

Bigger Cities Do More with Less

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

By Luis 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

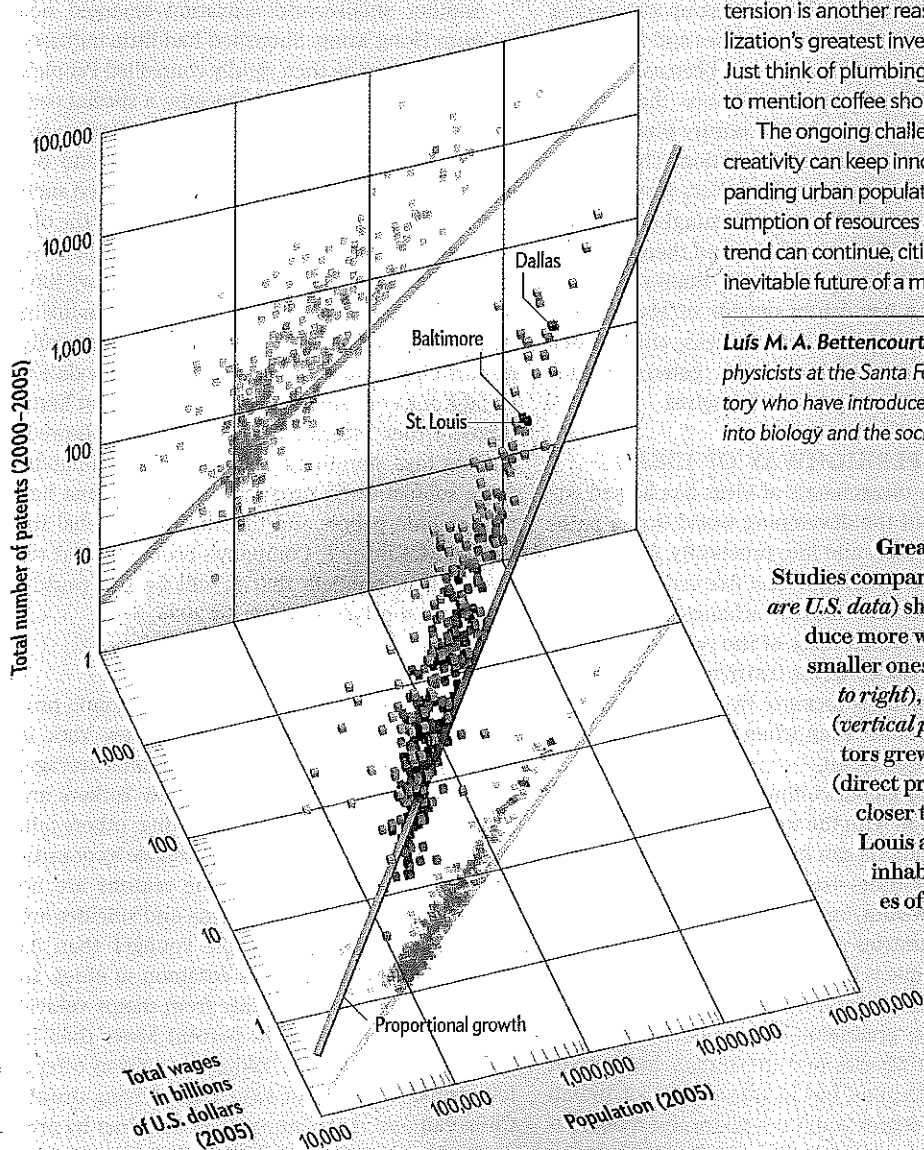
the savings comes from energy-efficient public transportation and simple walking instead of driving, which is almost 10 times more energy-intensive.

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. ■

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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.

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