USING DIGIT ANALYSIS TO EVALUATE FINANCIAL REPORTING RISK IN THE ENTERPRISE RISK MANAGEMENT PROCESS

Shirley J. Daniel*, Liming Guan**, John P. Wendell***

Abstract

Boards of Directors and their audit committees are responsible for the oversight of risk management for the enterprise. Because entities are being asked by rating agencies to more explicitly describe their enterprise risk management processes, boards and management will be well served to employ risk management tools to efficiently and effectively assist them in identifying areas of higher financial reporting risk. Studies using digit pattern analysis of earnings have consistently found that reported earnings are subject to misstatements due to inappropriate rounding. Recent actions by regulators make it clear that such misstatements, even when relatively small in magnitude, are unacceptable. This article provides guidelines and a new tool for preventing and detecting such misstatements.

Keywords: Benford's law; Rounding; Earnings management; Corporate governance

**Professor. Phone: (808) 956 3249*
sdaniel@hawaii.edu
*** Corresponding author.*
Associate Professor. Phone: (808) 956 7002
lguan@hawaii.edu
****Professor. Phone: (808) 956 6694*
cbaajwe@hawaii.edu
Authors are at School of Accountancy, Shidler College of Business, University of Hawaii,
2404 Maile Way, Honolulu, HI 96822
Fax: (808) 956-9888

1. Introduction

The recent announcement of Standard & Poors (2008) to include an evaluation of a firm's Enterprise Risk Management (ERM) processes into their ratings provides an opportunity and challenge for firms to not only examine, but to improve their risk management processes. S&P's evaluation of ERM processes was initially focused on the financial services industry, but has recently been expanded to all industries. Because of the need to explain their ERM processes to S&P in explicit ways, firms may be well served to use quantitative risk management tools and methodologies to help identify potential risk areas for management investigation and mitigation.

One methodology that could prove useful in identifying risk exposure in a number of areas of the enterprise, particularly in financial reporting, is digit analysis. This technique has already been shown to be beneficial to the analytical review procedures employed by external auditors (Nigrini, 1997) and internal auditors (Nigrini, 1999). Since the passage of the Sarbanes-Oxley Act of 2002, the audit committees of public company boards have been tasked with increasing responsibility for risk oversight, and especially for managing financial reporting risk. Digit analysis could be helpful to audit committees, which are now faced with severe time constraints in addition to increased legal liability. The technique can provide a particularly efficient mechanism for identifying potential risk areas and also in demonstrating the board's due diligence through the use of quantitative risk management tools as a part of their ERM processes.

It is well established from archival studies using digit analysis[29] that corporations throughout the world engage in the biased rounding of their reported earnings (Carslaw 1988; Thomas 1989; Kinnunen and Koskela 2003; Skousen et al. 2004, and Guan et al. 2006). Biased rounding occurs when numbers are consistently rounded up and not rounded down. Carslaw (1988) was the first to identify biased rounding in corporate earnings reports when he noticed that there were many more second digit zeros than expected and fewer second digit nines in New Zealand corporate earnings reports. This indicated that managers were rounding up earnings to turn a second digit nine into a second digit zero. Carslaw (1988) then examined second digit ones and found that they were close to the predicted value, indicating that rounding down was not taking place.

[29] See Appendix 1 for a detailed description of the theory and application of digit analysis to reported earnings.

To explain this biased rounding Carslaw (1998) hypothesized that managers were leveraging small and relatively easy to execute misstatements in order to have a larger impact on earnings by utilizing a well-known consumer pricing model that he dubbed the "$1.99" effect. The concept is that consumers will perceive merchandise priced at $2.00 to be significantly more expensive than the same merchandise priced at $1.99. Carslaw (1988) reasoned that this phenomenon also applies to earnings so that earnings of $2 million will be perceived as significantly better by stakeholders than earnings of $1.99 million. In addition, Thomas (1989) proposed that managers might be rounding up to meet performance targets or debt covenant agreements that are themselves often stated in round numbers.

Both of the above motivations for biased rounding involve the deliberate misstatement of earnings in order to gain an advantage. Although most biased rounding misstatements are well below the materiality thresholds used by auditors,[30] regulators have become increasingly intolerant of deliberate misstatements of *any* size as is evidenced by the issuance in 1999 of SEC Staff Accounting Bulletin: No. 99 – Materiality (SEC 1999) and Statement on Auditing Standards No. 89 (AICPA 1999). Specifically, the SEC has indicated that materiality must be judged based on the quarterly balances, not just annual amounts, and should even be applied down to the operating segment level when important future trends are implied. The firm is also expected to consider the impact of misstatements on totals and subtotals, as well as cumulative effects across years. Particularly if the misstatement might impact meeting earnings per share targets, bonus calculations, and debt covenant requirements, the materiality threshold may be considered as low as one cent. Management is responsible for maintaining an internal control system to reasonably ensure the accuracy of the financial statements, and a laissez faire attitude from management and the board with regard to rounding errors that could mislead investors may be an important indicator of a problem with the "tone at the top." To fairly present the results of their operations and avoid regulatory enforcement actions, corporate boards of directors need to ensure controls are in place to provide reasonable assurance that biased rounding will not find its way into the financial statements.

2. Corporate Boards Responsibilities for Preventing Misstatements

There are a number of recent developments that make it prudent for corporate boards to ensure that they have a robust ERM oversight process in place. The doctrine of duty of care and the exercise of good faith places an increasing burden on corporate boards to follow best practices in the management of risk. A number of organizations have published guidance for ERM at the Board level (DeLoach 2000; Brancato et al. 2006), including the Committee on Sponsoring Organizations of the Treadway Commission (COSO) 2004 *Enterprise Risk Management – Integrated Framework*, which has been endorsed by the SEC. Standard & Poor's (2008) recently announced that it will incorporate a review of an institution's ERM processes as an element in their ratings systems beginning in fall 2008. These events create an increased incentive and sense of urgency for firms to develop more explicit processes, including the use of quantitative tools to complement the high level judgment and heuristic methods that have typified risk management practices at the board level.

S&P (2008, p. 2) views ERM as:

· An approach to assure the firm is attending to all risks;

· A set of expectations among management, shareholders, and the board about which risks the firm will and will not take;

· A set of methods for avoiding situations that might result in losses that would be outside the firm's tolerance;

· A method to shift focus from "cost/benefit" to "risk/reward";

· A way to help fulfill a fundamental responsibility of a company's board and senior management;

· A toolkit for trimming excess risks and a system for intelligently selecting which risks need trimming; and

· A language for communicating the firm's efforts to maintain a manageable risk profile.

The use of digit analysis can help the board accomplish their responsibility for ERM in three key ways:

1) By providing a tool to identify anomalies in the reported financial results, digit analysis can help focus the board, especially the audit committee, on areas of increased risk for financial reporting misstatement;

2) By targeting the investigation of financial risk to a more limited domain which can be investigated with the help of internal and external auditors and other support personnel, digital analysis can free the board to focus on strategic and operational risks which may require higher levels of judgment and be less amenable to the use of quantitative tools with regard to risk management;

3) By providing an explicit process to demonstrate the board's due diligence, digit analysis helps the board document the discharge of their risk management responsibilities to regulators, rating agencies, and during litigation.

3. Policies to Prevent and Detect Biased Rounding

Boards of Directors need policies to both prevent and detect biased rounding in the financial statements.

[30] For example, Leslie (1985, p. 19) states "it would be fair to say that, at this time, there is more international support for the use of 5% to 10% of income as a rule of thumb for determining materiality than for any other guideline."

Prevention Policy

Rounding in the financial statements is necessary to make the statements easier to understand. Indeed, the unrounded financial statements of a multibillion dollar enterprise reporting results to the last penny would be confusing to read and give the incorrect appearance that the financial statements are accurate to the penny. However, firms should not round beyond the last significant digit shown in the financial statements. For example, a company whose financial statements amounts are shown in denominations of $1,000 should never round up to the nearest $10,000 but only to the nearest $1,000. This should be obvious but the digit analysis of archival earnings reports has revealed excess second digit zeros as large as 25% more than expected (Guan et al. 2006) indicating that explicit guidance to management regarding the acceptable level of rounding is needed.

The policy of rounding to the last significant digit should only apply to the final preparation of the financial statements. The trial balance from which the financial statements are prepared and all subsidiary schedules feeding into the trial balance should be left in their un-rounded state to prevent the accumulation of rounding amounts. This accumulation can occur when, for example, three instances of $1.50 are all rounded up to $2.00 and then added together yielding a total of $6.00 instead of the $5.00 that results when rounding up from $4.50. To avoid confusion, the rounding rule should be made explicit and consistent with the rule used by the computer. These days it is nearly universal that software rounds 0.5 up to one and anything less down to zero. Thus, if the financial statements are presented to the nearest $1,000, $45,499 should be rounded down to $45,000.

Finally, during the preparation of the financial statements rounding might accumulate in a way that keeps the rounded balance sheet from balancing or the rounded net income from the trial balance agreeing with the net income on the financial statements. If the rounding rules were rigorously followed the statements should not be out of balance by more than one or two significant digit amounts. The policy should be that the necessary adjustments are applied to the amounts that were rounded the most first. For example if the balance sheet is off by an excess debit of $1,000 and accounts receivable was rounded up by $500, which was the most of every debit account appearing on the financial statements, it would be the first to be rounded down.

Detection Policy

The mathematics of determining when there is an excess number of zeros in a series of numbers is complex. Appendix 2 provides the formulas for making this determination as well as our mathematical derivation of those formulas. To assist board members in detecting biased rounding, we have constructed Table 1 that provides the critical number of zeros in a particular position that allows the rejection of the null hypothesis that the observed number of zeros for a given number of periods was due to chance at a particular level of statistical significance. Quarterly and annual earnings reports should be compared against this table and when the number of zeros are at or above the critical number a review of all the statements in the period should done to determine if the preparation of any of the earnings reports violated the rounding policy. Equations in Appendix 2 can also be used to construct a table with a larger number of periods or different levels of statistical significance than are included in Table 1.

4. Conclusion

This paper has considered the research question of whether Corporate Boards of Directors can take action within the ERM framework to limit management's ability to engage in biased rounding misstatements. Through careful analysis of the ERM framework and the underlying mathematics of the distribution of digits in earnings reports combined with a review of existing empirical literature in this area we have shown that there are definite pro-active measures that Boards may take to reduce their exposure to this type of misstatement. Further, through a derivation of the sampling properties of second digit zeros in earnings reports we have provided the necessary equations and tables to allow Boards of Directors to effectively mitigate their exposure to biased rounding in their corporate earnings reports. Thus, the research question has been answered in the affirmative on a theoretical level and we have provided the tools to apply our research results in practice as well.

References

1. AICPA. 1999. Statements on Auditing Standards no. 89, *Audit Adjustments*, (AICPA, New York).
2. Benford, F. 1938. "The Law of Anomalous Numbers." *Proceedings of the American Philosophical Society* 78 (4): 551-572.
3. Brancato, C.R., E.S. Hexter, K.R. Newman and M. Tonello. June 2006. *The Role of US Corporate Boards in Enterprise Risk Management* The Conference Board.
4. Carslaw, C.A.P.N. 1988. "Anomalies in Income Numbers: Evidence of Goal Oriented Behavior." *The Accounting Review* 63 (2): 321-327.
5. Committee on Sponsoring Organizations of the Treadway Commission (COSO) September 2004. *Enterprise Risk Management – Integrated Framework*.
6. De Loach, J.V. May 2000. *Enterprise-Wide Risk Management: Strategies for Linking Risk and Opportunity*. The Financial Times Management Briefing, Pearson Education, U.K.
7. De Ceuster, M.J.K., G. Dhaene, and T. Schatteman. 1998. "On the Hypothesis of Psychological Barriers in Stock Markets and Benford's Law." *Journal of Empirical Finance* 5 (3): 263-279.
8. Guan, L., Lin, F., and Wei, J. 2006. "Window-dressing of financial reports: evidence from financial firms," *Corporate Ownership and Control* 4(1): 293-299. 2006.

9. Hill, T. P. 1998. “The First Digit Phenomenon.” *American Scientist* 86: 358-363.
10. Kinnunen, J., and M. Koskela. 2003. “Who is Miss World in Cosmetic Earnings Management? A Cross-National Comparison of Small Upward Rounding of Net Income Numbers Among Eighteen Countries.” *Journal of International Accounting Research* 2: 39-68.
11. Koedijk, K.G., and P.A. Stork. 1994. “Should We Care? Psychological Barriers in Stock Markets.” *Economic Letters* 44 (4): 427-432.
12. Leslie, D.A. 1985. *Materiality: The Concept and Its Application to Auditing.* Toronto, ON, CN: Canadian Institute of Chartered Accountants.
13. Mitchell, J. 2001. “Clustering and Psychological Barriers: The Importance of Numbers.” *The Journal of Futures Markets* 21 (5): 395-428.
14. Newcomb, S.: 1881, ‘Note on the Frequency of Use of the Different Digits in Natural Numbers’, *American Journal of Mathematics* 4(1/4), 39-40.
15. Nigrini, M.J., and L.J. Mittermeir. 1997. “The Use of Benford's Law as an Aid in Analytical Procedures.” *Auditing: A Journal of Practice & Theory* 16 (2), 52-67.
16. Nigrini, M.J. 1999. “Adding Value with Digital Analysis.” *The Internal Auditor;* Feb 1999; 56, p. 21-23.
17. Rodriguez, R.J. 2004a. “First Significant Digit Patterns From Mixtures of Uniform Distributions.” *The American Statistician* 58 (1): 64-71.
18. Rodriguez, R.J. 2004b. “Reducing False Alarms in the Detection of Human Influence on Data.” *Journal of Accounting Auditing and Finance* 19 (2): 141-158.
19. Securities and Exchange Commission (SEC). 1999. Materiality in Financial Statements: SEC Staff Accounting Bulletin 99 (SEC, Washington, DC).
20. Skousen, C., L. Guan, and T. Wetzel. 2004. “Anomalies and Unusual Patterns In Reported Earnings: Japanese Managers Round Earnings.” *Journal of International Financial Management and Accounting* 15 (3): 212-234.
21. Standard & Poors, RatingsDirect. May 7, 2008. *Enterprise Risk Management: Standard & Poor’s To Apply Enterprise Risk Analysis to Corporate Ratings.*
22. Thomas, J. 1989. “Unusual patterns in reported earnings.” *The Accounting Review* 64 (4): 773-787.

Table 1. Excess zeros

This table indicates the number of zeros necessary to conclude that there are more zero digits in a set of numbers in a particular position than could be explained by chance at various levels of statistical significance. For example, if 20 quarters of earnings reports have five zeros as the fourth significant digit there is sufficient evidence at the 0.05 significance level to conclude that improper rounding is occurring. As explained in Appendix 2, the values in the columns labeled 4+ can be used to evaluate the number of second digit zeros for any position number greater than the third position.

	P value								
	0.05			0.01			0.001		
	Digit Position			Digit Position			Digit Position		
Periods	2	3	4+	2	3	4+	2	3	4+
2	2	2	2	NA	NA	NA	NA	NA	NA
3	2	2	2	3	3	3	NA	NA	NA
4	3	3	3	3	3	3	4	4	4
5	3	3	3	4	3	3	4	4	4
6	3	3	3	4	4	4	5	5	5
7	3	3	3	4	4	4	5	5	5
8	4	3	3	4	4	4	6	5	5
9	4	4	4	5	4	4	6	5	5
10	4	4	4	5	5	5	6	6	6
11	4	4	4	5	5	5	6	6	6
12	4	4	4	5	5	5	7	6	6
13	5	4	4	6	5	5	7	7	6
14	5	4	4	6	5	5	7	7	7
15	5	5	5	6	6	6	7	7	7
16	5	5	5	6	6	6	8	7	7
17	5	5	5	7	6	6	8	7	7
18	6	5	5	7	6	6	8	8	8
19	6	5	5	7	6	6	8	8	8
20	6	5	5	7	7	7	9	8	8
21	6	6	6	7	7	7	9	8	8
22	6	6	6	8	7	7	9	8	8
23	6	6	6	8	7	7	9	9	9
24	7	6	6	8	7	7	10	9	9
25	7	6	6	8	8	7	10	9	9
26	7	6	6	8	8	8	10	9	9
27	7	7	6	9	8	8	10	9	9
28	7	7	7	9	8	8	11	10	10
29	8	7	7	9	8	8	11	10	10
30	8	7	7	9	8	8	11	10	10

Appendix 1. Digit Analysis

Processes often produce numbers where the distribution of the digits is known. Consider the following process for generating a number between zero and 999 inclusive: Ten ping-pong balls are numbered zero to nine. The ping-pong balls are then placed in a hat and thoroughly mixed. A ping-pong ball is then removed from the hat, its number recorded and then it is placed back in the hat, the balls are mixed and a second ball is selected. This process is then repeated a third time and a number is created by arranging the digits in the order in which they were selected and removing any leading zeros. For example, if 003 is selected then the number would be recorded as 3. If 000 is selected it is recorded as zero. Using this process the chance of the first digit being one is the same as all the other digits (0.111) except for zero (0.001). If this procedure is performed a large number of times and the number one appears as a first digit 25% of the time this would provide strong evidence that the balls were not being selected from the hat at random. If these numbers were being used for betting purposes that would provide strong evidence of cheating by those performing the procedure.

In the above example the integers 1 through 9 all have the same probability of being the first digit. However, a small change to the process can alter this substantially. If, instead of arranging the digits by the order they were selected, they are arranged from smallest to largest, then the first digit probabilities will no-longer be uniform. Under this process the smaller digits have a greater chance of being the first digit than the larger digits. For example, the probability that the first digit is one (1) will be 0.271 but the probability that the first digit is 9 will be only 0.007.

In the above examples the expected distribution of the digits could be calculated exactly because the workings of the process are understood in complete detail. This is not usually the case in real world situations; nonetheless, it is possible to calculate a very accurate expected distribution of digits when all that is known is that the process meets a set of very general criteria. This is the case for corporate earnings, where it can be demonstrated that the expected distribution of digits follows Benford's Law.

Benford's Law

Newcomb (1881) observed that lower numbered pages in books of logarithmic tables were worn more than pages later in the book indicating that users were looking up numbers beginning with one or two more than eight or nine. This aroused his curiosity and after some empirical investigation Newcomb proposed the following mathematical formula for the occurrence of digits in natural systems:

$$p = \log_{10}\left(1 + \frac{1}{x}\right), \qquad (1)$$

where p is the proportion of numbers in a data set that begin with a particular string of digits, x (Newcomb 1881; Hill 1998). When x is a single digit, equation (1) calculates the probability that x will occur as the first digit. Equation (1) can also be used to calculate the probability of digits occurring in other positions in a number. For example, the probability of observing i as the kth digit is:

$$p = \sum_{j=10^{k-2}}^{(10^{k-1})-1} \log_{10}\left(1 + \frac{1}{10j + i}\right) \qquad (2)$$

where i is a single digit positive integer and k is an integer > 1. Newcomb's distribution became well known in the 1930s due to the efforts of Frank Benford, a physicist working for General Electric Company. Benford (1938) provided a theoretical foundation for Newcomb's distribution and found that it applied to a large number of different types of data sets. Because of Benford's efforts Newcomb's distribution became known as Benford's Law.

The distribution of digits in a data set follows Benford's Law when the underlying process consists of a mixture of distributions, meaning that the process producing the digits is the result of many different factors with many different causes. Even when the individual distributions of digits resulting from these factors does not follow Benford's Law, the mixture of the distributions will (Hill 1998). Try collecting all of the numbers appearing on the front page of several newspapers, a collection of numbers that are definitely from different distributions, and compare the distribution of first digits to Table 1 and you should be convinced (Hill 1998). Because earnings are the result of thousands of transactions of different classes (sales, depreciation, accounts payable, exchange rates, etc.) actual corporate earnings will follow Benford's Law. In addition to these theoretical considerations, Rodriguez (2004a) provides empirical evidence that corporate earnings follow Benford's Law.

When a data set does not conform to Benford's Law, it is often interpreted as an indication that human factors have altered the distribution of the digits. For example, Koedijk and Stork (1994), De Ceuster et al. (1998), and Mitchell (2001) use Benford's Law to study psychological barriers in financial markets. Benford's Law is counterintuitive because most people would expect different digits to have the same probability of occurrence. The counterintuitive nature of Benford's Law makes it a useful tool for detecting fraud because it is very unlikely that defrauders will take Benford's Law into consideration when constructing a bogus set of transactions. Consequently, Nigrini and Mittermier (1997) proposed that auditors use Benford's Law as an analytical tool to detect fraudulent transactions in account balances and it is now widely used for this purpose.

However, some accounting processes do not provide a sufficient mixture of distributions for Benford's Law to apply, such as when the technique is applied by auditors to transactions in individual accounts. Misapplication of Benford's Law can lead auditors to waste audit resources looking for fraud when none is present (Rodriguez 2004b). The failure of Benford's Law to hold for a single class of transactions has no bearing on whether the combination of different classes of transactions, as is the case with corporate earnings, will follow Benford's Law.

Appendix 2. Determining Critical Number of Zeros

The values in Table 1 are derived from the binomial distribution,

$$\mathrm{b}\left(y,n,p\right)=\frac{n!}{y!\left(n-y\right)!}p^{y}\left(1-p\right)^{n-y}, \tag{3}$$

where y is the number of observations in a sample of size n having a particular dichotomous attribute drawn from a population or process where the attribute of interest has a rate of occurrence p. In the context of Table 1, y is the number of zeros appearing in a particular position in an earnings report during n periods, and p is determined using equation (2) in Appendix 1. The probability of getting y or greater zeros, p_r is calculated as follows:

$$p_r=\sum_{y=y_{obs}}^{n}\mathrm{b}\left(y,n,p\right) \tag{4}$$

where y_{obs} is the number of observed zeros. The critical value for y, y_c, used in Table 1 is:

$$y_c=\min(y\mid p_r\le p_t)\,. \tag{5}$$

The values for p calculated using equation (2) rapidly converge on the uniform distribution as k increases. For example, with k = 4, p = 0.1001761. This allows the values in Table 1 for k = 4 to be used for all cases where k > 4.