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Engines of Innovation

Most of humanity now lives in a metropolis. That simple fact helps to fuel our continued success as a species

By Edward Glaeser

Golden Prosperity Building, or the Jin Mao Tower, lords it over Shanghai's 23 million residents.

JOSEF HOFLEHNER *Gallery Stock*

CRIME, CONGESTION AND POLLUTION mar all cities, from Los Angeles to Mumbai. But another force trumps the drawbacks of urban living: cities bring opportunities for wealth and for the creative inspiration that can result only from face-to-face contact with others. In fact, the crush of people living in close quarters fosters the kind of collaborative creativity that has produced some of humanity's best ideas, including the industrial revolution and the digital age. In the years ahead such collaborations can be

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IN BRIEF

Teleconferencing and virtual meetings of all stripes were supposed to spell the death of distance. Yet the city (home of more than half the human species) continues to flourish.

Things seem to go better with closeness: a deal or relationship is often best sealed only with a handshake or a kiss.

Interchange of ideas that occur in the gargantuan urban swells of the developing world may help forge a pathway out of poverty.

Bigger Cities Do More with Less

New science reveals why cities become more productive and efficient as they grow

By Luís M. A. Bettencourt and Geoffrey B. West

For centuries, people have painted cities as unnatural human conglomerations, blighted by pathologies such as public health crises, aggression and exorbitant costs of living. Why, then, do people throughout the world keep leaving the countryside for the town? Recent research that is forming a multidisciplinary science of cities is beginning to reveal the answer: cities concentrate, accelerate, and diversify social and economic activity.

The numbers show that urban dwellers produce more inventions and create more opportunities for economic growth. Often large cities are also the greenest places on the planet because people living in denser habitats typically have smaller energy footprints, require less infrastructure and consume less of the world's resources per capita. Compared with suburban or rural areas, cities do more with less. And the bigger cities get, the more productive and efficient they tend to become.

THE POWER OF POPULATION

This new, more quantitative science of cities is becoming possible because of the increasing availability of information—official statistics as well as novel measures of human and social activity—on cities and metropolitan areas worldwide.

By sifting through this flood of data, covering thousands of cities around the world, we have unveiled several mathematical "laws" that explain how concentrating people in one place affects economic activity, return on infrastructure investment and social vitality. Despite the rich diversity of metropolitan regions across the U.S., China, Brazil and other nations, we found a remarkable universality in the way that socioeconomic characteristics increase with a city's population. For example, if the population of a city is doubled, whether from 40,000 to 80,000 or from four million to eight million, we systematically see an average increase of around 15 percent in measures such as wages and patents produced per capita. If eight million people all live in one city, their economic output will typically be about 15 percent greater than if the same eight million people lived in two cities of half the size. We call this effect "superlinear scaling": the socioeconomic properties of cities increase faster than a direct (or linear) relation to their population would predict [*see illustration on opposite page*].

The data also reveal that cities' use of resources follows a similar, though inverted, law. When the size of a city doubles, its material infrastructure—anything from the number of gas stations to the total length of its pipes, roads or electrical wires—does not. Instead these quantities rise more slowly than population size: a city of eight million typically needs 15 percent less of the same infrastructure than do two cities of four million each. This pattern is referred to as sublinear scaling. On average, the bigger the city, the more efficient its use of infrastructure, leading to important savings in materials, energy and emissions.

Our findings also show that these patterns of increased productivity and decreased costs hold true across nations with very different levels of development, technology and wealth. Although we have much more information for cities in richer parts of the world, we are beginning to obtain good data from rapidly developing countries as well, and they seem to fit the same mold. The gross domestic product for cities in Brazil and China, for instance, closely follows the same superlinear curve that western European and North American cities exhibit, though starting from a lower baseline. We believe that the pattern holds true because the same basic social and economic processes are at work, whether in São Paulo's favelas, under Beijing's smog-filled skies or along Copenhagen's tidy streets.

Although urban superlinear scaling, which represents the average, idealized behavior of a city of a given size, prevails around the globe, actual cities deviate to varying degrees from the roughly 15 percent enhancements that come with size. Detailed data covering 40 years show, for example, that San Francisco and Boston are richer than their size would indicate, whereas Phoenix or Riverside, Calif., are somewhat poorer. Curiously, these deviations persist for decades: cities tend to stay remarkably close to their overperforming or underperforming histories. For example, cities that have attempted to improve their lot by creating conditions for the "next Silicon Valley" have often had disappointing results. Our research suggests that certain intangible qualities of social dynamics—more than the development of material infrastructure—hold the key to generating virtuous cycles of innovation and creation of wealth. These processes, such as the development of a spirit of local entrepreneurship, a reputation for cutting-edge novelty, and a culture of excellence and competitiveness, are difficult to design through policy because they rely on the dynamics of a city's social fabric across many dimensions. We expect the results of this exciting area of research will lead to better "recipes" for sustainable socioeconomic development.

What we can say with certainty, however, is that increased population promotes more intense and frequent social interactions, occurrences that correlate with higher rates of productivity and innovation, as well as economic pressures that weed out inefficiencies. In a city with high rents, only activities that add substantial value can be profitable. These economic pressures push urbanites to come up with new forms of organizations, products and services that carry more value added. In turn, higher profitability, excellence and choice tend to attract more talent to the city, pushing rents higher still, fueling the need to find yet more productive activities. This feedback mechanism, in a nutshell, is the principal reason cities accelerate innovation, while diversifying and intensifying social and economic activity.

DENSER BUT GREENER

Although cities create economic opportunities in rich and poor countries alike, people living in wealthier areas find it difficult to imagine why so many inhabitants of poor countries are attracted to places such as Nairobi, Lagos or Mumbai, where newcomers often end up in slums marked by pollution, crime and disease. These appalling conditions, however, should remind residents in developed nations of their own urban past. When Charles Dickens wrote about life in mid-1800s London or when Jacob Riis photographed the Bowery district of New York City's Lower East Side in the late 1800s, each was reporting simi-

lar circumstances. These cities grew explosively during the 19th century—sevenfold for London and almost 60-fold for New York. Well-run modern cities have demonstrated that pervasive ills are not inescapable. The problems result primarily from nonexistent or poor planning and a lack of good governance. The development of these organizational traits may, in fact, be the most important and long-lasting effect of urbanization because it paves the way for socioeconomic development at the national level.

Some benefits besides wealth and innovation come about even when not legislated. One notable example is the impact of cities on the environment. Quality data are only now beginning to emerge, but we can already see that the largest U.S. cities have the lowest carbon dioxide emissions *per capita*. This gain is mostly an unplanned by-product of people living at greater densities because the bulk of the savings comes from energy-efficient public transportation and simple walking instead of driving, which is almost 10 times more energy-intensive.

Environmental efficiency becomes more challenging for developing nations such as India or China, where much urban infrastructure still needs to be built, although the trade-offs between a need for rapid growth versus the steps to achieve clean growth remain poorly understood. Still, urbanization may ultimately remain the most sustainable solution to our planet's environmental challenges.

Unbridled growth can nonetheless create crises that, in the extreme, could cause a city to collapse unless major innovations are found to stimulate new cycles of growth. In this sense, cities are never in a state of stable equilibrium. They exist in a dynamic balance—a kind of tug-of-war—between the forces that bind them together and those that can potentially tear them apart. That tension is another reason cities drive innovation: many of civilization's greatest inventions have come from dire necessities. Just think of plumbing, electricity and even democracy—not to mention coffee shops.

The ongoing challenge for urban growth is whether human creativity can keep innovating sufficiently fast to sustain ever expanding urban populations while decreasing our per capita consumption of resources and impact on the planet. As long as this trend can continue, cities will grow ever larger and will be the inevitable future of a more creative and prosperous humanity. SA

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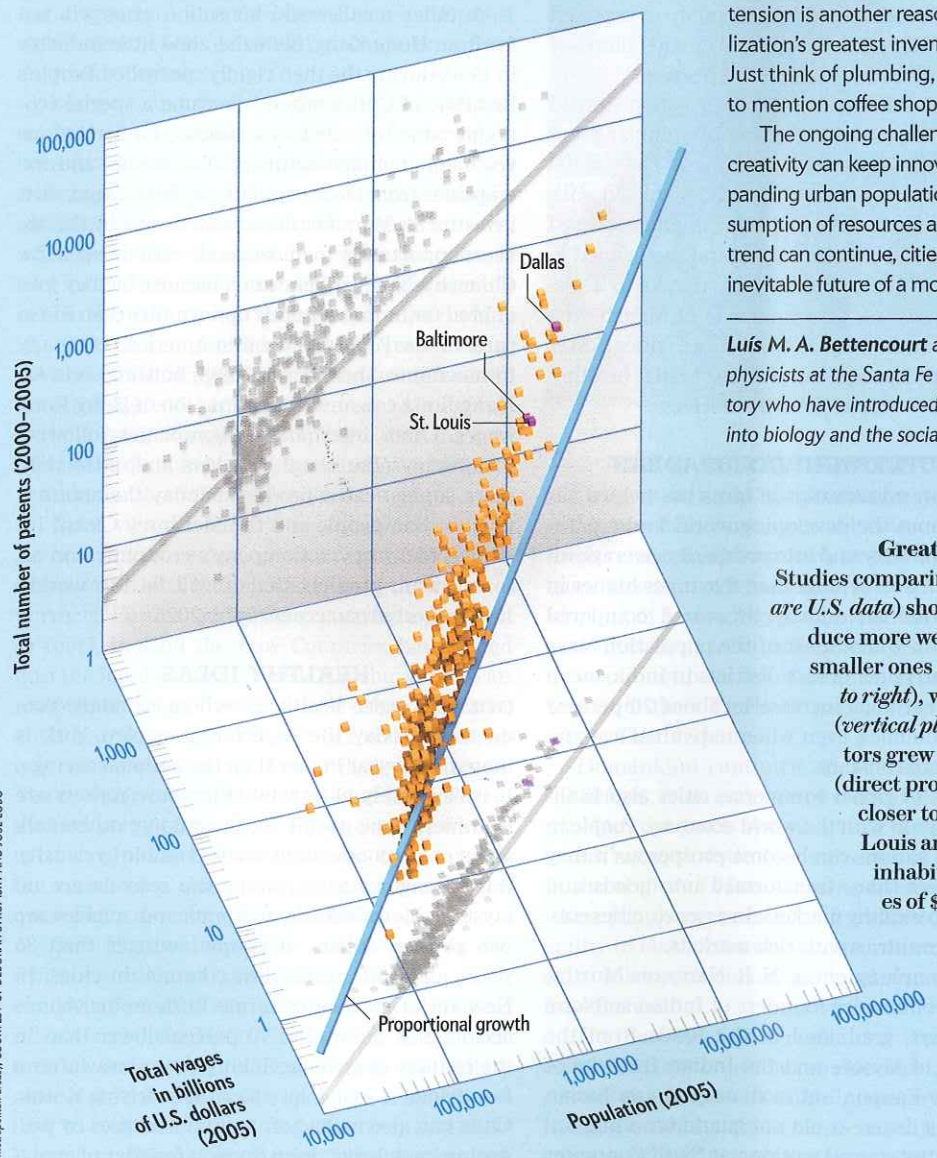

Greater Population, Greater Dividends
Studies comparing metropolitan areas (*orange cubes are U.S. data*) show that, on average, larger cities produce more wealth and innovation per capita than smaller ones do. As city population increases (*left to right*), wages (*horizontal plane*) and patents (*vertical plane*) rise even faster. If these indicators grew only at the same pace as population (direct proportionality), the cubes would align closer to the blue line. A typical example: St. Louis and Baltimore, with about 2.5 million inhabitants each, generate combined wages of $118 billion, yet Dallas, at five million people, has $130 billion in wages.

SOURCES: U.S. BUREAU OF ECONOMIC ANALYSIS (*wages of U.S. metropolitan areas*); U.S. PATENT AND TRADEMARK OFFICE (*data on patents filed between 2000–2005 for U.S. metropolitan areas*); COURTESY OF DEBORAH STRUMSKY AND JOSÉ LOBO

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Graphic by Bryan Christie

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expected to help solve the world's most pressing problems—poverty, energy shortages, climate change—and to promote the type of fundamental political transitions seen in Cairo that recently astonished the world.

Why do cities bring out the best in us? Technology lets us hold virtual meetings, and the Internet keeps us in touch 24/7, but neither can be a substitute for the types of social cues (a facial expression that signals comprehension or confusion) when people meet in an office, bar or gym. Cities deliver the random exchanges of insight that generate new ideas for solving the most intransigent problems [for more on this mechanism, see "Bigger Cities Do More with Less," by Luís M. A. Bettencourt and Geoffrey B. West, on the preceding two pages]. Young workers, whether they are on Wall Street or in Google's New York City offices, succeed by picking up unexpected bits of knowledge from the successes and failures of those around them. It has always been so.

Think of the chain of brilliance that spread throughout the towns of 18th-century England and brought us the industrial revolution. The crucial technology for spinning with rollers started with Lewis Paul and John Wyatt in Birmingham, passed to John Kay and Thomas Highs, and then ended in the hands of Richard Arkwright, thanks to a discussion over a few drinks outside of Manchester. By supercharging the flow of ideas, cities foster economic prosperity, innovation, better health—and even new ways to govern ourselves.

DHAKA
in Bangladesh is the world's most densely populated urban area (35,000 people per square kilometer)
SOURCE: Demographia

A SUPERHIGHWAY OF IDEAS

THE CONSTANT INTERCHANGE of ideas has helped cities throughout the developing world find a pathway out of poverty and into prosperity. Average incomes reach a level more than five times higher in countries that are mostly urbanized compared with those in which most of the population stays in the countryside. Across districts in India, mean individual earnings increase by about 20 percent as density doubles, even when individual age and education are constant.

As hubs of global commerce, cities also facilitate integration with the world economy. People in developing nations can become prosperous if they can sell their time—transformed into goods and services—to wealthy markets. In essence, cities connect poor countries with rich markets.

One example is telling. N. R. Narayana Murthy, one of the billionaire founders of Indian software giant Infosys, graduated in the 1960s from the University of Mysore and the Indian Institute of Technology Kanpur, but in those years an Indian engineering degree could not guarantee a high income. Murthy started working at Patni Computer Systems (now iGATE Patni), whose founders had lived in the U.S. and understood how to work with the American appetite for software. The founders took their knowledge back to India and, joined by Murthy, set up a back-office operation in Pune to serve U.S. companies, thereby linking Indian talent and American markets.

In 1981 they started their own software company and netted their first U.S. client in 1982. A year later they moved to Bangalore to work with a German spark-plug producer that wanted Infosys nearby. Almost 30 years on, Infosys is a flat-world phenomenon that has made billions of dollars for its founders and has trained thousands of Indians in Bangalore, helping them to become more prosperous by selling their engineering talents worldwide. That success has also rippled through the food chain in Bangalore to the service providers in local restaurants and taxis, which translates into jobs for thousands of other Indians.

Another small-world sensation emerged not far from Hong Kong. Shenzhen had little industry in 1980, during the then rigidly controlled People's Republic of China, when it became a special economic zone intended as a magnet for foreign investment in manufacturing. Tax breaks and exemptions from trade regulations encouraged such investment. Manufacturers were drawn by the obvious opportunity to make goods with inexpensive Chinese labor; workers came because factory jobs offered far more economic opportunity than life in rural China. Pepsi was the first American company to move into Shenzhen in 1982, bottling soda for Hong Kong consumers at a fraction of Hong Kong wages. Other international companies followed, making toys, handbags, sneakers and, ultimately, more sophisticated products. Today the area has nine million people and the McKinsey Global Institute, McKinsey & Company's economic and research arm, predicts that it will be the world's 10th-largest urban economy by 2025.

HANOI
Vietnamese city predicted to experience the greatest GDP growth between now and 2025
SOURCE: Pricewaterhouse Coopers

HEALTHY IDEAS

CITIES CAN BREED health as well as economic productivity. Today life expectancy in New York is more than a year higher than the national average. It isn't entirely clear why older New Yorkers are healthier. Some people credit walking; others talk about social connections made possible by density. But among younger people, the reasons are no mystery. Motor vehicle accidents and suicides are two primary killers of people younger than 35 years, and both are far less common in cities. In New York City the death rate from motor vehicle accidents is more than 70 percent lower than in the country as a whole. Taking the subway after a few drinks is just a lot safer than driving drunk. Cities can also make humankind healthier by producing knowledge. John Snow, a founder of epidemiology, had his great breakthrough in 19th-century London when the city itself provided the in-

formation he needed to understand cholera. By studying the urban map of a cholera outbreak, he was able to connect the disease to a water pump and grasp the connection between polluted water and infection. More recently, early breakthroughs in AIDS occurred when Parisian researchers perceived the pattern of infection within that city. The knowledge that cities can provide is often the best weapon against disease.

The cities of the developing world are not yet healthy, in part because their governments have been unable to provide the basic infrastructure that cities need. Still, cities themselves may supply their own solutions. Often they are where the seeds of revolution against bad government sprout, and living contiguously facilitates the coordination that enables citizens to create reform movements that rise up and oust dictators. Urban uprisings do not always end in stable democracies, but most stable democracies benefited at some time from an urban uprising.

Europe's first modern republic—the Netherlands—had its roots in centuries of popular rebellions in the wool-making towns of Flanders, such as Brugge. In the central square of Brugge stands a statue of a weaver and a butcher, urban artisans, who are celebrated not for their crafts but because they helped to organize their fellow guild members in the fight against French royal rule. On May 18, 1302, they organized an urban insurrection, now called the Brugge Matins, and massacred the French knights occupying their town. Almost two months later Brugge's disciplined artisans and their allies demolished the flower of French chivalry at the Battle of the Golden Spurs.

These victories did not produce a republican government for centuries, until the fire of the Reformation, which had spread across the cities of northern Europe, added an extra religious reason to rebel. In 1556 the Low Countries had passed into the hands of the Spanish Hapsburgs, who attempted to tax and regulate these urbanites. Cities once again managed to coordinate action: first, an orgy of iconoclasm and then full-fledged revolt. The uprising took decades, and Flanders itself remained part of Spain, but the end result was an urban republic—the Netherlands—that became the center of a global empire of trade and conquest and a model for many republics to come.

The U.S.'s own uprising had its start in the dense corridors of 18th-century Boston, which connected revolutionaries-to-be such as Samuel Adams and John Hancock. Hancock had a commercial interest in getting crowds to agitate against British mercantilist policies; Adams knew how to conjure a crowd. Together they and their Bostonian allies—John Adams, Paul Revere and many others—became the nucleus of a fight for popular sovereignty.

JOSEF HOFLEHNER *Gallery Stock*

THE FACEBOOK REVOLUTION

THE ABILITY OF CITIES to spread ideas of freedom and to coordinate mass action has led to countless revolts since then, from Paris in 1789 to St. Petersburg, Russia, in 1917 to Cairo in 2011. The recent toppling of former Egyptian president Hosni Mubarak has been called a Facebook revolution, but he would not have left if people had just blocked him from their Facebook pages. They needed to take to Tahrir Square.

Humankind continues to confront enormous challenges, from endemic poverty to global warming, but the track record of our urban species makes me optimistic. I have enormous confidence in the ability of *Homo sapiens* to work miracles when people cooperate. Our greatest gift is our ability to learn from one another, to work together, to solve problems by leveraging our collective intelligence.

The new electronic media can facilitate that collaborative process, but so does the face-to-face contact that is made possible by the physical proximity afforded by cities. Cities have been solving our species' principal challenges for millennia, and they are likely to keep on doing so for centuries to come. SA

Urban centers worldwide attract elite workforces whose collaborative creativity generates some of our best ideas.

MORE TO EXPLORE

The Rise of the Skilled City. Edward L. Glaeser and Albert Saiz in *Federal Reserve Bank of Philadelphia Working Papers*, 2003. http://ideas.repec.org/p/fip/fedpwp/04-2.html

Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier and Happier. Edward Glaeser. Penguin Press, 2011.

A collection of papers by Glaeser on his Harvard Web site: www.economics.harvard.edu/faculty/glaeser/papers_glaeser

SCIENTIFIC AMERICAN ONLINE

Read a chapter from Glaeser's book, *Triumph of the City*, at ScientificAmerican.com/sep2011/glaeser