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Statisticians Count Euros and Find More Than Money

By OTTO POHL

BERLIN — When the euro was introduced in 12 countries last Jan. 1, politicians called it the herald of a new era in European integration — the advent of a common currency that would help break down political and cultural barriers as well as economic ones.

But for mathematicians, the euro has turned those 12 countries (plus the three tiny states of the Vatican, Monaco and San Marino) into an almost ideal laboratory, providing a euros-and-cents way to measure the extent of European integration — and perhaps to understand other phenomena as well, from the course of epidemics to the movement of stock prices.

While the euro is worth the same in every country that uses it, each one mints its own euro coins, with a distinctive design on the reverse. Every time a euro coin from Finland appears in Greece, for example, it provides a tiny but precise data point about the relationship between the countries.

So to find out more about their continent, thousands of Europeans are digging through their pockets and keeping track of their coins, and mathematicians are tabulating the results in order to figure out just how fast the coins are spreading.

"This is a historically unique opportunity," said Dr. Dietrich Stoyan, a statistics professor at the University of Freiberg in Germany, who is in charge of one of the coin-counting projects. But the goal is not just to learn more about Europe. "I hope that studying this process will help people studying epidemics," Dr. Stoyan said. What makes this special is that the precise launching date of the coins is known. "We know when this `epidemic' broke out," he noted.

Moreover, the total amount minted was roughly proportional to each country's economy compared with the overall European economy. Germany, an economic powerhouse, minted 32.6 percent of all coins, France about 15 percent, and tiny Luxembourg (which used the face of its Grand Duke Henri) just two-tenths of 1 percent. (All of the euro notes look the same.) Each country introduced its own coins exclusively within its borders.

On New Year's Day, the coins, all of them valid across the entire euro zone, began to spread across national borders. Now, statisticians are looking forward to the summer travel season, when German tourists can simply pay for their espresso in Paris with the coins they received in change that morning at the baker's, back home in Munich.

But how does one model this mingling? Is it simple diffusion, like opening 12 cans of gas in a giant room and watching the molecules mix? Or does the relationship between each country depend on a complex set of equations between each country that considers the

distance between the countries and the number of commuters, travelers and bank trucks going back and forth?

Dr. Stoyan has gone the complex route. His model is composed of 144 interdependent differential equations that take as many of the known variables into account as possible, including traveler volume data from travel bureau associations.

Too many variables, says a group from the University of Amsterdam, which has chosen simply to take a high-level look at the coin flow. Its model, based on a branch of probability theory called Markov chains, assumes that a relatively constant percentage of Dutch coins will leave the Netherlands each month, and that a different, smaller percentage of Dutch coins that have already left the country will return. "It's just a guess," said Misja Nuyens, a doctoral candidate in probability theory at the University of Amsterdam, who is a member of the group. "We'll see if we were right, or sadly mistaken."

Each experiment has a Web site for participants to post the contents of their wallets. Data are tabulated and posted as the experiments go on.

So far, Dr. Stoyan and the Amsterdam group have been surprised to learn that large-denomination coins — for one and two euros — move much faster than smaller ones. Neither knows exactly why that is. Dr. Stoyan hypothesizes that people tend to dump their small coins out of their pockets at the end of the day and are therefore less likely to take them traveling. Mr. Nuyens believes that the coins are used much more often.

And when will the coins reach statistical equilibrium? The models have yielded different results. The Dutch group believes that half of all coins in Holland will be of foreign origin a year from now and that statistical equilibrium across Europe will be reached in five to seven years.

"I don't think it will go that fast," said Dr. Stoyan, whose differential equation model predicts it will take several decades.

Dr. Ger Koole, a mathematics professor at the Free University in Amsterdam who is involved with the Dutch project, hopes the findings will help expand understanding of applied mathematics.

Phenomena like the "on hold" times at call centers and stock price movements, he said, are similar to the movements of euro coins: systems whose development depends largely or entirely on the previous state the system was in.

For example, to predict the number of calls that will be on hold, you need to know how many calls were on hold in the previous minute and then calculate the probability that calls will have been added (new calls coming in) or have been removed (calls answered or hung up). These simple calculations, repeated for every time period in question, quickly can predict the development of complex systems.

Dr. Koole says it is too early to know what will be learned from the euro experiments. The only way to improve understanding of these phenomena is "the constant application of theory to see what you end up with," he said.

The groups agree that the experiment has so many unknowns that it is difficult to gain scientific clarity, at least at this point. "I have the distinct impression that a real mania has broken out among coin collectors," Dr. Stoyan said, which would take rare coins disproportionately more often out of circulation. In addition, the self-selected group of

participants who log their coins each month is not necessarily a statistically representative sample.

The best data sources have turned out to be classrooms. The two groups report that science and math teachers have latched onto the projects as a way to illustrate their subjects. They either ask all of the students to examine the change in their pockets or buy rolls of coins at the bank and count them in class.

Each team has a different model for the effect of the summer travel season. The Dutch expect that July and August, the two busiest months, will each count as two or three off-season months. Dr. Stoyan's model integrates the increased number of travelers. The two teams are hoping for a spike in interest in the projects, which will get even more coins counted and improve the results.

Dr. Stoyan, though, is already dreaming of one change that would really make a difference. "Now if I could just get them to send me the actual money," Dr. Stoyan said with a laugh.