



Left: Loose pocket change is a heavy, hidden burden. One dollar in various denominations can weigh more than three leather wallets.

Brother, Can You Spare 18¢?

What we really need to solve the problem of loose and useless lucre is a new coin

AMERICANS HAVE HAD IT WITH LOOSE change. It bursts pockets, fills piggy banks, spills from the little change bowl by the front door. By one estimate, \$10.5 billion in coins just sits around in people's homes gathering dust. What with fancy purses and expensive pocketbooks, "power wrappers," and automated coin sifters, it's fair to say that a decent chunk of that do-nothing change is spent simply trying to organize it.

Jeffrey Shallit has a suggestion. A mathematician at the University of Waterloo in Ontario, Shallit recently analyzed the average handful of change and has de-

vised a clever way to reduce its size. Getting rid of the 1-cent coin, a plot advocated by numerous antipennyists, would certainly help, he says. But Shallit's own scheme for reducing loose change involves the creation of an entirely new coin. What the United States needs, he says, is an 18-cent piece.

Shallit reached this conclusion by way of a common mathematical formula called a linear Diophantine equation, which dates back some 1,750 years to Diophantus, the Greek father of algebra. The simplest form of the equation looks like something straight out of a

high school textbook: $ax + by + \dots = c$.

Straightforward as they may appear, Diophantine equations have been used to expose some seriously challenging mathematical questions. A classic example is the traveling-salesman problem: A salesman must visit a certain number of cities at varying distances apart. What is the shortest path he can take such that he visits each city only once and returns to the city where he began? For any particular case—eight specific U.S. cities, say—some number crunching will produce an answer. But mathematicians typically want something more universal: an equation that works for all possible cases or, failing that, proof that no such equation exists. "It's not, 'Can you do it?' but, 'How do you know if you can do it?'" says Shallit.

The general traveling-salesman problem, it turns out, falls into a mathematical class labeled NP-hard. As Shallit says, "It's solvable, but not solvable efficiently." In math lingo, *not efficiently* may well mean "not in time bounded by a polynomial" or "in nondeterministic polynomial time." That means "not in your lifetime." Shallit recently achieved minor math fame by tackling a related puzzle called the postage-stamp problem: Given an envelope with room for a set number of stamps of varying denominations, and assuming you always use the fewest stamps possible to pay for your postage, what's the smallest amount of postage that *won't* fit on the envelope? Mathematicians have proved that the problem can be solved for certain cases. For example, if your stamps come in three denominations—1¢, 3¢, and 5¢—and the envelope has room for just three, the least postage that won't fit is 12¢. Last year, however, Shallit proved that the problem is NP-hard: "There's no one simple algorithm that works for all systems of stamps."

From postage stamps it's but a small leap to pocket change. The problem goes roughly like this: What coins will generate, on average, the least amount of change? There are two parameters: the



number of different coins the consumer is willing to tolerate and the total range of prices spanned by those denominations. Shallit worked with four denominations: 1¢, 5¢, 10¢, and 25¢. He ignored the half-dollar and dollar coins, he says, because like most consumers, “I never get either one in change.” The smallest U.S. bill is \$1, so the coins cover a range of 100 values, from 0 to 99.

Using those parameters, Shallit calculated that the average U.S. transaction produces 4.7 coins in change. How to reduce that burden? If we got rid of the dime and replaced it with an 18-cent coin, Shallit determined, the “cost” of the average transaction would drop from 4.7 to 3.89 coins. A system of coins worth 1¢, 5¢, 18¢, and 29¢ would have the same effect. Should we wish to keep the dime and simply add a fifth denomination, the best coin to add would be 32¢, for an efficiency of 3.46. Even better, if we kept the dime and actually used the half-dollar, then added an 18-cent coin to that mix, we’d gain maximum efficiency: You’d get back a mere 3.18 coins per transaction.

Shallit went on to analyze pocket change in Canada, where six coins are actually used: 1¢, 5¢, 10¢, 25¢, 100¢ (a dollar coin, popularly known as a “loonie,” because it bears a picture of a

loon), and 200¢ (the “toonie”). The smallest bill is \$5, so the six coins produce a range of 500 values (0 to 499). Plugging those figures into the equation, Shallit calculated that the average Canadian transaction generates 5.9 coins in change. The best way to lower that average, to 4.578, he found, would be for Canada to adopt an 83-cent coin.

Shallit took on the euro too. The European Union uses eight coins—worth 1, 2, 5, 10, 20, and 50 cents, plus 1- and 2-euro coins—with a range of values from 0 to 499. The average cost of making change in Europe, Shallit calculates, is 4.6 coins. The best way to lower the cost, to 3.92, would be for Europeans

less change, but you’ll have to wait a few extra moments of calculation to get it.

To the doubting Thomases and Franklins, Shallit responds: Lighten up, it’s a thought experiment. In the real world of cold cash, he says, the anti-pennyists are right: The most effective way to reduce the amount of spare change is to eliminate the 1-cent coin and simply round prices down or, more likely, up to the nearest 5-cent value. Shallit calculates that in a penny-less world, the average number of coins in any transaction would drop from 4.7 to just 2.7—a whopping 42 percent reduction. In Canada, tossing the penny would reduce change from 5.9 coins per

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to add yet another coin, worth either 1.33 or 1.37 euros.

Needless to say, Shallit’s 18-cent coin proposal for the United States has stirred up dissenters. One of Shallit’s central assumptions is that all amounts of change between 0¢ and 99¢ are equally likely. But some online message-group critics wonder if that’s fair. Wouldn’t certain pricing schemes, like the famous 99-cent bargain, tilt the equation? “The focus is misplaced,” Shallit counters, a little testily. “First of all, you have to make *some* assumptions.” Second, he says, the plethora of sales taxes here is likely to level the playing field. “Tax is probably a good randomizer.”

A more immediate issue is the practicality of an 18-cent coin. While certain mathematicians may be able to add and subtract multiples of 18 nimbly in their heads, one can fairly assume that the average teenage supermarket cashier is not so gifted. An 18-cent coin might give you

handful to just 3.9. Shallit says Australia got rid of both its 1-cent and 2-cent coins with nary a whimper.

“Eliminating the penny is by far the best solution anyone has come up with,” he says. And you can do your part to put it into effect now. “Whenever you get change, don’t accept the pennies. You’ll reduce your change by half.”

Still, that 18-cent piece would help too. Perhaps it simply needs a good name to catch on. Shallit has an idea there too: “I call it the Elvis,” he says. “It’s just as evanescent.” He calls his proposed 83-cent Canadian coin the “Mulroney,” after Canada’s former prime minister Brian Mulroney, “because it’s about as unpopular as he is.” (Also, it rhymes with loonie and toonie.) Shallit’s critics, meanwhile, have coined their own name for his new American piece. “Actually the United States does have an 18-cent coin,” wrote one message-group wisecracker. “It’s called the Canadian quarter.” ☒

Change in My Pocket

- About \$600 worth of coins pass through the hands of a typical American each year.
- More than \$10 billion in coins is sitting around in drawers, cans, bottles, and bins in American homes. About 80 percent of adults say they save loose change rather than try to spend it.
- Another \$13.5 billion in coins is in circulation.
- About 90 percent of people over 65 say they have never thrown away a penny. About half of all people between 18 and 34 say they have.
- A group calling itself Americans for Common Cents claims the cost of minting a penny is .81¢ and that the U.S. Treasury makes as much as \$35 million a year on them.
- It may take up to three seconds longer to complete a transaction that involves pennies.



According to a Coinstar National Currency Poll, 73 percent of Americans use coins to scratch off lottery tickets, 29 percent use them in magic tricks, and 7 percent use them to steady table legs. Among men, 65 percent use coins as makeshift tools or screwdrivers.