# CURRICULUM VITAE

## Andres Gomez-Lievano

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CONTACT INFORMATION

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EXECUTIVE SUMMARY


Applied mathematician, engineer, and physicist, with expertise in statistical, computational and mathematical modeling. Research experience investigating topics in economic development, urban science, and statistical methodologies. Consulting experience developing tools for economic diversification for local governments, analyzing large administrative datasets, and evaluating the Colombian system of pensions. Professional experience in the banking sector doing financial risk analysis. Extensive experience applying machine learning to surveys, census, and microdata, working in multidisciplinary teams, leading scientific publications, and writing policy recommendations. Independent, question-driven, passionate about learning, unafraid of tackling difficult and ambitious challenges. Always seeking opportunities to apply mathematics and machine intelligence to solve real-world challenges. I am fluent in R, Python, Mathematica and Stata.


PROFESSIONAL POSITIONS

2014-Present **Postdoctoral fellow** at the Center for International Development at Harvard University. I developed probabilistic model to answer why some cities are wealthier than others, resulting in 2 peered reviewed academic publications, including one in Nature; Developed a methodology to visualize and quantify how economic development is a process in a high-dimensional space, resulting in Open Source repositories of code published in *GitHub*; Collaborated with researchers from the School of Public Health applying tools from computer science and physics to understand how urbanization affects the contagion of sexually transmitted diseases which resulted in 2 academic papers and insights for health policy; Participated in two large projects that used, analyzed, and integrated Social Security microdata with Census Surveys, leading to the development of 2 online websites: the "Atlases of Economic Complexity" for Colombia and Mexico, whose goal is to inform decision-making with regards to strategies for urban economic development; Led research project developing machine-learning-powered tools, whose results were visualized in Tableau, for local decision makers to accelerate economic growth by promoting agricultural diversification in rural areas and export diversification in cities, resulting in 2 research policy reports; Mentored colleagues in the use of Python and Machine Learning through weekly meetings; Co-organized a weekly seminar, bringing researchers from Biology, Physics, Anthropology and Computer Science to discuss multidisciplinary opportunities to understand economics. Implemented a weekly 30-minute "tea time" to foster integration between the people at the lab (postdocs, junior researchers, staff, interns and visitors).

2016-2018 **International Consultant**, for Colpensiones, Colombian Government Pension Administrator. This was joint project with Colombian economist Eduardo Lora, to assess the sus-

tainability of the public pension system in Colombia. I developed a Variable Order (non-homogeneous) Markov Chain, inspired by speech and language modeling, for learning the statistical patterns of job trajectories of all Colombian formal workers, using full Social Security data from 2008 to 2016. The stochastic model made it possible, for the first time, to forecast all Colombian workers individually and their life trajectory, for several future scenarios, which we used to assess the sustainability of different systems. One of the keys for the model to work was the appropriate imputation of missing values of age and sex.

Summer, 2014 **Data and Models Analyst for Complex Datasets**, School of Human Evolution and Social Change, ASU. Studied the career progression and mobility patterns of a large survey of scientists. I generated visualization tools to characterize whether there were differences in the speed of progression, depending on gender, age, and the scientific discipline.

2013-2014 **Research Assistant**, School of Human Evolution and Social Change, ASU. Developed computational and statistical models of terrorism and crime. Collaborated in the implementation and analysis of a stochastic Self-exciting Hawkes process to model the contagion of mass killings and school shootings in the US. The results were published and featured in Scientific American, CNN, The Verge, The Smithsonian, The Washington Post, among other media outlets.

2011-2012 **Research Assistant**, Mathematical, Computational & Modeling Sciences Center, ASU. Mentored undergraduate students, gathered data and helped with the preparation of research material for Dr. Carlos Castillo-Chavez.

2009-2010 **Financial Risk Analyst and Actuary in Training**, Grupo Empresarial Bolívar, Bogotá, Colombia. I worked in a team of mathematicians, economists, engineers and physicists analyzing, in general, financial data for risk assessment of the holding companies. I developed a program (in Visual Basic) for identifying irregular over-the-counter market transactions involving moral hazard. I wrote a program that would automatically generated simple and concise reports, highlighting key statistics and quantities. The latter program converted a process that used to take a week to generate the risks reports into a daily routine, enabling the ability to take effective and timely actions.

## EDUCATION

2014 **Ph.D.**, Applied Mathematics for the Life and Social Sciences, Arizona State University. Dissertation Co-chairs: José Lobo & Rachata Muneepeerakul. Committee: Luis. M. A. Bettencourt & Gerardo Chowell-Puente.

2008 **M.Eng.**, Industrial Engineering, Universidad de los Andes, Bogotá, Colombia. Thesis Advisor: Roberto Zarama. Committee: Juan A. Valdivia & Jorge Acevedo.

2007 **B.S.**, Physics, Universidad de los Andes, Bogotá, Colombia. Thesis Advisor: Alonso Botero. Committee: Gabriel Téllez.

## RESEARCH COLLABORATIONS

Summer, 2013 Martin Prosperity Institute, Rotman School of Management, University of Toronto.

2011-present Santa Fe Institute, *Cities, Scaling, and Sustainability* project.

Spring, 2008 Complex Systems Group at Physics Department at Universidad de Chile in Santiago de Chile.

## TEACHING EXPERIENCE

Fall, 2018 **Tutor**, Machine Learning and Python, Growth Lab Workshop Series, Harvard University.

Spring, 2013 **Instructor**, College Mathematics (MAT-142), School of Letters and Sciences, Arizona State University.

Fall, 2012 **Instructor**, Enhanced Freshman Mathematics (MAT-110), School of Letters and Sciences, Arizona State University.

Fall, 2011 **Mentor**, Joaquin Bustoz Math-Science Honors Program, Mathematical, Computational & Modeling Sciences Center, Arizona State University.

Fall, 2010 **Invited lecturer**, "Complex Systems: The Interdisciplinary Science of Collective Systems and Their Hidden Patterns". In: *The History of Proportions (ARQU*1226)*, Universidad de los Andes, Bogotá, Colombia. Sept. 1-3.

Spring, 2010 **Invited lecturer**, "Complex Systems: The Interdisciplinary Science of Collective Systems and Their Hidden Patterns". In: *The History of Proportions (ARQU*1226)*, Universidad de los Andes, Bogotá, Colombia. Feb. 16-18.

Fall, 2009 **Invited lecturer**, "Complex Systems: The Interdisciplinary Science of Collective Systems and Their Hidden Patterns". In: *The History of Proportions (ARQU*1226)*, Universidad de los Andes, Bogotá, Colombia. Aug. 25-27.

Fall, 2006 **Tutor**, Physics Help Room, Universidad de los Andes, Bogotá, Colombia.

Spring, 2006 **Teaching Assistant**, Physics 1 (FISI*116B), Universidad de los Andes, Bogotá, Colombia.

Fall, 2005 **Teaching Assistant**, Calculus 2 (MATE*120B), Universidad de los Andes, Bogotá, Colombia.

## ADDITIONAL TRAINING

2019 Practical Deep Learning for Coders–V3, fast.ai course, Jan-March.

2017 Social & Behavioral Research, Collaborative Institutional Training Initiative (Citi Program), December 30
(Verify at www.citiprogram.org/verify/?k275d3136-5f3f-452f-a5ac-4aab2035f204-25589198).

2016 Machine Learning, Stanford Online, Stanford University, July 30
(Verify at coursera.org/verify/MDHKX9GVWMZQ).

2012 Complex Systems Summer School, Santa Fe, New Mexico, Santa Fe Institute, June 4 – 29.

## ARTICLES AND PUBLICATIONS

2020 Brummitt, C. D., Gomez-Lievano, A., Hausmann, R., and Bonds, M. H., Machine-learned patterns suggest that diversification drives economic development. *(Royal Society Open Science)*. **17**: 20190283.

2019 Gomez-Lievano, A., Strumsky, D., Henrich, J., and Lobo, J., Invention as Cultural Accumulation. *(In preparation)*.

2019 Gomez-Lievano, A., Coscia, M., and Neffke, F., Linking structure to the dynamics of collective learning. *(In preparation)*.

2019 Gomez-Lievano, A., Vysotsky, V., and Lobo, J., Artificial Increasing Returns to Scale and the Problem of Sampling from Lognormals. *(In review at the Journal of Business & Economic Statistics)*.

2019 O'Clery, N., Gomez-Lievano, A., Chaparro, J.C., and Lora, E., Skill diversity and the evolution of formal employment in cities. *(In review at Research Policy)*.

2019 Gomez-Lievano, A., and Patterson-Lomba, O., The drivers of urban economic complexity and their connection to urban economic performance. *(In review at Research Policy)*.

2018 Gomez-Lievano, A., Methods and Concepts in Economic Complexity. *arXiv*, preprint arXiv:1809.10781.

2018 Patterson-Lomba, O. and Gomez-Lievano, A., On the scaling patterns of infectious disease incidence in cities. *arXiv*, preprint arXiv:1809.00277.

2017 Gomez-Lievano, A., Ravinutala, S., and Lora, E., Datlas 2.0: Assessing how industry-related capabilities affect export possibilities in cities. *(Harvard CID Research Report)*.

2017 Ravinutala, S., Gomez-Lievano, A., and Lora, E., Datlas 2.0: Assessing rural productive capabilities and identifying potential agricultural products by municipality. *(Harvard CID Research Report)*.

2017 O'Clery, N., Gomez-Lievano, A., Chaparro, J.C., and Lora, E., The Path to Labor Formality: Urban Agglomeration and the Emergence of Complex Industries. *CID Working Paper*.

2016 Gomez-Lievano, A., Patterson-Lomba, O., and Hausmann, R., Explaining the Prevalence, Scaling and Variance of Urban Phenomena. *Nature Human Behaviour*, **1**(0012).

2016 Gomez-Lievano, A., Lora, E., and Tellez, J., New Insights About Wage Inequality in Colombia. *Latin America Policy Journal*, 5th Edition, December.

2015 Gomez-Lievano, A., The Mechanics of Cities: The Statistical Laws Behind Urban Behavior. *AngleJournal*, June, 2015.

2015 Towers, S., Gomez-Lievano, A., Khan, M., Mubayi, A., and Castillo-Chávez, C., Contagion in Mass Killings and School Shootings. *PLoS ONE*. **10**(7), e0117259.

2015 Patterson-Lomba, O., Goldstein, E., Gomez-Lievano, A., Castillo-Chavez, C., and Towers, S., Per capita incidence of sexually transmitted infections increases systematically with urban population size: a cross-sectional study. *Sexually Transmitted Infections*. sextrans-2014-051932.

2014 Gomez-Lievano, A., Bettencourt, L.M.A., Stolarick, K., Strumsky, D., and Lobo, J., Are There Constraints on Creative and Inventive Activities in Urban Areas? *Working Paper*.

2012 Brummitt, C.D., Gomez-Lievano, A., Goudemand, N. , and Haslam, G., Hunting for keys to innovation: The diversity and mixing of occupations do not explain a city's patent and economic productivity. *Complex Systems Summer School Proceedings*, Santa Fe Institute.

2013 Muneepeerakul, R., Lobo, J., Shutters, S. T., Gomez-Lievano, A., and Qubbaj, M. R., Urban Economies and Occupation Space: Can They Get "There" from "Here"? *PLoS ONE*. **8**(9), e73676.

2012 Gomez-Lievano, A., Youn, H., and Bettencourt, L.M.A., The Statistics of Urban Scaling and Their Connection to Zipf's Law. *PLoS ONE*. **7**(7), e40393.

PRESENTATIONS

2019 Gomez-Lievano, A., *State variables and dynamics of economic complexity, and their connection to economic performance*. Workshop on Economic Complexity and Development, Federal University of Paraná, Curitiba, Brazil, December 10. (Invited Keynote Speaker)

2019 Gomez-Lievano, A., *Ciudades como systemas complejos*. Diálogos Uniandinos con Colombia, Sede Nacional Uniandinos, Bogota, Colombia, July 3. (Invited Speaker)

2019 Gomez-Lievano, A., *Do "binding constraints" exist?* Workshop: Small Adaptations–Large Impact, University of Chicago, Illinois, March 27–28. (Invited Speaker)

2018 Gomez-Lievano, A., *Cities, collective knowhow and economic development*. Workshop: Computational Social Science, University of Chicago, Illinois, May 17. (Invited Speaker)

2018 Gomez-Lievano, A., *Invention as cultural accumulation: Evidence from patenting*. Workshop: The Complexity of the Patenting System, Santa Fe Institute, New Mexico, March 12–14. (Invited Speaker)

2017 Gomez-Lievano, A., *Theory and practice in a New Science of Cities*. Industrial Engineering Seminar Cycle (CSII), Universidad de los Andes, Bogota, Colombia, November 28. (Invited Speaker)

2017 Gomez-Lievano, A., *Modeling cities using ideas from Economic Complexity and Cultural Evolution*. SALURBAL meeting, Lima, Peru, November 13–15. (Invited Speaker)

2017 Gomez-Lievano, A., *Análisis y Métodos de Proyección del RAIS y el RPM a Partir de las Transiciones Laborales*. Seminario Modelos Pensionales, Bogotá, Colombia, March 23. (Invited Speaker)

2017 Gomez-Lievano, A., *Explaining the prevalence, scaling and variance of urban phenomena*. Workshop: Updating the Production Function for the Algorithmic Economy, Menlo Park, California, February 28–29. (Invited Speaker)

2015 Gomez-Lievano, A., *The Product Space as a network of brains*. Workshop: Innovation as Search on a Space of Possibilities: Constructed or Discovered? Metaphorical Device or Analytical Construct? Santa Fe Institute, New Mexico, October 14–16.

2015 Gomez-Lievano, A., *Explaining the Prevalence, Scaling, and Variance of Urban Phenomena*. Conference: Complex Systems 2015. Tempe, Arizona, September 28–October 2.

2015 Gomez-Lievano, A., *Explaining the Prevalence, Scaling, and Variance of Urban Phenomena*. Workshop: XIV Latin American Workshop on Nonlinear Phenomena, Cartagena, Colombia, September 21–25. (Invited Speaker)

2014 Gomez-Lievano, A., *On the Statistics of Scaling*. Workshop: The Principles of Complexity: Life, Scale, and Civilization III. Santa Fe Institute, New Mexico, August 25–26.

2013 Gomez-Lievano, A., *Are There Constraints To Urban Creative and Inventive Activities?* Conference: 60th Annual North American Meetings of the Regional Science Association International. Atlanta, Georgia, November 13–16.

2013 Gomez-Lievano, A., *The Scales of Creativity: A Distributional Approach to Characterize Creative Class Employment, Inventors, and Patents, and Their Relation to Urban Population Size in Cities*. Conference: 2013 Experience the Creative Economy (ECE). Martin Prosperity Institute, Toronto, Canada, June 18–21.

2012 Gomez-Lievano, A., *Can There be a Science of Cities? The Evidence from Crime*. Workshop: Can There Be a Science of Cities? Santa Fe Institute, New Mexico, July 12–14.

## Selected Media Coverage and Mentions to my Work

Article about my paper "The Statistics of Urban Scaling and Their Connection to Zipf's Law" (Gomez-Lievano, A., Youn, H., and Bettencourt, L.M.A., *PLoS ONE*, 2012, **7**[7], e40393):

- **Statistical analysis that fits the crime**, Santa Fe Institute News

Articles about my paper "Contagion in Mass Killings and School Shootings" (Towers, S., Gomez-Lievano, A., Khan, M., Mubayi, A., and Castillo-Chávez, C., *PLoS ONE*, 2015, **10**[7], e0117259):

- **Mass Shootings Are Contagious**, Scientific American
- **School shootings, mass killings are 'contagious,' study finds**, CNN
- **Mass killings spread like a disease – and a federal ban makes it hard to find the cure**, Vox
- **US mass killings 'may be contagious'**, The Telegraph
- **Mass Shootings in America Are Spreading Like a Disease**, The Atlantic
- **Mass shootings and news media: A connection?**, Newsweek
- **Concern over 'copycat' shooters has some asking: Should media coverage change?**, The Christian Science Monitor
- **Here's What We Know About The Contagion Effect Of Mass Shootings**, HuffPost
- **How Not to Cover Mass Shootings**, The Wall Street Journal
- **Are the media complicit in mass shootings?**, Los Angeles Times
- **Deadly July: Five mass killings in 10 days**, USA Today
- **U.S. media challenged not to name perpetrators of mass violence**, Reuters
- **More police refusing to name shooters for fear of copycats**, ABC News
- **Study: Mass killings, school shootings can be contagious**, CBS News
- **Mass Killings Inspire Copycats, Study Finds**, NBC News
- **Six radical ways to tackle US school shootings**, BBC News
- **Study: Why some mass killings and school shootings seem to be contagious**, The Washington Post
- **How do we stop killers from exploiting social media?**, The Verge

Articles about my paper "Explaining the Prevalence, Scaling and Variance of Urban Phenomena" (Gomez-Lievano, A., Patterson-Lomba, O., and Hausmann, R., 2016, *Nature Human Behaviour*, **1**[0012]):

- **Cities: Where the economy plays scrabble**, The Brookings Institution
- **Recipes for Thriving Cities**, Harvard Magazine
- **The Urban Theory of Everything**, Center for International Development News
- **Urban studies: Diverse cities, successful cities**, Nature Human Behavior News & Views
- **The Prevalence, Scaling and Variance of Urban Phenomena**, Professor Michael Batty, Emeritus Professor of Planning – Blog

## THESES

2014 *Applying Distributional Approaches to Understand Patterns of Urban Differentiation.* Doctoral dissertation, Applied Mathematics for the Life and Social Sciences, Arizona State University. Advisors: Dr. José Lobo; Dr. Rachata Muneepeerakul.

I studied how the diversity of individuals living in cities aggregate into different levels of innovation and economic performance at the urban system's level. The big questions guiding me were: Why are cities so different from one another, how do those differences emerge, and does the economic structure within cities explain their differences? Using Extreme Value Theory, I studied how increasing returns to scale at the level of cities emerge from the distribution of individual-level productivities; I then analyzed the distribution of aggregate urban output to conclude that urban phenomena must emerge from multiplicative processes, not additive ones; Multiplicative processes suggested a theory about the complementarity of inputs for urban productivity. During the PhD I developed an expertise in probability, large datasets, maximum likelihood, bayesian inference, stochastic processes, and dynamical systems.

2008 *Emergent Hierarchical Properties of a Transportation Network.* Master thesis, Industrial Engineering Department, Universidad de los Andes, Bogotá, Colombia. Advisors: Dr. Roberto Zarama; Dr. Juan Alejandro Valdivia.

The question in the thesis was: How does the statistical distribution of the size of blocks across the urban street transportation network affect the traffic through the nodes? I became familiar with the literature on cities as fractal objects, the literature on transportation within cities, and the simulation and construction of large networks for data analysis. During the Masters I developed an expertise in complex network analysis, fractal dimensions and scaling analysis, high-performance computing, financial risk analysis, optimization and linear programming.

2007 *Critical Behavior of a BTW Sandpile Model on a Scale-Free Network.* Undergraduate thesis, Physics, Universidad de los Andes, Bogotá, Colombia. Advisor: Dr. Alonso Botero.

The question guiding the thesis was: How do small perturbations in a system of connected nodes spread across the system? I solved analytically a model of the statistical distribution of avalanche size and duration, where the avalanches occur and spread through a Scale-Free Network. I was able to provide answers to questions like: how does the degree distribution of the network affect the critical exponents of the avalanches? Are the statistics of avalanche activity universal? I then implemented all the required simulations to analyze their statistical distributions and test the validity of the mathematical predictions.

## AWARDS

Recipient of O-1A Visa (Jan 8, 2020 - Aug 31, 2022)

"To qualify for an O-1 visa, the beneficiary must demonstrate and possess extraordinary ability by sustained national or international acclaim in the sciences, arts, education, business, or athletics."

## PROFESSIONAL SERVICE

**Organizer:**

- Workshop *Using machine learning to understand labor mobility, knowledge diffusion and exporting behavior*. Harvard University. March 22, 2018.
- Workshop *Knowledge diffusion, skill complementarity, and the future of work*. Harvard University. November 19, 2018.
- Conference *IV Colombian Conference*. Harvard University, MIT, BU, Tufts. April 18–23, 2016.

**Number of Referee Services in the following journals:**

- *Nature Human Behaviour*: 1

- *Habitat International*: 1
- *Cities*: 1
- *Research Policy*: 1
- *Science Advances*: 1
- *Structural Change and Economic Dynamics*: 1
- *Revista de Matemática: Teoría y Aplicaciones*: 1
- *Royal Society Open Science*: 2
- *PLoS ONE*: 10

**Memberships, examination boards, program committees, and editorial services:**

- *PLoS ONE*: Guest Editor
- *Northeast Regional Conference on Complex Systems*: Program Committee
- *Complex Systems Society*: Member
- *Cultural Evolution Society*: Member

**Community Service:**

- Providing support to Mather House at Harvard University as Non-Resident Tutor. I helped undergraduate students as an advisor in Applied Mathematics and attended weekly meetings in the Spanish Table to support students interested in learning Spanish.
- Technical assistance in the collection of census data from local communities in slums in Cochabamba, Bolivia, in October, 2013. This was part of the larger project led by Luis Bettencourt from the Santa Fe Institute, funded by the Bill & Melinda Gates foundation, in collaboration with nonprofit Slum Dwellers International, to study the development of slums in cities worldwide.

## SKILLS

**Programming languages and softwares:** proficiency in R, Python, Mathematica, STATA, C/C++, Visual Basic, LaTeX, MS Office. Basic experience in MATLAB, SAS, arcGIS and Xpress. Comfortable with Windows, Linux, and Mac.

**Languages:** Spanish (native tongue), English (full proficiency), French (limited working proficiency), Italian (reading).

**Other:** Guitar, painting, tennis, scuba diving, passionate reader and traveler.