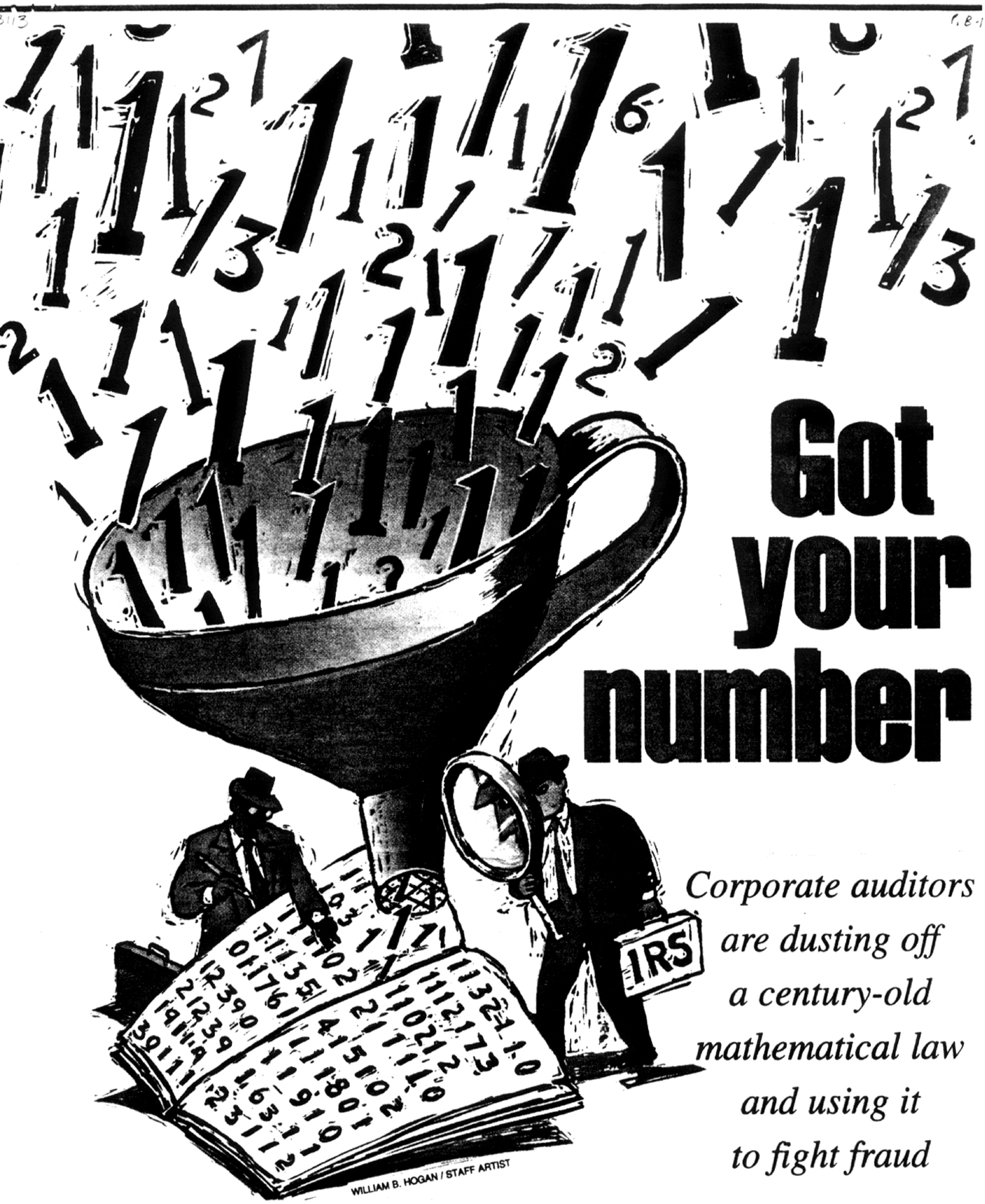

WILLIAM B. HOGAN / STAFF ARTIST

Got your number

Corporate auditors are dusting off a century-old mathematical law and using it to fight fraud

By LOUIS LAVELLE
Staff Writer

In 1881, the astronomer Simon Newcomb noticed something that seemed odd: The first few pages of his logarithm books were grubbier than the rest.

He suspected that his fellow scientists tended to look up smaller numbers, at the front of the book, more often than larger ones. From that, he proposed a theory — greeted with a collective yawn at the time — that is having important ramifications for corporations and crime fighters more than a century later.

Numbers, Newcomb decided, don't appear in nature with equal frequency. Numbers starting with 1 appear more frequently than those starting with 2, and those starting with 2 are more numerous than those starting with 3, and so on.

Twenty-nine years after Newcomb died, and 57 years after he stumbled on his theory, an American physicist, Frank Benford, rediscovered the phenomenon — in exactly the same way.

Newcomb's idea seemed to work everywhere. It was true for baseball statistics, the atomic weights of elements, stock prices, numbers from stories on the front pages of newspapers, populations of U.S. counties, street addresses, the half-lives of radioactive atoms, even electricity bills on the Solomon Islands.

When other mathematicians tried creating new sets of numbers — by changing stock prices from dollars to pesos, for instance — they found Newcomb's theory lurking in the data.

After 118 years and more than 150 academic papers, the world of mathematical theory came to a remarkably familiar conclusion:

One isn't the loneliest number. Nine is.

* * *

Newcomb's theory — now known as Benford's law — is, finally, an idea whose time has come.

Salvaged from the dustbin of history and the arcane world of mathematical theory, Benford's law is being put to a very modern use. Taxing authorities, more

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than 50 large corporations, and at least one major auditing firm are using it to combat fraud.

Benford's law predicts that numbers, with few exceptions, will follow a specific distribution: 30.1 percent will begin with 1, 17.6 percent with 2, 12.5 percent with 3, and so on down to 9, which shows up as the first digit 4.6 percent of the time.

To understand why this is so, consider a mutual fund growing at 10 percent a year. When the total assets are $100 million — and the first digit is a 1 — reaching $200 million will take 7.3 years, with compounding. But when total assets are $500 million, reaching $600 million will take only 1.9 years. And at $900 million, total assets will hit $1 billion in just 1.1 years.

A year-by-year list of the fund's assets would be littered with 1s, and have progressively fewer 2s, 3s, 4s, and so on. That explains why any phenomenon with a fairly constant growth rate — from population statistics to the odometer on your car — would conform closely to Benford's law, but assigned or random numbers such as Social Security numbers, ZIP codes, bank accounts, and lottery numbers don't follow it at all.

It also explains the potential of Benford's law for fighting fraud. By checking data that should conform to the law against Benford's predictions, fraud fighters can tell whether some of the numbers have been fudged.

It works because of human psychology. Asked to choose numbers at random, human beings will show a preference for certain numbers, consistently choose certain sequences of numbers, or studiously avoid number repetitions — in short they'll do anything but choose numbers that follow Benford's law.

An experiment conducted by Mark Nigrini demonstrates just how powerful a fraud detection tool Benford's law can be.

Nigrini, a professor at Southern Methodist University in Dallas, took numbers from 169,662 federal tax returns and found they conformed closely to Benford's law. But fraudulent data on cash disbursements and payroll at seven New York businesses provided by the Brooklyn District Attorney's Office, and 743 six-digit numbers chosen at random by 743 students, both diverged wildly.

Both had far too few numbers that started with 1, and far too many that began with 6.

Roger Pinkham, a mathematics professor at Stevens Institute of Technology in Hoboken whose 1961 article on Benford's law laid the theoretical groundwork for much of what followed, said that combination — a mathematical constant and a human incapacity for random thought — creates a powerful fraud-fighting tool.

"Any professional statistician will tell you the following: It's enormously difficult to fake random numbers," said Pinkham, who's writing a book on Benford's law. "Utilizing Benford's law is one of many ways to detect the nonchance nature of numbers. Certain aspects of the numbers you're dealing with ought to be purely random; if they're not, that means someone's been fudging them."

While companies who use Benford's law to detect fraud are reluctant to disclose details of specific cases, several said they employed it successfully to uncover fraudulent activity, both internally and for their clients. One telecommunications company discovered a $1 million duplicate payment to a vendor using the method.

Fraud detection methods based on Benford's law can be used to unveil check-kiting schemes, bogus vendor payments, accounting fraud, and other internal problems. In fact, the Institute of Internal Auditors in Altamonte Springs, Fla., offers seminars where company auditors learn how to do just that.

The possibilities are endless. A manager with the authority to approve cash disbursements of up to

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$3,000 might approve bogus payments of $2,700 to $2,999. A bank officer with the authority to declare credit card balances of up to $5,000 uncollectable might write off bogus debts of $4,800 to $4,999. In both cases, the increased frequency of certain two-number sequences — 27, 28, and 29 in the former case, 48 and 49 in the latter — would give away the fraud.

In 1992, Wayne James Nelson was working as a manager in the office of the Arizona treasurer. In three days he wrote 23 checks totaling nearly $2 million to a bogus vendor and diverted the funds to himself, a crime for which he was subsequently convicted. The case was solved without Benford, but when it was applied later, the dollar amounts of the checks — all but two were for more than $70,000 — were almost exactly the opposite of what Benford's law would have predicted. Intended not to arouse suspicion, they would have done the opposite.

Ted Hill, who in 1996 provided one of the first scientific explanations for why Benford's law is so common, said the law is both easy to apply and difficult to thwart.

With sufficient forethought and a hand calculator, Wayne James Nelson could have written checks that perfectly mirror Benford's law. But coming up with dollar amounts that contain the proper two-digit, three-digit, and four-digit sequences would have been nearly impossible.

"It's simple to use: If the data doesn't fit, it says, 'Let's look a little further,'" said Hill, a mathematics professor at the Georgia Institute of Technology in Atlanta who first encountered Benford's law as a doctoral student at the University of California at Berkeley 24 years ago. "It's a simple test, and a surprising one that not too many people know about. It's clean and it's counterintuitive as can be."

One computer program incorporating Benford's law is DATAS, for Digital Analysis Tests and Statistics. It was developed by Nigrini, who first read Bedford's paper outlining the theory in 1989.

Nigrini said more than 50 large U.S. companies use DATAS — including American Airlines, Deloitte & Touche, U S West, Atlantic Richfield, Texaco, and Nortel — to detect errors, biases, processing inefficiencies, and fraud.

In addition, several taxing authorities — including the Dutch government and the state of California — use it, and at least one other country, Canada, is actively considering it. The Internal Revenue Service won't say whether it is or isn't using it; New Jersey does not.

Still, no one is more indebted to Simon Newcomb and Frank Benford than the Big 5 accounting firm, Ernst & Young. One of the company's fraud-detection products incorporating Benford's law has been used to audit hundreds of companies worldwide since it was first made available in 1994, and a new product is being rolled out in the United States this fall.

That new product, EY3D, is already used for Ernst & Young's Canadian clients, said Nick Hodson, a partner in the firm's forensic accounting and litigation practice in Toronto. He described it as one of several weapons in the firm's fraud-detection arsenal.

"It's a no-brainer," he said. "You don't have to rack your brain [and ask], 'If I were going to steal something how would I do it?' It's like, 'Come in here, sit down, and we'll put the thermometer under your tongue.'"

Nigrini points out that Benford's law took as long as it did to emerge as a modern crime-fighting tool because technology — the same computer technology that opened up vast new opportunities for fraud — until recently hadn't made the leaps and bounds that allowed auditors to analyze vast amounts of data.

It took the technological advances of the late 20th century, and new psychological insights into human thought, to make a 19th century notion about mathematical order an auditor's best friend.

"When I read Bedford's paper in April 1989, I said, 'I think auditors can use this.' But the computing power wasn't there," Nigrini said. "Now, for $3,000, every auditor can have a powerful machine on their desk, and the cost and effort to do the analysis has dropped dramatically."

Ray Brindley, who developed a seminar on Benford's law for the Institute of Internal Auditors, said the mathematical formula unearthed from Simon Newcomb's grubby logarithm books will prove to be a major advance.

"It's one of the most exciting things in 10 years," Brindley said. "Before this test, it was like looking for a needle in a haystack. Now, with Benford's law, you know where to look."