Keynote Address with Luís Bettencourt, Ph.D.

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Introduction:
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Dr. Luís M.A. Bettencourt is Professor of Complex Systems at the Santa Fe Institute (SFI) in New Mexico. His academic background is in theoretical physics, but he has done significant work on economics and urbanization in recent years. To some, this may seem a surprising shift in research emphasis, but the link is more natural than it might appear.

Dr. Bettencourt and his colleagues at SFI have been leaders in a scientific exploration known as complexity theory. They approach the economy itself, and cities, as complex adaptive systems.[1] Most of us would agree with the "plain English" interpretation of that view: cities are complex, and they do adapt to change over time. But the idea of complex adaptive systems is incredibly richer than it appears on the surface.

Complexity theory involves an interdisciplinary synthesis to describe cities in quantitative and predictive ways, informed by the growing availability of empirical data worldwide. So-called "Big Data" is invaluable to this effort. The research also includes the modeling of innovation and sustainability in developing human societies.

Dr. Bettencourt is particularly focused on the interplay between information, structure and scale in setting the properties of diverse complex systems.[2]

Personally, I had the privilege of participating with Luís Bettencourt, Goeffrey West, José Lobo, Michael Batty and another twenty or so scholars at a colloquium at Arizona State University.[2] That meeting in 2013, brought together specialists in urban history, urban planning, archeology, sustainability and other fields. To my knowledge, this was the first time that real estate, as a scholarly discipline, had a seat at the table for such interdisciplinary work. Dr. Bettencourt's participation in the Global Cities conference at Stanford indicates that real estate's important role in the study of cities is now finding more general acceptance.

Dr. Bettencourt opened his talk in Stanford with the famous image of the "earthrise," the view of our planet as seen from the moon. This image, like many views from space (especially nighttime satellite images), draws attention to the many "bright spots" of human habitation and suggests the importance of interconnectivity of the globe. The idea of cities as a "system" is not a particularly novel one. Research into urban hierarchy goes back at least into the 1930s,[3] and yet the way we think about systems today has undergone a sea change since then.

One of the biggest shifts was triggered, as Dr. Bettencourt noted, when Jane Jacobs pointed out that the problems of cities were not primarily engineering problems.[4] Generations of city planners (both before and after Jacobs) approached the issues of cities as

About the Author

Hugh F. Kelly, Ph.D., CRE, *is the principal of Hugh Kelly Real Estate Economics, since 2001 a private consultancy serving investors, lenders, and real estate services firms. He is currently a Special Advisor to Fordham University and a member of the Board of Regents of Realtor University. He has published more than 300 articles in industry and peer-reviewed academic journals. From 1984 through 2016 he was a faculty member at New York University's Schack Real Estate Institute, first as an adjunct professor and after 2003 as a Clinical Professor of Real Estate. Hugh was Chair of The Counselors of Real Estate in 2014, and his book* 24-Hour Cities: real investment performance, not just promises *was published by Routledge in 2016.*

though the city were a kind of machine that could be functioning well, or not so well. Transportation, zoning, density, crime, education and so forth were treated as elements that could be addressed the way that a mechanic might: identify the problem, define it, isolate it and repair whatever malfunction existed. Jacobs saw things differently, where the socio-economic fabric of a city was best conceived almost organically, and the community was the organism that generated vitality, or disease if it were impaired.

The basic conceptual model of the city is a crucial public policy concern that increases in importance as urbanization becomes more widespread. It is now well understood that the world passed a threshold during the past decade when, for the first time in history, the majority of the global population could be found in urban areas.[5] Dr. Bettencourt pointed out that there are now 4,000 cities around the world with populations of 100,000 or greater. Demographers now count 538 metropolitan areas with populations of one million or more.[6] Large city growth will be particularly evident in the developing world — particularly Africa and Asia in places like Lagos, Nairobi, and Mumbai — but countries like the United States that are already developed and largely urbanized will find that growth in and around cities will be shaping the socio-economic future as well. Along the path of this growth (a greater number of large cities, and an overall tendencies of cities to increase in size), we will likely find a rearrangement of urban systems.

In this context, Dr. Bettencourt spoke about "power laws" that he and other researchers have identified that sort out the impacts of size and density on factors like infrastructure, relative costs and economic output. Infrastructure, for instance, grows as cities "scale up," according to a mathematical relationship where the exponent of growth is "sub-linear" (1-density), meaning that infrastructure capacity increases at a slower rate than population size. Economic output, however, increases at a "super-linear" rate (1+density), meaning that larger cities tend to be more productive because of increased social/economic interactions.[7] Of course, both the infrastructure cost and the economic output effects impact cities at the same time. So there is a tradeoff in transportation costs and gross city product,[8] and such a tradeoff can be expected to influence real estate values.[9]

Physics has provided the conceptual framework for many studies of location in space, including urban geography. One of the most powerful relationships in classical physics is the Second Law of Thermodynamics. According to this law, heat flows from a hotter body to a cooler one — inexorably. In any process, some energy is wasted as heat is lost. A quantity called "entropy" increases. For many years, the scientific consensus held that this was an irreversible condition, a diffusion of energy that marked a movement from order to disorder. Mountains erode. Stars die out. Living beings decay. Monuments go to ruin. The arrow of time runs in one direction — toward a final equilibrium.[10]

Why does this matter at all for cities and for real estate? For approximately fifty years the dominant theoretical model for city growth was the Alonso-Mills-Muth framework (AMM). A brilliant and coherent intellectual structure, AMM provided a way to understand — and to predict — why and how cities tended to grow at their perimeters, as those who could afford to, sought the greatest amount of land (and house) in a metro area for the least amount of price. At the same time, AMM provided an elegant explanation of how and why those who could not make such a location choice had to share more costly land closer to the center by crowding at greater and greater densities to minimize costs. In a word, AMM helped explain both sprawl and inner city impoverishment in an urban equilibrium model that was driven by entropy.[11]

Researchers in complexity science, however, discovered in a variety of natural processes that there is a phenomenon of "emergent organization" that is not consonant with the hypothesis of constantly increasing entropy in systems. In apparent chaos, patterns emerge, often strikingly so. In apparently random flux, recurrent configurations arise. And, as cities sprawl toward their perimeters, nodes are formed within the arc of the metropolis and — most surprisingly — the pattern of the "hollowing out of the center" can, and in some cases does, reverse itself and downtowns revive after having been written off as unsalvageable.[12]

Dr. Bettencourt recommended to the audience that they look at the February 2016 report of the President's Council of Advisors on Science and Technology.[13] The report details the developing

science of cities, focusing on subjects ranging from information sharing to transformations in urban development districts. Cities are about connections, and Dr. Bettencourt stressed that it is the exchange of skills and ideas, an exchange enhanced by diversity, leads to improvements in urban quality of life for such areas as education, health, economics, and recreation. Real estate is a crucial component of the complex urban system, and our understanding of real estate within the urban system is sharpened by greater insights derived from technology and big data. Technology may have its disruptive impacts, but on the whole it plays to the strengths of cities. Much of the wealth generated by cities over history has flowed precisely from their role as laboratories for technological innovation.[14]

Admittedly, the benefits and costs of urbanization have been spread unevenly. Cities are not all one-of-a-kind and it is unwise, for instance, to generalize as if Austin and New York City can be conflated by a law of generalized density. But it would also be a mistake, Dr. Bettencourt argued, to think that cities are therefore not systematically understandable, and that it is useless to try to predict the course of 21st century urbanization. On the contrary, he concluded, we have a profound need — becoming ever more urgent — to understand the places that more and more of the earth's population calls home, using the wealth of data already available and soon to come to make life better for humanity. ■

ENDNOTES

1. There is a growing bookshelf of writing about complexity science, which covers fields from physics to biology to information technology, as well as economics and urban studies. An early discussion that is highly readable is M. Mitchell Waldrop's Complexity: The Emerging Science at the Edge of Order and Chaos (Simon & Schuster Touchstone, 1992). A more recent treatment, also eminently accessible to non-scientists, is Melanie Mitchell's Complexity: A Guided Tour (Oxford University Press, 2009). For those seeking more detail and a specific focus on cities, there is Michael Batty's Cities and Complexity: Understanding Cities with Cellular Automata, Agent-Based Models, and Fractals (MIT Press, 2005).
2. An important article covering such topic, jointly authored by Dr. Bettencourt, José Lobo, Geoffrey West, Dirk Helbing, and Christian Kuhnert, was published in the Proceedings of the National Academy of Sciences (104:17; April 2007). The subject of the "metabolism of cities" has been discussed for decades, at least as far back as Abel Wolman's work in the mid-1960s. See Wolman's article with that title in Scientific American, Volume 213, Pages 179-190 (September 1, 1966).Those wishing to access an overview of some of these scholars in a video format may find Geoffrey West's TED Talk at *http://www.ted.com/talks/geoffrey_west_the_surprising_math_of_cities_and_corporations;* Luís Bettencourt has a number of videos available. There is a 2016 talk at the University of Michigan at *https://www.youtube.com/watch?v=0xyfc6kDof4,* and a 2014 talk at the Universidad Nacional Autonomia de Mexico at *https://www.youtube.com/watch?v=vp6eKjQHNl0*. Michael Batty's talks can also be found at *https://www.youtube.com/watch?v=cdZYDKQmias* ("Smart Cities and Big Data") at University College London, and his TEDx Talk on "Cities 2.0" at *https://www.youtube.com/watch?v=qO0h_oSwySw*
3. Walter Cristaller, *Central Places in Southern Germany*, (1933; issued in translation by Prentice-Hall in 1966).
4. See Jane Jacobs, *The Death and Life of Great American Cities,* (Vintage Books, 1963).
5. It is even more vital, given population projections through the middle of this century. The United Nations estimates that we are at about 54% urban in a world population of 7.4 billion currently. But we will be at 67 percent urban for a 2050 population of 9.7 billion. That means the world's urban population will expand from 4 billion now to 6.5 billion at mid-century. That is a 63% increase in urban dwellers in just 35 years. The implications for real estate, as well as for the economy and society generally are profound.
6. 2016 population estimates for urban agglomerations from Thomas Brinkerhoff, City Populations, *http://www.citypopulation.de/world/Agglomerations.html*
7. One might call the negative impacts sublinear growth instances of "bad density" and superlinear growth effects of "good density." Congestion would be an example of bad density. The concentration of innovation would be an effect of good density.
8. For a technical discussion of the theory behind this, econometrically minded readers can see Dr. Bettencourt's working paper, "The Origins of Scaling in Cities," Santa Fe Institute Working Paper 2012-09-014 (2012) accessible at *www.santafe.edu*.
9. This is consonant with my own research findings on U.S. cities. See Hugh F. Kelly, et al., "Twenty-four Hour Cities and Commercial Office Building Performance." *Journal of Real Estate Portfolio Management*: 2013, Vol. 19, No. 2, pp. 103-120, and *Hugh F. Kelly: 24-Hour Cities: real investment performance, not just promises* (Routledge, 2016).
10. See Peter Coveney and Roger Highfield, *The Arrow of Time: A Voyage through Science to Solve Time's Greatest Mystery*, Fawcett Columbine (New York, 1990)
11. The above brief description hardly does justice to the Alonso-Mills-Muth framework, which served to provide a rational basis for planning development patterns, transportation needs, land use choices, and other urban issues for many decades. Edwin Mills, one of its central architects, did acknowledge the limitations of AMM late in his career, but it has nevertheless been a singular contribution to urban studies and continues to have significant predictive power.
12. Again, for the technically minded, see Michael Batty, "Cellular Automata and Urban Form: A Primer," J*ournal of the American Planning Association* 63, pp. 266-274 (1997); M. Batty & Y. Xie, "Self-Organized Criticality and Urban Development," *Discrete Dynamics in Nature and Society* 3, pp. 109 – 124 (1999).
13. Report to the President: "Technology and the Future of Cities," Executive Office of the President, Washington D.C. (2016). Original report, originally accessed at whitehouse.gov, is no longer available from original source and has been removed. PDF, accessed January 30, 2017, is available at *http://www.cre.org/wp-content/uploads/2017/01/PCAST-Cities-Report-_-FINAL.pdf*
14. For more on innovation districts, see Bruce Katz and Julie Wagner, "The Rise of Innovation Districts," accessible at *https://www. brookings.edu/essay/rise-of-innovation-districts/*