Evaluating the effectiveness of Benford's law as an investigative tool for forensic accountants

L Kellerman
21103259

Dissertation submitted in fulfilment of the requirements for the degree *Magister Commercii* in Forensic Accountancy at the Potchefstroom Campus of the North-West University

Supervisor: Miss Jacqui-Lyn McIntyre

May 2014

It all starts here ™

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

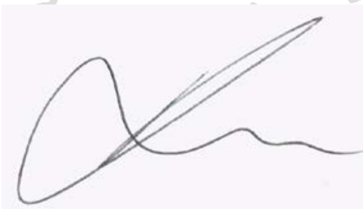
PROOF OF LANGUAGE EDITING

8 November 2013

I, Elmarie Viljoen, hereby certify that I have language edited the dissertation *Evaluating the effectiveness of Benford's Law as an investigative tool for forensic accountants* by Lizan Kellerman.

I am a language practitioner registered at the South African Translators' Institute (member number 1001757) and my highest qualification is an MA Language Practice.

Please contact me should there be any queries.



Elmarie Viljoen

Elmarie Viljoen · (BA (Hons) Sielkunde MA (Taalpraktyk) Vertaling) · SAVI-lidnommer: 1001757
+27 76 7401 367 · elmarie.viljoen@gmail.com · Posbus 39044 Langenhovenpark 9330

Elmarie Viljoen Taalpraktisyn · Language Practitioner

ABSTRACT

"Some numbers really are more popular than others."

Mark J. Nigrini (1998a:15)

The above idea appears to defy common sense. In a random sequence of numbers drawn from a company's financial books, every digit from 1 to 9 seems to have a one-in-nine chance of being the leading digit when used in a series of numbers. But, according to a mathematical formula of over 60 years old making its way into the field of accounting, certain numbers are actually more popular than others (Nigrini, 1998a:15).

Accounting numbers usually follow a mathematical law, named Benford's Law, of which the result is so unpredictable that fraudsters and manipulators, as a rule, do not succeed in observing the Law. With this knowledge, the forensic accountant is empowered to detect irregularities, anomalies, errors or fraud that may be present in a financial data set.

The main objective of this study was to evaluate the effectiveness of Benford's Law as a tool for forensic accountants. The empirical research used data from Company X to test the hypothesis that, in the context of financial fraud investigations, a significant difference between the actual and expected frequencies of Benford's Law could be an indication of an error, fraud or irregularity.

The effectiveness of Benford's Law was evaluated according to findings from the literature review and empirical study. The results indicated that a Benford's Law analysis was efficient in identifying the target groups in the data set that needed further investigation as their numbers did not match Benford's Law.

Keywords: Analytical procedures; Benford's Law; Data irregularities; Digital analysis; First digit distributions; First digit law; Fraud detection; Investigative accounting; Forensic accounting.

OPSOMMING

Sommige getalle is meer gewild as ander.

Mark J. Nigrini (1998a:15)

Bogenoemde idee blyk teen logika in te druis. In ŉ ewekansige volgorde van getalle uit ŉ maatskappy se finansiële boeke, blyk dit dat elke syfer van 1 tot 9 ŉ een-uit-nege-kans het om die voorste syfer te wees wanneer dit in ŉ reeks getalle gebruik word. Maar volgens ŉ wiskundige formule van ouer as 60 jaar, wat in die veld van rekeningkunde begin opgang maak, is sommige getalle werklik meer gewild as ander (Nigrini, 1998a:15).

Rekenkundige syfers volg gewoonlik ŉ wiskundige wet, bekend as Benford se wet, en die resultaat is so onvoorspelbaar dat bedrieërs en manipuleerders in die reël nie daarin slaag om die wet te volg nie. Die forensiese rekenmeester kan, toegerus met hierdie kennis, onreëlmatighede, ongerymdhede, foute of bedrog wat in ŉ finansiële datastel voorkom, opspoor.

Die hoofdoel van hierdie studie is om die doeltreffendheid van Benford se wet as ŉ instrument vir forensiese rekenmeesters te evalueer.

Die empiriese studie maak gebruik van data verkry van Maatskappy X om die hipotese te toets dat, indien daar in die konteks van finansiële bedrog-ondersoeke ŉ beduiende verskil tussen die werklike en verwagte frekwensies van Benford se wet voorkom, dit ŉ aanduiding van ŉ fout, bedrog of ŉ onreëlmatigheid kan wees.

Die doeltreffendheid van Benford se wet is deur middel van die literatuurstudie en die empiriese studie geëvalueer. Daar is bevind dat Benford se wet bevoeg is om die teikengroepe te identifiseer wat verdere ondersoek noop weens die feit dat hulle syfers nie met die wet ooreenstem nie.

Sleutelwoorde: Analitiese prosedures; Benford se wet; Data-onreëlmatighede; Digitale analise; Eerste-syfer-verdelings; Eerste-syfer-wet, Bedrog-opsporing; Forensiese rekeningkunde.

ACKNOWLEDGEMENTS

I wish to express sincere gratitude to the following people who contributed towards the completion of the dissertation:

- The Lord, for giving me the talent and the strength to keep going when I needed it most;
- My parents, for giving me the opportunity to further my studies and for all their support;
- Andrew, for all his support during the completion of the study;
- All my friends, for their support and advice;
- Miss Jacqui-Lyn McIntyre, for her availability, patience, support and excellent advice throughout the study;
- Ms Elmarie Viljoen, for professional language editing of this dissertation.

TABLE OF CONTENTS

CHAPTER 3

DEFINING FORENSIC ACCOUNTANCY

CHAPTER 4

FINANCIAL CRIMES

CHAPTER 9

SUMMARY, CONCLUSION AND RECOMMENDATION

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
PURPOSE, SCOPE AND PROGRESS OF STUDY

1.1 Introduction and Background

“Some numbers really are more popular than others.”
Mark J. Nigrini (1998a:15)

The above idea appears to defy common sense. In a random sequence of numbers drawn from a company’s books, every digit from 1 to 9 seems to have a one-in-nine chance of being the leading digit when used in a series of numbers. But, according to a mathematical formula of over 60 years old making its way into the field of accounting, certain numbers are actually more popular than others (Nigrini, 1998a:15).

Benford’s Law is based on a theory that there are expected frequencies of digits in a list or data set (Nigrini & Mittermaier, 1997:53). The significant feature of Benford’s Law, which was first applied by accountants in the late 1980s, is that these frequencies are evident only in naturally occurring numbers, in other words, not in numbers that have been falsely invented (Kumar & Bhattacharya, 2007:81).

Various researchers have tested data of different categories to detect fraud and irregularities, but Carslaw (1988:321-327) was the first to apply Benford’s Law to accounting. He found that reported earnings numbers based on firms in New Zealand did not conform to the expected frequencies of certain second digits. According to Durtschi, Hillison and Pacini (2004:22), Mark J. Nigrini seems to be the first researcher to have applied Benford’s Law extensively to accounting data with the aim of detecting fraud.

This law takes its name from Frank Benford, a physicist, born in 1883 (s9.com, 2012). He noticed that the pages of logarithms tables containing low numbers, such as one and two, were more worn than those with higher numbers, eight and nine (Benford, 1938:551). Benford (1938:552-553) tested his theory by analysing 20,229 sets of numbers gathered from a variety of fields, for example, surface areas of rivers, baseball averages, numbers in magazine articles, and atomic weights. The data ranged from sources that include random numbers to types that followed mathematical laws. The results of the analysis substantiated the empirical observation. The chance of a multi-digit number beginning with 1 was, without a doubt, higher than for the first digit to be 9. By means of Benford's Law, the individual digits have diverse probabilities of occurrence as the first digit; for this reason, the law is also referred to as the "first digit law" (Bhattacharya & Kumar, 2008:152).

An insightful rationalisation of Benford's Law is to think about it with respect to a savings account that is increasing at 10% per year in interest. When the investment amount is R100, with the first digit as 1, the first digit will remain 1 until the account balance reaches R200. The 100% increase (from 100 to 200), at a growth rate of 10% per year compounded, would take approximately 7.3 years. At R500 the first digit will be 5. Growing at 10% per year, the total balance will rise from R500 to R600 in about 1.9 years, significantly less time than it took the account balance to grow from R100 to R200. At R900, the first digit will be 9 until the account balance reaches R1,000, or about 1.1 years at 10%. Once the account balance reaches R1,000, the first digit will again be 1 until the account balance grows by another 100%. The persistence of a 1 as a first digit will occur with any phenomenon that has a constant or even a variable growth rate (Nigrini, 1999a:80).

Within the framework of financial fraud detection, the more an observed set of accounting data differs from the pattern predicted by Benford's Law, the bigger the possibility that the data have been manipulated (Kumar & Bhattacharya, 2007:81-82).

With regard to the practical application in fraud investigations, in 1993, *State of Arizona v. Wayne James Nelson*, the accused was found guilty of attempting to defraud the state of almost $2 million. Nelson, employed as a manager in the office of the Arizona State Treasurer, disputed that he had redirected money to a false vendor in order to reveal the lack of safeguards in a new computer system. The amounts of the 23 cheques which were issued during the period 9 October 1992 to 19 October 1992 are listed in table 1.1 below.

Table 1.1: List of fictitious cheques in *State of Arizona v. Wayne James Nelson*	
DATE OF CHEQUE	**AMOUNT**
09 October 1992	$1,927.48
↓	$27,902.31
14 October 1992	$86,241.90
↓	$72,117.46
↓	$81,321.75
↓	$97,473.96
19 October 1992	$93,249.11
↓	$89,658.17
↓	$87,776.89
↓	$92,105.83
↓	$79,949.16
↓	$87,602.93
↓	$96,879.27
↓	$91,806.47
↓	$84,991.67
↓	$90,831.83
↓	$93,766.67
↓	$88,338.72
↓	$94,639.49
↓	$83,709.28
↓	$96,412.21
↓	$88,432.86
	$71,552.16
TOTAL	**$1,878,687.58**

(Nigrini, 1999a:82)

Nigrini (1999a:81) gives a brief explanation of how a Certified Public Accountant (CPA) familiar with Benford's Law could have, without a doubt, spotted that these amounts did not compare to the expected distributions and, therefore, needed closer examination.

The digit distributions of the amount of the cheques are just about contrary to those expected by Benford's Law. More than 90% of the amounts begin with a 7, 8 or 9. If each of the vendors had been tested against Benford's Law, this particular data set would have had a low conformity, indicating an irregularity. The numbers appear to have been chosen to give the manifestation of unpredictability. In this sense, Benford's Law is somewhat counterintuitive: people do not logically imagine that some numbers occur more than others. An initial observation is that there were no duplications of the cheque amounts; no round numbers; and all the amounts included cents. Nevertheless, some digits and digit combinations were repeated. The following first two digits were all used twice: 87, 88, 93 and 96. For the last two digits, 16, 67 and 83 were copied. They were leaning toward the higher-ranked numbers: note how 7 through 9 were the most repeated digits, contradicting to Benford's Law (Nigrini, 1999a:81).

Nigrini and Mittermaier (1997:57-64) provided an overview of digital tests to determine whether data sets conform to the expected frequencies of Benford's Law. The tests determine the comparative frequency of the following digit combinations: first digits; second digits; first two digits; first three digits; and last two digits.

According to Kumar and Bhattacharya (2007:83), in context of practical application in financial fraud detection to date, Benford's original first digit law is by far the leading test used.

1.2 Motivation

According to Hill (1999:31), with the exponentially increased availability of digital data and computer force, the use of subtle and vigorous statistical tests for fraud detection and other manufactured data is to increase dramatically. Benford's Law is just the start.

The method of financial reporting is based on the primary rule of double entry bookkeeping, meaning that each transaction must consist of two entries in the books with opposite effects, both a debit and a credit entry. Such duality amplifies the probability of the fraud being captured in a forensic investigation, because the offenders have to cover up a financial fraud twice to make it bypass any internal auditing system. When offsetting entries are recorded in accounting books to cover either sides of a fraudulent transaction, some digits are made up. This implies that the numbers are no longer naturally occurring in a random selection of accounting records, and Benford's Law can become helpful (Bhattacharya & Kumar, 2008:152).

Benford's Law offers a unique method of data analysis, allowing the forensic accountant to identify fraud, manipulative prejudice, processing inefficiencies, errors, and other non-compliant abnormal patterns as applicable to the accounting records of a company (Warshavsky, 2010:2). Saville (2006:342) states that, despite the potential of Benford's Law and its use by practitioners in the South African context, it is surprising to find that no attempt has been made to publish proof on the effectiveness of Benford's Law in the detection of accounting data error or fraud in a domestic environment.

Benford's Law can be applied widely and, since it is not well known, chances are slim that those individuals manipulating data would try to find preserve fit to the distribution of the Law. In this context, it seems to be a superior diagnostic tool, at least until it becomes commonly known (Cho & Gaines, 2007:218).

1.3 Problem Statement

Organisations lose an estimated 5% of their annual revenue due to fraud, according to the Association of Certified Fraud Examiners (ACFE, 2012). Until now, the approach to detect commercial frauds has been based mostly on traditional investigative accounting methods and techniques. In this era of information, the potential of fraud is wider in scope. Consequently, new tools and techniques are presented to combat this increase in fraud. Uncovering signs of fraud amid millions of transactions within an organisation, entails that the forensic accountant applies analytical skills and work experience to create a profile against which to test the data for possible fraud (Weirich, Pearson & Churyk, 2010:207).

It is important to firstly identify and understand the theory related to Benford's Law; its background and history; its effectiveness as a tool for identifying fraud and error; and its limitations and benefits. In light of the above, the problem statement is formulated as follows: What is the effectiveness of Benford's Law as an investigative tool in forensic accounting investigation?

1.4 Research objectives and goals

The main objective is to determine whether Benford's Law can be used as an effective investigative tool in forensic accounting investigation. In order to reach this primary objective, the following secondary objectives are to be addressed:

- To gain understanding of what Benford's Law entails;
- To determine what the field of forensic accountancy entails;
- To understand the concept of "financial crimes";
- To determine whether Benford's Law can be an objective and effective tool for identifying possible fraud, errors or irregularities in accounting data;
- To determine the application of Benford's Law in forensic accounting investigation;
- To determine the type of data sets that complies with Benford's Law;
- To determine the limitations and constraints of Benford's Law;
- To determine the benefits of using Benford's Law in a forensic investigation;
- To conduct an empirical study and report the findings; and
- To draw conclusions and make recommendations.

1.5 Hypothesis

In the context of financial fraud investigations, a significant difference between the actual and expected frequencies of Benford's Law could be an indication of an error, fraud or irregularity.

1.6 Method of Research

Research will consist of both a literature review and an empirical study.

1.6.1 Literature Review

To address the relationship between forensic accounting and Benford’s Law, as much as possible relevant literature needs to be reviewed. The literature consulted in this study included, but was not limited to, books; applicable journals and web-based articles; and other publications.

1.6.2 Empirical Research

The empirical study will focus on the South African forensic accounting environment and will attempt to determine the effectiveness of Benford’s Law as an investigative tool in the forensic accountant’s arsenal. Furthermore, the empirical study will endeavour to clarify the research objectives referred to above.

The research population will consist of a financial data set of a specific company, allegedly involved in fraudulent activity, which contains all the Electronic Fund Transfers (EFTs) for the period January 2012 to 31 March 2013. The data set will include all the payment transactions from the specific bank accounts of the entity. The EFTs used in the case study derived from an actual fraud investigation and as such the figures used were in respect of possible fraud committed by the mentioned company in Chapter 8.

1.7 Chapter Overview

Chapter 1: Introduction and background

This chapter serves as an introduction to the research and a backdrop to Benford’s Law. The problem statement, research objectives, hypothesis, method of research and the proposed chapter layout are structured in this chapter.

Chapter 2: History and the development of the Benford’s Law theory

This chapter discusses the history, development and fundamental principles of the Benford’s Law theory. The contributions of some individuals to the development of the theory will also be mentioned and the mathematics behind the law will be explained briefly.

Chapter 3: Defining forensic accountancy

The aim of this chapter is to define the term "forensic accounting" and explain the role of a forensic accountant in the detection, prevention and investigation of complex financial crimes.

Chapter 4: Financial crimes

Financial fraud can be perpetrated through various approaches. This chapter will cover some of the most significant financial crimes and provide a clear definition of the different types of financial crimes found in the current South African business environment.

Chapter 5: The application of Benford's Law to forensic accounting investigation

In this chapter the application of Benford's Law to forensic accounting, in particular fraud detection, is discussed together with the reasons as to what makes Benford's Law useful for this kind of forensic investigation. The types of data sets which are expected to conform to Benford's Law are also analysed.

Chapter 6: The benefits of Benford's Law

This chapter sets out the benefits of the use of Benford's Law.

Chapter 7: Limitations and constraints regarding Benford's Law

This chapter reviews some of the limitations and constraints regarding the use of Benford's Law in an investigation, as well as certain aspects that the forensic investigator needs to consider when applying this law.

Chapter 8: Empirical study and results

This chapter presents an explanation of the research methodology, the objectives of the empirical study, and the method of investigation. The results acquired from the empirical study will be thoroughly discussed in this chapter.

Chapter 9: Conclusions and recommendations

In this chapter conclusions are drawn based on the findings of this study, and recommendations for further study are made.

CHAPTER 2

HISTORY AND DEVELOPMENT OF THE BENFORD'S LAW THEORY

2.1 Introduction

Benford's Law, also recognised as the first digit law, has long been seen as an exciting and mystifying law of nature (Fewster, 2009:26). For about 90 years mathematicians and statisticians presented a variety of explanations for this phenomenon (Durtschi *et al.,* 2004:20). Even though Frank Benford provided ample evidence of the authenticity of the Law and its general application, mathematical evidence was not obtained until 1996 (Lowe, 2000a:33).

Hill (1998:359-360) explains that, in the 60 years from the time when Benford's article appeared, there have been several efforts by physicists, mathematicians and amateurs to "demonstrate" Benford's Law. There were, however, two major obstacles: The first was that some data sets complied with the Law and some did not. By no means was there a clear definition of a common statistical experiment that would foresee which data sets would correspond and which would not. Efforts at substantiations were based on a variety of mathematical averaging and integration techniques, as well as probability schemes. The second obstacle was that none of the evidence was precise as far as the current theory of probability is concerned (Hill, 1998:359-360).

This chapter discusses the history, development and fundamental principles of the Benford's Law theory; outlines the contributions of some noteworthy individuals to the development of the theory; and briefly explains the mathematics behind the Law.

2.2 The history of Benford's Law

2.2.1 Simon Newcomb

The Law was first discovered by the astronomer and mathematician, Simon Newcomb, who published his research in 1881 in a paper titled *Note on the frequency of use of the different digits in natural numbers* (Newcomb, 1881:39-40). He stated that the ten digits, 0 to 9, do not occur with equal rate of recurrence, which should be obvious when observing how much faster the first pages of logarithm tables wear out than the last ones. In the days before calculators, logarithmic tables were used to multiply and divide large numbers.

Newcomb (1881:40) determined that the probability that a number has any particular non-zero first digit, is:

$P(d) = Log_{10}(1+1/d)$ where *d* is a number 1, 2, 3 ... 9, and P is the probability.

Table 2.1 presents Newcomb's (1881:40) findings of the required probabilities of occurrence in the case of the first two significant digits of a natural number.

Table 2.1: Expected frequencies based on Benford's Law (Newcomb)

Digit	1st place	2nd place
0		0.11968
1	0.30103	0.11389
2	0.17609	0.10882
3	0.12494	0.10433
4	0.09691	0.10331
5	0.07918	0.09668
6	0.06695	0.09337
7	0.05799	0.09035
8	0.05115	0.08757
9	0.04576	0.08500

(Lowe, 2000b:24).

The above-mentioned table indicates that:

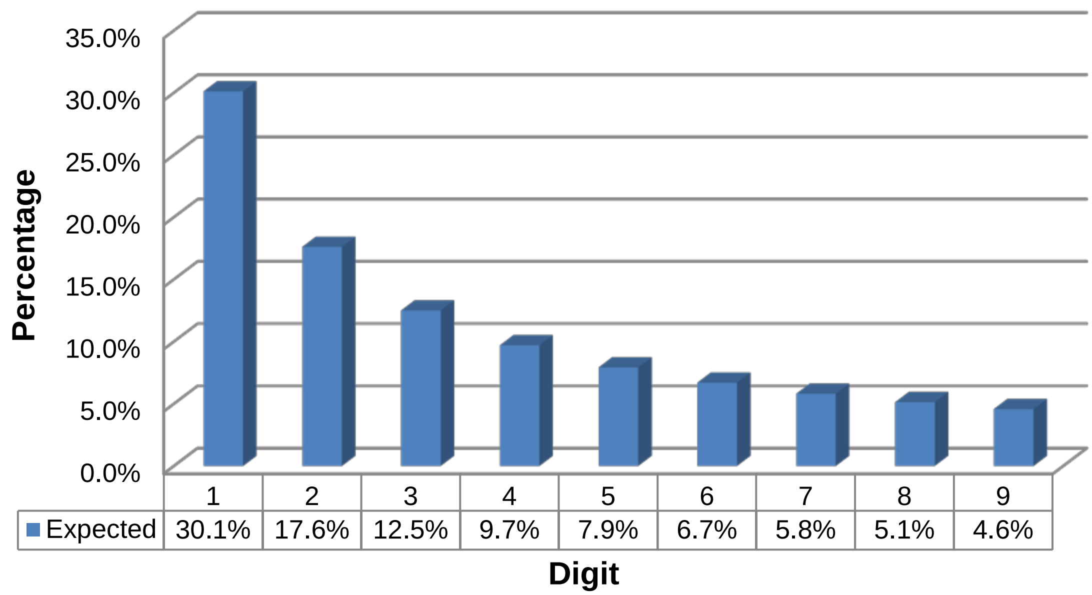
- In 30.103% of the cases, numbers start with the digit 1;
- In 17.609% of the cases, numbers start with the digit 2;
- In 12.494% of the cases, numbers start with the digit 3;
- In 9.691% of the cases, numbers start with the digit 4;
- In 7.918% of the cases, numbers start with the digit 5;
- In 6.695% of the cases, numbers start with the digit 6;
- In 5.799% of the cases, numbers start with the digit 7;
- In 5.115% of the cases, numbers start with the digit 8; and
- In 4.576% of the cases numbers start with the digit 9.

Using the same technique, one can conclude from table 2.1 the percentages of cases in which digits 0 to 9 would be in the second place of a natural number, for example:

- In 11.968% of the cases, numbers start with the digit 1;
- In 11.389% of the cases, numbers start with the digit 2;
- In 10.822% of the cases, numbers start with the digit 3;

Figure 2.1 below explains the distribution of the first digit as expected by the Benford's distribution.

Figure 2.1 – Benford's Law: Expected distribution of first digit



(Singleton, 2011)

The figure indicates clearly a downwards trend from the occurrence of digit 1 to digit 9.

Newcomb (1881:40) concluded*:* "The law of probability of the occurrence of numbers is such that all mantissae of their logarithms are equally probable". "Mantissa" may refer to the fractional part (written to the right of the decimal point) of a decimal fraction, or the decimal part of a common logarithm (Business Dictionary, 2012a).

With no persuasive argument for why the formula should work, Newcomb's paper failed to provoke any significant attention (Matthews, 1999:27). One of Newcomb's shortcomings was that he failed to provide any theoretical explanation for the phenomenon he described and his article went practically unnoticed (Durtschi *et al.*, 2004:20).

2.2.2 Frank Benford

Almost half a century after Newcomb's discovery, unaware of Newcomb's paper, Frank Benford, made the same observation: The first few pages of the logarithm books were more dog-eared than the last pages (Benford, 1938:551). In the 1920s Frank Benford was employed as a physicist at the General Electric Research Laboratory in Schenectady, New York (Benford, 1938:551). The variety of log tables were printed in logarithm books and all the engineers at the GEC research centre would have used them extensively. Benford concluded from this pattern that fellow engineers were inclined to look up logs of multi-digit numbers beginning with low digits more frequently than multi-digit numbers beginning with high digits (Johnson, 2005:16).

As opposed to his predecessor, Benford attempted to test his hypothesis by gathering and analysing data (Durtschi *et al.*, 2004:20) and spent a number of years gathering proof of the phenomenon (Geyer & Williamson, 2004:230). Also, he enthusiastically pursued this phenomenon and published his findings in a number of scholastic papers (Kumar & Bhattacharya, 2007:81). The mathematical theory defining the frequency of digits became known as Benford's Law, although it was Newcomb who first discovered the phenomenon (Durtschi *et al.*, 2004:20).

2.2.3 Empirical evidence for Benford's Law

The list of data collected and composed by Frank Benford covered both independent and weakly dependent data. Independent lists were compiled from sources such as the street addresses of the American Men of Science, the numbers appearing in an issue of *Reader's Digest*, and the drainage areas of rivers. Weakly dependent lists consisted of mathematical tables from engineering handbooks and tabulations of weights and physical constants, for example, molecular weights, specific heats, physical constants and atomic weights (Nigrini & Mittermaier, 1997:53).

The results of the above-mentioned data are contained in table 2.2, where “Group” indicates the set to which the data belongs; “Title” the independent/dependent lists; “First digit 1 to 9” the occurrences of the number used as first digit; and “Count” the count of data used for the specific group.

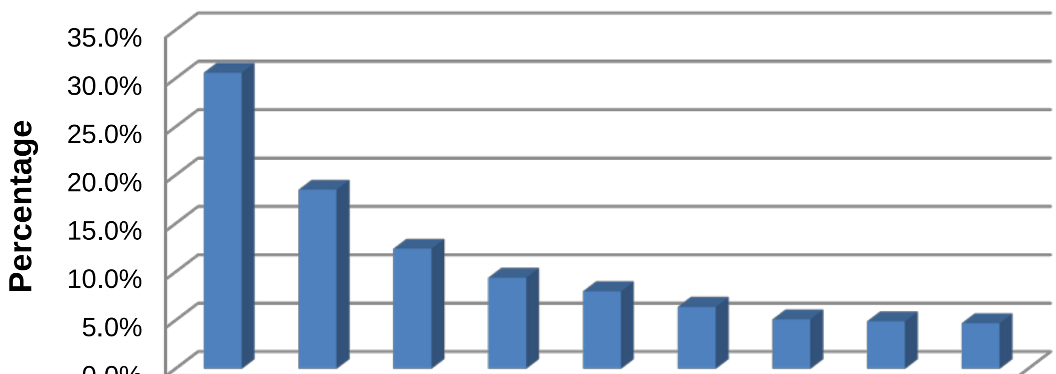
Table 2.2: Percentage of times the natural numbers, one to nine, are used as first digits in numbers											
Group	Title	First digit									Count
		1	2	3	4	5	6	7	8	9	
A	Rivers, area	31.0	16.4	10.7	11.3	7.2	8.6	5.5	4.2	5.1	335
B	Population	33.9	20.4	14.2	8.1	7.2	6.2	4.1	3.7	2.2	3259
C	Constants	41.3	14.4	4.8	8.6	10.6	5.8	1.0	2.9	10.6	104
D	Newspapers	30.0	18.0	12.0	10.0	8.0	6.0	6.0	5.0	5.0	100
E	Spec. heat	24.0	18.4	16.2	14.6	10.6	4.1	3.2	4.8	4.1	1389
F	Pressure	29.6	18.3	12.8	9.8	8.3	6.4	5.7	4.4	4.7	703
G	H.P. lost	30.0	18.4	11.9	10.8	8.1	7.0	5.1	5.1	3.6	690
H	Mol. wgt.	26.7	25.2	15.4	10.8	6.7	5.1	4.1	2.8	3.2	1800
I	Drainage	27.1	23.9	13.8	12.6	8.2	5.0	5.0	2.5	1.9	159
J	Atomic wgt.	42.7	18.7	5.5	4.4	6.6	4.4	3.3	4.4	5.5	91
K	n^{-1}, $\sqrt{n}$	25.7	20.3	9.7	6.8	6.6	6.8	7.2	8.0	8.9	5000
L	Design	26.8	14.8	14.3	7.5	8.3	8.4	7.0	7.3	5.6	560
M	Digest	33.4	18.5	12.4	7.5	7.1	6.5	5.5	4.9	4.2	308
N	Cost data	32.4	18.8	10.1	10.1	9.8	5.5	4.7	5.5	3.1	741
O	X-ray volts	27.9	17.5	14.4	9.0	8.1	7.4	5.1	5.8	4.8	707
P	Am. league	32.7	17.6	12.6	9.8	7.4	6.4	4.9	5.6	3.0	1458
Q	Black body	31.0	17.3	14.1	8.7	6.6	7.0	5.2	4.7	5.4	1165
R	Addresses	28.9	19.2	12.6	8.8	8.5	6.4	5.6	5.0	5.0	342
S	n^1, $n^2 \cdots n!$	25.3	16.0	12.0	10.0	8.5	8.8	6.8	7.1	5.5	900
T	Death rate	27.0	18.6	15.7	9.4	6.7	6.5	7.2	4.8	4.1	418
Average…		30.6	18.5	12.4	9.4	8.0	6.4	5.1	4.9	4.7	1011
Probable error		±0.8	±0.4	±0.4	±0.3	±0.2	±0.2	±0.2	±0.2	±0.3	—

(Benford, 1938:553)

A study of the items in table 2.2 demonstrates a distinct trend for those of a random nature to agree better with the logarithmic law than such of a formal or mathematical nature (Benford, 1938:556). At the bottom of each column in table 2.2 the average percentage is given for each one of the leading digits, as well as the possibility of error in the calculation of the average (Benford, 1938:553).

Figure 2.2 below depicts the frequencies of the 20,229 observations that consisted of the list of data collected and composed by Frank Benford. The frequencies of the first digit 1 to 9 were used to illustrate this phenomenon.

Figure 2.2: Observed frequencies – Frank Benford

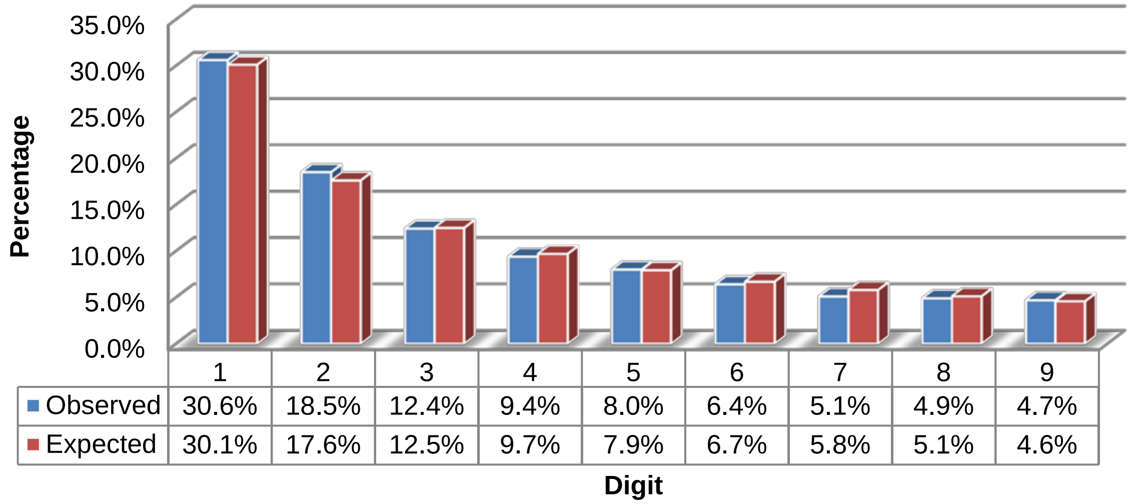


	1	2	3	4	5	6	7	8	9
Observed	30.6%	18.5%	12.4%	9.4%	8.0%	6.4%	5.1%	4.9%	4.7%

(Source: Author)

Figure 2.3 shows the detail between the frequencies of the list of data collected and composed by Frank Benford versus the expected frequencies as noted by Newcomb. From this figure it is evident that these frequencies are very similar. The correlations are illustrated in this figure also.

Figure 2.3: Observed frequencies (Benford) vs expected frequencies (Newcomb)



(Source: Author)

With reference to the table 2.2, the frequency of the first digit as determined by 20,299 observations made by Frank Benford is equal to 0.306. This is in close relation to the expected frequency of the first digit as determined by Simon Newcomb, which is 0.301. It is, thus, evident that there is only a slight difference of 0.005 regarding the first digit.

Table 2.3 depicts the differences in frequencies.

Table 2.3: Comparison of observed and expected frequencies

Digit	Observed frequency	Expected frequency	Difference
1	30.6%	30.1%	0.50%
2	18.5%	17.6%	0.89%
3	12.4%	12.5%	−0.09%
4	9.4%	9.7%	−0.29%
5	8.0%	7.9%	0.08%
6	6.4%	6.7%	−0.29%
7	5.1%	5.8%	−0.70%
8	4.9%	5.1%	−0.22%
9	4.7%	4.6%	0.12%

(Benford, 1938:554)

The differences for all the digits can be calculated easily by deducting the expected frequencies from the observed frequencies. The difference will be positive in some instances and negative in others (Benford, 1938:554). The above-mentioned table indicates no significant differences between the observed frequencies and the expected frequencies. Therefore, the average frequencies of the 20,229 observations follow closely the logarithmic relation.

Similar to Newcomb, Benford failed to give any quality explanation for the existence of the Law. Yet, the pure wealth of evidence he provided to reveal the reality and omnipresence of this Law has resulted in his name being linked with the Law ever since (Matthews, 1999:28).

2.2.4 Roger Pinkham

The first significant step towards explaining this mathematical curiosity was taken in 1961 by Rodger Pinkham. With some creative thinking on his part, Pinkham presented what seems to be a sound mathematical explanation for this phenomenon. Pinkham (1961:1223) introduces his paper by stating that any reader formerly unaware of this curiosity called Benford's Law would find an actual sampling experiment wondrously tantalizing.

Pinkham's paper then presents a theoretical discussion of why and to what extent this so-called abnormal law must hold. He made the following remark: "The only distribution for first significant digits which is invariant under scale change of the underlying distribution is $\log_{10}(n+1)$. Contrary to suspicion this is a non-trivial result, for variable 'n' is discrete" (Pinkham, 1961:1223).

Pinkham separated the evidence into two main sections: scale invariance and distinctiveness of Benford's Law (DeHaan, 2011). Scale invariance is a feature of objects or laws that do not change if scales of lengths, energy or other variables are multiplied by a common factor. For example, when converting a distance from miles to kilometres, the common factor is 1.6. According to Pinkham, the confirmation that only

Benford's Law is invariant under a change of scale, is a non-trivial mathematical result (DeHaan, 2011).

Matthews (1999:28) claims that the work done by Pinkham gave Benford's Law a major boost regarding its credibility, and encouraged fellow mathematicians and statisticians to take it more seriously and come up with additional potential applications of the law.

However, the law remained mysterious for almost 90 years, as mathematically accurate evidence was not presented until Theodore P. Hill published his theorem in 1995 that finally provided a proof for Benford's Law (Durtschi *et al*., 2004:20).

2.2.5 Theodore P. Hill

To demonstrate probability to his mathematics students, Dr. T.P. Hill used to ask his students to do the following homework assignment on the first day: to either flip a coin 200 times and record the results, or simply pretend to flip a coin and fake the results. The following day, to the students' amazement, he would run his eye over the homework data, separating just about all the true sets of data from the fake sets. But there is more to this than a classroom trick (Hill, 1999:27).

Subsequent to the examination of numerous empirical studies using Benford's Law, Hill (1995:354) showed that, if probability distributions are selected at random and random samples are then taken from each of these distributions in a way that renders the overall process "unbiased", the leading significant digits of the combined sample will always converge to Benford's Law, even though the individual distributions may not closely follow the Law.

The essential point of Hill's theorem is that there are numerous natural sampling methods that lead to Benford's Law. Hill's confirmation relies on the fact that the numbers in data sets that conform to Benford's distribution are second generation distributions, meaning combinations of other distributions (Durtschi *et al*., 2004:20).

2.3 The first application of Benford’s Law to accounting and auditing

Carslaw (1988) and Thomas (1989) both applied Benford’s Law to investigate the possible manipulation of reported net income. Carslaw (1988:321) provided evidence that the frequency of occurrence of certain second digits (especially zero) contained in the net income numbers of some New Zealand firms departs extensively from expectations. In particular, he observed the more than expected frequency of 0s and the less than expected frequency of 9s in the second digit position.

Carslaw’s paper was followed by Thomas (1989:773-787) who performed a study to establish whether reported earnings of United States firms followed similar patterns as those of New Zealand firms. Thomas’s paper extended Carslaw’s paper in a number of ways:

1. Earnings for COMPUSTAT firms were examined to determine whether the unusual patterns observed by Carslaw (1988) were abnormal to New Zealand firms;
2. Losses were examined to determine whether a reversal of the pattern observed for the positive earnings sample was present;
3. Firms were divided into positive and negative earning change subsamples and subsamples based on industry membership; and
4. Quarterly earnings and earnings per share data were examined (Thomas, 1989:774).

Thomas (1989:773-787) determined a similarity in the patterns in the net income of both US and New Zealand firms. Consequently, he discovered the opposite effect for companies reporting losses: these companies appeared to avoid round net income numbers. These results suggested that net income and earnings per share were rounded up and that net losses were rounded down (Nigrini & Mittermaier, 1997:56).

2.3.1 Mark J. Nigrini and the fraud detection idea

In a ground-breaking doctoral thesis by Nigrini in 1992, “The detection of income tax evasion through an analysis of digital distribution”, the application of Benford’s Law to cases of tax evasion was pioneered.

In June 1993, Nigrini published his first article on Benford’s Law, consisting of only two pages, in *The Balance Sheet*, the journal of the Investigative and Forensic Accounting Interest Group of the Canadian Institute of Chartered Accountants. He made a somewhat daring prophecy on the subject of analysis of digital frequencies, namely that Benford’s Law can be used in fraud detection (Nigrini, 1994:3). The study was based on the suggestion that “individuals, either through psychological habits or other constraints peculiar to the situation, will invent fraudulent numbers that will not adhere to the expected digit frequencies”.

Nigrini encouraged others to see that Benford’s Law is much more than just a mathematical frivolity. Over the past years, Nigrini has turned out to be the driving force behind a far from light-hearted use of the Law: fraud detection (Matthews, 1999:29).

2.4 Formulas for expected digital frequencies

By making use of integral calculus, Benford formulated the expected digital frequencies for the first and second digits and digit combinations in lists of numbers. The formulas for the expected digital frequencies are shown below, where D_1 represents the first digit of a number; D_2 represents the second digit of a number; and a two digit combination is D_1D_2. Making use of base ten logarithms, the formulas are expressed as follows by Nigrini (2012:4):

For the first digit of the number

$$\text{Probability}\ (D_1 = d_1) = \log\left(1 + \left(\frac{1}{d1}\right)\right);\ ;\ d1 \in \{1, 2, 3\ \dots\ 9\}$$

For the second digit of the number

$$\text{Probability } (D_2 = d_2) = \sum_{d1=1}^{9} \log\left(1 + \left(\frac{1}{d1d2}\right)\right); \; d_2 \in \{0,1,2 \ldots 9\}$$

For the first two digit combination

$$\text{Probability } (D_1D_2 = d_1d_2) = \log\left(1 + \left(\frac{1}{d1d2}\right)\right); \; d1 \in \{10, 11 \ldots 99\}$$

2.4.1 Examples

In order to facilitate the above-mentioned formulas, the following examples are provided by Nigrini (2012:5):

The probability of the first digit being equal to 2 is calculated as:

Probability (D_1=2) $= \log\left(1 + \left(\frac{1}{2}\right)\right) = \log\left(\frac{3}{2}\right) = 0.17609$

The probability of the second digit being equal to 2 is calculated using the formula for the second digit of a number, and the steps are set out as follows:

$$Probability\ (D2 = 2) = \sum_{d1=2}^{9} \left(1 + \frac{1}{d1d2}\right)$$

$$= log\left(1 + \frac{1}{12}\right) + log\left(1 + \frac{1}{22}\right) + \ log\ \left(1 + \frac{1}{32}\right)$$

$$= log\left(1 + \frac{1}{42}\right) + log\left(1 + \frac{1}{52}\right) + \ log\ \left(1 + \frac{1}{62}\right)$$

$$= log\left(1 + \frac{1}{72}\right) + log\left(1 + \frac{1}{82}\right) + \ log\ \left(1 + \frac{1}{92}\right)$$

$$= 0.10882$$

The steps in the above equation are based on the fact that the second digit is equal to 2 if the first two digits are one of the following: 12, 22, 32, 42, 52, 62, 72, 82 or 92. The probability of the second digit being 2 is calculated as the sum of the nine probabilities.

The probabilities can also be written as a general significant digit law (Hill, 1995) where, for example:

$$\text{Probability } (D_1D_2D_3=147) = \log(1+(1/147)) = \log(148/147) = 0.0029$$

Table 2.4 depicts the expected frequencies for all digits 0 through 9 of the first four positions in any number.

Table 2.4: 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	0.10882	0.10097	0.10010
3	0.12494	0.10433	0.10057	0.10006
4	0.09691	0.10331	0.10018	0.10002
5	0.07918	0.09668	0.09979	0.09998
6	0.06695	0.09337	0.09940	0.09994
7	0.05799	0.09035	0.09902	0.09990
8	0.05115	0.08757	0.09864	0.09986
9	0.04576	0.08500	0.09827	0.09982

(Nigrini, 1996:74)

In order to gain better understanding of abovementioned table 2.4, the following scenario is used as explanation. A number at random, for instance, the number 1,528, consists of four digits, see table 2.5 below.

Table 2.5 : Explanation scenario				
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	0.10882	**0.10097**	0.10010
3	0.12494	0.10433	0.10057	0.10006
4	0.09691	0.10331	0.10018	0.10002
5	0.07918	**0.09668**	0.09979	0.09998
6	0.06695	0.09337	0.09940	0.09994
7	0.05799	0.09035	0.09902	0.09990
8	0.05115	0.08757	0.09864	**0.09986**
9	0.04576	0.08500	0.09827	0.09982

(Source: Author)

The first digit equals 1, the second digit equals 5, the third digit equals 2 and the fourth digit equals 8. When using the same table and highlighting the identified numbers in their positions, the expected frequencies of each digit is clear.

Table 2.6 derived as a summary from the previous table and reveals that, according to Benford's Law, the expected frequency of the digits is as follows:

Table 2.6: Summary of expected frequencies		
Digit	**Place**	**Frequency**
1	1^{st}	0.30103
5	2^{nd}	0.09668
2	3^{rd}	0.10097
8	4^{th}	0.09986

(Source: Author)

It can, thus, be concluded that the lower the number, and depending on the position of the digit, the higher the expected frequency. It is clear that digit 1, in the first position, has the highest frequency of 30.103%, whereas digit 8, in the fourth position, has a much lower frequency of 9.986%.

2.5 Conclusion

For many years Benford's Law has been recognised as a mathematical curiosity. Various researchers have contributed to the development of the Benford's Law theory and provided explanations for the theory, from Simon Newcomb being the first researcher, to Frank Benford from whom the Law has taken its name, Theodore Hill who provided the first mathematical proof of the Law, and Mark Nigrini who is the driving force behind the fraud detection application of the Law. As per Benford's Law, the digits 1 to 9 have different probabilities of occurrences as the first digit. The formula $P(n) = \log(n+1) - \log(n)$ was created to describe the empirical relationships. By replacing n with various values, the probability for $n = 1$ is 30.1% and $n = 9$ is 4.6%.

In the 19th century, the first application of Benford's Law to accounting and auditing was recorded. Carslaw (1988) and Thomas (1989) both applied Benford's Law to investigate the possible manipulation of reported net income. In this environment where the level and complexity of commercial crime is increasing constantly, the demand for a useful and cost-effective tool is growing rapidly.

The primary goal of this chapter was to demonstrate Benford's Law and to establish a simple mathematical foundation in this regard. The next chapter will address the field of forensic accountancy, with the aim on how Benford's Law can be applied to the profession.

CHAPTER 3
DEFINING FORENSIC ACCOUNTANCY

3.1 Introduction

Prior to the most recent economic downturn, the accounting profession had undergone radical changes as the result of high profile cases such as Worldcom, Enron and other accounting scandals (Davis, Farrell and Ogilby, 2009:2). The downfall of the Arthur Anderson firm was related directly to Enron and brought the accounting profession to the forefront more than any other single event (Silverstone & Sheetz, 2007:61). With the attention drawn to the accounting profession, a new market with a new breed of accountants, namely forensic accountants, surfaced (Davis *et al.,* 2009:2).

According to some, forensic accounting is one of the oldest professions and dates back to the Egyptians. The "eyes and ears" of the Pharaoh was usually a person who, in essence, served as a forensic accountant for Pharaoh, standing guard over inventories of grain, gold and other assets. This person had to be reliable, accountable and capable of handling a position of influence (Singleton & Singleton, 2010:3).

The aim of this chapter is to define the term "forensic accounting" and explain the role of a forensic accountant in the detection, prevention and investigation of complex financial crimes. This chapter will also outline some differences between the work of forensic accounting investigators and the work of financial statement auditors.

3.2 Defining forensic accounting

Great uncertainty exists on the subject of "forensic accounting". While it is a term that is being used more often, it has various connotations for different authors and associations.

3.2.1 Forensic

The word “forensic” is an adjective which owes it origin to the Latin word *forensis,* relating to a “forum”.

According to the Concise Oxford Dictionary (2002:555) “forensic” means: “(1) relating to or denoting the application of scientific methods and techniques to the investigation of crime, (2) or relating to courts of law”.

3.2.2 Accounting

The Concise Oxford Dictionary (2002:8) describes “accounting” as the action of keeping financial records. A variety of authoritative bodies, such as the American Accounting Association (AAA) and the American Institute of Certified Public Accountants (AICPA), have issued a standard definition of “accounting”. AICPA views the term as “the art of recording, classifying and summarizing in a significant manner and in terms of money, transactions and events which are, of a financial character and interpreting the results thereof”. The AAA defines “accounting” as: “the process of identifying, measuring, and communicating economic information to permit informed judgements and decisions by users of the information”.

3.3 Forensic accounting defined

In the vocabulary of accounting, terms such as “fraud auditing”, “forensic accounting”, “fraud examination”, “investigative accounting”, “litigation support” and “valuation analysis” are not distinctly defined. There are a number of distinctions between fraud auditing and forensic accounting(Singleton & Singleton, 2010:12). Forensic accounting, in general, refers to the integration of all the terms concerned with accounting investigation, together with fraud auditing, which implies that fraud auditing is a division of forensic accounting (Singleton & Singleton, 2010:12).

3.3.1 The ACFE, CICA and other authors' definitions of forensic accounting

ACFE (2012) defines forensic accounting as follows:

> Forensic accounting is the use of professional accounting skills in matters involving potential or actual civil or criminal litigation, including, but not limited to, generally acceptable accounting and audit principles; the determination of lost profits, income, assets, or damages; evaluation of internal controls; fraud; and any other matter involving accounting expertise in the legal system.

The Canadian Institute of Chartered Accountants (CICA) (2010) describes "investigative and forensic accounting engagement" as:

a. requiring the application of professional accounting skills, investigative skills and an investigative mindset; and
b. involving disputes or anticipated disputes, or where there are risks, concerns or allegations of fraud or other illegal or unethical conduct.

Forensic accounting is broader than fraud examination (Hopwood, Leiner & Young, 2008:4). Fraud examination is similar to the field of forensic accounting in some aspects, but these two concepts are not exactly equivalent. Forensic accounting is not limited to fraud, but also includes bankruptcy, business valuations and disputes, divorce, and a multitude of other litigation support services (Wells, 2008:4).

Brennan and Hennessy's (2001:5-6) definition of forensic accounting highlights the following aspects:

- Integrating accounting, auditing and investigative skills and applying litigation;
- Applying financial expertise to financial investigation;
- Applying financial expertise to legal problems, disputes and conflict resolution;
- Describing expert specialist accounting work conducted for court or other legally sensitive purposes;
- Gathering information and providing an account analysis to determine the facts necessary to resolve a dispute;

- Performing an orderly analysis, investigation, inquiry test, inspection or examination, or any combination of financial information, in an effort to assess the merits of a situation and form an expert opinion;
- Looking behind and beyond, rather than merely at the numbers;
- Performing work with a view to its potential use in a legal environment; and
- Not contesting in cases, but conducting evaluations, examinations, and inquiries and reporting findings in an unbiased, objective and professional manner.

The following definition is provided by Hopwood *et al.* (2008:3-5) within the field of forensic accounting: "Forensic accounting is the application of investigative and analytical skills for the purpose of resolving financial issues in a manner that meets standards required by courts of law." The authors further state that forensic accountants apply special skills in accounting, auditing, finance, quantitative methods, certain areas of the law, research, and investigative skills to collect, analyse and evaluate evidential matter and to interpret and communicate findings.

A similar definition is provided by Kranacher, Riley and Wells (2011:9) who refer to the term "financial forensics" as the application of financial principles and theories to facts and hypotheses at issue in a legal dispute. Two key functions are highlighted:

1. Litigation advisory services, which identify the responsibility of financial forensic professional as an expert or consultant; and
2. Investigation services which make use of the financial forensic professionals and may or may not lead to courtroom testimony.

3.4 Knowledge, skills and abilities of the forensic accountant

To meet the criteria of being an effective forensic accountant, one must have skills in many areas. Singleton and Singleton (2010:22-23) provide a list of the required skills, abilities, and knowledge accompanied by the reason as to their importance:

i. *The ability to identify frauds with minimal information*. When fraud occurs, the forensic accountant is usually left with minimum knowledge of the details. One requires competency in identifying the potential scheme and the method used to orchestrate the fraud.

ii. *Interviewing skills.* The interviewing process is an essential part of the investigation in searching for information and evidence.

iii. *Mindset.* A good forensic accountant has a distinct mindset; the ability to think outside the box.

iv. *Knowledge of evidence.* It is vital that a forensic accountant understands the rules of evidence in order to ensure the evidence is admissible in a court of law. In addition, one must be capable of differentiating between primary and secondary evidence.

v. *Presentation of findings*. The results from the investigation need to be communicated clearly. The forensic accountant as an expert witness is required to have excellent communication skills in order to carry out expert testimony in the court of law.

vi. *Knowledge of investigative techniques.* It is important to know what techniques need to be performed to obtain supplementary information.

According to Kranacher *et al*. (2011:9), a financial forensic professional's skill set consists of the following:

- Technical skills of different areas such as accounting, finance, auditing and certain areas of the law;
- Investigative skills for the collection, analysis and evaluation of evidence; and
- Critical judgment to interpret and communicate the results of an investigation.

It is clear that a forensic accountant is more than just a good accountant. A forensic accountant needs to have a specific set of skills in order to perform the work, including a decisive mindset, which is one of the most critical skills, yet also the most difficult to define. Furthermore, it is important that the forensic accountant does not lack any of the above-mentioned skills. The specific set of knowledge, skills and abilities is the differentiating factor between a good forensic accountant and a great forensic accountant.

3.5 Litigation support, investigation and dispute resolution

Forensic accounting encompasses two main areas: litigation support, and investigation and dispute resolution, which will be discussed below.

3.5.1 Litigation support

Litigation services involve the role of the forensic accountant as an expert or consultant (Hopwood *et al*., 2008:5) and comprise the provision of specialist advice in legal disputes or where a claim for financial damages is at issue (Brennan & Hennessy, 2001:11). Litigation services, in general, consist of expert witnessing, consulting and other services. These services are defined as follows:

a. Forensic accountants as expert witnesses

Where general witnesses may not give opinion evidence, expert witnesses are permitted to give their opinions in court on matters within their area of expertise (Golden *et al*., 2011:20). Forensic accountants are often called upon to testify as expert witnesses in court proceedings such as fraud trials or other legal disputes (Kramer & Barnhill, 2005:29).

b. Consulting services

A forensic accountant can serve as an expert consultant who performs expert investigations, analyses facts, and offers what-if analyses that can be used by more than one party to a dispute (Hopwood *et al*., 2008:472).

c. Other services

Other services refer to alternative dispute resolution services where forensic accountants serve as mediators and arbitrators in disputes that call for mediation or arbitration (Hopwood *et al.*, 2008:472).

3.5.2 Dispute resolution

Forensic accountants' role in the resolution of disputes has become progressively important, according to Brennan and Hennessy (2001:7). This can be attributed to the following:

- More individuals and companies are seeking the law to resolve disputes;
- The sum of amounts involved in disputes are growing;
- Both business transactions and relevant legislation, together with taxation legislation, are growing in complexity; and
- Professional advisers are being sued more frequently by former clients and third parties.

Hopwood *et al.* (2008:473) outlined a number of areas of disputes that most generally involve forensic accountants:

- Bankruptcy disputes;
- Insurance claims;
- Fraud investigations;
- Financial and economic damages;
- Government grants and contracts;
- Intellectual property and technology assets;
- Antitrust and anti-competition issues;
- Merger, acquisition and divestiture problems; and
- General contract disputes.

3.5.3 Fraud and investigative accounting

A forensic investigation can be defined as the practice of lawfully establishing evidence and facts that are to be presented in a court of law (Taylor, 2012). A predicate must exist before an investigation can be undertaken. A predicate is defined as the totality of circumstances that would lead a reasonable, professionally trained, and prudent individual to believe a fraud has occurred, is occurring, and/or will occur. The general rule of forensic accounting investigation is that predication is the basis for undertaking an investigation. It would be inappropriate to conduct an investigation without proper predication (Golden *et al.*, 2011:79).

In general, investigative accounting entails the application of accounting principles and standards to basic financial data with a view to test the validity of assertions based on accounting information or the verification of the accuracy and comprehensiveness of financial statements. The availability and quality of books and records most likely determines the level of investigation (Golden *et al*., 2011:9).

Together with their accounting knowledge, forensic accountants develop an investigative mentality, allowing them to go further than the boundaries set out in either accounting or auditing standards (Bologna & Lindquist, 1995:45).

The spotlight of investigative accounting is based on accounting issues; however, the role of forensic accountants can be extended to more common investigations, which include the gathering of evidence, or to forensic audits, which involve the examination of evidence of an assertion to verify whether it is supported sufficiently by underlying evidence, generally of an accounting nature. Investigative accounting is, time and again, connected with criminal investigations (Golden *et al*., 2011:9).

3.6 Forensic accounting vs traditional accounting

According to Hopwood *et al.* (2008:4), traditional accounting involves the use of financial language to communicate the end results of transactions and to make decisions based on that communication. Accounting can be divided into various categories such as financial accounting, managerial accounting, information systems, tax, consulting, auditing, and forensic accounting; each one serving a different purpose. For the most part, auditing resembles forensic accounting the closest, but forensic accounting is not auditing, although the information exposed by means of a detailed auditing procedure will possibly form the foundation for a subsequent forensic investigation (Bhattacharya & Kumar, 2008:152). On the other hand, auditing is the process of gathering and evaluating evidence about information to determine the degree of correspondence between the information and the standards used to prepare the information (Hopwood *et al.,* 2008:96).

3.7 Forensic accountants vs auditors

In the accounting profession, auditing and forensic accounting are two separate disciplines. Olejar (2008:60) outlines the characteristics that distinguish the forensic accountant from the auditor in terms of breadth, depth, audience, knowledge of the legal system, quality of the evidence gathered, and contingent fees:

- The auditor is concerned with whether the financial statements taken as a whole present the incomes and assets fairly, whilst the forensic accountant is focused on evidence that will quantify or prove a specific fact;
- Forensic accountants drill down to examine records that may or may not support the transactions in question, and compare them to other records of the client or adverse parties;
- The auditor does not know exactly who will read and rely on the report, whilst the audience of a forensic accountant report is limited, in general, to all parties to the litigation, together with their counsel and the finder of fact, be it a court or arbitrator;
- The forensic accountant must have a working knowledge of the legal system, whilst it is not a requirement for auditors;
- There is a distinction between audit evidence and trial evidence; and
- Contingent fees are permissible in forensic accounting engagements, whilst in audit engagements it is prohibited.

Golden *et al.* (2011:80-83) explain the reason as to why to call in forensic accounting investigators. This highlights the main differences between the services of a forensic accountant and an auditor:

- Auditors are not forensic accounting investigators based on skills, training, education and experience;

- Auditors are not authenticators; regulation does not require them to detect counterfeit documents;
- Auditors have limited exposure to fraud and their focus area is not that of investigating fraud;
- Auditors are not guarantors; they are not insurers or guarantors of the financial statements; and
- Historically, audits may have been predictable.

3.8 Forensic accounting and data analysis

In today's era, computers are an essential part of fraud examination (ACFE, 2012). According to Runkler (2012:2) data analytics can be defined as: "the application of computer systems to the analysis of large data sets for the support of decisions".

To the advantage of fraud examiners, software entities have developed computer programmes that allow users to sort through embankments of information. These software programs perform two key functions that fraud examiners use to investigate and analyse large amounts of data, namely data mining and data analytics (ACFE, 2012). The ACFE (2012) provides the following definitions, data mining is the science of searching large volumes of data for patterns and data analysis refers to any statistical processed used to analyse data.

According to the ACFE (2012) using data analysis software has the following five significant advantages:

I. Data analysis permits the fraud examiner to centralise an investigation;
II. It ensures that an investigation is accurate and complete;
III. Data analysis permits the fraud examiner to base predictions about the probability of a fraudulent situation on reliable statistical information;
IV. It allows the fraud examiner to search entire data files for red flags of possible fraud; and
V. It can assist the fraud examiner in developing reference files for ongoing fraud detection and investigative work.

There are many types of data mining and data analysis software available, and because every forensic investigation involving data analysis is different, each case must be evaluated individually. For the purpose of this study, the focus will be drawn to IDEA (Interactive Data Extraction and Analysis) which is a generalised audit software program. Fraud examiners can use IDEA to perform data analysis using Benford's Law (ACFE, 2012).

3.9 Conclusion

In literature relating to forensic accounting there is no unified definition of the term "forensic accounting". Several associations and authors provide a different definition of the term but, in simple words, forensic accounting can be described as the application of accounting concepts and investigative techniques in support of cases prepared for a court of law.

An excellent forensic accountant is much more than a great accountant. To be a successful forensic accountant one needs to possess a certain set of skills, knowledge and abilities. This includes an inquisitive mindset, tenacity and attention to detail, excellent communication skills, interviewing skills, knowledge of relevant investigative techniques and the ability to identify frauds with minimal information. These skills play a crucial role in the profession.

Furthermore, forensic accounting includes two key areas: litigation support, and investigation and dispute resolution, where litigation services commonly consist of expert witnessing, consulting and other services.

Forensic accounting should be differentiated from traditional accounting and the same applies for forensic accountants and auditors. The following quote draws a clear distinction between the two: "the auditor should be the watchdog and not the bloodhound". Forensic accounting involves looking beyond the numbers and grasping the substance of the situation. The next chapter will focus on the nature of financial statement fraud and elaborate on different fraud schemes.

CHAPTER 4
FINANCIAL CRIMES

4.1 Introduction

According to Cendrowski *et al*. (2007:15), fraud is as old as mankind itself. In Genesis, the first book of the Bible's Old Testament, fraud occurred at least twice. In the beginning the serpent deceived Eve in the Garden of Eden, and later in the same book Jacob stole the birthright of Esau (Bible, 1995). Greek mythology also tells many tales of fraud of which one of the most renowned is the Trojan Horse (Cendrowski *et al*., 2007:15).

Fraud is an action that takes place in a social setting and has rigorous outcomes for the economy, corporations and individuals (Silverstone & Sheetz, 2004:5). Panigrahi (2006:1426) maintains that financial fraud has developed into a familiar trend, resulting in the collapse of numerous companies and the deterioration of the economy. According to Manning (2011:15), there are numerous forms of financial crimes. Several of these crimes can be resolved in a short period, whilst others will take much more time. For complex financial crimes, the collection of large amounts of data to sustain a conviction is very time consuming. Nevertheless, all financial crimes have one general factor: greed. Manning (2011:15) lists three factors that are always present in financial crimes:

1. Something of value;
2. An opportunity to take something of value without being detected; and
3. A perpetrator who is willing to commit the offense.

This chapter will outline some of the most common financial crimes, together with the reasons as to why people commit these crimes. But first a clear definition of fraud needs to be established for the purpose of this study.

4.2 Definition of fraud

Fraud can be defined in various ways, and each definition addresses a different element of the concept. A general meaning of fraud from Oxford Dictionaries (2012) is a "wrongful or criminal deception intended to result in financial or personal gain".

Singleton and Singleton (2010:39) purport that fraud has numerous potentially indefinite definitions and is categorised in a variety of approaches. Terms that are frequently used as synonyms are "theft", "irregularities", "defalcation", "white-collar crime", and "embezzlement". Even though they have common characteristics, these terms are not similar in the sense of the criminal law (Singleton & Singleton, 2010:42).

More specific definitions are, for instance, mentioned by Snyman (2008:531) who sees fraud as the unlawful and intentional making of a misrepresentation which causes actual prejudice or which is potentially prejudicial to another. Snyman (2008:531) lists the four elements of fraud as:

1. Misrepresentation;
2. Prejudice or potential prejudice;
3. Unlawfulness; and
4. Intention.

The ACFE (2012) views occupational fraud and abuse as "the use of one's occupation for personal gain through the deliberate misuse or theft of the employing organisation's resources or assets". Golden *et al*. (2011:2) concur with the above definitions by stating that all acts of fraud can be categorised into four indispensable elements, namely 1) a false representation of a material nature; 2) scienter; 3) reliance; and 4) damages.

With regard to accounting methodology, it is essential to understand what defines 'fraud' and what gives rise to 'error'. According to ISA 240 (International Standard on Auditing, 2010), the term "error" refers to:

> an unintentional misstatement in financial statements, including the omission of an amount or disclosure, such as the following:

a) A mistake in gathering or processing data from which financial statements were prepared;

b) An incorrect accounting estimate arising from oversight or misrepresentation of facts; and

c) A mistake in the application of accounting principles relating to measurements, recognition, classification, presentation or disclosure.

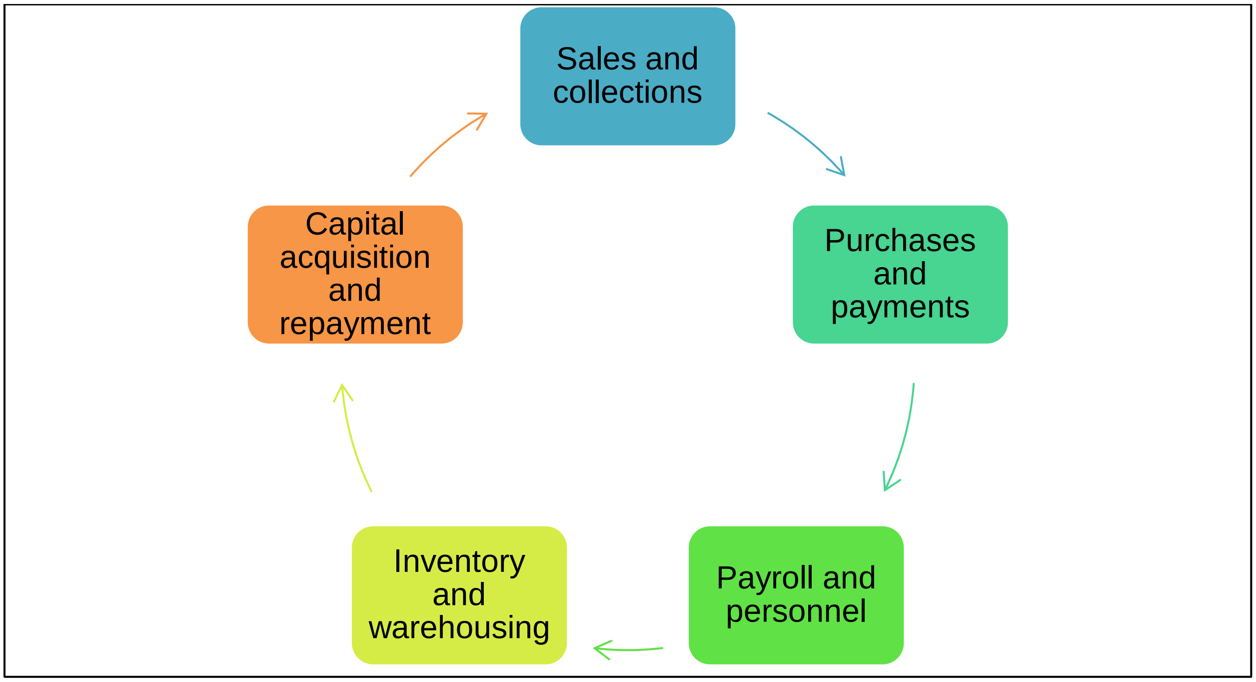
Fraud, on the other hand is defined as “an intentional act by one or more individuals among management, those charged with governance, employees, or third parties, involving the use of deception to obtain an unjust or illegal advantage”.

The distinguishing factor between fraud and error is, thus, intention. ISA 240 states the following: “the distinguishing factor between fraud and error is whether the underlying action that results in a misstatement in the financial statements is intentional or unintentional”.

4.3 The accounting cycle

Silverstone and Sheetz (2004:8) contend that the most useful way to classify the activity of the fraudster is by locating it within the five accounting cycles of any business where it will likely leave some kind of trail.

Figure 4.1: The five accounting cycles



(Silverstone &Sheetz, 2004:8)

The accounting process consists of five cycles, each of which presents a certain type of business activity. Forensic accountants can define each transaction by allocating the transaction to the accounting cycle as follow:

Sales and collections. Within the sales and collection cycle clients are invoiced for sale of goods and services as well as processing the payments received in the form of money.

Purchases and payments. This cycle processes non-capital procurements and payments for goods, equipment, and services which are used in company operations.

Payroll and personnel. This cycle is about hiring and termination, salaries, timekeeping, expense account reimbursements, and health and other types of employee insurance coverage.

Inventory and warehousing. This cycle manages the purchase and storage of goods and/or stock for later processing and sale, or just sale.

Capital acquisition and repayment. This cycle accounts for debt and equity financing, interest, and dividend payments. The results of these transactions are reflected on the financial statements of the company.

4.4 Types of fraud

According to Golden *et al*. (2011:5), the types of fraud with which forensic accountants are confronted with most are the following broad categories:

4.4.1 Misappropriation of assets

Asset misappropriation is the most common type of fraud (ACFE, 2012). Primary examples are fraudulent disbursements including false refunds, falsified wages, expense reimbursement schemes and cheque tampering.

a. False refunds

According to Wells (2011:165), a refund is processed at the register when a client returns an item which was purchased from that specific store. A refund, in other words, shows a disbursement of money from the register, as the client receives money back. In a fictitious refund scheme, a transaction is being processed by the perpetrator as if a client has returned goods, despite the fact that, in reality, no return took place. Two results from this deceitful transaction are:

i. The perpetrator obtains cash from the register in the amount of false returns; and

ii. A debit entry is made to the inventory system which illustrates that the goods had been returned to the inventory.

b. Expense reimbursement schemes

Employees incur out-of-pocket expenses regularly in the course of executing their obligation to their employer. Appropriate to the type of the business, along with the nature of expenses incurred, such expense may be reimbursed to the employers (Zweighaft, 2009). Expense reimbursement schemes take place when employees make false claims for reimbursement of inflated or fictitious business expenses. This is a well-known type of occupational fraud and can be complicated to detect (Kranacher *et al*., 2011:371).

c. Falsified wages schemes

Fraudsters every so often use fabricated hours and salary schemes to overstate the employees' pay rates or to even pay employees inflated overtime (Singleton & Singleton, 2010:88). Another popular scheme is that of ghost employees, which refer to people on the payroll who are, in fact, not employed by the victim company. Falsification of personnel or payroll records results in cheques to be produced to this "ghost" (Wells, 2011:213). In other words, while the ghost employee reflects on the payroll of the company, the individual collects wages at regular intervals without working for the company in reality.

d. Cheque tampering schemes

Singleton and Singleton (2010:89) state that cheque tampering schemes are exclusive amidst fraudulent disbursement schemes for the reason that it is the solitary scheme in which the fraudster physically prepares the falsified cheque.

4.4.2 Financial statement fraud

According to the ACFE (2012), these types of schemes pertain to the intentional misstatement or omission of material information in the company's financial reports. Common methods of fraudulent financial manipulation involve recording fictitious revenues, concealing liabilities or expenses, and artificially inflating reported assets. Moreover, financial statement fraud includes manipulation, falsification, or alteration of accounting records or supporting documents from which financial statements have been prepared (Golden *et al*., 2011:5).

Albrecht *et al*. (2012:40) contend that, similar to other frauds, financial statement fraud entails intentional deceit and attempted concealment. These authors (2012:406) describe the relationship between financial statement numbers as predictable and explain that financial statements tell a story to individuals who really understand accounting. The components of the story have to be consistent internally. Numerous large financial frauds might perhaps have been discovered if the preparers of financial statements, auditors and other third parties had understood the financial statements.

4.4.3 Procurement Fraud

Procurement fraud can be a very complex fraud to investigate because it can be committed in various manners. According to the ACFE (2012) procurement systems are predisposed to bribery and corruption. The procurement system refers to those processes, procedures and companies involved in the purchase of goods and services by public or private companies (ACFE, 2012). According to Guile (2012:189) a definition of procurement fraud can be formulated as: “fraud within the procurement lifecycle of a product or service, not forgetting long-term maintenance contracts”. Another definition is provided by Surveilligence (2011), referring to procurement fraud as illegal conduct by which the offender gains an advantage, avoids an obligation or causes damage to his organisation.

According to KPMG (2010:5) the structure and nature of the company can also provide opportunities for fraud. Procurement is where the money is, and thus an area ripe for fraud and misconduct (KPMG, 2010:24).

4.4.4 Types of Procurement Fraud

Procurement fraud can be committed in many ways, but according to Guile (2012:189) the essential categories include:

- Bid rigging/bid splitting;
- Creation of shell companies to facilitate fraudulent payments;
- Collusion between suppliers;
- Purchase order and contract variation orders;
- Unjustified single source awards; and
- False invoices for products and services for suppliers who do not exist

4.4.5 Profile of economic crime in South Africa

The PwC Global Economic Crime Survey (2014) has found that South African companies experience

Figure 4.2. illustrates the occurrences of different types of economic crimes in South Africa that is relevant to this study.

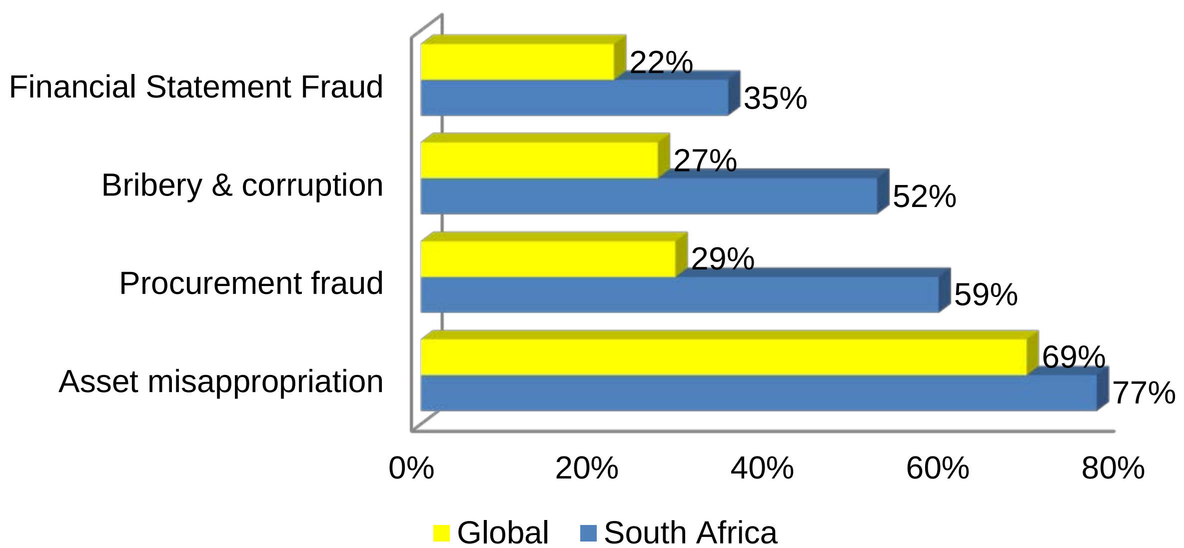


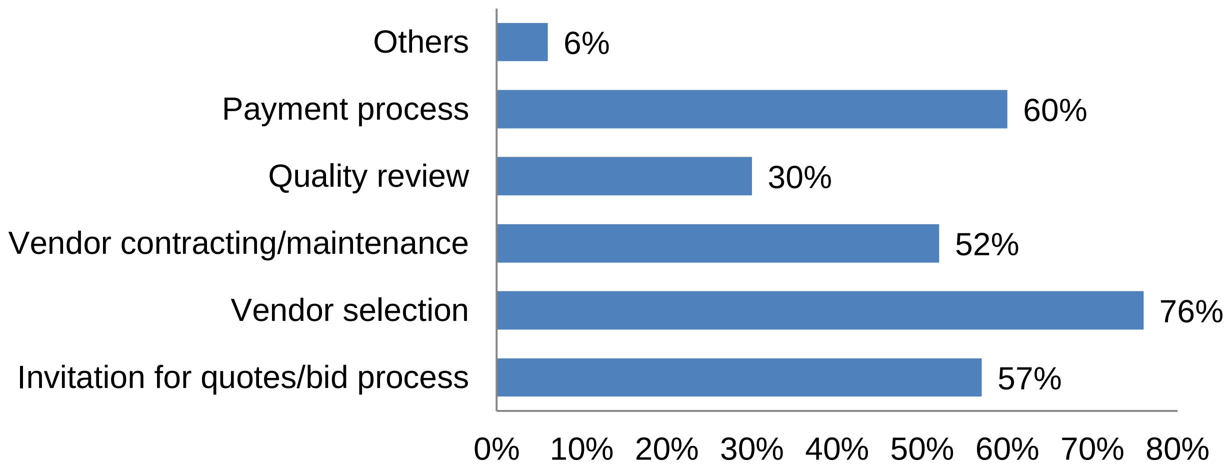
Figure 4.2:Types of economic crimes experienced in South Africa

(PWC, 2014)

From Figure 4.2 it is evident that financial statement fraud affected 35% of South African respondents during the past 24 months, compared to only 22% of global respondents. Bribery and corruption affected 52% of South African respondents during the past 24 months, compared to only 27% of global respondents. Procurement fraud affected 59% of South African respondents during the past 24 months, compared to only 29% of global respondents. Asset misappropriation affected 77% of South African respondents during the past 24 months, compared to only 69% of global respondents.

Figure 4.3 depicts the steps in the procurement process where fraud occurred.

Figure 4.3 : Steps in the procurement process where fraud occurred



(PWC, 2014)

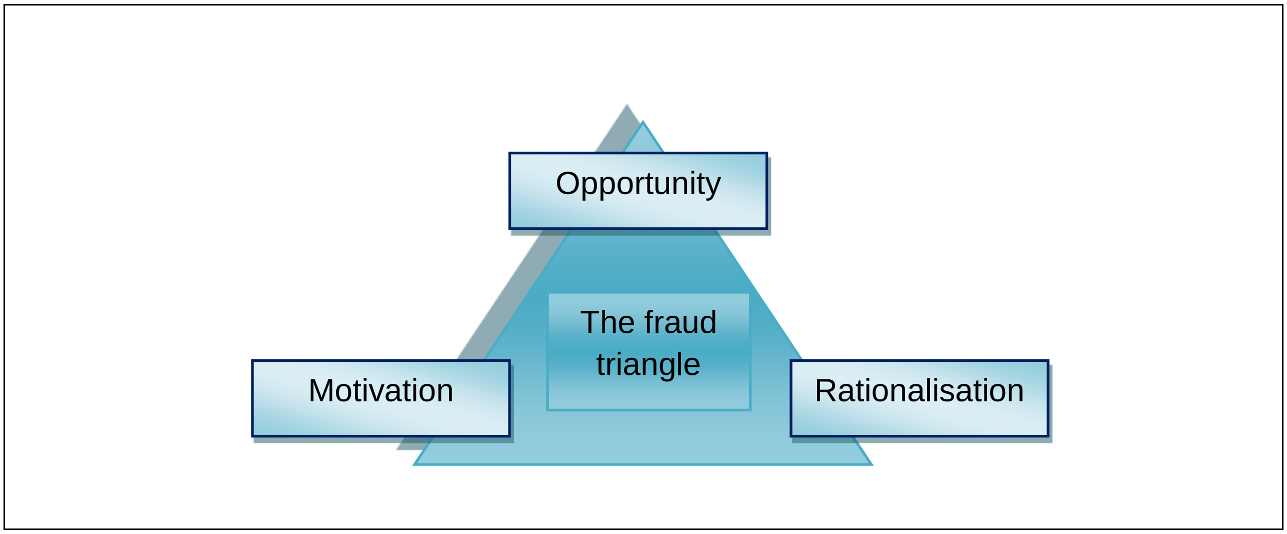
In South Africa, vendor selection was the step in the procurement process that was targeted most by fraudsters with 76%. The second highest percentage of fraud occurred in the payment process with 60%. It is clear that all steps within the procurement process appear to be exposed to fraud.

4.5 The fraud triangle

Once a fraud definition has been adopted by a company, it is important to integrate the fraud triangle into the investigation (Vona, 2012). Dr Donald R. Cressy, a fraud researcher, created the concept of the fraud triangle to explain the three fundamental conditions which are present in each case of fraud (Cendrowski *et al*., 2007:41).

The three primary factors which facilitate any fraud are confined by the fraud triangle shown in figure 4.4 below.

Figure 4.4: The fraud triangle



These three elements are 1) perceived pressure; 2) perceived opportunity; and 3) some way to rationalise the fraud as acceptable (Albrecht *et al*., 2012:298).

4.5.1 The three elements of the fraud triangle

All three elements have to be present for the fraud to occur; if one element is eliminated, the fraud will not be committed or will be prevented by the organisation's internal controls (Cendrowski *et al*., 2007:41).

a. Pressure

Pressure refers to events taking place within the individual's life or organisation (Vona, 2012:7). According to Albrecht *et al*. (2012:300), the majority of fraud experts are of the opinion that pressure can be separated into four main groups: 1) financial pressure; 2) vices; 3) work-related pressure; and 4) other pressure.

It is important to note that, because pressure is a factor particular to the individual, only indirect evidence can be gathered, which is, in general, circumstantial. Accordingly, forensic accountants should not keep their eyes open only for symptoms, they should also be open-minded (Kranacher *et al*., 2011:204).

b. Rationalisation

Although individuals rationalise their actions, the reasons may fluctuate; however, the justification is always present (Vona, 2012:7). Kranacher *et al.* (2011:204) explain rationalisation as “a manufactured, somewhat arbitrary justification for otherwise unethical or illegal behaviour”. Fraud perpetrators portray their actions as something other than executing a crime or taking unfair advantage of another person or organisation (Cendrowski *et al*., 2007:43).

c. Opportunity

Cendrowski *et al*. (2007:44) describe opportunity as the condition that allows fraud to occur. In general, this refers to a weakness in the internal control structure of the company which allows an asset to be converted and the act concealed. A direct relationship exists between opportunity to commit fraud and the ability to conceal the fraud (Vona, 2012:8). Kranacher *et al*. (2011:204) claim that, without opportunity, fraud is very much unlikely.

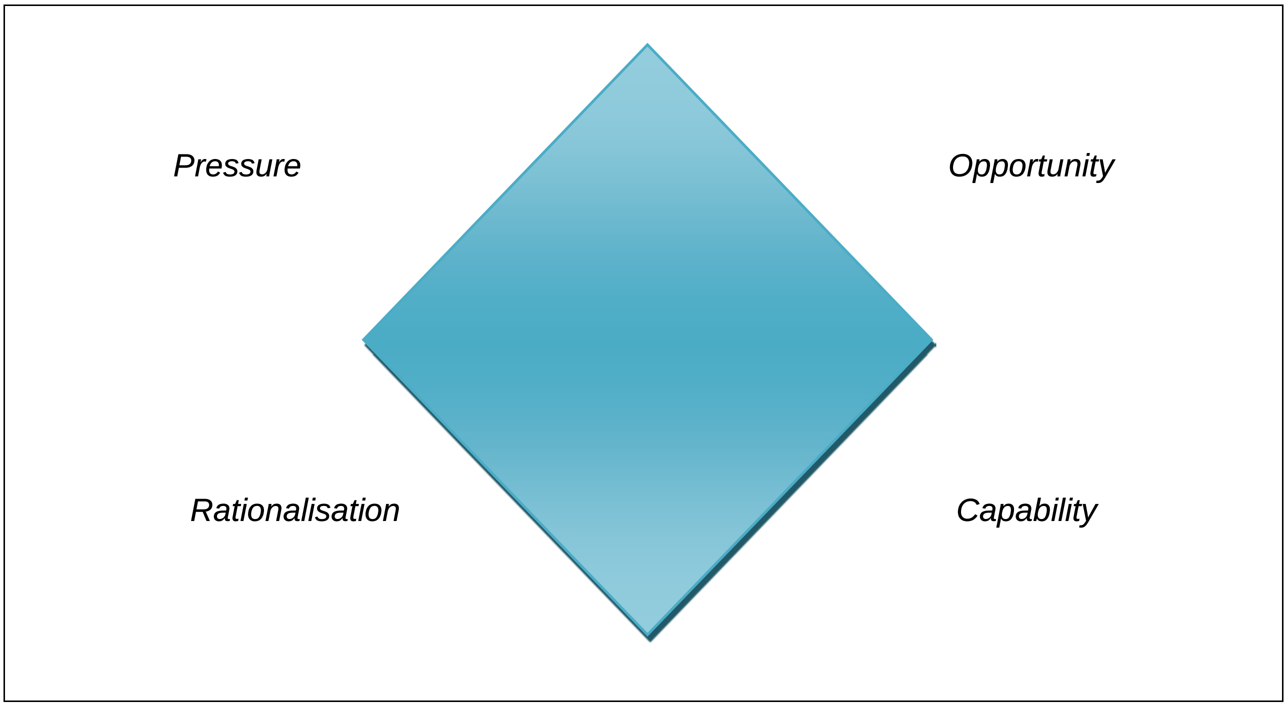
According to Vona (2012:8), to understand the application of the fraud triangle concepts, one has to focus on the following six arguments:

1. The three elements of fraud, namely pressure, rationalisation and opportunity, coexist at different levels per individual;
2. The elements of fraud will fluctuate based on personal situations;
3. The power of one element might result to a person’s perpetrating a deceitful act;
4. One element’s power might eradicate the concern of detection;
5. Identifying the three elements is easier than measuring the three elements; and
6. The fraud risk factors may originate from internal sources or external sources.

4.5.2 The fraud diamond

Wolfe and Hermanson (2004:38) attempted to enhance the fraud triangle in order to advance both fraud prevention and detection. They added a fourth element, namely the *capability* of the individual, to create the four-sided fraud diamond. This capability can be labelled as the personal traits and abilities which contribute to whether fraud may, in fact, take place even with the presence of the other three elements. In 2004, Wolfe and Hermanson introduced the fraud diamond as shown in figure 4.5 below.

Figure 4.5: The fraud diamond



(Wolfe & Hermanson, 2004:38)

4.6 Red flags, symptoms or indicators

Singleton and Singleton (2010:95) explain that, in the process of committing, converting and concealing fraud, “fingerprints” are left behind, which are known as “red flags”. When fraud occurs, traces of the perpetrator are left at the scene where the crime took place, similar to fingerprints left at a crime scene.

In contrast to murder or bank robbery, fraud is not often observed. However, symptoms, indicators, or red flags can be observed. In order to detect fraud, a forensic accountant needs to be able to identify these symptoms or red flags (Albrecht *et al*., 2012:80).

Symptoms of fraud can be divided into six groups:

1. Accounting anomalies;
2. Internal control weaknesses;
3. Analytical anomalies;
4. Extravagant lifestyle;
5. Unusual behaviour; and
6. Tip-offs and complaints.

For the purpose of this study, the focus will be on accounting anomalies and analytical anomalies.

4.6.1 Accounting anomalies

Kranacher *et al*. (2011:187) describe accounting anomalies as "unusual activities that seem to violate normal expectations for the accounting system". Some of the most common accounting anomaly fraud symptoms are 1) problems with source documents; 2) faulty journal entries; and 3) inaccuracies in ledgers (Albrecht *et al*., 2009:136). Kranacher *et al*. (2011:187) contend that some of the problems which may be observed in documentation are duplicate payments; second endorsements on cheques; increases in past due accounts receivables; missing documents; excessive voids or credits.

a. Erroneous journal entries

Accounting is said to be the language of business. For example, consider the following journal entry:

Dt Fixed Asset	20,000	
Ct Bank		20,000

(Albrecht *et al*., 2009:137).

In the English language, the above-mentioned articulates, “A fixed asset was paid for R20 000 in cash”. In the language of accounting, this journal entry says, “debit Fixed Assets; credit Cash”. An individual who speaks both English and accounting will understand these two statements to be equivalent. The predicament with the language of accounting is that it can be manipulated to tell a lie (Albrecht *et al*., 2009:137).

b. Inaccuracies in ledgers

The definition of a ledger is “a book or other collection of financial accounts” (Oxford Dictionaries, 2013). In other words, for the preparation of the monthly and year-end financial reports, the journal entries are summarised in a ledger which records every transaction for all accounts (Coe, 2011:25). Many frauds involve manipulating payables to vendors or receivables from customers.

Albrecht *et al.* (2009:139) explain two common fraud symptoms relating to ledgers:

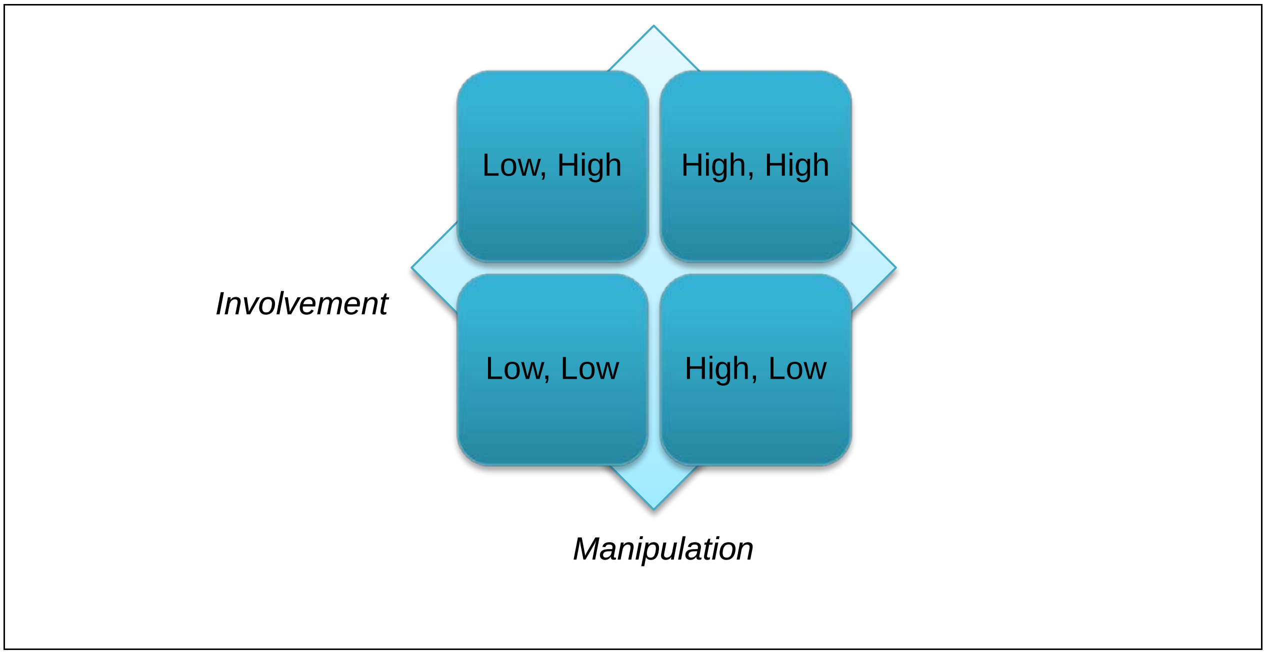
1. A ledger which does not balance; in other words, the total of all debit balances does not equal the total of all credit balances;

2. Master (control) account balances which do not equal the sum of individual customer or vendor balances.

c. Manipulation of transaction records or ledgers

According to Bhattacharya *et al*. (2010:6), when a fraudster is very creative, knowledgeable and organised, one would expect the manipulation of transaction records or books of accounts to have been executed with a fair amount of sophistication in order to avoid being detected by the internal control systems. Furthermore, when more than one perpetrator are involved, a great percentage of the detectable manipulations at the primary starting point of the fraud might be buried as the perpetrators worked together to cover up their tracks at their respective ends, in effect, opposing the majority, if not all of the "check-and-balance" type internal control systems that are used in general. Therefore, the complexity of a financial fraud, for example, how well it is covered up, would depend on both the level of sophistication of manipulating the financial records (the manipulation variable) and the extent of involvement of multiple perpetrators (the involvement variable). Figure 4.6 adopted from Bhattacharya and Kumar (2008:150) demonstrates this concept.

Figure 4.6: Manipulation and involvement variables



(Bhattacharya & Kumar, 2008:150)

For example, when the involvement variable is low and the manipulation variable is low, one can expect that the fraud will be detected easily. On the other hand, if the involvement and the manipulation are high, one can assume that the fraud will be more sophisticated and more difficult to detect.

4.6.2 Analytical anomalies

Albrecht *et al.* (2012:80) explain analytical symptoms as accounting transactions, economic events, or financial or non-financial relationships which are abnormal. Examples are: a balance might be too small, sales might be too large, transactions might be recorded by the incorrect person or at the incorrect time. These are unpredicted or inexplicable events or actions which are unusual or unexpected. According to Kranacher *et al.* (2011:186), analytical anomalies are transaction or financial statement relationships that do not make sense, for example, transactions which are too small or too big when compared to normal activity.

4.7 Conclusion

The term “fraud” can be defined in numerous ways and has different meanings and connotations to different people and associations. The most common way to label fraud is Snyman’s (2008:531) definition that it is the unlawful and intentional making of a misrepresentation which causes actual prejudice or which is potentially prejudicial to another. Financial frauds can be perpetrated in many ways. The three primary factors which facilitate any fraud are confined by the fraud triangle which consists of opportunity, pressure, and rationalisation. With the purpose of detecting fraud, a forensic accountant needs to be competent in identifying an event or action as being a symptom or red flag. A forensic accountant ought to understand the definition of fraud and be aware of the different types of fraud. A clear understanding of the term “fraud” will contribute to implementing the correct investigative techniques to detect fraud, since some types of fraud are not detected easily.

CHAPTER 5

FORENSIC ACCOUNTING AND BENFORD'S LAW

5.1 Introduction

Regardless of its origin in the 1920s, Benford's Law was not recognised as a useful technique for forensic accounting analysis until the late 1990s (Dorrell & Gadawski, 2012:379). In the forensic accounting environment, the application of Benford's Law has been identified as a technique to point out irregularities in numerical data (Odueke & Weir, 2012:33).

The numbers conceived by fraudsters for non-existent goods or services are not likely to follow the sequence of Benford's Law. Vigilant to this fact, there are several practical applications of Benford's Law in financial forensic investigation (Dorrel & Gadawski, 2012:274).

A forensic accountant can apply Benford's Law as a wide-ranging tool to benchmark the results of the analysis of the target company's accounting records because the principle of this application is to examine series of digits in a number set which follow a predictable pattern (Warshavsky, 2010:2). Benford's Law provides this benchmark of comparison by defining the expected digit distributions, allowing the forensic accountant to interpret the observed results. If any number in the target company's accounting records falls outside the benchmark of Benford's Law, further investigation can be executed to the specific transactions (Warshavsky, 2010:2).

Benford's Law is usually employed by forensic accountants and auditors in regards to fraud. According to Durtschi *et al*. (2004:22), when an auditor, in this case a forensic accountant, decides to use digital analysis in a fraud detection effort, several matters need to be considered:

1. Types of accounts on which Benford's Law may be effective;
2. Types of tests that should be run, as well as the interpretation of those tests; and

3. At which stage digital analysis is seen as ineffective.

This chapter will outline the link between Benford's Law and forensic accounting, together with the issues mentioned above. The aim of this chapter is to highlight how Benford's Law can be applied in forensic accounting investigation.

5.2 Types of accounts

Based upon the knowledge of others in testing Benford's Law, the set of data has to meet specific criteria for the result to be significant (Dorrell & Gadawski, 2012:274). Durtschi *et al*. (2004:24) summarised a table to indicate when it is appropriate to use digital analysis based on Benford's Law, and when to bring prudence into play. Tables 5.1 and 5.2 provide examples of when Benford's Law is likely to be effective and when not, as well as an example of a specific data set.

Table 5.1: Effectiveness of Benford's Law – likely effective

When Benford's Law is likely to be effective	**Examples**
Sets of numbers that result from mathematical combinations. Result comes from two distributions	Accounts receivable (number sold x price) Accounts payable (number bought x price)
Transaction-level data. No need to sample	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[1] is positive	Most sets of accounting numbers

(Durtschi *et al*., 2004:24)

[1] Skewness refers to the measure of the degree of asymmetry of a distribution.

Table 5.2: Effectiveness of Benford's Law – not likely effective	
When Benford's Law is not likely to be effective	**Examples**
Data set comprises assigned numbers	Cheque numbers, invoice numbers, postal codes
Numbers that are influenced by human thought	Prices set at psychological thresholds (R1.99); ATM withdrawals
Accounts with large number of firm-specific numbers	An account specifically set up to record R100 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

(Durtschi *et al*., 2004:24)

Nigrini (1999a:81) listed a number of potential accounts for which Benford's Law and digital analysis might be useful:

- Accounts payable data;
- Estimations in the general ledger;
- The relative size of inventory unit prices among locations;
- Duplicate payments;
- Computer system conversion;
- Processing inefficiencies due to high quantity/low dollar transactions;
- New combinations of selling prices; and
- Customer refunds.

Other objectives which are likewise applicable include analysis of credit card transactions, purchase orders, loan data, stock prices, and customer balances (Singleton, 2011:2-3).

In order to illustrate the fraud detection application of Benford's Law, Bell (2009) prepared a table (table 5.3 below) with the following column headings: Area, Objective and Test unit. "Area" refers to the type of account or financial statement item, "Objective" is the defined target, and the "Test unit" consists of the amount or component that needs to be tested. The purpose of table 5.3 is to exemplify the broad area of accounts that is suitable for Benford's Law along with the purpose as to why the specific account would be selected.

Table 5.3: Fraud detection application of Benford's Law (Bell, 2009)

Area	**Objective**	**Test unit**
Accounts payable	Identify questionable or unusual vendor disbursements	Amount paid
Accounts receivable	Identify questionable or unusual receivables	Invoice amount
Expense reports	Identify questionable or unusual employee disbursements	Amount paid
Fixed assets	Identify questionable or unusual vendor disbursements	Amount paid
Income tax	Compliance – identify suspicious corporate returns	Amount
Insurance claims	Identify potentially fraudulent claims	Amount paid
Inventory	Identify potentially over/under reported inventory valuation	Physical inventory counts
Net income	Identify potentially fraudulent net income	Amount
Payroll	Identify potential ghost employees	Address
Sales	Identify potentially fraudulent revenue	Amount
Total assets	Identify potentially fraudulent assets	Amount

It is evident from table 5.3 that Benford's Law can be applied to an array of areas by means of different objectives and implementing various test units. Once the forensic accountant has identified the objective, the area and test unit can be selected. For example, if the forensic accountant uncovered red flags with regard to unusual receivables, the area of selection will be accounts receivable and the amount will be the test unit.

5.3 Creating data sets

Nigrini (2000a) provides a synopsis of the seven rules that should be kept in mind when creating data sets:

> A data set suitable for digital analysis should form a coherent whole pertaining to a distinct corporate entity, for a definite accounting period, with transactions separately and uniquely enumerated; a legend of expected transaction types should be provided, and data should be reconciled to financial records before analysis begins. Finally, where it is possible to subdivide the work, the smallest statistically valid set should be chosen.

The subsequent elements can be highlighted from the summary:

1. Ensure that the data form a coherent whole;
2. Make use of data relevant to a distinct corporate entity;
3. Select a definite accounting period;
4. Make sure transactions are independently and uniquely catalogued;
5. Acquire a legend of anticipated transaction types;
6. Reconcile to the financial records; and
7. Employ the smallest statistically valid set.

5.4 Tests and interpretation of tests

5.4.1 Series of tests

Nigrini and Mittermaier (1997:57) recommended six digital tests which can be utilised by internal and external auditors. According to Warshavsky (2010:3), several of the digital analysis tests can be employed by a forensic accountant during a forensic investigation. In the application of these tests, the forensic accountant evaluates the output activity from chosen accounting records and books of the target entity to the expected digit frequency according to Benford's Law.

These are the five major digital tests which can be used to ascertain whether data sets conform to Benford's Law (Nigrini, 2000a; 2012; Nigrini & Mittermaier, 1997). The tests are listed in the way they are performed usually, with a brief description of their specific use:

1. First digit test

   The first digit of a number is the leftmost digit, with the understanding that the digit can never be equal to 0. For example, the first digit of the number 4,535 is 4. The first major digital analysis test is merely a test of reasonableness. It can be compared to the view of the countryside from an aeroplane window: It is a high-level test, and the forensic accountant will not spot anything abnormal except if the view is exceptionally transparent. It is not proposed to use the test for choosing audit targets for follow-up. The selection of audit targets is the work of the more focused tests.

2. Second digits test

   The second digits test, similar to the first digit test, is a high-level test best used as a preliminary test of reasonableness. The second digit in the number 7,939 is 9. This test is not a resourceful way to select an audit sample for the reason that the actual proportion is large. On the other hand, this test can promptly turn up basic problems in the data.

3. First two digits test

The first two digits test is more focused than the aforementioned tests. The objective of this test is to narrow down the size of the target. For example, the first two digits of 9,434 are 94. This test is executed to discover anomalies in the data which are not readily evident from either the first or second digits when seen on their own. This test is, to a certain extent, powerful for the detection of biases in the data, for example, numbers gravitating to certain values.

4. First three digits test

There are 900 possible first three digits combinations (100 to 999 inclusive). The first three digits in the number 83,924 are 839, excluding leading 0s. In fact, there can be an unlimited number of 0s following the decimal point. This is a highly focused test which gives the auditor comparatively small enough samples. Whereas the first two digits test has a propensity to pick up broad categories of irregularity such as purchases and contracts issued at just below the threshold, the first three digits test, by way of its greater accuracy, have a tendency to pick up duplications.

5. Last two digits test

The purpose of the last two digits test is to discover made-up and rounded numbers. In support of data sets below 10,000 observations, this test may perhaps present a sample too small to efficiently choose audit targets. The last two digits of 8,537 are 37. One hundred last two digit combinations are possible (00 to 99 inclusive). Even though Benford’s Law has a bias in favour of the lower digits in the third and fourth positions, the last two digits test hypothesise that this prejudice is of no consequence. Thus, the expected proportion for each of the possible 100 last two digit combinations is 0.01.

Data can be analysed further by means of subsetting. Data subsets can be described as natural groupings of the data, for example, vendor numbers, transaction dates and employees in payroll (Nigrini, 1999a:82). Subset tests discover small listings of severe abnormalities in major sets of data, which simplifies the analysis and making it, to a great extent, more manageable. These tests focus on errors as in contrast to biases, fraud or processing inefficiencies.

As soon as the test has been run, the forensic accountant will have to establish which results require more consideration or whether the results provide evidence or information according to the audit objective (Singleton, 2011).

The goal with testing by Benford's Law is to segregate the abnormal group from hundreds or thousands of results in order for more in-depth examination of the group. Lowe (2000b:24) describes the four stage process as:

1. The identification of the first digit in which the observed count is more than the predicted count;
2. The use of Benford's Law formula to evaluate the distribution of the second digit of the unacceptable digit;
3. The observation of the results of the second digit analysis to identify evident anomalies; and
4. The Benford procedure comes to an end once the group of anomalous results has been detected.

5.4.2 Interpretation of tests

When performing each of the aforementioned tests, the auditor needs to frequently maintain professional judgement along with determining the other compulsory analytical procedures. Auditors need to examine the unusual data cautiously and look at the supporting evidence to conclude the presence of the inconsistencies (Ashcroft *et al.*, 2002:8).

5.4.3 Measuring goodness of fit

According to Dorrel and Gadawski (2012), there is no definite technique to ascertain how an observed data set measures up to Benford's Law. Hence, the forensic accountant has to determine the most suitable goodness of fit for the observed data by employing one of the existing methods.

a. The null hypothesis

In statistical inference the null hypothesis refers to a proposal that endures verification to establish whether it should be accepted or rejected in goodwill of a substitute proposal. In short, there is no relationship between two measured observable facts (Business Dictionary, 2012b).

Bhattacharya *et al*. (2005:10) formulated the following hypotheses:
H_0: The observed first digit frequencies in a data set are distributed according to Benford's Law.
H_1: The observed first digit frequencies in a data set are not distributed according to Benford's Law.

This statistical test will not disclose whether fraud has, in fact, been committed. If H_0 is rejected, this would imply that the digits do not approximate a Benford distribution. Conversely, given that H_1 is accepted and H_0 is rejected, it could imply any of the four possible explanations:

i. Manipulation does not exist – Type I error has occurred, i.e. H_0 rejected when true;
ii. Manipulation exists and such manipulation is without a doubt fraudulent;
iii. Manipulation exists and such manipulation may or may not be fraudulent;
iv. Manipulation exists and such manipulation is without a doubt not fraudulent.

b. Chi-square test

Another method is the Chi-square test. For the reason that the Chi-square test makes use of the expected number of observations in the computation of the Chi-square statistic it experiences the excess power problem, referring to the circumstance where, for large data sets, the null hypothesis will be rejected when no significant differences have been found between the actual and expected proportions for practical reasons. Thus, any goodness-of-fit test seems to require being independent of the data set volume to be helpful in this context (Nigrini, 2000b).

c. Z-statistic

A third alternative is to exploit z-statistic. According to Nigrini (2012:150), the z-statistic is the approved test to determine whether the actual frequencies for a digit deviate from the expected frequencies of Benford's Law. The z-statistic formula takes three elements into account, namely the absolute magnitude of the difference, the size of the data set and, lastly, the expected proportion.

Z-statistics can also be applied to check for significant difference between the expected and actual values, in other words, the margin of error. The greater the z-score, the lower the probability that the result is due to chance.

The z-statistic is calculated as follows:

$$\frac{/Po - Pe/ - (\frac{1}{2n})}{\sqrt{(Pe * \frac{1-Pe}{n})}}$$

Where: *Pe* represents the expected proportion;

Po is the observed proportion;

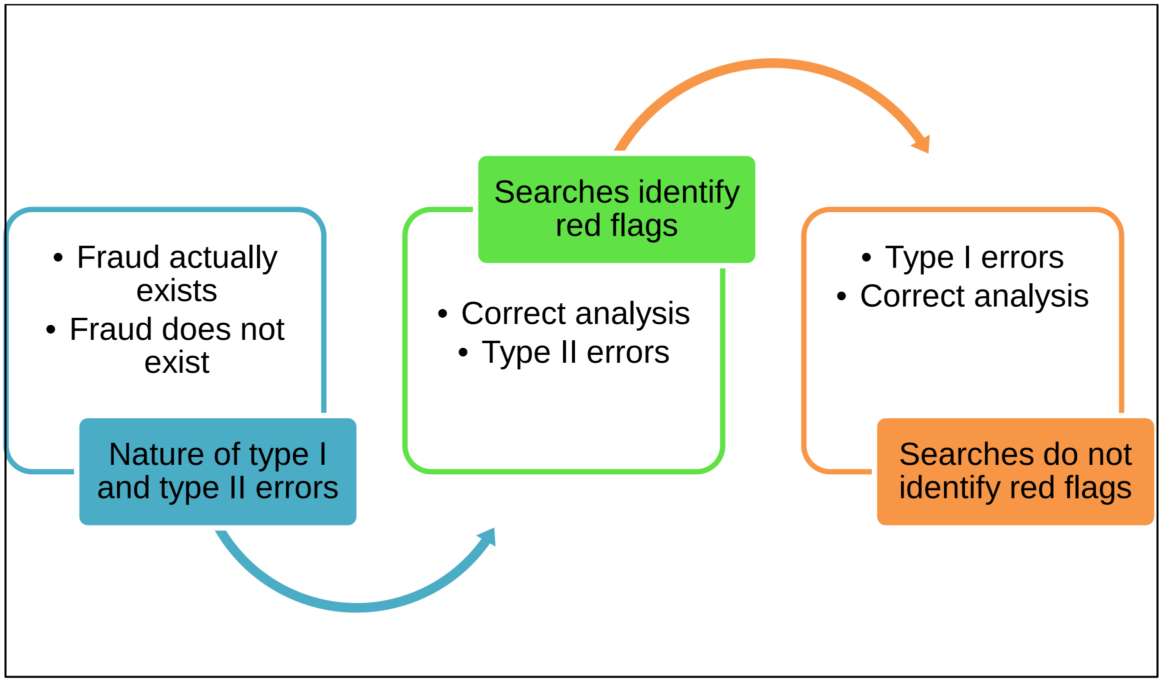
n is the number of observations, whilst the (*1/2n*) term is a continuity factor and is only used when it is smaller than the first term in the numerator.

With regard to the application of Benford's Law, the norm is the use a significance level of 5%. Furthermore, a forensic accountant should remember that the z-statistic is created to test a single digit at a time and is not expected to point out complete conformity or non-conformity (Nigrini, 2012:151).

The forensic accountant will normally discover variations in the data analysis, but the employment of z-statistics allows the forensic account to establish the implications of the difference. Calculating the z-statistic manually can be very complicated, however, most digital analysis software programs that include the Benford Analysis function perform these calculations automatically. The significant aspect that the forensic accountant should keep in mind is that, if the z-statistic for a point not following Benford's Law exceeds 1.96 when applying a 5% significance level, the comprehensive data entail further investigation (Mantone, 2013).

The above-mentioned statistical items need to be considered in order to decrease the threats posed by type I and type II errors (Overhoff, 2011). Barnes (2009) explains that a type I error is when the auditor's bargaining authority is moderately high, and a type II error is when the auditor's bargaining authority is moderately low. Overhoff (2011) puts it as follows: type I is where the auditor believes that fraud has taken place when, in fact, fraud does not exist (over-auditing), and type II is when the auditor believes that no fraud has taken place, whilst fraud has been committed (under-auditing). These types of errors are described in the figure below.

Figure 5.1: The nature of type I and type II errors



(Albrecht *et al*., 2001:210)

Nigrini (2000b) highlights the characteristics of a valid goodness-of-fit test as follows:

1. The test needs to evaluate the goodness of fit of the whole distribution and not just a single first two digit combination;

2. The test should not make use of the sample volume (n) in view of the fact that the excess power problem will constantly lead to the rejection of the null hypothesis for larger sets of data;

3. Practitioners need to understand the test in addition to the test's programmability into software; and

4. The accept or reject pronouncement has to be determined without prejudice.

A goodness-of-fit test that has been applied to an observed accounting set of data so as to uncover statistical evidence of non-conformity to Benford's Law cannot be regarded as definite. Nevertheless, it is one of various investigative tools that have to be exploited by a forensic accountant in the detection of fraud (Kumar & Battacharya, 2007:83).

5.5 Actual application

Benford's Law has been employed effectively to expose fictitious business and financial data (Hassan, 2003:123). According to Nigrini (cited by Matthews, 1999:30), digital analysis is being employed by listed companies, large private companies, professional firms and government agencies in the US and Europe, along with one of the world's largest audit firms.

Tapp and Burg (2000) provided three scenarios with detailed examples of fraud and how each can be detected by using technology. These scenarios include alleged vendor kickbacks, fictitious vendors and overstated divisional performance.

The following are some scenarios in which Benford's Law has been used as an aid in financial fraud detection:

Collapse of bank

Forensic accountants have, with great success, utilised Benford's Law to trace down shady transactions in one of the largest financial frauds of recent times. In due course, this led to the downfall of a major international bank with losses of millions (Bhattacharya & Kumar, 2007:82).

Signing authority

The auditors for Company Z investigated the likelihood of fraud in the contracting department where thousands of contracts were issued monthly. The analysis disclosed that the first two digit combination "49" appeared more frequently than expected. The classification of the contracts revealed that the manager was raising contracts between values of $49,000 and $49,999 in order to avoid contracting regulations stating that contracts less than $50,000 can be sole-sourced (supplier is the only source for the contract item); contracts more than $50,000 had to be submitted to the bidding process. The contract manager was committing fraud by raising contracts simply below the financial limit and referring these contracts to an entity owned by his wife (Coderre, 2009:207).

Coderre (2009:207) provided the following summary for the above-mentioned case:

i. Schemes: Contracting officer bypasses limits and directs contracts;
ii. Symptoms: Amounts simply below financial limits; and
iii. Data requirements: Contracting vendor, date, amount and contracting officer.

Falsified sales for tax evasion

According to Nigrini (1999c), the bookkeeper of a fast-food restaurant was aware of the fact that, at the end of the week, the owner fabricated the daily sales. The intention was to understate sales in order to both avoid the high sales tax and evade income tax. The data set used was a full year's daily sales numbers. The owner did not use two first digits, but he did include cents in all the amounts for daily sales. The last two digits were compared to the benchmark created by Benford's Law. The result indicated that the last two digit combination "40" occurred 5.6% more than expected, and for the "87" digit combination the benchmark was exceeded by 2.5%. Such types of duplications indicate made-up numbers. The owner was under the impression that she was making up genuine-looking numbers but, subconsciously, several duplications were repeated in the fraudulent data.

Employee reimbursement

During an employee reimbursement audit, the auditor became aware of unusual first two digit excesses at 95, 99 and 10. Further examination revealed that employees were excessively claiming breakfast expenses of $9.50, $9.90 and $10.00. According to the corporate policy, meal expenses of $10.00 and below did not require a supporting voucher Nigrini (1998b).

Accounts payable

In another case, an accounts payable audit at a utility demonstrated too many 50s on the first two digit graph. The auditor discovered that many of the numbers beginning with 50 were attributable to the car batteries with a cost of $50.00. The investigation uncovered that the number of batteries which was paid for throughout the year was equal to twice as many cars in the fleet (Nigrini, 1999b:26).

Altered cheque amounts

Berton (1995) reported in *The Wall Street Journal* that the district attorney's office in Brooklyn, New York, employed Benford's Law in order to investigate financial figures. The amounts of 784 cheques issued by a total of seven companies were set out in a table. The frequencies of the leading digits were compared with the expected frequencies of Benford's Law. The amounts on 103 cheques did not correspond to the expected distribution. Upon further investigation it was discovered that the amounts were, without a doubt, not genuine and were modified on purpose via payroll clerks and bookkeepers.

American leisure and travel company

Another example involves an American leisure and travel company with a national chain of motels. Using digital analysis, the company's audit director noticed something unusual regarding the claims which were made by the company's healthcare supervisor. The first two digits of the healthcare payments were verified for conformity to Benford's Law, of which the results showed a spike for the first two digits "65". An audit confirmed a total of 13 fraudulent cheques between $6,500 and $6,599 with regard to deceitful heart surgery claims being processed by the supervisor, with the cheque ending up in her possession. Regardless of her best efforts to make the claims look authentic, Benford's Law exposed the supervisor. The analysis disclosed other fraudulent claims with a total value of approximately $1 million (Nigrini, 2012:181-182).

Credit card balances written off as uncollectable

Digital analysis was carried out at a bank on the amounts written off as uncollectable credit card balances. The first two digit graph for the data set revealed that the balances had an excessive amount of numbers for the "49" combination. Investigation revealed that $5,000.00 was the limitation for internal write-offs for several internal collection personnel. An in-depth analysis of the first two digits "49" demonstrated that an individual fabricated the amounts. The employee's modus operandi was as follows: friends applied for a credit card, run up balances to just under $5,000.00, and the bank employee would subsequently write off the debts (Nigrini, 1999b:26).

Johannesburg Stock Exchange (JSE) listed companies

In Saville's (2006:341-354) study, *Using Benford's Law to detect data error and fraud: An examination of companies listed on the Johannesburg Stock exchange*, the goal was to analyse the potential effectiveness of Benford's Law in the detection of data error and fraud in accounting data generated by JSE-listed companies. In order to examine the potential of Benford's Law, a common regression tool was applied to data produced by a set of 34 JSE-listed companies. For the purpose of the study, the test sample comprised data drawn from an equal number of companies categorised as "errant" and "compliant". "Errant" refers to companies that were suspended or known to have committed accounting fraud or created incorrect data and, as a result, had their shares suspended or delisted. "Compliant" companies, on the other hand, consisted of a group of companies that were ranked as having the best reporting standards among listed companies.

The study concluded that all 17 of the "errant" companies failed the test, whilst only three of the "compliant" companies did not pass the test. Saville (2006:352) made the statement that Benford's Law has the prospective to operate as an extremely successful detector of data error or fraud in accounting data.

Iranian presidential elections

Roukema employed Benford's Law to assess the results from an Iranian election. He observed an abnormality in Mehdi Karroubi's votes, who came in third position. He found that the first digit was an excessive number 7. Further examination revealed that this anomaly took place in three of the six largest voting areas, in which Mahoud Ahmedinejad (the winner) had a larger section of the votes. Roukema concluded that an error occurred in the official count of votes (Roukema, 2009).

Fabricated numbers will not conform to Benford's Law, except if the fraudster intentionally follows this Law in allocating values to fake data (Lowe, 2000a:34). Forensic accountants can, thus, employ Benford's Law to detect possible error, fraud, manipulative bias or processing inefficiency.

5.6 Conclusion

Benford's Law is a powerful investigative tool to support the forensic accountant in detecting fraudulent activities in an organisation's accounting records. The forensic accountant can apply the digital tests discussed in this chapter to determine the actual frequency of the digits in the data set. The five major digital tests are the first digit test, second digit test, first two digits test, first three digits test, and last two digits test. The first digit test is a high-level test, whereas the other digital tests are more specific. These tests permit the forensic accountant to separate and focus on target data groups (Warshavsky, 2010:4). An essential part of performing these tests is the interpretation of the test's results. There is no specific technique to conclude how the data set measures up to Benford's Law. Various goodness-of-fit measures are available and the most suitable method has to be selected, for example, the null hypothesis, Chi-square test or z-statistics. With regard to actual application, Benford's Law has been employed with great success to fictitious business and financial data. The following are some scenarios in which Benford's Law has been used as an aid in financial fraud detection: falsified sales for tax evasion, employee reimbursements, Iranian presidential elections, and accounts payable. One of the issues outlined by Durtschi *et al*. (2004:22) refers to the inefficiency of digital analysis. This issue will be discussed in the next chapter, together with the benefits of using Benford's Law as a fraud detection tool.

CHAPTER 6

BENEFITS OF BENFORD'S LAW AS A TOOL FOR FORENSIC ACCOUNTANTS

6.1 Introduction

Since the Law has been discovered, promoters of Benford's Law have proposed that it would be an advantageous tool for fraud detection (Singleton, 2011). There are various advantages of using Benford's Law to detect fraud and it has a broad spectrum of applications which are useful to forensic accountants. This chapter will outline the benefits of Benford's Law in forensic accounting investigation and why it is important for a forensic accountant to have knowledge about data mining techniques.

6.2 Benefits of applying Benford's Law in forensic accounting investigation

6.2.1 Cost-effectiveness

Lowe (2000a:36) contends that Benford's Law offers a powerful, economical and accessible tool for auditors, managers and analysts to verify a large data set of calculated totals for possible fraud, error, manipulative bias or processing inefficiency or other anomalies. Lynch and Xiaoyuan (2008) concur by describing Benford's Law as a useful and inexpensive tool for uncovering suspect accounts for supplementary analysis.

Stephens (2013) recommends the application of technology to combat fraud by means of uncomplicated, cost-effective, fraud-busting tools which, inter alia, includes Benford's Law.

6.2.2 Large sets of data

Stalcup (2010) maintains that fraud is persuasive and fraud examiners have to be acquainted with all potential tools and techniques to avoid and identify errors and anomalies. In addition, Benford's Law is a rapid, sophisticated tool that a fraud examiner might find valuable in auditing enormous pools of data. This law is capable of narrowing the testing as required, emphasising the irregularities, and smoothing the progress of fraud detection.

6.2.3 Additional approach of looking at a company's financial data

Benford's Law has a diverse approach of looking at numbers. In combination with additional audit tools, Benford's Law assists auditors to reduce the "expectation gap" by increasing the possibilities of uncovering fraud and by uncovering mistakes and inefficiencies in the bottom lines of businesses. Furthermore, it enhances sampling so that auditors can pay attention to fraudulent or otherwise suspicious areas (Overhoff, 2011).

Already a decade ago, James Searing, partner and Ernst & Young LPP (Limited Liability Partnership) director of strategic service development, drew a medical comparison, saying that just as X-rays give doctors an additional approach to examining the body, Benford's Law provides fraud examiners another approach of looking at a company's financial data (Nigrini, 1998a:15).

Warshavsky (2010:1) maintains that digital analysis techniques, such as Benford's Law, provide the forensic accountant with various prospective computer-related approaches to successfully carry out financial forensic investigations. Moreover, digital analysis enables the forensic accountant to take an unprejudiced glance at the whole data set, which ought to aid the forensic accountant to better plan the engagement scope.

An analytical review procedure (ARP) based on Benford's Law is not influenced by the size or history of a transaction. It is, thus, a powerful instrument in detecting "bleeding frauds" where small amounts are fraudulently obtained over a period of time by means of dubious transactions which fail to alert internal controls. Despite the fact that traditional review procedures may be able to identify frauds in connection with a single high-value transaction, it might not be successful in detecting such frauds (Bhattacharya *et al*., 2010:572).

Warshavsky (2010:2) contends that a forensic accountant can perform a more effective examination by using a high-level Benford's Law analysis, with the ability to drill down deeper into the original documents as required. Through the application of professional judgement and statistical techniques, a forensic accountant can discover anomalies that meet the criteria for additional investigation.

6.2.4 Easy to apply

Besides the fact that Benford's Law offers a tool which can make users attentive to possible errors or potential fraud, Benford's Law holds another benefit over other techniques employed for the detection of fraud: the law is applied without difficulty (Saville, 2006:345).

According to Ashcroft *et al.* (2002), digital analysis extensively amplifies the auditor's success and efficiency by allowing the auditor to, without difficulty, detect groups of transactions which are expected to be falsified or misstated more than the average. Kumar and Bhattacharya (2007:83) state that Benford's Law provides a counter-intuitive, nevertheless easy-to-implement data mining technique for an auditor or financial investigator with which to determine the validity of an accounting data set.

Lanza (2000:291) adds that forensic accountants should make of use of Benford's Law because it is understood without difficulty and the information can be easily presented to management.

6.2.5 Proactive approach

Given that fraud is committed frequently in a replicated and coordinated approach, Benford's Law can help many companies in the early detection of some forms of fraud (Tapp & Burg, 2000). Furthermore, Coderre (2009:209) maintains that, with the use of digital analysis, systems can be created to examine transactions on an ongoing basis as a proactive method to early fraud detection.

6.2.6 The missing link

Mehta and Mathur (2007:1576) mention two advantages of using Benford's Law: First, the Law is not influenced by means of scale invariance and, secondly, the Law can assist when a supporting document is missing to provide evidence regarding the legitimacy of the transactions listed in the missing document.

Durtschi *et al.* (2004:31) describe a Benford's Law analysis as a predominantly helpful analytical technique, because it does not use combined data, but is performed on particular accounts using all the data accessible instead. The Law can be of exceptional aid in identifying particular accounts for additional analysis and investigation.

6.3 The forensic accountant's knowledge of data mining

Golden *et al.* (2011:334) contend that forensic accountants need to comprehend the capability of data mining for numerous reasons:

- The best evidence in an investigation frequently exists in its original, electronic form;
- Given enormous amounts of data throughout today's entities, along with the fact that the majority if not all business events have many data fingerprints, data mining is frequently most efficient and occasionally the only manner in which to assemble required evidence;
- Data analysis allows investigators to combine different data sets and present insight and information that would not have been available through manual review; and
- Application of company rules for the identification of suspicious transactions can be utilised more resourcefully on large sets of data by means of data mining.

6.4 Conclusion

The main benefits of Benford's Law are the following: it is a powerful and cost-effective tool which can be applied without difficulty; it offers an additional approach to viewing a company's financial data; and it can identify fraud or data irregularities which might not have been identified by traditional review procedures. The chapter has also shown that the forensic accountant ought to understand the capability of data mining techniques and methods, because they are advantageous in forensic accounting investigation. Despite its numerous advantages, Benford's Law has some limitations and constraints, which will be discussed in the next chapter.

CHAPTER 7
LIMITATIONS OF BENFORD'S LAW

7.1 Introduction

When data are all about similar magnitude, the distributions as predicted by Benford's Law will not hold; thus, Benford's Law is not applicable universally. In essence, Benford's Law is not expected to apply to measurements where human intervention has occurred, for instance, rent income based on a contractual lease or where random numbers have been allocated, such as telephone numbers (Cleary & Thibodeau, 2005:77). Also, some populations of accounting-related data do not conform to the expected distributions as predicted by Benford's Law. Consequently, not all accounts labelled as "non-conforming" will be the result of fraud (Durtschi *et al.*, 2004:23).

Tests based on Benford's Law are conducted frequently for the purpose of fraud detection in the accounting literature and by articles from other disciplines. The charm of this method seems to dismiss legitimate uncertainties regarding its practicability. Nevertheless, doubts arise regarding the prejudiced power of this method. Surprisingly, little concern exists on the subject of the validity of Benford tests (Diekmann & Jann, 2010).

While Benford's Law presents itself as a useful tool currently available to forensic accountants, there are limitations to its capability. This chapter outlines the limitations and the reasons for such limitations of the Benford fraud-detection method.

7.2 Limitations

7.2.1 Sample data, categorical data and data with range limits

According to Panigrahi (2006:1427), one possible shortcoming of using the Benford fraud-detection technique is that this Law cannot be applied to sample data, categorical data and data with range limits. Durtschi *et al.* (2004:23) state that results from a Benford's Law analysis are more reliable when the account as a whole has been analysed instead of samples from the account. The reason is that the greater the numbers of items or transactions in a set of data, the more accurate the analysis.

7.2.2 One variable at a time

Panigrahi (2006:1427) further states that this Law can be applied only to one variable at a time and the experiences gained can neither be generalised nor used in other variables or other situations.

7.2.3 Unable to match symptoms with specific types of fraud

A concern voiced by Albrecht and Albrecht (2002:32) is that, although Benford's Law is usually easy to apply and useful when searching large, unsorted databases, this undemanding, cost-effective technique does not allow forensic accounts to match the symptoms they find with specific types of fraud. Consequently, the leads it produces are merely indicators of probable problems; they are not comprehensive prognoses. Once a forensic accountant discovers a doubtful entry through digital analysis, the forensic accountant is still required to conclude what kind of fraud is involved and who committed it.

7.2.4 Does not apply to all numeric populations

An important consideration to bear in mind according to Nigrini (2000a:24-25), is that the Law does not apply to all numeric populations. The data must meet the following criteria for the Law to apply:

1. All the transactions should measure the same phenomena. Corporate examples include the market values of companies on the JSE, the revenue of JSE-listed companies, or inventories of companies on the JSE. The amounts should all be in the same currency;

2. There should be no built-in minimum or maximum values in the data set except for the number zero, which is an acceptable minimum. The presence of minimums or maximums will distort the digit frequencies;

3. The numbers should not be assigned numbers; they should be random in nature. Assigned numbers are numbers allocated to things to replace words, for example, telephone numbers, postal codes and bank account numbers. These invented numbers would have their digit distribution determined by the individual assigning the numbers;

4. The data set should have more observations of small items than large items. The number of small financial events is greater than the number of large financial events;

5. The numbers of the data should, in general, have four or more digits for a good fit with Benford's Law; and

6. A large data set is required for a close fit to the Benford distribution. A small sample cannot render the expected Benford frequencies, which will cause deviations from the Law. When a data set increases in size, it turns out to be more reasonable to acquire the expected frequencies of Benford's Law.

7.2.5 Corporate data do not constantly follow natural patterns

The major concern regarding Benford's Law, according to Albrecht (2008), is that corporate data do not follow natural patterns all the time. There are many reasons as to why transactions may not conform to the expected distributions of Benford's Law such as unusual business cycles, recurring fixed expenses, and assigned amounts.

7.2.6 Perception is not prediction

Albrecht (2008) has taught digital analysis to thousands of professional accountants. In ten years of asking participants to share their success with digital analysis, just three individuals have stated to have found fraud by means of Benford's Law. The other individuals said that digital analysis could have been used to expose frauds that had been discovered already. However, hindsight is not prediction.

7.2.7 Large samples required

Stalcup (2010) mentions a flaw of Benford's Law in that it will not work on small samples. For example, if a forensic accountant examines a bank account with 20 cheques for the year, the sample should not to be expected to follow the patterns as predicted by Benford's Law. A larger sample is required to make the test work.

Moreover, Benford's analysis will not capture a fraudster who manipulates one or a very small amount of transactions. This implies that the analysis is not likely to catch a perpetrator who wrote one cheque to himself, but a savvy forensic accountant might catch someone who, in the course of a series of transactions, manipulates the billings or payments as much as necessary to distress the pattern as predicted.

7.2.8 Completeness of records

According to Lu *et al*. (2006:348), one of the limits of Benford's Law in fraud detection has been its requirement that analysed records not have artificial cut-offs, meaning that records must be complete.

7.2.9 Benford's Law is still in the early phases

Bhattacharya and Kumar (2008:150) add that, although Benford's Law has been utilised in other divisions of forensic science, forensic accounting using Benford's Law and other data mining tools are still in the early phases. The aim is to create available toolkits which can be applied in a selection of forensic accounting circumstances. In order to accomplish this goal, two challenges need to be addressed (Bhattachyra & Kumar, 2008:150):

1. Formulation of rules and collection of data sets are needed for the application of vague and neural network methods in real life. Particularly, with regard to neural network methods, training and testing data sets which permit good generalisation performance are required for forensic accounting applications; and

2. A better understanding is needed of how to distinguish hostile from benign data manipulation in accounting, and to determine the reliability of methods based on empirical rules such as Benford's Law.

A stronger penetration of the signal processing methods into the field of forensic accounting is required. Therefore, the forensic accountant should not only be familiar with the potential use of rules such as Benford's Law in the detection of non-natural patterns in a set of accounting data, but also perceive the signal processing methods as valid and practical, and not just as theoretical exercises.

7.2.10 Not all data sets are suitable for the proposed analysis method

Bierstaker *et al.* (2006:526) specified the nature of frauds that could not be detected by digital analysis for the reason that the data sets under examination were not suitable for the proposed analysis method. According to these authors (Bierstaker *et al.*, 2006:526), digital analysis will not detect frauds such as contract rigging, defective shipments or defective deliveries. Furthermore, duplicate bank accounts or addresses cannot be uncovered; however, two employees with the same address might signal a shell company.

Durtschi *et al.* (2004:23-24) also consider the likely limitation of Benford's Law and suggested that accounts that might not follow a Benford distribution will be firm specific, for instance, an account specifically set up to record R100 refunds. According to the authors, Benford's Law is not likely to be useful where no transaction has been recorded, for example, include thefts, kickbacks and contract rigging.

According to Cho and Gaines (2007:218), a significant caveat is that not all the numbers follow the predicted pattern of the Law. For example, in accounting, the first digit distribution can become distorted when receipts include a great amount of indistinguishable transactions which reflect the sales of a particularly popular item whose price is invariable.

7.2.11 False positives and anomalies

Nigrini (quoted by Browne, 1998) mentions a problem regarding some of the digital tests, namely that it might turn out to have many false positives, and several anomalies can appear that have no relation to fraud. Diekmann and Jann (2010) remarked that, apart from the problem of false positives, the question can be raised as to whether a test based on digit distributions is, in fact, a powerful tool to differentiate between fraudulent and non-fraudulent data.

A concern voiced by Kumar and Bhattacharya (2007:82) is that, although Benford's Law may be a guide, it can also wrongly imply fraud. These authors mention that data which have been rounded up or down may not follow Benford's Law.

Furthermore, forensic accountants need to be attentive of recurring payments, for example, rental payments on a monthly basis or monthly pay cheques, because the duplication of such numbers may generate false anomalies when the data are being tested against Benford's law (Dorrell & Gadawski, 2012:274).

7.3 Conclusion

In spite of its effectiveness in assisting forensic accountants in the detection of fraud, the Benford's Law theory shows questionable reliability and special care has to be taken in the interpretation of the tests. In order for Benford's Law to be applicable to numeric data sets, the following criteria must be met: the transactions should assess the same phenomenon; no built-in minimum or maximum values should be present in the data set; numbers should not be assigned; and the data set should be large enough for the Benford distribution to emerge. In addition, Benford's Law will not be successful where no transaction has been recorded, for example, kickbacks. It is important to bear in mind that not all deviations from the Benford distribution are due to fraud; they can be attributed to false positives. Albrecht (2008) stated that, in several ways, the fraud detection field might have overestimated the effectiveness of digital analysis but, regardless of its limitations, Benford's Law continues to be one of the most popular data mining techniques for detecting fraud.

CHAPTER 8
EMPIRICAL CASE STUDY

8.1 Introduction

This chapter deals with the empirical study performed, namely the analysis of financial data, in an attempt to address the research objectives posed in chapter 1. A case study method was selected, since it is associated with the purpose of this study. Benford's Law was used to compare the actual and expected distributions of the data of Company X, which contained all the Electronic Fund Transfers (EFTs) for the period January 2012 to 31 March 2013, to determine the effectiveness of Benford's Law as a tool for forensic accountants. Although the period is not a definite accounting period as mentioned in the literature study, this period, consisting of almost 15 months, was selected to include a larger volume of accounting transactions and this specific period was highlighted as the problem area for Company X. The name of the company will not be disclosed in support of confidential reasons.

According to Yin (2012:3), the complete set of procedures required to do case study research include collection of the data; analysis of the data; and presentation and report of results. In addition, tables and charts will be drawn up depicting some of the greatest differences.

8.2 Empirical study

An empirical study was conducted by means of the quantitative research approach. Distinctions between qualitative and quantitative research methods will be elaborated on later in this chapter.

8.3 Overview of the empirical research methodology

Some of the specific components of the research will be outlined in the following sections to provide clear understanding of the research methodology applied in this study.

8.3.1 Definition of research

Weirich *et al*. (2010:2) maintain that the goal of performing any kind of research regarding auditing, tax and accounting, is a systematic investigation of a subject or problem in which the professional judgment of the researcher is employed. In addition, Weirich *et al*. (2010:2) classify research as either theoretical or applied. Theoretical research examines questions which appear interesting to the researcher, however, may have no practical application at the present time, whereas applied research examines an issue of instantaneous practical importance.

8.3.2 Research process

In general, the research process is defined as a "scientific method of inquiry, a systematic study of particular field of knowledge in order to discover scientific facts or principles". An effective definition of research includes the following process (Weirich *et al*., 2010:2):

i. Investigate and analyse a comprehensibly defined issue or problem;
ii. Apply a suitable scientific approach;
iii. Gather and document sufficient and representative evidence;
iv. Use logical reasoning in drawing conclusions; and
v. Support the validity and equanimity of the conclusion.

8.3.3 Definition of case study

Swanborn (2010:22) presents the following summarised definition of a case study. It refers to the study of a social phenomenon:

- In a single, or merely a few, of its manifestations;
- In its natural context;
- For the duration of a definite period;
- Which focuses on detailed descriptions, interpretations and explanations of several processes;

- Where the researcher commences with a broad research question on an in-progress social process and makes use of existing theories, nevertheless refraining from pre-fixed methods of data collection and analysis;
- That utilises numerous sources of data;
- In which occasionally the participants in the studied cases are employed in a process of confrontation with the explanation, views and behaviours of other participants together with the resulting preliminary results of the researcher.

Another definition raised by Smith (2003:134) is that the term "case study" frequently means research focused on a single unit of analysis that can be a single department, industry, etc.

The abbreviated definition presented by Yin (2009:18) for the case study is as follows: "An empirical inquiry about a contemporary phenomenon (e.g., a 'case'), set within its real world context – especially when the boundaries between the phenomenon and context are not clearly evident."

Simons (2009:21) extended her definition to include the purpose and research focus. A case study is an in-depth examination from numerous points of views of the intricacy and exceptionality of a particular policy, institution, system or programme in a real-life framework. She further touches upon the fact that it is research based, inclusive of diverse techniques, and evidence led. Furthermore, the main purpose is to produce a comprehensive understanding of a precise topic.

The definition that Woodside (2010:1) proposes is as follows: "Case study research is an inquiry that focuses on describing, understanding, predicting, and/or controlling the individual".

8.3.4 Types of case studies

According to Stake (1995:3-4), there are three types of case studies:

i. Intrinsic: where the case is studied for the fundamental significance of the case;

ii. Instrumental: where a case is selected to view a problem or research question concluded on some other basis, in other words, the case is selected to gain an understanding or insight into something else; and
iii. Collective: where numerous cases are studied to form a collective perceptive of the issue.

Furthermore, Stake (1995:4) maintains that the rationale for the distinction between these three types of cases is not to arrange case studies into categories, but to be able to choose the methods suitable to the type of case study.

8.3.5 Selecting the case study method

Case studies as a key research strategy are chosen under one or more of the following sets of conditions (Swanborn, 2010:41):

i. The impracticality to isolate or simulate the phenomenon;
ii. The scarcity of the phenomenon;
iii. Design problems; and/or
iv. The intention to merge research and action.

Yin (2012:4-5) emphasises three circumstances in which the case study as a research method is relevant:

a. The choice between different types of research, counting the case study method, can be made according to the type of research or question that the study is attempting to address (what, why, how, etc.);
b. The study highlights a phenomenon within its real-world context; and/or
c. At present, the case study method is regularly being employed in performing evaluations.

8.3.6 Objective of the case study method

One of the key strategies for the completion of successful case studies is the dependence on the theoretical concepts to guide the design and data collection (Yin, 2003:3). The objective is to develop introductory concepts at the outset of a case study.

Yin (2003:3) explains the two main purposes of the role of theory when doing case studies:

i. To base the case study on suitable literature in such a way that lessons from the case study will more likely advance knowledge and understanding of a given topic; and
ii. To facilitate the identification of the unit of analysis; to classify the selection criteria for the potential cases to be studied; and to recommend the appropriate variables of interest and, consequently, data to be collected as part of the case study.

8.3.7 Advantages of the case study approach

Bennett (2004:19) highlights the relative advantages of case study methods:

a. The identification of innovative or absent variables and hypotheses;
b. The assessment of prevailing variables in single cases to formulate conclusions;
c. The development of historical rationalisations of explicit cases;
d. The accomplishment of high levels of construct validity;
e. The employment of contingent simplifications to model complex relationships, for example, path reliance and manifold interaction effects; and
f. The competency to identify new hypotheses that case studies can test through a combination of deduction and induction.

8.3.8 Limitations of the case study approach

The natural limitations of case study methods include their comparative lack of ability to make judgment on the frequency or representativeness of specific cases and their weak competency for assessing the average casual weight of variables. This statement contains three key elements: i) inability to exclude all but one explanation; ii) a lack of independence of cases; and iii) the impracticality of absolutely controlling case comparisons (George & Bennett , 2004:22).

Regardless of its evident applicability in studying numerous appropriate real-world conditions and addressing significant research questions, case study research has not accomplished extensive acknowledgment as a method of selection; for some researchers it is a method of last resort (Yin, 2012:5). The reasons are voiced by Yin (2012:5-6) as:

1. Case study research emerges to serve merely as an introduction; and
2. A lack of trust in the credibility of the procedures performed by the researcher.

8.4 Quantitative and qualitative techniques

A general option in research is using quantitative or qualitative data. In short, quantitative data use numbers to explain what exists, whereas qualitative data rely on words, particularly nouns and adjectives, to express what exists (Gray *et al*., 2007:42).

Despite the sources of evidence, case study evidence can consist of both qualitative and quantitative data (Yin, 2012:10-11). The difference between the two types of data can be explained as follows: qualitative data could be regarded as non-numeric data, for example, categorical data which can be collected systematically and presented in descriptive form, such as word tables. On the other hand, quantitative data could be regarded as numeric data, for example, information based on the application of ordinal if not ratio or interval measures (Yin, 2012:11).

The following table exemplifies the difference between the two types of data (Eising, 2010):

Table 8.1 Comparison of qualitative and quantitative data

Qualitative data	***Quantitative data***
Data are observed	Data are measured
Involve descriptions	Involve numbers
Emphasis is on quality	Emphasis is on quantity
For example, colour, smell, taste	For example, volume, weight

(Eising, 2010)

8.4.1 Advantages vs disadvantages

Gray *et al*. (2007:42) highlight the following advantages and disadvantages of quantitative and qualitative data:

A key benefit of quantitative data is that it can be fed into a computer where the data can be counted, stored and manipulated. On the other hand, numbers are regularly a poor replacement for the vibrant descriptions of the researcher.

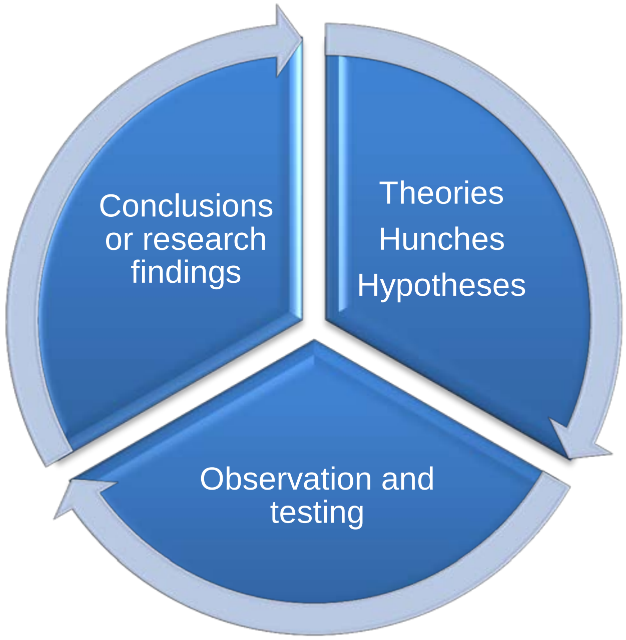
The primary advantage of qualitative data is that it captures details of meaning and interpretation that numbers do not communicate. Conversely, using numbers in quantitative research makes it more probable that studies can be replicated and that the results of the study are dependable. It is easier to repeat a data collection procedure that produced numbers than to re-create the observations and conversations which normally form the foundation of qualitative research.

8.5 Empirical cycle of research

Swanborn (2010:32) states that all kinds of scientific efforts have in common the empirical cycle of research, being:

- The problem;
- A tentative solution;
- Data collection and analysis; and
- Confronting the timid solution with the data, frequently directing to a new problem and a new cycle of research.

Figure 8.1: The research cycle



(Gray *et al*., 2007:5)

Figure 8.1 illustrates the research cycle, which is clearly an ongoing process. First, the researcher needs to develop a theory or hypothesis. Secondly, the observation and testing need to occur and, lastly, conclusions are drawn or findings are made.

8.6 Research ethics

Wheelwright (cited by ACFE, 2012) labelled ethics as: "The branch of philosophy which is the systematic study of reflective choice, of the standards of right and wrong by which it is to be guided, and of the goods toward which it may ultimately be directed".

Gray *et al*. (2007:88) maintain that disguised observation is not the only research strategy which raises ethical questions with reference to the relationship between social researchers and their subject. Other manipulations and deceptions are used from time to time by various types of researchers. Newell (cited by Gray *et al.*, 2007:88) mentions a selection of these strategies as evasion, suppression, and euphemism.

A number of violent incidents during World War II in the name of medical research provoked the development of a generally accepted code of research ethics which has stretched from the medical arena to all other research disciplines. Unfortunately, the shift of such code to the business discipline has been perceived by many researchers as a burden limiting their activities (Smith, 2003:91).

The following research insight is an example from the NWU (2008) research guidelines:

Ethical approval for protection

The primary goal of ethical approval is the protection of (1) the participants (subjects) or animal subjects, (2) the project team (e.g. researchers) and (3) the employer. Ethical screening is a quality control measure that monitors whether the actions were ethically responsible and legal and whether all appropriate safety measures were in place. Ethical approval does not attempt to stymie research or undermine it unnecessarily, but merely to assist the project leader in managing responsible conduct.

Ethical approval is compulsory

Ethical approval is not optional, but compulsory, and no project may be initiated before this approval has been received. Approval must comply with the requirements of all authorities under which the project team falls (e.g. the country's laws, employer, professional councils, etc.) and, where requirements differ, the strictest requirement applies. All relevant approval must already have been obtained (inter alia, an allocated ethics number) before any project may commence. Without the necessary ethical approval any project is illegal and furthermore there is NO protection from the employer (e.g. from the North-West University). The project leader may then also be prosecuted and is personally legally responsible for any problems that may arise and claims that may be instituted. Ethically responsible use (according to international convention) and ethical approval is also a prerequisite for most grant applications and for publication in all good, accredited international scientific journals. Furthermore, any person has the right to request to see and study the original data of published results in order to verify the accuracy and validity thereof.

Olivier (2010:9) deems it imperative to consider ethical concerns from the beginning phases of the research. From the early stages of the design process, interim choices are made, in general, with reference to the nature of the research sample along with the methodology. Without a doubt, these choices entail various methods of cooperating with the individuals engaged in the research project. Olivier (2010:9) maintains that researchers often attempt to articulate the predictable goals of the research in terms of research aims which, frequently, emphasise likely ethical concerns.

According to Resnik (2011), there are numerous reasons as to why researchers need to adhere to ethical norms:

i. Support the aim of research;
ii. Promote the values that are important to combined work;
iii. Help to certify that researchers can be held accountable to the public;
iv. Facilitate building public support for research; and
v. Promote a multiplicity of other moral and social values.

8.7 Data collection

Data collection can proceed once the researcher has recognised precisely what he wants to know and why he wants to know this (Smith, 2003:18). In other words, data collection is to observe, measure and record information (Gray *et al*., 2007:2). There is no single best technique for gathering data any more than there is a single best theory for analysing and drawing conclusions from the data (Gray *et al*., 2007:2).

Case study research is not limited to a distinct source of data, as in administering questionnaires for executing a survey. In reality, excellent case studies benefit from having more than one source of evidence. Yin (2012:10) lists six frequently used sources of evidence: direct observations; interviews; archival records; documents; participant observation; and physical artefacts.

8.8 Data analysis and interpretation

According to Smith (2003:18), methods of data analysis and software requirements need to be clear at the beginning of the research process. Data analysis can be described as arranging and organising data so that a researcher can determine their connotation, generalise or inform their meaning (Gray *et al*., 2007:2). The essential predicament of data analysis is similar for all kinds of research, namely to decrease a vast quantity of data in order to acquire an answer to the research question (Swanborn, 2010:77).

Gray *et al*. (2007:48) describe data processing as usually consisting of "translating raw information, which may appear in the form of word or descriptions, into letters or numbers", which can be manipulated by a computer at high volume. The authors also refer to interpretation as the exercise of data which is exploited to draw conclusions from behaviour.

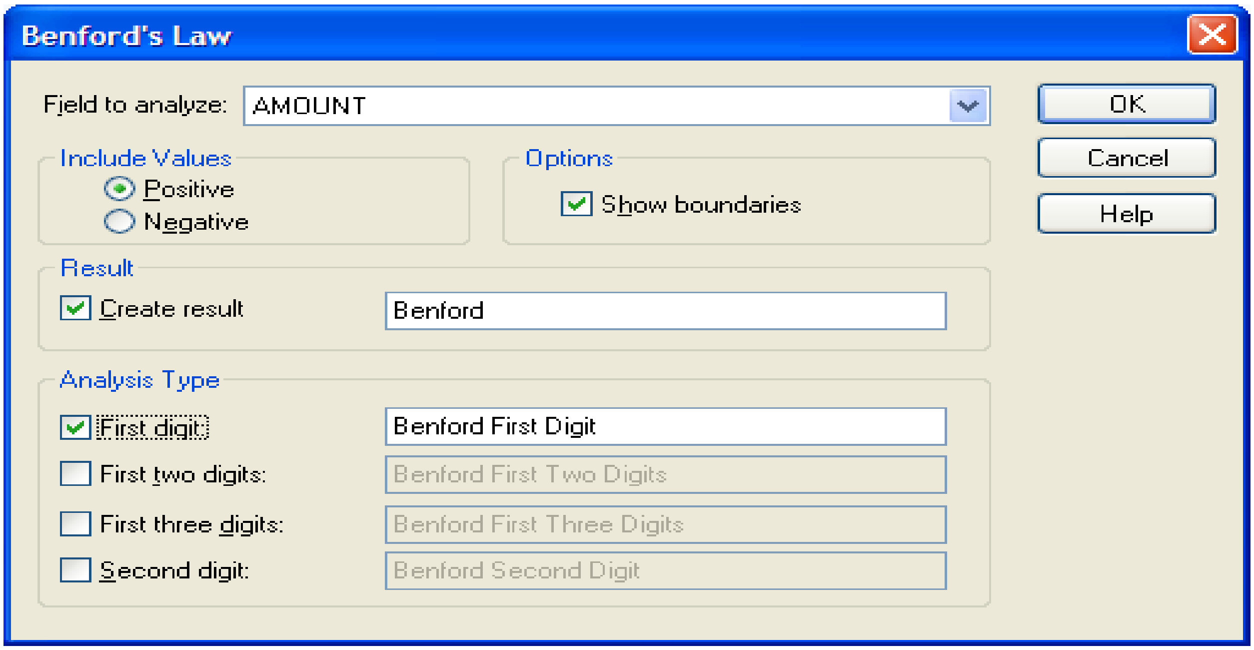
8.9 Data mining software

Data mining software is a tool that models a database with the aim of determining patterns and relationships among the data. Computer-based data analysis tools can provide very useful evidence when investigating the possibility of fraud. From the analysis of data, the forensic accountant can develop fraud profiles from the patterns present in the database, which can lead to uncovering fraudulent activities. An additional use of data mining software is that it provides the opportunity to establish mechanical red flags which will disclose inconsistencies in data that have to be homogeneous (Weirich *et al*., 2010:207).

IDEA is one of the more common commercial data mining software used by fraud examiners. It is a powerful, simplified audit software package that allows the user to display, analyse, manipulate, sample, or extract data from files created by a broad array of computer systems (Weirich *et al*., 2010:207).

8.10 Analysis type

Figure 8.2: Major digital tests



(IDEA, 2007)

The preceding figure illustrates the analysis type area which a forensic accountant can choose from: first digit; first two digits; first three digits and the second digit. Alternatively, a combination of the analysis types can be selected.

8.11 Empirical results

The following results and observations were derived from the Benford's Law analysis. The analysis was performed using a financial data set of Company X which contained all the Electronic Fund Transfers (EFTs) for the period January 2012 to 31 March 2013. The data set includes all payment transactions from the specific bank accounts of Company X, namely 128,463 records. The following analysis tests were applied: first digit; first two digits; first three digits; and second digit. The following analysis test, last two digits was not applied in this study and the reason therefore is that last mentioned test is merely a more focused test for rounded numbers. This test is used to analyse the relative increasing frequency of rounded numbers.

8.11.1 Brief overview of tests

First digit test: The first digit of a number is the first digit with the perceptive that the first digit can under no circumstances be a 0. For instance, the first digit of 5,742 is "5."

Second digit test: The second digit of a number is determined by its position within the number; hence, the second digit of 8,647 is "6."

First two digits test: This test is more specific than the two previous tests and exploits the first two leading digits, once again not including 0s. For instance, the first two digits of 5,732 are "57" and the first two digits of 0.05732 are also "57."

First three digits test: This highly focused test implies abnormal duplications. For instance, the first three digits of 98,3243 are "983".

8.11.2 Brief overview of terminology

- "Digits": the digits that Benford's Law analyses (1 through 9);
- "Expected": the expected number of records with the listed digit in the place specified by the analysis type;
- "Lower bound": the low boundary number of records with the listed digit in the place specified by the analysis type;
- "Higher bound": the high boundary number of records with the listed digit in the place specified by the analysis type;
- "Actual": the actual number of records with the specified digit in the place specified by the analysis type;
- "Difference": the number of records between the expected number and the actual number.

8.12 First digit test

The detailed output is illustrated in table 8.2. The format of the table is as follows with columns for Expected, Low bound, High bound, Actual, and Difference.

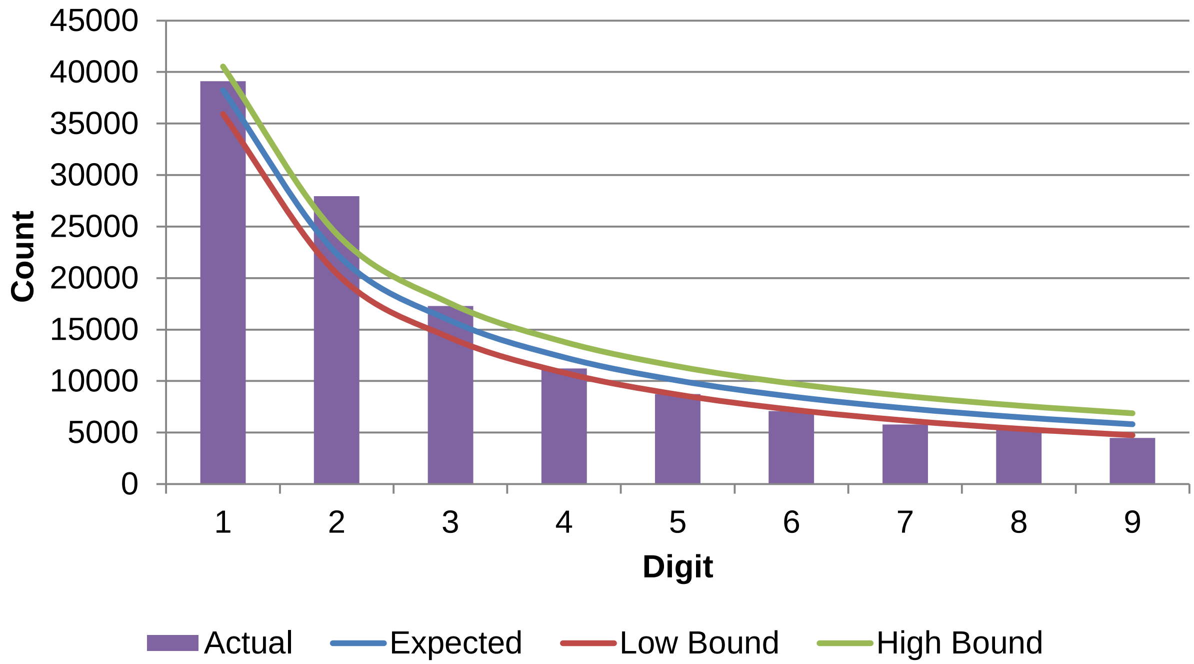
Table 8.2: Results of the first digit test

Digits	Expected	Low bound	High bound	Actual	Difference
1	38,229.30	35,920.37	40,538.23	39,105	−875.70
2	22,362.71	20,441.12	24,284.30	27,955	−5,592.29
3	15,866.59	14,195.16	17,538.03	17,294	−1,427.41
4	12,307.09	10,808.96	13,805.21	11,224	1,083.09
5	10,055.62	8,686.00	11,425.24	8,727	1,328.62
6	8,501.91	7,232.31	9,771.51	7,105	1,396.91
7	7,364.69	6,175.74	8,553.63	5,775	1,589.69
8	6,496.11	5,373.97	7,618.26	5,332	1,164.11
9	5,810.97	4,745.33	6,876.61	4,477	1,333.97

(Source:Author)

Table 8.2 provides the results of the first digit test. The first digit test is a test for reasonableness. The greatest difference appear at digit 2 where the actual count equals 27,955 and the expected count is 22,362, leading to a difference of 5,592 observations. The results of the first digit test are depicted by the graph below.

Figure 8.3: Benford's Law – first digit



(Source: Author)

Figure 8.3 signifies that the digits 1, 2 and 3 appear much more than expected, thus, symptomatic of anomalies, irregularities or errors that may exist in the data set. The remaining digits 4 to 9 appear less than expected. It is clear that the digit distribution is very similar to the expected distribution according to Benford's Law, with no major spikes in the data set.

8.13 First two digits test

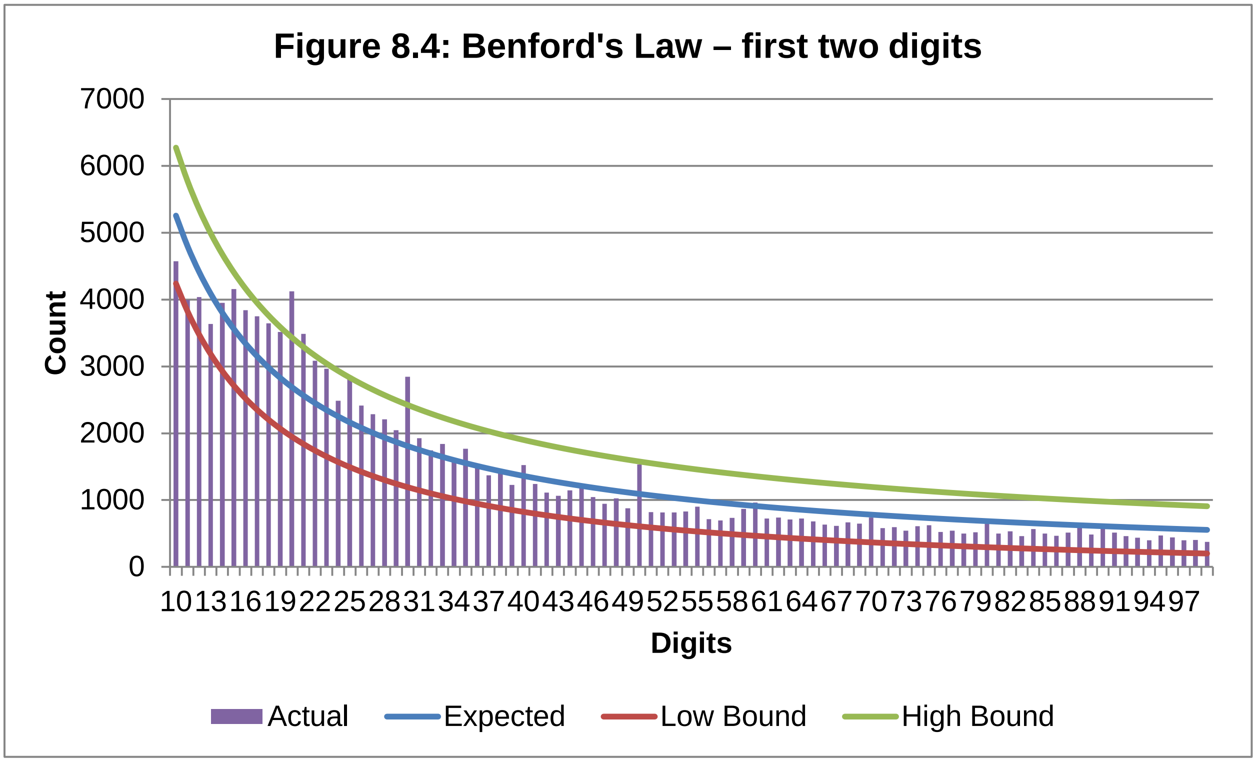
Table 8.3: Results of the first two digits test

Digits	Expected	Low bound	High bound	Actual	Difference
10	5,256.66	4,239.62	6,273.70	4,572	684.66
11	4,798.96	3,824.29	5,773.62	3,997	801.96
12	4,414.61	3,477.32	5,351.90	4,039	375.61
13	4,087.29	3,183.29	4,991.30	3,637	450.29
14	3,805.18	2,931.07	4,679.29	3,951	−145.82
15	3,559.51	2,712.43	4,406.58	4,157	−597.49
16	3,343.64	2,521.18	4,166.11	3,842	−498.36
17	3,152.47	2,352.53	3,952.41	3,749	−596.53
18	2,981.98	2,202.75	3,761.21	3,643	−661.02

Table 8.3: Results of the first two digits test (*Continued from previous page)*					
Digits	**Expected**	**Low bound**	**High bound**	**Actual**	**Difference**
19	2,828.99	2,068.90	3,589.08	3,518	−689.01
20	2,690.94	1,948.60	3,433.27	4,123	−1,432.06
21	2,565.73	1,839.92	3,291.54	3,486	−920.27
22	2,451.66	1,741.28	3,162.03	3,084	−632.34
23	2,347.30	1,651.38	3,043.22	2,963	−615.7
24	2,251.46	1,569.12	2,933.81	2,486	−234.54
25	2,163.15	1,493.59	2,832.71	2,863	−699.85
26	2,081.50	1,424.01	2,738.99	2,413	−331.5
27	2,005.79	1,359.72	2,651.87	2,285	−279.21
28	1,935.40	1,300.14	2,570.66	2,207	−271.6
29	1,869.78	1,244.79	2,494.77	2,045	−175.22
30	1,808.46	1,193.25	2,423.68	2,844	−1,035.54
31	1,751.04	1,145.13	2,356.96	1,925	−173.96
32	1,697.16	1,100.12	2,294.19	1,745	−47.84
33	1,646.49	1,057.94	2,235.04	1,839	−192.51
34	1,598.76	1,018.32	2,179.19	1,577	21.76
35	1,553.71	981.06	2,126.37	1,768	−214.29
36	1,511.14	945.94	2,076.34	1,550	−38.86
37	1,470.84	912.80	2,028.88	1,370	100.84
38	1,432.63	881.48	1,983.79	1,451	−18.37
39	1,396.36	851.83	1,940.89	1,225	171.36
40	1,361.88	823.73	1,900.03	1,524	−162.12
41	1,329.06	797.06	1,861.06	1,241	88.06
42	1,297.78	771.72	1,823.85	1,112	185.78
43	1,267.95	747.61	1,788.28	1,064	203.95
44	1,239.45	724.65	1,754.25	1,147	92.45
45	1,212.21	702.76	1,721.65	1,241	−28.79
46	1,186.14	681.88	1,690.40	1,044	142.14
47	1,161.16	661.92	1,660.40	944	217.16
48	1,137.22	642.85	1,631.59	1,028	109.22
49	1,114.24	624.59	1,603.90	879	235.24
50	1,092.18	607.11	1,577.25	1,532	−439.82

(Source: Author)

Table 8.3 lists the results obtained for the first two digits test. Owing to the length of the table, only the two digit combination from 10 to 50 is displayed. The first two digits test is a much more focused test than the first digit test, and figure 8.4 indicates the results obtained in this test.



(Source: Author)

The first two digits in figure 8.4 show spikes at the digits 15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 30 and 50. All these two digit combinations appear more frequently than expected. On the other hand, there are various two digit combinations which appear much less than expected. As a result, it is possible that anomalies, irregularities or errors may exist in the data set.

8.14 First three digits test

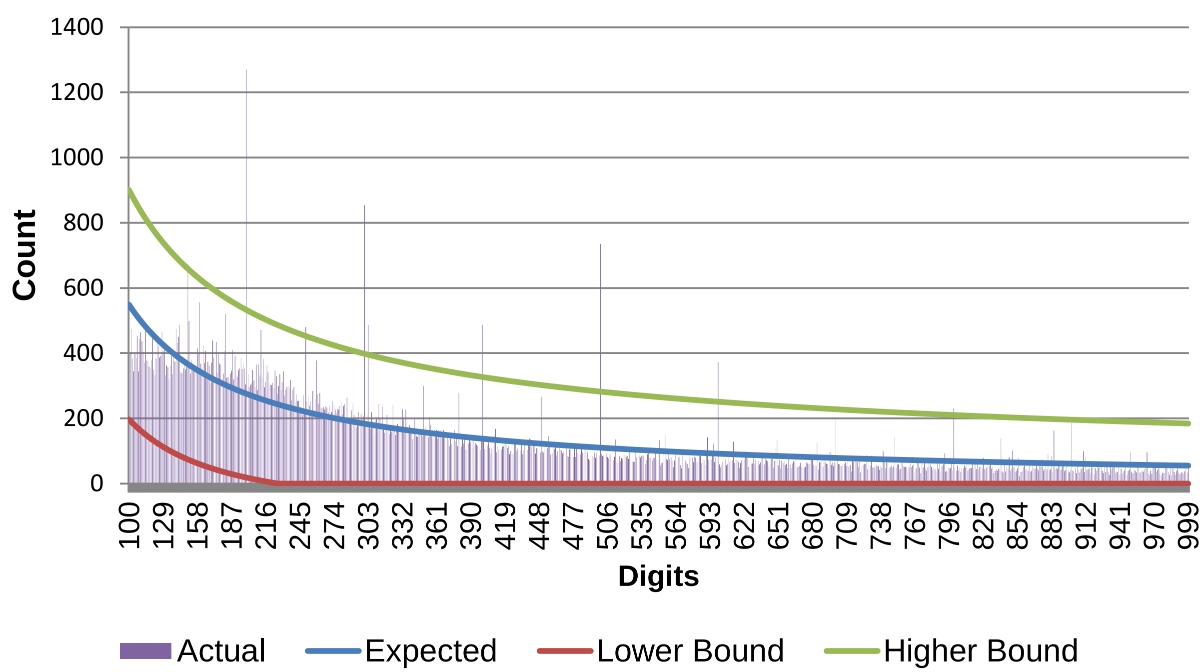
Table 8.4: Results of the first three digits test					
Digits	**Expected**	**Low bound**	**High bound**	**Actual**	**Difference**
100	548.79	196.85	900.74	947	−398.21
101	543.39	193.05	893.72	401	142.39
102	538.08	189.33	886.84	474	64.08
103	532.89	185.69	880.08	384	148.89
104	527.79	182.13	873.45	344	183.79
105	522.78	178.64	866.93	397	125.78
200	275.08	18.24	531.92	1,270	−994.92
201	273.71	17.45	529.98	336	−62.29
202	272.36	16.67	528.06	295	−22.64
203	271.02	15.89	526.15	303	−31.98
204	269.70	15.13	524.27	307	−37.30
205	268.39	14.37	522.40	348	−79.61
300	183.54	0	398.05	854	−670.46
301	182.93	0	397.13	183	−0.07
302	182.32	0	396.21	211	−28.68
303	181.72	0	395.30	487	−305.28
304	181.13	0	394.40	184	−2.87
305	180.53	0	393.50	169	11.53
400	137.71	0	326.95	487	−349.29
401	137.37	0	326.41	136	1.37
402	137.03	0	325.86	106	31.03
403	136.69	0	325.32	122	14.69
404	136.35	0	324.78	116	20.35
405	136.01	0	324.24	127	9.01
500	110.20	0	282.18	735	−624.80
501	109.98	0	281.81	90	19.98
502	109.76	0	281.44	84	25.76
503	109.54	0	281.08	86	23.54
504	109.32	0	280.72	109	0.32
505	109.11	0	280.36	92	17.11
600	91.85	0	251.07	373	−281.15
601	91.69	0	250.81	59	32.69
602	91.54	0	250.55	50	41.54
603	91.39	0	250.28	59	32.39
604	91.24	0	250.02	67	24.24
605	91.09	0	249.76	86	5.09
700	78.73	0	228.05	202	−123.27
701	78.62	0	227.85	69	9.62
702	78.51	0	227.65	60	18.51
703	78.40	0	227.45	60	18.40
704	78.29	0	227.25	54	24.29

Table 8.4: Results of the first three digits test *(Continued from previous page)*					
Digits	**Expected**	**Low bound**	**High bound**	**Actual**	**Difference**
705	78.18	0	227.05	54	24.18
800	68.90	0	210.22	231	−162.10
801	68.81	0	210.06	49	19.81
802	68.73	0	209.90	39	29.73
803	68.64	0	209.75	55	13.64
804	68.56	0	209.59	40	28.56
805	68.47	0	209.43	48	20.47
900	61.25	0	195.95	197	−135.75
901	61.18	0	195.82	40	21.18
902	61.11	0	195.69	37	24.11
903	61.04	0	195.56	47	14.04
904	60.98	0	195.43	32	28.98
905	60.91	0	195.31	55	5.91

(Source:Author)

The preceding table contains the results of the first three digits of the Benford's Law analysis. This test focused on the 900 possible first three digit combination, 100 to 999. Again, only an incomplete table is displayed due to its the length.

Figure 8.5: Benford's Law – first three digits



(Source: Author)

It is evident from figure 8.5 that the major spikes (among other observations) are evident at 100, 200, 300, 400, 500 and 600, thus all the three digit combinations appear much more than expected. From the results obtained, it is clear that the numbers do not match Benford's Law, indicating anomalies, irregularities or errors may be present in the data set.

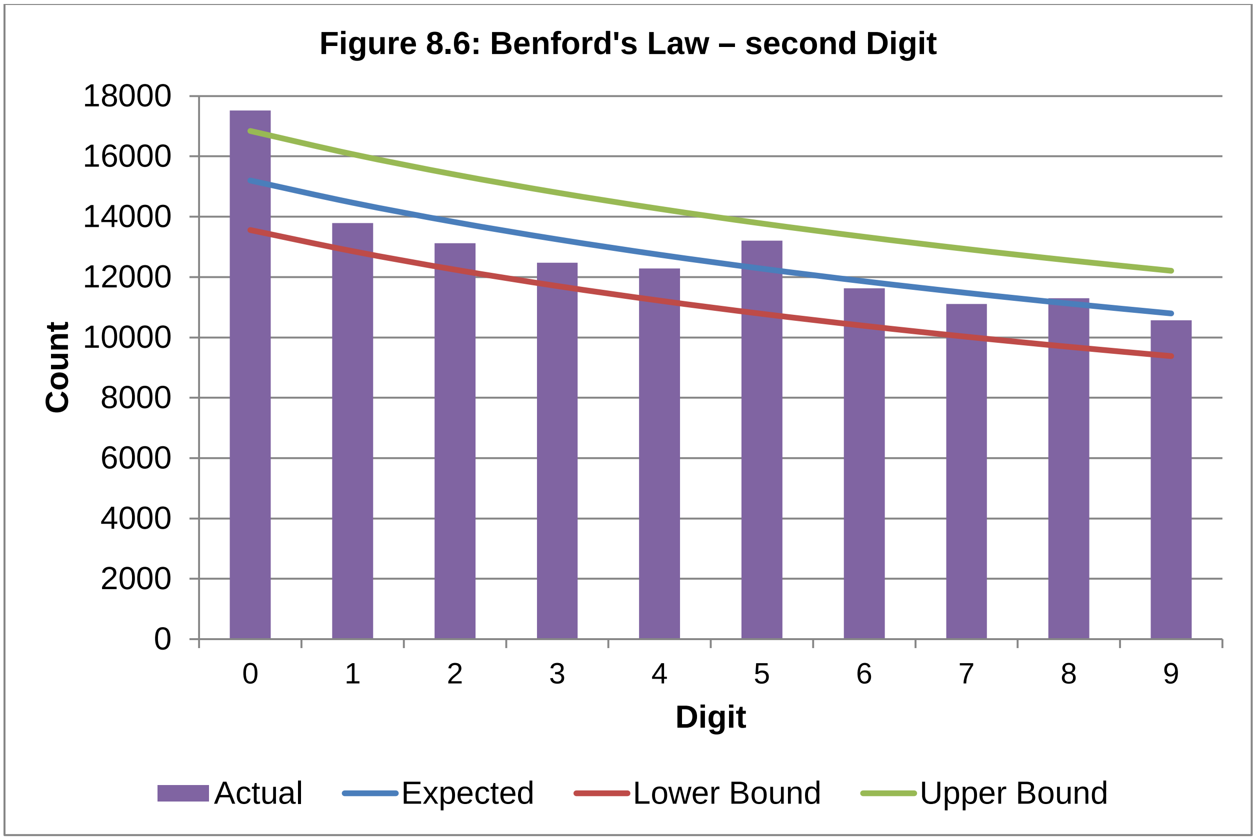
8.15 Second digit test

Table 8.5: Results of the second digit test

Digits	Expected	Low bound	High bound	Actual	Difference
0	15,198.67	13,557.41	16,839.92	17,522	−2,323.33
1	14,463.47	12,856.61	16,070.34	13,788	675.47
2	13,819.79	12,244.10	15,395.47	13,125	694.79
3	13,249.33	11,702.16	14,796.51	12,472	777.33
4	12,738.64	11,217.74	14,259.54	12,287	451.64
5	12,277.53	10,780.98	13,774.07	13,203	−925.47
6	11,858.12	10,384.28	13,331.97	11,628	230.12
7	11,474.25	10,021.67	12,926.83	11,110	364.25
8	11,120.96	9,688.38	12,553.54	11,296	−175.04
9	10,794.24	9,380.53	12,207.95	10,564	230.24

(Source: Author)

Table 8.5 contains the detailed output of the second digit test. This particular test is also considered a high-level test of reasonableness. The output shows that the greatest difference is present at digit 0, where there are 2,323 more observations than expected.



(Source: Author)

Figure 8.6 illustrates that the digits 0 and 5 appear much more than expected, whilst the rest of the digits appear less than expected, with the exception of digit 8 that is very similar to the expected distribution. From the results obtained, it is evident that the numbers do not match Benford's Law, indicating anomalies, irregularities or errors may be present in the data set.

8.16 Results of the Benford's Law analysis

The Benford's Law analysis was proficient to identify the target groups that needed further investigation due to the fact that the numbers did not match Benford's Law (i.e. indicating possible anomalies, irregularities, errors or fraud).

The numbers identified as requiring additional investigation by using the digital analysis tests are as follows:

i. First digit test: 1; 2 and 3;
ii. First two digits test: 15; 16; 17; 18; 19; 20; 21; 22; 23; 25; 30 and 50;
iii. First three digits test: 100; 200; 300; 400; 500 and 600; and
iv. Second digits test: 0 and 5.

It is not sufficient to only identify unambiguous data sets of records that illustrate the irregularities. Additional analysis has to be performed on those records identified with the purpose of measuring their value in the fraud detection process. An in-depth analysis is also required to diminish the number of records in the target groups, since the target group consisted of a large number of transaction records.

Owing to limited access to financial data from Company X, it was not possible to perform further analysis on the target groups identified. Without further research, and on the basis of the Benford's Law analysis applied to the complete set of records within the data set, all four major digital tests failed to comply 100% with the expected distributions of Benford's Law. The implication of the anomalies can lead to the following conclusions:

- Anomalies, irregularities, errors or fraud may be present in the data set; and
- There can be acceptable reasons (for example, false positives) for deviation from Benford's Law, and only further investigation of the results can provide the reasons for the non-conformity.

8.17 Conclusion

The purpose of this chapter was to evaluate the effectiveness of Benford's Law as an investigative tool for forensic accountants. Although five major digital tests are available to ascertain whether data sets conform to Benford's Law, it is not compulsory to apply all the tests. By implementing the first digit, first two digits, first three digits and second digit test, the study showed the differences between the actual and expected digit frequencies for the data set. Tables and charts were drawn up and all the actual and expected digit counts were compared to one another. In conclusion, all the tests failed to comply 100% with Benford's Law, thus, suggesting that anomalies, irregularities, errors or fraud may be present in the data set. Owing to limited access to the financial data from Company X, it was not possible to perform further analysis on the target groups identified

Valuable lessons were learned regarding the use of Benford's Law as an investigative technique for forensic accountants. The most valuable lessons learned from the literature study conducted include, the application of Benford's Law in forensic accounting investigations; the type of data sets that complies with Benford's Law; the limitations and constraints of Benford's Law; and the benefits of using Benford's Law in a forensic accounting investigation.

In the final chapter the conclusions, limitations and recommendations of the study will be discussed. A summary will also be provided of the objectives given in the first chapter.

CHAPTER 9

SUMMARY, CONCLUSION AND RECOMMENDATION

The aim of this research was to investigate and evaluate the effectiveness of Benford's Law as a tool for forensic accountants. A summary of the objectives put forward in the first chapter will be outlined in this chapter, and conclusions will be drawn and recommendations made.

9.1 Research findings

The research consisted of both a literature and empirical study. The literature study was performed in chapter 2 to chapter 7, while chapter 8 contained the results of the empirical study.

9.1.1 Literature findings

The first objective of the study was to examine the background and mathematical foundation of the phenomenon of Benford's Law. The fundamental principles of Benford's Law were discussed, amongst other things.

History and development of the Benford's Law theory

Many researchers, including scientists and mathematicians, have contributed to the development of the Benford's Law theory. The first was Simon Newcomb who observed that some numbers appear more than others in logarithm tables; however, his work went unnoticed. The Law takes its name from Frank Benford, who made the same observation years later. According to Benford's Law, the digits 1 to 9 have different probabilities of occurrences as the leading digit.

The following formula is used to calculate the probability:

$$P(n) = \log (n+1) - \log (n)$$

By replacing n with various values, the probability for n = 1 is 30.103% and n = 9 is 4.576%.

Forensic accountancy

The second objective was to define forensic accountancy. The literature showed no unified definition of the term “forensic accounting”; however, a number of associations and authors provide different definitions of the term. In chapter 3 the definitions and the field of forensic accountancy were discussed. Simply stated, forensic accounting is the application of accounting and investigative techniques in support of cases prepared for court of law.

A forensic accountant needs to possess a certain set of skills, knowledge and abilities such as:

- Inquisitive mindset;
- Tenacity and attention to detail;
- Communication skills;
- Interviewing skills;
- Knowledge of relevant investigation techniques; and
- Ability to identify fraud with minimal information.

Fraud

The third objective was to investigate some of the most common financial crimes and provide a clear definition of the different types of financial crimes found in the South African business environment today. Fraud is labeled by the definition of Snyman (2008:531) as the unlawful and intentional making of a misrepresentation which causes actual prejudice or which is potentially prejudicial to another. In today’s society, fraud is an exceedingly general predicament and there are several ways in which financial fraud can be committed. The most common ways include:

- Misappropriation of assets
    - False refunds;
    - Expense reimbursement schemes;
    - Falsified wages schemes; and

    - Cheque tampering schemes.

- Financial statement fraud
- Accounting anomalies
    - Erroneous journal entries;
    - Inaccuracies in ledgers; and
    - Manipulation of transaction records or ledgers.
- Analytical anomalies

The application of Benford's Law to forensic accounting investigations

The fourth, fifth and sixth objectives were to explore the application of Benford's Law to forensic accounting investigations, in particular to fraud detection. The types of data sets which are expected to conform to Benford's Law were also analysed.

The conclusion can be drawn that Benford's Law is an influential tool for supporting the forensic accountant in the detection process of fraudulent activities in the accounting records of an entity. By implementing the five major digital tests, the forensic accountant can determine the actual frequency of the digits in the data set. The five major digital tests are:

- First digit test;
- Second digit test;
- First two digits test;
- First three digits test; and
- Last two digits test.

The most important aspects to bear in mind when performing these tests are the analysis and interpretation of the test results. Although no explicit method exists for the forensic accountant to analyse and interpret the results of the digital analysis tests performed, various goodness-of-fit measures can be utilised. It is imperative that the most suitable method be selected, for example, null hypothesis, chi-square test and z-statistics. Furthermore, Benford's Law has been employed with great success to detect irregularities, errors and fraud in real-life scenarios, as many empirical studies have shown in the past years.

The seventh and eighth objectives were to deliberate on the benefits and limitations of the use of Benford's Law respectively. The advantages of the Benford's Law analysis are the following:

- Cost-effective;
- Can be applied to large sets of data;
- Additional approach of looking at a company's financial data;
- Easy to apply;
- Proactive approach; and
- The missing link when a supporting document has been omitted.

The limitations of Benford's Law are:

- The transactions should assess the same phenomenon;
- No built-in minimum or maximum values should be present in the data set;
- Numbers should not be assigned;
- The data set should be large enough for the Benford distribution to emerge;
- Benford's Law will not be successful where no transaction has been recorded; and
- False positives.

9.1.2 Empirical research findings

The ninth objective was to develop an empirical case study based on all the Electronic Fund Transfers (EFTs) of Company X for the period January 2012 to 31 March 2013. The following analysis tests were performed: first digit; first two digits; first three digits; and the second digit.

The numbers identified as requiring additional investigation by using the digital analysis tests were as follow:

i. First digit test: 1; 2 and 3;
ii. First two digits test: 15; 16; 17; 18; 19; 20; 21; 22; 23; 25; 30 and 50;
iii. First three digits test: 100; 200; 300; 400; 500 and 600; and
iv. Second digits test: 0 and 5.

Despite the fact that the results of all the tests were significant, the research study had limitations that require additional research. The value of Benford's law is in its use as a signaling device. Benford's law, when used correctly, can be a useful tool for identifying suspect accounts for further analysis. While this analysis method by itself might not be a guaranteed approach to detect fraud, it can be very helpful to forensic accountants to identify some accounts for further testing and therefore should assist forensic accountants in their pursuit to detect possible errors, anomalies or fraud.

9.2 Recommendations

The tenth objective was to make recommendations regarding the effectiveness of Benford's Law as a tool for forensic accountants. Little research exists on the topic of Benford's Law and forensic accountancy in a South African context. The only domestic researcher who has attempted to assess the use of Benford's Law to detect error and fraud was A.D. Saville (2006:341-354). Further research on Benford's Law in forensic accounting investigation would be valuable, as it could promote the use of Benford's Law in a South African setting. It is also proposed that further studies are motivated stemming from the findings of the study, for example specific further studies to address some of the limitations voiced in this study.

REFERENCE LIST

Albrecht, C.C. 2008. Fraud and forensic accounting in a digital environment. *White paper for the institute of fraud detection*. http://www.theifp.org/research-grants/IFP-Whitepaper-4.pdf Date of access: 18 Jun. 2012.

Albrecht, C.C., Albrecht, W.E. & Dunn, J.G. 2001. Conducting a pro-active fraud audit: a case study. *Journal of forensic accounting*, 2:203-218.

Albrecht, W.S. & Albrecht, C.C. 2002. Root out financial deception: detect and eliminate fraud or suffer the consequences. *Journal of forensic accountancy*:30-34.

Albrecht, W.S., Albrecht, C.O., Albrecht, C.C. & Zimbleman, M.F. 2009. Fraud examination. 3rd ed. Australia: Southern-Western Cengage Learning.

Albrecht, W.S., Albrecht, C.O., Albrecht, C.C. & Zimbleman, M.F. 2012. Fraud examination. 4th ed. Australia: Southern-Western Cengage Learning.

Ashcroft, P., Bae, B. & Norvell, J. 2002. Application of digital analysis in the audit. http://www.csub.edu/~bbae/publication/digital%20analysis%20in%20audit.todays%20cpa%202002.pdf Date of access: 7 Jul. 2012

Association of Certified Fraud Examiners (ACFE). 2012. Report to the nations on occupational fraud and abuse. [CD]

Barnes, P. 2009. Stock market efficiency, insider dealing and market abuse. London: Gower Publishing.

Bell, A. 2009. Benford's Law: a practical application for fraud analysis. http://alexiscbell.com/page30.php Date of access: 25 Jul. 2012.

Benford, F. 1938. The law of anomalous numbers. *Proceedings of the American philosophical society*, 78(1):551-572.

Bennett, A. 2004. Case study methods: design, use and comparative advantages. (*In* Sprinz, D.F. & Wolinsky-Nahmias, Y., *eds*. Models, numbers, and cases: methods for studying international relations. USA: University of Michigan Press.).

Berton, L. 1995. He’s got their number: scholar uses math to foil financial fraud. *The Wall Street Journal*: 1, Jul.

Bhattacharya, S. & Kumar, K. 2008. Forensic accounting and Benford’s law. *IEEE signal processing magazine*, 25(2):152.

Bhattacharya, S., Kumar, K. & Smarandache, F. 2005. Conditional probability of actually detecting a financial fraud – a neutrosophic extension to Benford’s law. *International journal of applied mathematics*, 17(1):7-14.

Bhattacharya, S., Xu, D. & Kumar, K. 2010. An ANN-based auditor decision support system using Benford’s Law. *Decision support systems*, 50(3):576-584.

Bible. 1995. The Holy Bible: new international version. Cape Town: Bible Society of South Africa.

Bierstaker, J.L., Brody, R.G. & Pacini, C. 2006. Accountants’ perceptions regarding fraud detection and prevention methods. *Managerial auditing journal*, 21(5):520-535.

Bologna, J. & Lindquist, R.J. 1995. Fraud auditing and forensic accounting: new tools and techniques. 2nd ed. New York: Wiley.

Brennan, N. & Hennessy, J. 2001. Forensic accounting. Dublin: Round Hall Sweet & Maxwell.

Browne, MW. 1998. Following Benford’s law, or looking out for no. 1. *The New York Times*, 4 Aug.

Business Dictionary. 2012a. Mantissa. http://www.businessdictionary.com/definition/mantissa.html Date of access: 20 Jun. 2012.

Business Dictionary. 2012b. Null hypothesis. http://www.businessdictionary.com/definition/null-hypothesis.html Date of access: 20 Aug. 2013.

Carslaw, C.A.P.N. 1988. Anomalies in income numbers: evidence of goal oriented behavior. *The accounting review,* 63(2):321-327.

Cendrowski, H., Martin, J.P. & Petro, L.W. 2007. The handbook of fraud deterrence. Hoboken, NJ: Wiley.

CICA. (Canadian institute of chartered accountants). 2008. Standard practices for investigative and forensic accounting engagements. http://www.levifca.com/documents/Fraud-CICAForensicStandards.pdf Date of access: 5 Jul. 2012.

Cho, W.K.T. & Gaines, B.J. 2007. Breaking the (Benford) law: statistical fraud detection in campaign finance. *American statistician*, 61(3):218-223.

Cleary, R & Thibodeau, J.C. 2005. Applying digital analysis using Benford's law to detect fraud: the dangers of type I errors. *Auditing: a journal of practice & theory*, 24:77-81.

Coderre, D. 2009. Computer aided fraud prevention and detection: a step by step guide. Hoboken, NJ: Wiley.

Concise Oxford Dictionary. 2002. Oxford: Oxford University Press.

DeHaan, M. 2011. The surprising "Benford's law" of leading digits. http://www.decodedscience.com/the-surprising-benford-law-of-leading-digits/1762 Date of access: 12 Jun. 2012.

Diekmann, A. & Jann, B. 2010. Benford's law and fraud detection. Facts and legends. *German economic review*, 11(3):397-401.

Dorrel, D.D. & Gadawski, A.G. 2012. Financial forensics body of knowledge. Hoboken, NJ: Wiley.

Durtschi, C., Hillison, W. & Pacini, C. 2004. The effective use of Benford's law to assist in detecting fraud in accounting data. *Journal of forensic accounting*, 1524-5586(5):17-34.

Eising, M. 2010. Data analysis overview. http://www.dundas.com Date of access: 15 Nov. 2012

Fewster, R.M. 2009. A simple explanation of Benford's law. *American statistician*, 63(1):20-25.

George, A.L. & Bennett, A. 2004. Case studies and theory development in the social sciences. Cambridge, MA: Belfer Centre for Science and International Affairs.

Geyer, C.L. & Williamson, P.P. 2004. Detecting fraud in data sets using Benford's law. *Communications in statistics: simulation and computation*, 33(1):229-246.

Golden, T.W., Skalak, S.L., Clayton, M.M. & Pill, J.S. 2011. A guide to forensic accounting investigation. 2nd ed. Hoboken, NJ: Wiley.

Gray, P.S., Williamson, J.B., Karp, D.A., Dalphin, J.R., Halnon, K.B. & Caritte, J. 2007. The research imagination: an introduction to qualitative and quantitative methods. New York: Cambridge University Press.

Guile, P. 2012. Procurement Fraud. (*In* Doig, A., *ed.* Fraud: The Counter Fraud Practitioner's Handbook. Burlington: Gower Publishing. p. 89-204).

Hassan, B. 2003. Examining data accuracy and authenticity with leading digit frequency analysis. *Industrial management & data systems*, 103(2):121-125.

Hill, T.P. 1995. A statistical derivation of the significant-digit law. *Statistical science*, 10(4):354-363.

Hill, T.P. 1998. The first-digit phenomenon. *American scientist,* 86(4):358-363.

Hill, T.P. 1999. The difficulty of faking data. *Chance*, 12(3):27-31.

Hopwood, W.S., Leiner, J.J. & Young, G.R. 2008. Forensic accounting. Boston: McGraw-Hill/Irwin.

IDEA. 2007. Benford's Law. Canada: CaseWare IDEA Inc. [CD].

ISA 240 (International auditing standards). 2010. The auditor's responsibilities relating to fraud in an audit of financial statements. http://www.ifac.org/sites/default/files/downloads/a012-2010-iaasb-handbook-isa-240.pdf Date of access: 22 May 2012.

Johnson, P. 2005. Fraud detection with Benford's law. *Accountancy Ireland*, 37(4):16-17.

Kramer, B.K.P. & Barnhill, D.R. 2005. Accountants as expert witnesses: a primer on meeting daubert challenges. (*In* Pagano, W.J. & Buckhoff, T.A., *eds.* Expert witnessing in forensic accounting, USA: Edwards).

Kranacher, M.J., Riley, R.A.D & Wells, J.T. 2011. Forensic accounting and fraud examination. Hoboken, NJ: Wiley.

Kumar, K. & Bhattacharya, S. 2007. Detecting the dubious digits: Benford's law in forensic accounting. *Significance*, 4(2):81-83.

KPMG. 2010. Procurement fraud in consumer companies: preventing, detecting and taking action. http://www.kpmg.com/SK/sk/IssuesAndInsights/ArticlesPublications/Documents/Procurementfraudinconsumercompanies.pdf Date of access: 23 Apr 2014.

Lanza, R.B. 2000. Using digital analysis to detect fraud. *Journal of forensic accountancy*, 1:291-296.

Lowe, R. 2000a. Benford's law and fraud detection. *Chartered accountants journal of New Zealand*, 79(10):32-36.

Lowe, R. 2000b. When Benford's law is broken. *Chartered accountants journal of New Zealand*, 79(11):24-27.

Lu, F., Boritz, J.E. & Covvey, D. 2006. Adaptive fraud detection using Benford's Law. Springer: Heidelberg.

Lynch, A. & Xiaoyuan, Z. 2008. Putting Benford's law to work. http://www.theiia.org/intAuditor/itaudit/archives/2008/february/putting-benfords-law-to-work/ Date of access: 6 Aug. 2012.

Manning, G.A. 2011. Financial investigation and forensic accounting. 3rd ed. Boca Raton, FL: CRC Press.

Mantone, P.S. 2013. Using analytics to detect possible fraud: tools and techniques. Hoboken, NJ: Wiley.

Matthews, R. 1999. The power of one. *New Scientist*, 163:26-30.

Metha, G.S. & Mathur, T. 2007. Preventing financial fraud through forensic accounting. The chartered accountant, (1):1575-1580.

Newcomb, S. 1881. Note on the frequency of use of the different digits in natural numbers. *American journal of mathematics,* 4(1):39-40.

Nigrini, M.J. 1992. The detection of income tax evasion through an analysis of digital frequencies. Cincinnati, OH: University of Cincinnati. (Thesis – PhD).

Nigrini, M.J. 1994. Using digital frequencies to detect fraud. *The White Paper index* 8(2):3-6.

Nigrini, M.J. 1996. A taxpayer compliance application of Benford's law. *Journal of the American taxation association*, 18(1):72-91.

Nigrini, M.J. 1998a. Numerology for accountants. *Journal of accountancy*, 186(5):15.

Nigrini, M.J. 1998b. Digital analysis: a computer-assisted data analysis technology for internal auditors. http://www.theiia.org/ITAuditarchive/index.cfm?act=itaudit.archive&fid=95 Date of access: 15 Oct. 2012.

Nigrini, M.J. 1999a. I've got your number. *Journal of accountancy,* 187(5):79-83.

Nigrini, M.J. 1999b. The peculiar patterns of first digits. *IEEE potentials*, 18(2): 24-27.

Nigrini, M.J. 1999c. Fraud examination for managers and auditors. http://www.jsrsys.com/fema/new15sys.htm Date of access: 6 Aug. 2012.

Nigrini, M.J. 2000a. Digital analysis using Benford's law: tests statistics for auditors. Canada, Vancouer: Global Audit Publications.

Nigrini, M.J. 2000b. Continuous auditing. (Preprint).

Nigrini, M.J. 2012. Benford's law: applications for forensic accounting, auditing and fraud detection. Hoboken, NJ: Wiley.

Nigrini, M.J. & Mittermaier, L.J. 1997. The use of Benford's Law as an aid in analytical procedures. *Auditing – a journal of practice & theory*, 16(2):52-67.

NWU (North-West University). 2008. Information guide for the NWU ethics application form: application for approval for scientific projects with human participants, biological samples of human origin or vertebrates http://www.nwu.ac.za/webfm_send/14872 Date of access: 12 Oct. 2013.

Odueke, A. & Weir, G.R.S. 2012. Triage in forensic accounting using Zipf's law. *Issues in cybercrime and digital forensics:* 33-43.

Olejar, R.J. 2008. Forensic accountants in business litigation. *New Jersey lawyer*: 250:59-63.

Olivier, P. 2010. The student's guide to research ethics. 2nd ed. NY: McGraw-Hill.

Overhoff, G. 2011. The impact and reality of fraud auditing – Benford's law: why and how to use it. Paper presented at the 22nd annual ACFE Fraud Conference and exhibition. http://www.fraudconference.com/uploadedFiles/Fraud_Conference/Content/Course-Materials/presentations/22nd/cpp/4D_Overhoff.pdf Date of access: 26 Jul. 2012.

Oxford Press University. 2012. Fraud. http://www.oxforddictionaries.com/definition/english/fraud Date of access: 7 Jun. 2012.

Oxford Press University. 2013. Ledger. http://www.oxforddictionaries.com/definition/english/ledger Date of access: 5 Feb. 2013.

Panigrahi. 2006. Discovering fraud in forensic accounting using data mining techniques. *The chartered accountant*:1426-1430.

Pinkham, R.S. 1961. On the distribution of first significant digits. *Annals of mathematical statistics,* 32(4):1223-1230.

PWC. 2014. Global Economic Crime Survey. http://www.pwc.com/gx/en/economic-crime-survey/downloads.jhtml Date of access: 23 Apr 2014.

Resnik, D.B. 2011. What is ethics in research & why is it important. http://www.niehs.nih.gov/research/resources/bioethics/whatis/ Date of access: 24 Aug. 2012.

Roukema, B.F. 2009. Benford’s law anomalies in the 2009 Iranian presidential election. http://t1.physik.tudortmund.de/kierfeld/teaching/CompPhys_09/benford_iran_0906.2789v1.pdf Date of access: 7 Sep. 2012.

Runkler, T.A. 2012. Data Analytics: Models and Algorithms for Intelligent Data Analysis. Germany: Springer.

Saville, A. 2006. Using Benford’s law to detect data error and fraud: an examination of companies listed on the Johannesburg Stock Exchange. *South African journal of economic and management sciences*, 9(3):341-354.

Silverstone, H. & Sheetz, M. 2004. Forensic accounting and fraud investigation for non-experts. Hoboken, NJ: Wiley.

Silverstone, H. & Sheetz, M. 2007. Forensic accounting and fraud investigation for non-experts. 2nd ed. Hoboken, NJ: Wiley.

Simons, H. 2009. Case study research in practice. London: Sage.

Singleton, T.W. 2011. Understanding and applying Benford's law. http://www.isaca.org/Journal/Past-Issues/2011/Volume-3/Pages/Understanding-and-Applying-Benfords-Law.aspx Date of access: 4 May 2012.

Singleton, T.W. & Singleton, A.J. 2010. Fraud auditing and forensic accounting. 4th ed. Hoboken, NJ: Wiley.

Smith, M. 2003. Research methods in accounting. London: Sage.

Snyman, C.R. 2008. Criminal law. 5th ed. Durban: LexisNexis.

Stake, R.E. 1995. The art of case study research. Thousand Oaks, CA: Sage.

Stalcup, K. 2010. Benford's law. http://www.fraud-magazine.com/article.aspx?id=203. Date of access: 4 Jun. 2012.

Stephens, T.G. 2013. Use technology to reduce fraud. http://www.mncpa.org/publications/footnote/2013-02/use-technology-to-reduce-fraud.aspx Date of access: 23 Sep. 2013

Surveilligence. 2011. Corruption and procurement fraud. http://www.surveilligence.com/en/services/fraud-detection/corruption-and-procurement-fraud.html Date of access: 23 Apr. 2014

Swanborn, P.G. 2010. Case study research: what, why and how? London: Sage.

S9.com Biographical Dictionary. 2007. http://www.s9.com/Biography/Benford-Frank Date of access: 2 Apr. 2012

Tapp, D.J. & Burg, D.B. 2000. Using technology to detect fraud. http://www.picpa.org/Content/cpajournal/2000/winter/19.aspx Date of access: 26 May. 2012.

Thomas, J.K. 1989. Unusual patterns in reported earnings. *Accounting review*, 64(4):773-787.

United States of America. 1993. State of Arizona v Wayne James Nelson 1993 (CV92-18841).

Vona, L.W. 2012. Fraud risk assessment: building a fraud audit program. Hoboken, NJ: Wiley.

Warshavsky, M.S. 2010. Applying Benford's law in financial forensic investigations. *National litigation consultant's review*, 10(2):1-4.

Weirich, T.R., Pearson, T.R. & Churyk, N.T. 2010. Accounting & auditing research: tools & strategies. 7th ed. Hoboken, NJ: Wiley.

Wells, J.T. 2008. Principles of fraud examination. 2nd ed. Hoboken, NJ: Wiley.

Wells, J.T. 2011. Corporate fraud handbook: prevention and detection. 3rd ed. Hoboken, NJ: Wiley.

Wolfe, D.T. & Hermanson, D.R. 2004. The fraud diamond: considering the four elements of fraud. http://www.nysscpa.org/cpajournal/2004/1204/essentials/p38.htm Date of access: 17 Aug. 2013.

Woodside, A.G. 2010. Case study research: theory, methods, practice. UK: Emerald group publishing.

Yin, R.K. 2003. Applications of case study research. London: Sage.

Yin, R.K. 2012. Applications of case study research. Thousand Oaks, CA: Sage.

Zweighaft, D. 2009. Forensic accountants focus on fraud. Don't underestimate the damage of small-dollar recurring frauds. http://www.cpa2biz.com/Content/media/PRODUCER_CONTENT/Newsletters/Articles_2009/CPA/June/OnFraud.jsp Date of access: 13 Oct. 2012.