud
- Owner used Excel program based on Benford's Law to analyze the store's disbursement data

Small Business Owner Example

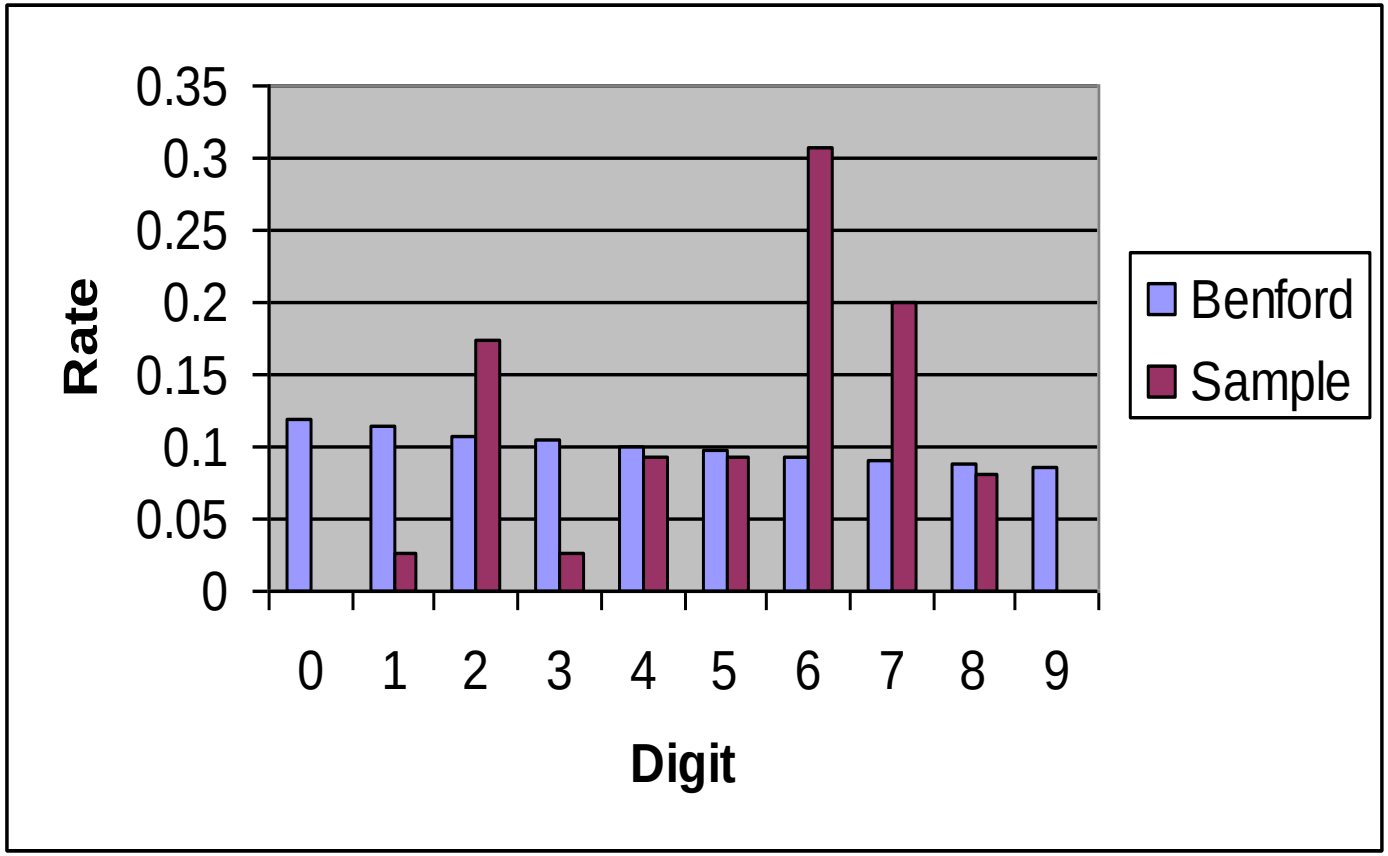
(Source: Rose, 2003)

- First Digits Test



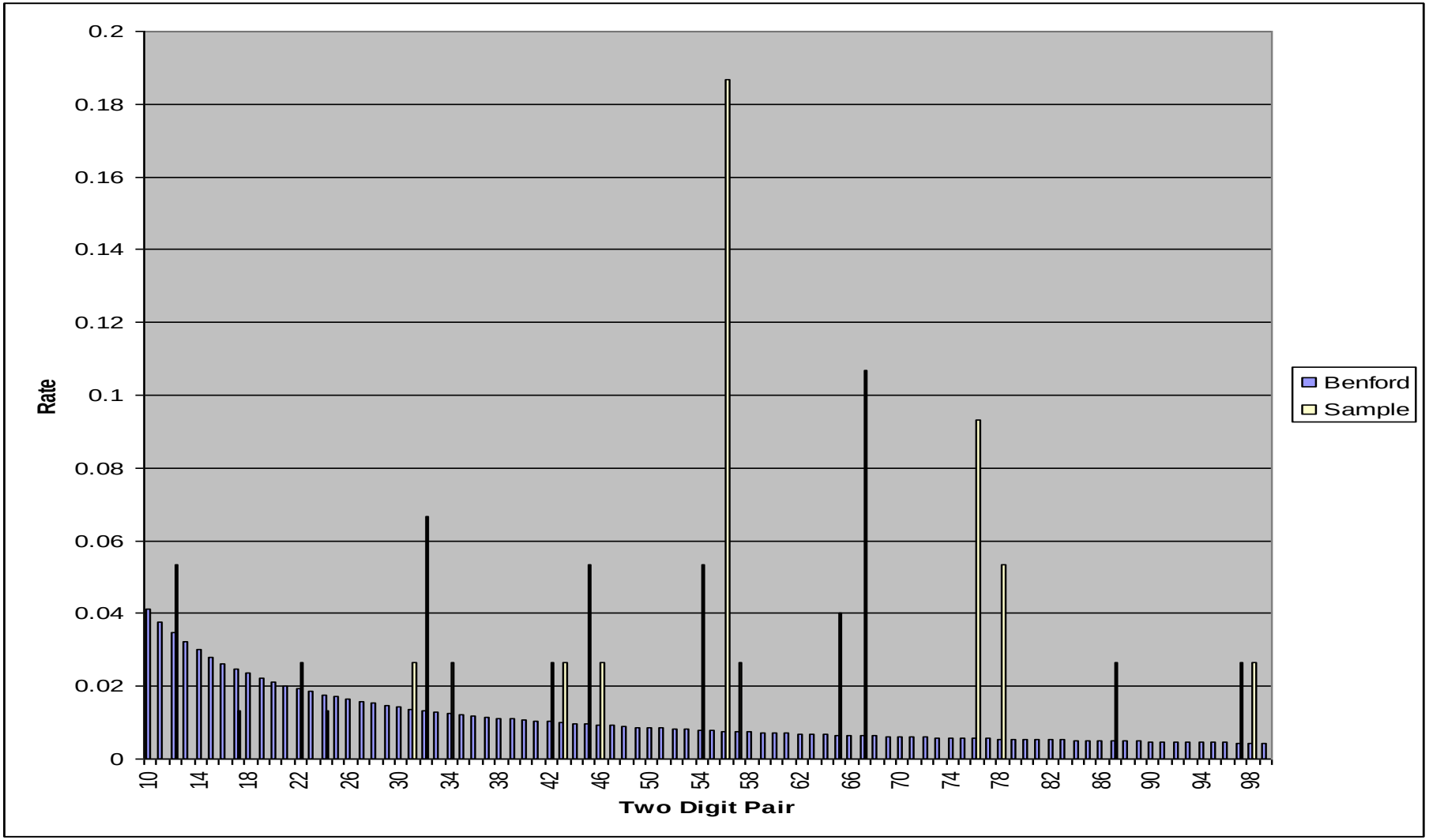
Small Business Owner Example

- Second Digits Test



Small Business Owner Example

- First 2 Digits Test



Small Business Owner Example

- Benford's Law Analysis
- First Digits Test
  - Digits 5, 6, & 7 appear much more than expected, while the digit 1 appeared much less than expected
- Second Digits Test
  - Again, the digits 6 & 7 appear much more often than expected, and 0 did not occur at all

Small Business Owner Example

- Benford's Law Analysis cont.
- First Two-Digits Test
  - 56 & 67 are the two digit combinations that appear more frequently than expected
- Owner pulled sample of disbursements starting with the 56 & 67 sequences
  - Discovered pymts to unfamiliar vendor
  - Addtl invest revealed vendor did not exist – pymts going to personal acct

Other Uses of Benford's Law

- allocating computer disk space
- detect irregularities in clinical trials
- Demographic models of population statistics & vital statistics
- Custom's officials
- ballot fraud in Ukraine's republic elections

Cautions

- Not necessarily fraud
- False positives
- Certain types of fraud will not be detected using Benford's Law analysis