What Cities Can Tell Us About Companies

BY JOHN WHITFIELD

When Geoffrey West arrived in the United States from England at the end of 1961, one corporation seemed to embody American dynamism and expertise: General Motors. "That was when I first heard the phrase 'what's good for GM is good for the country,' " he recalls. And now GM is recovering from a near-death experience, saved only by the U.S. government's $50 billion in survival aid.

But perhaps Rick Wagoner, who resigned as the company's CEO shortly before it filed for bankruptcy protection in 2009, shouldn't feel too bad. All companies die. "I can walk into Google and know, despite the fact that it seems all-powerful and it looks as if we'll still be Googling in 1,000 years, it probably won't be around in 25 years," West adds.

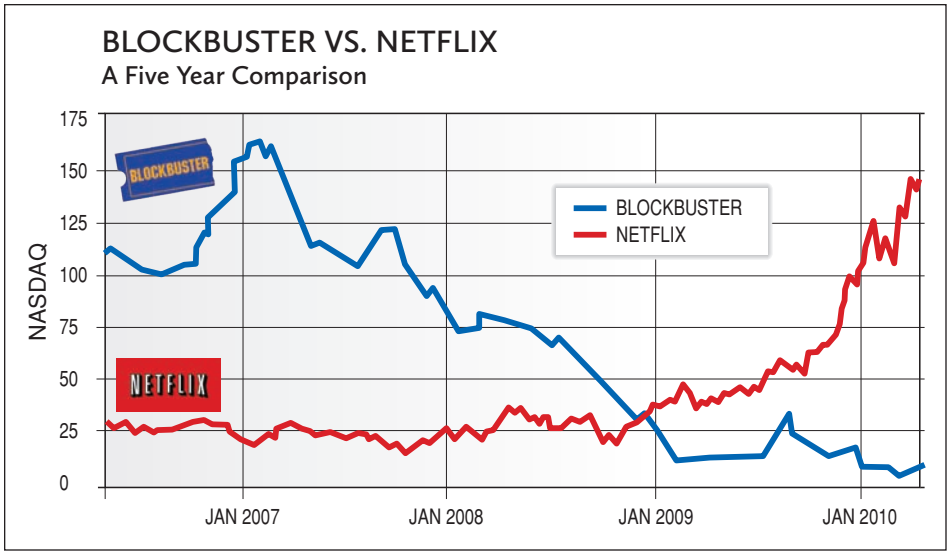
The question of what makes businesses mortal set West, a distinguished professor and past president of SFI, off down a path that he hopes will lead to a general theory of social organization. Ultimately, this theory might explain the startling regularities seen in human institutions and societies due to underlying structures of the social networks that make up their fabric. It may also help us understand what makes some social institutions robust and successful, and help us move toward sustainability in the face of climate change, pollution, resource depletion, and other environmental threats.

Back in the mid-1990s, West asked a similar question—why do people live for about a century, and not 10 years, or 1,000? The quest to answer it lured him away from his previous career in high-energy physics and toward a theory that explains why the measurable properties of living things, such as their lifespans, growth rates, and reproductive capacities, change in predictable ways with their size. West, together with his collaborators and SFI External Professors James Brown and Brian Enquist, explained this in terms of the changes imposed by increasing size on the geometry of an organism's transport networks, such as blood vessels. The bigger you are, the more slowly your networks deliver resources to your cells. As a result, your life runs more slowly: you live longer, grow more slowly, and have fewer offspring.

Whether companies show similar scaling behavior—whether, for example, you can predict when a firm will go out of business from its turnover—is an obvious question. But it was inaccessible, because the data for companies are proprietary and prohibitively expensive. So West turned instead to something for which ample data are freely available: cities. Unlike companies and people, cities are remarkably robust. They seem able to stick around in perpetuity, and those like Carthage that have disappeared are rare enough to be remarkable.

West joined forces with a cross-disciplinary team comprising urban economist José Lobo (Arizona State University), complex systems researchers Christian Kühnert (Dresden University of Technology) and Dirk Helbing (Swiss Federal Institute of Technology, Zurich), and theoretical physicist Luis Bettencourt (Los Alamos National Laboratory), the latter two also external professors at SFI. The team began analyzing every variable relating to urban life that it could get its hands on and examining how each related to the population of U.S. cities. "We discovered what I think is an extraordinary result," says West. "Cities scale. They satisfy simple power laws."

In some respects, cities and organisms scale in the same way. The bigger the organism, the less food per pound it needs, because each of its cells burns energy relatively slowly. Likewise, the bigger the city, the less infrastructure per person it needs. Large cities, for example, have fewer roadways, less electrical cable, and fewer gas stations per person than small ones. City dwellers use less energy and produce less carbon dioxide, on average, than small-town folk. For all these variables, the



The dramatic rise and fall of these two leading DVD rental companies raises the question of what makes businesses mortal. The answer may contribute to a general theory of social organization.

infrastructure per person declines steadily as a function of the city's population raised to the power of about 0.8. That means that although Houston, population 2.25 million, has ten times as many people as Baton Rouge, it only has about six times as much infrastructure.

But in other ways cities and living things are quite different. Some things do not slow down as cities get bigger. In particular, the researchers found that variables related to social life scale superlinearly. That is, they become proportionately larger as the city's size increases. That goes for economic and intellectual activities such as wealth, wages, and the number of higher education institutions and patents produced. The average household income in Houston in 2008 was $44,315, whereas in Baton Rouge it was $37,869. The same goes for crime and disease—which, much as we might not like it, are also forms of innovation. It even goes for the speed at which people walk. Again, the scaling is consistent across the whole range of variables, with an exponent of about 1.15. In other words, plunk a small-town person into a city twice as large, and she will become 15 percent wealthier, 15 percent more innovative, and 15 percent more likely to be victimized by crime.

The paper that unveiled these results, published in *Proceedings of the National Academy of Sciences* in 2007, speculated that the scaling was, as in organisms, a product of networks—in the case of cities, the social networks between people. Since then, West hasn't had as much time as he would have liked to pursue this line of thought—being SFI president, and helping the Institute survive the financial crisis, slowed his research. But since stepping down as president, he has immersed himself in the question.

Biological scaling emerges because living transport networks (like the circulatory system) have a fractal-like structure, meaning that a small part looks the same as a larger part, which looks the same as the whole. This is called self-similarity. West has found that if you assume the same for social networks, and posit social life as a self-similar network where constant and intense interactions at the family level give way to links with, say, friends, colleagues, acquaintances, bosses, and public officials, then a superlinear pattern of increasing group size leading to greater social productivity results. In the next year, he hopes to make some progress toward conceptualizing what is actually flowing in these networks, be it information, money, or some combination of these and others.

Superlinear scaling sounds great—the more the merrier. But there's a catch. A superlinear power law produces a curve that tips ever upward, and terminates in a point where, for a city, a finite number of people are producing an infinite amount of activity, consuming an infinite amount of resources in the process. That's called a "finite-time singularity," and it's impossible. What would really happen at such a point would be a crash, after which everyone goes back to being hunter-gatherers, suggests West.

Technological innovation, however, can push

the reset button, returning a society to a gentler point on the curve and allowing it to start growing again. "When you have a major innovation—such as the discovery of iron, or coal, or oil, or the invention of computers—it completely changes the culture and resets the clock," says West.

But there's another catch. To keep dodging the singularity, each innovation must come quicker than the last. So, at the risk of caricaturing human progress, the Stone Age lasted more than two million years, with each of its subdivisions—lower, middle, and upper Palaeolithic—being shorter than the last. That ended when the Bronze Age began about 5,000 years ago. The Iron Age followed about 2,000 years after that, and things have been speeding up ever since. The gap between each cycle of innovation shrinks in a systematic way, determined by the exponent 1.15 in the equation for social scaling.

"Not only does the pace of life get faster as society gets larger, you're forced to make major changes in an accelerated fashion," says West. That, in other words, is why your smartphone seems obsolete by the time you've got it out of its packaging. Life doesn't just feel like it's speeding up. It really is.

At some point, West notes, we are going to need an industrial revolution every half hour to keep on our current course. "That's clearly not sustainable. The treadmill is going to run so fast that

Unlike companies and people, cities are remarkably robust. They seem able to stick around in perpetuity, and those like Carthage that have disappeared are rare enough to be remarkable.

ISTOCKPHOTO.COM

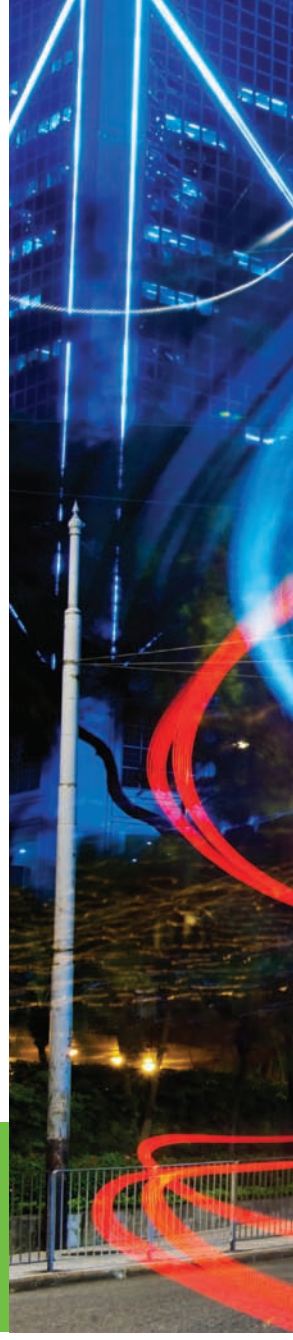
Researchers have found patterns in cities: While Corvallis, Oregon, for example, has produced more patents than any other U.S. city, Las Vegas is among the nation's least intellectually productive.

you'll fall off." In other words, it's hunter-gatherer time again. Can we stop growing, and maintain a developed society without sliding backward? "To my amazement, economists haven't answered that question," says West. The lack of intellectual understanding, not to mention the political will to act on what we do know, is daunting. "I've become a terrible pessimist," he says. "Every time terrible things happen I'm beginning to see them as mini indicators. That may just be paranoia, but the financial collapse, and the fact that we're still in it, may be the beginning of a sign that we'd better be doing something. I think that this problem, if it's soluble, is one that we needed to have started thinking about at least 50 years ago. I fear for my grandchildren."

Not that this pessimism has translated into inertia. West and his colleagues' work seems to be accelerating towards a singularity in its own right. There's new data to analyze: SFI has made a deal with Compustat, a leading commercial database of company information, to gain access to its numbers for a bargain price. Preliminary analysis shows that companies scale too: "If you tell me what the assets of that company are, I can tell you most of the things about that company—how many employees, how much it pays for taxes, all these variables that we've now looked at," says West. There are also new theoretical avenues to pursue: West believes the tools of thermodynamics and information theory will help us understand how information and resources flow through social networks.

And there are new puzzles. Those regularities in cities hide a lot of variation. Some places overachieve—Corvallis, Oregon, for example, lies higher above the curve for patent production than any other U.S. city. Others go the opposite way: by the same measure, Las Vegas is the nation's least intellectually productive city. And a city's performance remains constant through time. "If they're a good city in 1950, they're still overperforming to the same degree today," says West. "And if they're a lousy city, they're still a lousy city, no matter what the urban planners have done. The most amazing case, to me, is San Jose. The city was overperforming before Silicon Valley grew up, and after the [tech] crash it relaxed back to where it was, but it still overperformed. What is going on in San Jose, culturally, that ensured that if Silicon Valley started there it was going to be a good place to incubate?"

You can imagine that's the kind of question policy makers would like answered. But before you begin making recommendations, West says, you need a theoretical understanding of where such patterns come from. He is cautiously optimistic that such an integrated theory is possible, and that as well as helping policy makers in their quest to create sustainable communities, it will give archaeologists, anthropologists, economists, and geographers new questions and tools. A meeting in Italy in July 2010 brought 15 people from across the academic spectrum together to imagine what form such a project might take. The meeting was funded by the Rockefeller Foundation, which provided seed funding to work



Not only does the pace of life get faster as society gets larger, you're forced to make major changes in an accelerated fashion, says West. Life doesn't just feel like it's speeding up. It really is.

ISTOCKPHOTO.COM

A city photo taken with a slow shutter speed illustrates the high velocity of contemporary life. West says such a pace is "clearly not sustainable."

out the questions and may also fund a larger project to pursue the answers and their implications.

The universality of social scaling laws shows that energy, finance, transport, and crime are all parts of the same whole, and manifestations of the same underlying dynamics, says West. To make our society sustainable, we must see them as such.

"Until we have an integrated approach, I don't think we can attack these problems. We need to get people thinking in a much more integrated way. That's what I think SFI is trying to do." ◀

John Whitfield is a London-based science writer. He is currently working on a book about reputation.