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Recommended Citation

Auditing Symposium XIII: Proceedings of the 1996 Deloitte & Touche/University of Kansas Symposium on Auditing Problems, pp. 069-081;

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Digital Analysis and the Reduction of Auditor Litigation Risk

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INTRODUCTION

Digital analysis is an audit technology that has recently been introduced to the auditing community. The tests are based on mathematical principles first published in 1881. However, it is only due to recent tax evasion and auditing research, and the decline in the cost of computing, that the techniques have become viable from a cost/benefit perspective. This paper discusses the potential of digital analysis to reduce the litigation risk of auditing.

The basis of digital analysis is that, in the absence of certain types of fraud and other irregularities, the digital frequencies of client financial data should conform to Benford's Law. Since Benford's Law is expected to govern the digital frequencies, the literature is reviewed so that users can assess the feasibility of this assertion. The chronological review concentrates on the factors relevant to an audit application. The objective is to demonstrate that the expected frequencies of Benford's Law do form a valid *a priori* distribution.

Extracts from the literature on auditor litigation are reviewed. Joint and several liability makes litigation potentially very expensive. A principal defense is non-negligent performance or, stated differently, that the audit was conducted in accordance with generally accepted auditing standards. The responsibility of the auditor to detect errors and irregularities is however still open to differing interpretations.

The conclusion discusses the viability of digital analysis as a litigation reduction risk tool. If used correctly, digital analysis has characteristics that would work favorably for auditors in a litigation situation. A major advantage is that it removes some subjectivity from the decision as to whether client data appears to be reasonable.

BENFORD'S LAW

Newcomb (1881) notes that the first pages of books of logarithm tables appear to be more worn than the later pages. Since people used these books like dictionaries, it seemed that the first pages were *used* more than the later pages. The first pages coincide with numbers with low first digits. Newcomb, an astronomer, suggested that the first few pages were worn because people had to look up the logarithms of numbers with low first digits more often than the logarithms of numbers with high first digits. The modern equivalent would be observing that the keys of the low digits on a computer or calculator were more worn than the keys of the higher digits. Without much explanation, Newcomb presented the probability of the occurrence of digits in lists of natural numbers. He stated that the usefulness of the discovery was that if someone were presented with a list of digit strings, they could conclude whether the list was the logarithms of numbers, or the numbers themselves.

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Benford (1938) does not cite Newcomb, yet his introduction makes the same observation about worn logarithm table books as does the Newcomb introduction. Benford, a physicist at the GE research laboratory, empirically tested the frequencies of digits in numerical data using 20 lists of numbers (20,229 observations). The lists covered data that were both independent and weakly dependent. Independent lists were constructed from sources such as the first 342 street addresses of the then current American Men of Science, and a complete tabulation of the numbers appearing in an issue of Readers Digest. Weakly dependent lists included mathematical tables from engineering handbooks and tabulations of weights and physical constants. Benford computed the frequency of the first digits for each list and averaged the frequencies to obtain his actual (observed) results.

For audit purposes the details of Benford's lists and the level of conformity of his lists is not all that relevant. What is relevant is the mathematical assumption underlying the expected frequencies. Benford stated that natural data when ordered (ranked from smallest to largest) should form a geometric sequence. The geometric assumption is the basis of the Law and Benford (1938, 562) states that, "In natural events and in events of which man considers himself the originator, there are plenty of examples of geometric or logarithmic progressions." He cites a number of real world settings such as our sense of brightness, loudness, and weight, engineering and astronomical measurements, and the musical scales. Benford concluded that "Nature counts geometrically, and builds and functions accordingly."

Benford used integral calculus to derive the formulas for the expected frequencies of the various digits in the various positions in a number. A comprehensive table of the expected frequencies and formulas is presented in Nigrini (1996a). If a list of numbers does not (at least approximately) follow a geometric pattern (when ranked from smallest to largest), the frequencies of Benford's Law will not apply to the list of numbers.

The first follow-on papers were published by Goudsmit and Furry (1944) and Furry and Hurwitz (1945). The first paper suggests that Benford's Law is merely the result of the way that we write numbers and the second paper is a mathematical discussion of Benford's formulas. Interestingly, Stigler (1945) wrote a working paper in which he challenged the basis of Benford's Law and gave an alternative distribution of the digits in lists of numbers. Even more interesting is the fact that Nobel-laureate Stigler never published the paper. Stigler's logic is severely questioned in Raimi (1976) and it would therefore appear that to win a Nobel prize, one should know what to publish and what to leave in working paper format.

The sixties

The most significant advance in the field in the 1960s was by Pinkham (1961). Pinkham posed the question that if there was indeed some Law governing digital distributions then this Law should be scale invariant. In other words, if the digits of the areas of the world's islands, or the length of the world's rivers followed some Law, then it should be immaterial if these measurements were expressed in (square) miles or (square) kilometers. He went on to prove that Benford's Law is scale invariant under multiplication. In other words, if all the numbers in a list that followed Benford's Law were multiplied by a (nonzero) constant, then the new list would also follow Benford's Law. A list of numbers that conform to Benford's Law is known as a Benford Set. What is notable is that Pinkham proved that *only* the frequencies of Benford's Law were invariant under multiplication. In other words if a list of numbers has digit frequencies other than those of Benford's Law, then multiplication by a (nonzero) constant will result in different digital frequencies. I believe that the closer the fit before multiplication (irrespective of the constant), then the closer the fit after multiplication. I found it interesting that Pinkham's introduction states that any reader formerly unaware of Benford's Law would find an actual sampling experiment

“wondrously tantalizing.” Twenty-five years ago such an experiment would have required a great deal of effort. It is only with the recent introduction of digital analysis software that such an experiment would really be wondrously tantalizing without being mentally exhausting.

Good (1965) was the first to use Benford’s Law. He noted that certain random number tables had been formed by taking the middle three digits of the areas of English parishes. Good claimed that this would not produce random number tables because under Benford’s Law not all digits are equally likely, and such a table would have biased digit sequences.

There were two developments in 1966. Feller (1966) developed a proof that the empirical distribution of any integer appearing as a first digit in observational data follows Benford’s Law. Flehinger (1966) also developed a proof that first digits should follow Benford’s Law. Flehinger’s proof has been criticized because she uses a special summation and averaging method (Holder sums), and mathematicians contend that using special tricks that end up with Benford’s frequencies do not constitute a proof.

Adhikari and Sarkar (1968) provided a few theorems relating to numbers distributed uniformly over the range 0 to 1 (written (0,1)). They showed that after certain mathematical operations the numbers formed a Benford Set. Raimi (1969a) provided mathematical support for Benford’s Law using Banach and other scale invariant measures. Raimi (1969b) is an excellent non-mathematical review of Benford’s Law with some intuitive explanations of what thereafter came to be called “the first digit phenomenon” in many papers. Adhikari (1969) followed his earlier paper with a few more theorems. Knuth (1969) completed the sixties with a simplified proof of Flehinger’s result and a reasonably in-depth discussion of Benford’s Law.

The seventies

The seventies started with Hamming’s (1970) discussion of the usefulness of Benford’s Law. Hamming considers the mantissa distribution of products and sums and gives applications of Benford’s Law in round-off error analysis and computing accuracy considerations. The early seventies also started a stream of articles by Fibonacci theorists that showed that the familiar Fibonacci sequence (1,1,2,3,5,8, ...) follows Benford’s Law perfectly. For the mathematically curious I should stress that the sequence should have more than 100 elements. The more elements, the closer the fit.

Varian (1972) advocated another use for Benford’s Law. He tabulated the first digit frequencies for a few sets of demographic data. The original data conformed quite closely to Benford’s Law. He then checked the frequencies of forecasts made from the data. The forecasts also followed Benford’s Law. Varian concluded that checking forecasts against Benford’s Law was a potential test of the *reasonableness* of the forecasts. After Varian there were a few more papers that addressed the potential usefulness of Benford’s Law. Tsao (1974) applied Benford’s Law to roundoff errors of computers.

Goudsmit (1977) provided an interesting bit of insight. Benford’s 1938 paper was followed in the 1938 journal by an important physics paper by Bethe and Rose. This was the reason that Benford’s paper caught the attention of physicists. Goudsmit himself coauthored the first two papers on the topic. It is amazing to think that had a stream of literature not been started by the readers of Bethe and Rose, that Benford’s gem would not have been noted by academics or practitioners. I can only speculate that even if accounting practitioners noted casually that more numbers began with a 1 than any other digit, they would probably not have thought that exact expected frequencies existed.

The eighties

The eighties began with two papers that again addressed the potential usefulness of Benford's Law. Becker (1982) compared the digit frequencies of failure rate and Mean-Time-to-Failure tables with Benford's Law. He concludes that Benford's Law can be used to "quickly check lists of failure rate or MTTF-values for systematic errors." Nelson (1984) discussed accuracy loss due to rounding to two significant digits. He used Benford's Law to compute the average maximum loss in accuracy.

A literature set would not be complete without some challenges to the concepts. Such challenges should be expected, especially given the counter intuitiveness of Benford's Law. What is surprising in this case is the source of the challenge. Raimi (1985) discusses the basis and logic of Benford's Law. His paper concludes with an extract from a letter from Samuel Goudsmit (dated 21 July, 1978) in which Goudsmit claims that:

... To a physicist Simon Newcomb's explanation of the first-digit phenomenon is more than sufficient "for all practical purposes." Of course here the expression "for all practical purposes" has no meaning. There are no practical purposes, unless you consider betting for money on first digit frequencies with gullible colleagues a practical use (Goudsmit as quoted in Raimi 1985, 218).

Recent tax evasion and auditing research show that there *are* practical uses of Benford's Law. It is interesting that (1) Goudsmit published the first paper on Benford's Law after the publication of Benford's paper (Goudsmit and Furry, 1945), and (2) Ian Stewart wrote a paper on Benford's Law that starts with a story about a trickster betting on first digits with the public at a trade fair in England (Stewart 1993).

The first accounting application was by Carslaw (1988). Carslaw hypothesized that when corporations' net incomes are just below psychological boundaries, managers would tend to round these numbers up. For example numbers such as \$798,000 and \$19.97 million would be rounded up to numbers just above \$800,000 and \$20 million respectively. The belief was that the latter numbers convey a larger measure of size despite the fact that in percentage terms they are just marginally higher. Management usually have an incentive to report higher income numbers. A sign that this rounding-up was occurring would be an excess of second digit 0s and a shortage of second digit 9s. A natural academic question was an excess and shortage as compared to what yardstick. Carslaw used the expected second digit frequencies of Benford's Law. His results based on reported net incomes of New Zealand companies showed that there were indeed more second digit 0s and fewer second digit 9s than expected.

The 1980s were a strong foundation for the advances of the 1990s. Hill (1988) provided experimental evidence that when individuals invent numbers these numbers do not conform to Benford's Law. Hill's subjects had no incentive to bias the numbers upward or downward. Hill used the basic Chi-square and Kolmogorov-Smirnoff tests plus a little subjectivity to evaluate his results. The analysis suggests that more work is needed when it comes to evaluating results objectively.

Carslaw's paper was soon followed by Thomas (1989). Thomas found excess second digit 0s in US net income data. Interestingly Thomas also found that Earnings Per Share numbers in the US were multiples of 5 cents more often than expected. My own research has shown that the rounding-up phenomena is present in net income numbers of random samples of UK companies and Canadian companies. My research has also shown that this phenomenon is absent in the quarterly results of the 650-700 largest companies in the US. *The Wall Street Journal* tabulates these numbers about

six weeks after the end of each quarter. It is interesting that rounding up does not occur in the largest corporations, especially when quarterly earnings can be relatively easily rounded-up.

The nineties

The nineties have provided advances in the body of empirical evidence, and mathematical and auditing theoretical developments. Papers increasing the body of empirical evidence on the applicability of Benford's Law include Burke and Kincanon (1991) who test the digital frequencies of physical constants. Buck, Merchant, and Perez (1993) show that the digit frequencies of alpha-decay half-lives conform to Benford's Law.

One paper deals with a phenomenon affecting our everyday lives. Christian and Gupta (1993) analyzed taxpayer data to find signs of secondary evasion. Secondary evasion occurs when taxpayers reduce taxable income from above a table step boundary to below a table step boundary. The table steps referred to are the tax tables in US income tax returns that are used by taxpayers with incomes below \$100,000 to determine their tax liability. The tables are meant to assist those that would have difficulties with using the formula. Generally the reduction in taxable income of a few dollars (when the income is just above a table step boundary, say \$40,102) could lead to a tax saving of \$50 times the applicable marginal rate. Christian and Gupta assume that the ending digits of taxable incomes should be uniformly distributed over the 00 to 99 range, and Benford's Law is used to justify this assumption.

Craig (1992) examines round-off bias in EPS calculations. He tested whether EPS numbers are rounded up more often than rounded down, indicating some manipulation by managers. Unfortunately his paper falls a little short theoretically. He acknowledges that Benford's Law exists and that it could affect digit frequencies. Yet he chooses to ignore it in his analysis. It was disappointing to read a paper that searches for a bias but ignores such an important consideration. What Craig might not have realized was that Benford's Law would work in favor of his detecting manipulation. Since Benford's Law favors lower digits the probability of rounding down an EPS number to whole cents is larger than the probability of rounding up an EPS number. His roundup frequency of .551 was therefore more significant than he realized.

Nigrini (1994) questions whether the digital frequencies of Benford's Law can be used to detect fraud. Using the numbers from a payroll fraud case, he compared the first two-digit frequencies to those of Benford's Law. The premise was that over time individuals will tend to repeat their actions, and furthermore people do not think like Benford's Law, consequently their invented numbers are unlikely to follow Benford's Law. Their fraudulent numbers might stick out from the crowd. For the ten-year period of the fraud the fraudulent payroll numbers deviated significantly from Benford's Law. Furthermore, the deviations were greatest for the last five years. Presumably the fraudster was getting into a routine and did not even try to make up different numbers.

By the mid-1990s it seems that strides were being made in both the mathematical and application aspects of the Law. Boyle (1994) adds to earlier theorems by generalizing some more specific work in the 1960s. Referring to Benford's Law as the log distribution. Boyle proves that:

1. The log distribution is the limiting distribution when random variables are repeatedly multiplied, divided, or raised to integer powers, and
2. Once achieved, the log distribution persists under all further multiplications, divisions, and raising to integer powers.

Boyle concludes by asserting that Benford's Law has similar properties to the central limit theorem in that Benford's Law *is* the central limit theorem for digits under multiplicative operations.

Hill (1995) clearly represents the most significant mathematical advance since Pinkham (1961). After reviewing my work and other empirical studies, Hill shows that if distributions are selected at random (in any "unbiased" way), and random samples are then taken from each of these distributions, the significant digits of the resulting collection will converge to the logarithmic (Benford) distribution. This helps explain why the significant-digit phenomenon appears in many empirical contexts, and helps explain its recent application to computer design, mathematical modeling, and detection of fraud in accounting data. In other words, Hill shows that Benford's Law is the distribution of *all distributions*. It would be valuable if simulation studies draw random samples from the family of common distributions, to confirm Hill's theorem.

Nigrini and Mittermaier (1996) propose six digital tests that could be used by external and internal auditors. External auditors could use the tests to determine if a data set appears to be reasonable and to direct their attention to questionable groups of transactions. Internal auditors could also use the tests to direct their attention to biases and irregularities in data. The six tests are the first six tests listed in Appendix A.

In Nigrini (1996a) I develop a Distortion Factor model that signals whether data appears to have been manipulated upwards or downwards. Based on the digit patterns, are there signals of an overstatement or signals of an understatement? The empirical tests include digital tests of interest received and interest paid data for US taxpayers. The interest data conformed quite well to Benford's Law, but for interest received there was an excess of low digits as the first digits in interest numbers suggesting an understatement of these numbers. In contrast there was an excess of the higher digits as the first digits in interest paid numbers, suggesting an overstatement of these numbers. The paper cites a study by the Dutch Ministry of Finance in which interest paid numbers per the third-party bank returns showed a near-perfect conformity to Benford's Law. In the absence of errors these should have been the interest received numbers declared by Dutch taxpayers.

In Nigrini and Wood (1996) we analyze the population counts for the 3,141 counties of the United States per the 1990 census. There was a near-perfect conformity to Benford's Law. The 1991 and 1992 population forecasts also had a near-perfect conformity to Benford's Law. Using goodness-of-fit tests there was an even closer fit of the forecasts than the actual count numbers.

Nigrini and Levy (1996) develop a small sample test based on digital frequencies. The first seven tests in the Appendix require large samples (more than 1,000 observations). The individual Distortion Factor model caters for small samples and facilitates the detection of abnormal digit patterns. Using this model small data sets can be ranked in terms of their nonconformity and the worst conformers could be selected for closer scrutiny. Furthermore, data can be partitioned into subsets and conclusions can be drawn as to which subsets have the lowest level of conformity and which subsets have data that appears over or understated. In a tax situation the subsets could be regions of the country or certain attributes of taxpayers (balance due or refund due).

My most recent work in the field is directed at reaching objective conclusions in an auditing context. Does the data conform to Benford's Law within tolerable error bounds? The forthcoming Global model (Nigrini, 1996b) will allow data sets to be ranked in terms of their conformity to Benford's Law. The model is a composite test of the first six tests listed in the Appendix. The model will give a score of 1 for perfect conformity, and 0 for the worst case of nonconformity (all numbers in the list equal a string of two or more 9s). This test will allow auditors to rank data sets. For example, the inventory counts of 25 warehouses each having 20,000 products could be ranked,

and attention directed at the least conforming data set. Alternatively an airline could compare the digit frequencies of its tickets issued to the frequencies of refunds issued.

AUDITOR LITIGATION

The status of the liability crisis in the US is documented in the joint paper by the Big 6 (Arthur Anderson & Co. et. al., 1992). The Big 6 senior executives state that the present liability system has produced an epidemic of litigation that is spreading throughout the accounting profession and the business community. They openly criticize the doctrine of joint and several liability that makes each defendant fully liable for all assessed damages in a case, regardless of the degree of fault. They estimate that in 1991, the total expenditures for settling and defendant lawsuits were 9 percent of auditing and accounting revenues. There appears no end to the continuous upward spiral.

An implication is that increased litigation costs increase the cost of audit services and tend to reduce access to the capital markets. The large firms are avoiding high-risk clients, and smaller and medium-sized audit firms are dropping their public clients or abandoning their audit practices altogether. The litigious practice environment is making it increasingly difficult to attract and retain the most qualified individuals at every level. The Big 6 make the strong case for ending the joint and several liability rule, and state their preference for a proportionate liability rule. They conclude that the Big 6 are exploring all possible alternatives for reducing the liability threat. It is disappointing that this report focuses almost entirely on a call for legal reform. No mention is made of the reduction in liability that could arise from improved audit technology.

Arens and Loebbecke (1991) outline the four sources of legal liability. The first source is where the client sues the auditor for not discovering a defalcation during an audit. The increase in litigation is partially due to the greater complexity of auditing and accounting because of factors such as the increasing size of business, the existence of the computer, and the intricacies of business operations. They note that the typical lawsuit involves a claim that the auditor did not discover an employee defalcation due to negligence in the conduct of the audit. The lawsuit could be for breach of contract, a tort action for negligence, or fraud. The principal issue in cases involving alleged negligence is usually the level of care required. One of the principal defenses against negligence is that the audit was performed in accordance with generally accepted auditing standards. Non-negligent performance is also a defense available against suits initiated under Section 10 and Rule 10b-5 of the federal Securities Exchange Act of 1934.

Arens and Loebbecke describe a number of steps that the profession could take to reduce the threat of litigation. The first item on their list is research in auditing. They highlight the fact that continued research is important in finding better ways to uncover unintentional misstatements or management and employee fraud. On an individual level they include in their list of specific actions that could reduce liability, (1) perform quality audits which require that appropriate evidence be obtained and appropriate judgments be made about the evidence, and (2) proper documentation through good working papers which is essential if an auditor has to defend an audit in court.

Carmichael, Rennie, Rennie, and Willingham (1995, 162) review management fraud. Their suggested approach is that auditors first assess the likelihood of material fraud in the client company's circumstances and then, if material fraud is assessed as likely, plan the audit to provide reasonable assurance of detecting it.

Kell and Boynton (1992) note that prior to the issuance of SAS 52, the auditor was only required to plan the audit to *search* for errors and irregularities that would have a material effect on the financial statements. SAS 53 extends the auditors responsibility to design the audit to provide

reasonable assurance of *detecting* errors and irregularities that are material to the financial statements. The auditor is expected to exercise due care and a proper degree of professional skepticism in performing the audit and in evaluating the findings. The failure to detect a material misstatement in the financial statements does not, in and of itself, indicate that the audit was not made in accordance with GAAS. Their anti-litigation strategy is that the auditor comply fully with professional pronouncements in each audit engagement, and the use of sound professional judgment during the audit.

The National Commission on Fraudulent Financial Reporting (1987) noted that users of financial statements expect auditors to bring to the reporting process technical competence, integrity, independence, and objectivity. Users also expect auditors to *search for* and *detect* material misstatements, whether intentional or unintentional, and to prevent the issuance of misleading financial statements. Four steps were identified to improve the auditor's ability to detect fraudulent financial reporting. First, the profession must recognize its responsibility to design the audit scope to consider the potential for fraudulent financial reporting and to design audit procedures to detect such reporting. Second, independent public accountants can and should do more to improve their detection capabilities. Third, audit quality should be improved. Fourth, users should understand the nature, scope, and the limitations of an audit.

Palmrose (1988) states that the value of external audits derives from users' expectations that auditors will detect and correct/reveal any material omissions or misstatements of financial information. Failure to do so is termed an audit failure, which typically results in litigation when clients/users incur losses in conjunction with materially false or misleading financial information. The suggestion is made that users can view auditors with relatively low (high) litigation activity as higher (lower) quality suppliers. Palmrose finds that non-Big Eight firms had higher litigation occurrence rates than the Big Eight and concludes that the Big Eight are quality differentiated auditors.

Lys and Watts (1994) state that there are three factors necessary for a disclosure lawsuit. These are (1) the existence of a cause, (2) plaintiffs' discovery of cause, and (3) the net benefits to the suit. The existence of a cause depends on (1) the probability that management issues false or misleading financial statements, (2) the probability that the auditor failed to discover that the financial statements are false or misleading, and (3) the existence of loss by a plaintiff. Structured technologies use statistical sampling, structured internal control evaluations that lead to a prescribed audit plan, formal means of integrating test results, and less audit staff per partner. Unstructured technologies rely more on subjective judgment. They do not state which technology is more likely to discover financial statement problems when they exist. But to the extent that structured technology provides better documentation of the conduct of the audit, it may provide a more effective defense in a lawsuit. The results of their empirical study suggest that the likelihood of a lawsuit is *greater* if the auditor uses a *less* structured audit technology.

DISCUSSION

A decrease in employee morale or employee loyalty is a red flag that should signal an increased potential for employee fraud. The 1990s has seen large scale restructuring by US businesses. Employees in the US are currently very insecure about their jobs. The large scale restructuring and job insecurity has some detrimental consequences. In business, the climate is now much more one of "them and us." Employees that were not laid off have seen the harsh impersonal nature of downsizing when friends and coworkers were given pink slips despite many years of loyal service (Globe and Mail, 1996). The impersonal harsh treatment given to workers during a restructuring must have the effect of lowering morale and employee loyalty. Employees might even see fraud as a means of saving up for the day when they too are laid off with short notice. The

temptation or moral justification for employees to commit fraud has increased. Managers are also not immune to the stress of insecurity. Managers know that they too could be laid off hence they have an increased incentive for outright embezzlement or fraudulent financial reporting.

The increased potential for fraud, together with the public's perception of the auditor's responsibilities to detect fraud, increases the magnitude of the problem. For example, the attorney for Leslie Fay stated that Leslie's Fay's board relied on false information as blessed by its auditor, BDO, whose job it was to protect the company from fraudulent bookkeeping (The Wall Street Journal, 1995a). Unfortunately, the attorney's opinion is shared by others, notably jury members. In the Phar-Mor case a federal jury *unanimously* found Coopers and Lybrand liable to a group of investors on fraud charges in the 1992 fraud and embezzlement case of its former client Phar-Mor Inc. (The Wall Street Journal, 1996a). Coopers was found liable both under federal securities-fraud law and Pennsylvania common-law fraud.

From the above two cases it can be seen that irrespective of how the Auditing Standards Board tries to position itself with respect to fraud detection, the lawsuits continue. Furthermore, the lawsuits bypass the SASs and are filed under securities or common-law fraud. The profession cannot use ASB statements as a defense, and in addition, common profession-wide or firm-wide defenses are not too helpful because the liability laws differ from state to state. Clearly Coopers was not saved by any defense in its loss in Pennsylvania. To complicate the situation further, the ASB is in the process of revising its draft SAS related to fraud (Pany, 1996). The task force continues to work on the overall structure of possible guidance on the consideration of fraud in a financial statement audit. The draft contains a requirement that, on each audit, CPAs make an assessment of whether there is a heightened risk of fraud.

With respect to auditor litigation, on one side of the litigation spectrum we have those cases where the auditor was lacking due diligence. Clearly damages are due to the plaintiff in such cases. On the other side of the spectrum are those cases where the auditor used due diligence. Clearly here no damages are due to any plaintiff. In the center portion of the spectrum is the gray area where due diligence is questionable.

Within the gray area, plaintiffs have a clear monetary incentive to claim a lack of due diligence. Also within the gray area defendants (auditors) have a clear monetary incentive to be claim that the audit was done with due diligence. Irrespective of how the Auditing Standards Board and the profession try to limit auditor exposure by trying to define due diligence, there will still exist a gray area in which plaintiffs have a clear monetary incentive to sue.

Using digital analysis based on Benford's Law as an auditing tool is advantageous to auditors because it *reduces* the size of the gray area zone. Digital analysis, as described in Nigrini and Mittermaier (1996) has two basic objectives. First, as an analytical procedure it confirms the *reasonableness* of the data. Second, as a directed sampling procedure, it *directs* the auditor's attention to transactions or groups of transactions that merit further audit attention. It is a tool that if used properly, will *detect* the fraudulent transactions that are the subject of many lawsuits. It is most appropriate when used to detect fictitious transactions such as the cases listed above, or other cases such as L.A. Gear's fictitious inventory (The Wall Street Journal, 1995b), or Bennett Funding Group's office equipment leases that did not exist (The Wall Street Journal, 1996b).

The first advantage of digital analysis is that jury members will find the techniques easy to understand and a credible source of evidence. People find Benford's Law interesting because it is somewhat counter intuitive. Use of even the basic digital tests will impress a jury and will favor a due diligence decision. Not using digital analysis will have the opposite effect. If plaintiffs can show that tests existed that would have detected the fraud, but such tests were not used, the auditors

can expect to lose the case and face damage awards. Plaintiffs can run digital tests on all sorts of permutations, combinations, and subsets of the data until the fraudulent transactions stand out as clearly significant deviations. In other words, plaintiffs can run the tests until the fraudulent transactions are near the top of the directed sampling list. They can massage the data until they obtain the most favorable output to make their case.

The second advantage is that for most of the tests an objective conclusion can be reached, such as there was not enough evidence at the 0.05 level to reject the null hypothesis that the data conformed to Benford's Law. The more opinions are based on objective tests, the more the auditor stands to show due diligence. Objective tests lend themselves to being more concrete evidence in a set of working papers.

The third advantage is that digital analysis tests can be carried out on most balance sheet and income statement items. The only exceptions are the equity accounts that may contain too few entries to test for statistical significance. Consequently, each and every business transaction of the auditee could be represented somewhere on the digital graphs and tables. The jury might be more likely to accept the due diligence argument when it is shown that every single transaction appeared somewhere on the output graphs. The fact that the fraudulent transactions did not stick out enough to be noticed could be ascribed to the fact that deviations from Benford's frequencies are expected due to chance alone. That is, Benford's frequencies are a set of expected frequencies, and all expectations have room for deviations from the expected values.

Digital analysis is also a sign that auditors are using the most recent computer technology. Many transactions now occur only in electronic format. This makes traditional paper-record auditing impossible. Advanced payment systems have electronic transaction matching systems, the output of which needs to be tested for reasonableness. In other situations the sheer volume of transactions makes a representative sample costly due to the costs of substantive procedures. Using technology to audit technology will impress jurors. Using technology to audit large volumes of data is cost effective.

From a professional perspective, digital analysis levels the playing field. Research shows that the Big Six are quality differentiated firms. Digital analysis is a technology that can be used by all members of the profession, both large and small. Digital analysis tests could become part of an expert system giving all auditors access to expert knowledge. I currently view it as a decision support system, the decision being whether detection risk and control risk are at acceptable levels.

Auditors using digital analysis must use the techniques properly. There should be adequate internal guidance. Users should know enough about the mathematics to form an *a priori* opinion as to whether a data set should conform to Benford's Law. Users should be trained as to how to interpret the output. Auditors that use the tool, but fail to interpret the output correctly, would find it more difficult to use the due diligence defense.

The recent declines in the cost of computing power and increases in the ease with which software can be purchased or written, make digital analysis more and more attractive from a cost/benefit perspective. As an anti-litigation tool it can be used by auditors to demonstrate that they have met or even surpassed the due diligence criteria.

Appendix A: Summary of Digital Analysis Tests

1. **First digits** (1, 2, ... ,9). Probabilities range from 0.046 to 0.301.
2. **Second Digits** (0, 1, ... ,9). Probabilities range from 0.085 to 0.120.
Tests (1) and (2) flag large samples (relative to the population).
3. **First two-digit combinations** (10, 11, ... , 99). Probabilities vary from 0.004 to 0.041.
4. **Last two-digit combinations** (00, 01, ... , 99). All probabilities equal 0.01.
Tests (3) and (4) are best-suited to selecting audit samples.
5. **Tests for rounding.** A strong test for the prevalence of rounding or estimation. Test only gives a small sample if multiples of 100 or 1,000 are selected.
6. **Hit parade test.** This is a strong test for the abnormal recurrence of certain numbers. Test usually gives a very small sample as being in need of attention.
7. **Distortion Factor Model.** This test signals whether a data set appears to be over- or understated. It gives the percentage over- or understatement and the statistical significance can be calculated.
8. **Global test.** A global test for conformity of a data to Benford's Law where all digits and digit combinations are taken into account. A score of zero signals the most extreme case of non-conformity and a score of one signals perfect conformity. Algorithm and significance scores available in June, 1996.
9. **Test for small samples.** This test will score small samples (e.g., eight observations) according to the extent of abnormalities therein.
10. **Summation Theorem compliance.** This test checks for compliance with Nigrini's Summation Theorem. Test is appropriate to detect abnormalities in $[10^m, 10^{m+1})$ strata. Test suited to data that are only expected to approximate Benford's Law (medical expense claims) or where there are many relatively small numbers.
11. **Second Digit Probability Revision.** This test used corrected second digit expected probabilities when there is non-conformity in the first digits of a data set.
12. **Patterns test.** This series of tests identifies patterns in the digital frequencies. Test is appropriate when subsets are ranked in terms of abnormal patterns. The population could be payments for a period, and the subsets could be individual suppliers. Test will identify the suppliers with digital patterns that deviate most systematically (i.e., with a pattern to the deviations). Test cancels the need to test each supplier individually and to rank them in terms of systematic patterns. Available by August, 1996.
13. **Non-Benford data test.** These tests would apply to data that is not expected to follow Benford's Law such as medical expense claims, USDA Food Stamp Program claims, or checking account transactions (especially if they include ATM transactions). Expected digit frequencies are formulated based on past experience (i.e., empirical data) and (1) to (12) are amended to test for deviations from the revised expected distribution.

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