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Applying Benford's Law to internal audit

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Nearly 80 years after an amateur mathematician noticed that the first few pages of his logarithm tables looked more worn than the later pages, the explanation behind that observation is helping some of the world's largest corporations detect fraud, waste and errors.

Now, powerful computers and software programs are making use of the discovery by General Electric Co. physicist Frank Benford. Jon Bryant, manager of the information technology audit department for US$15 billion (revenues) American Airlines, says there's no need to do random sampling. He can analyze every bit of information, tens of millions of entries.

"Digital Analysis gives us the ability to analyze the entire set and then determine areas for focus rather than just randomly selecting focus areas. It provides us with a mechanism to ensure we are focused in the right areas," says Bryant.

American Airlines has used the tool to uncover fraud, duplicate payments and data entry errors, among other things, Bryant says.

Benford may not be a household name, but Professor Mark Nigrini of Southern Methodist University in Dallas is beginning to make a name for himself in accounting circles by using the principles formulated by Benford. Nigrini and his partner, Rich Lanza, are among the chief proponents of Digital Analysis, the name they have given to the applications of Benford's Law.

That law demonstrates that seemingly random numbers in large volumes of data have digits that can be predicted to occur with certain frequencies. If digits occur in frequencies that fall outside the predictive parameters, there could be cause for further investigation.

"I was in a statistics class that was talking about Bayes Theory," Nigrini recalls. "One little section mentioned Benford's Law. I looked up his paper and thought, 'Wow, if this is really true, maybe we could use it to see if data appears to be authentic.'

"Things are now happening, and not by chance. Every morning I thank Intel and Microsoft for making computers so cheap and powerful that they can do thousands of numbers in a matter of minutes. Benford never said his law could be used, and he was quite right then. There were no computers in the 1920s. He did 20,229 observations over six years. A good PC could do that, with graphs and all combinations, in a minute."

Forming a geometric sequence
Benford found that about 31 percent of his numbers had a first digit 1 and about 18 percent had a first digit 2. The 9 occurred as a first digit about only 5 percent of the time. Benford reasoned that natural data, when ranked from smallest to largest, should form a geometric sequence.

He wrote: "In natural events and in events of which man considers himself the originator, there are plenty of examples of geometric or logarithmic progressions" and cited engineering and astronomical measurements, musical scales and our sense of brightness, loudness and weight.

With that observation, he used mathematics to formulate the expected frequencies for the various digits. No one used Benford's Law until 1989, when Nigrini became fascinated by it, applied it and found that it

worked.

Nigrini and Lanza have developed DATAS (Digital Analysis Tests and Statistics) software that enables companies to analyze large data sets to search for digit sequences that could indicate fraud or other problems. Their product may have received an indirect boost May 31, when the Public Oversight Board's Panel on Audit Effectiveness issued a report exposure draft that recommends a forensic analysis in all audits. "Use of technologically advanced auditing tools should be encouraged," the draft states. The use of Digital Analysis might also help satisfy auditors' obligations under SAS 82.

The Institute of Internal Auditors each year conducts six two-day seminars on Digital Analysis taught by Nigrini, so news of its possible uses is spreading.

Best applied to large data sets

Nigrini says the biggest users are airlines, banks and oil companies. "It's not surprising businesses in those industries are using it, because they have large data sets," Nigrini told KnowledgeSpace in a telephone interview. "It's best applied to large sets of data, where a statistical sample of observations would be almost meaningless. This looks at every number in the database and includes it in an analysis.

"In accounts payable, we frequently find errors. We often find duplicate payments. It's not uncommon to have recoveries of over $1 million. I can think of three offhand."

Bryant says one way American Airlines has used Nigrini's tool is to review the company's AAdvantage Account program.

"We have 30 million AAdvantage Account holders. That is an awful lot of data. We have used the tool to tear down data sets and find accounts to focus on," he says. "We have found instances where miles in accounts were obtained fraudulently. We have also found system processing errors, usually keying entry errors or system problems. We have also reviewed accounts payable and found duplicate payments and keying errors that we probably wouldn't have caught if we hadn't been using Digital Analysis."

Bryant recalls a recent incident in which the company was tipped off to a fraud scheme. As a test, Bryant had auditors use Digital Analysis to look at data in that area of the company but did not tell them of the fraud suspicions. Out of 250,000 vendors, they returned with three fraud suspects. One of the three was the fraud about which the company had received the tip. The second turned out to be legitimate business transactions. The third is still being studied.

Results no surprise

Those results do not surprise Geoffrey Nielson in the Arthur Andersen Silicon Valley, California, office. Nielson has used Digital Analysis with eight clients, most of them large hospitals. He also has used it for a mining company.

Nielson learned of Digital Analysis from an article called "The Power of One" that appeared last year in the Journal of Accountancy. He says he realized that for situations with large volumes of numbers, it could be a good tool to see if numbers occur as expected.

"It's mostly used for accounts payable and purchasing reviews," he says. "The law also applies to sales. However, you must have a large volume of numbers or you will get skewed results. When doing sales, you have to consider that one price may appear in your list more often than normal if that's the price of your best selling item. It's a little easier to get skewed results."

"My advice is to use it. It's a quick tool to get you started, but don't jump to quick conclusions. It might come out that results are skewed at the number 2 -- don't jump to the conclusion that somebody's cutting checks for $2,000. Benford does not give you a conclusion. You still have to investigate the results to determine whether there is really a business issue."

Useful tool for internal audit
James Zinn, a manager in the Arthur Andersen Business Fraud and Investigation Services practice in Chicago, agrees with Nielson that Digital Analysis is a useful tool to point internal auditors toward areas where more investigation may be warranted.

In the four years he has used Digital Analysis, he says he has learned that, "the highest success rate occurs when the data set is large and the fraud is one which occurs repetitively. It's important to understand the underlying statistical principles (of Digital Analysis). For example, the data set can't have built-in maximums or minimums."

The data set also cannot represent assigned numbers, such as Social Security numbers, bank account numbers or telephone numbers.

When used in the right situations, though, Digital Analysis can be an excellent tool to help auditors determine where they need to look more closely.

"It takes time to find the best applications, to get people trained and to get them to be keen to run a rigorous analysis of numbers," Nigrini says. "I think auditors enjoy asking control questions and checklists more than crunching numbers. I hope this will change that."

Additional resource
Digital Analysis -- strengths and weaknesses

Further reading
"Following Benford's Law, or Looking Out for No. 1," by Malcolm W. Browne, published in The New York Times.

Benford's Law articles, compiled by Rich Lanza.

Benford's Law by Kevin Brown.

Digital Analysis Using Benford's Law: Tests Statistics for Internal Auditors, (Second Edition) by Mark J. Nigrini, Ph.D.

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