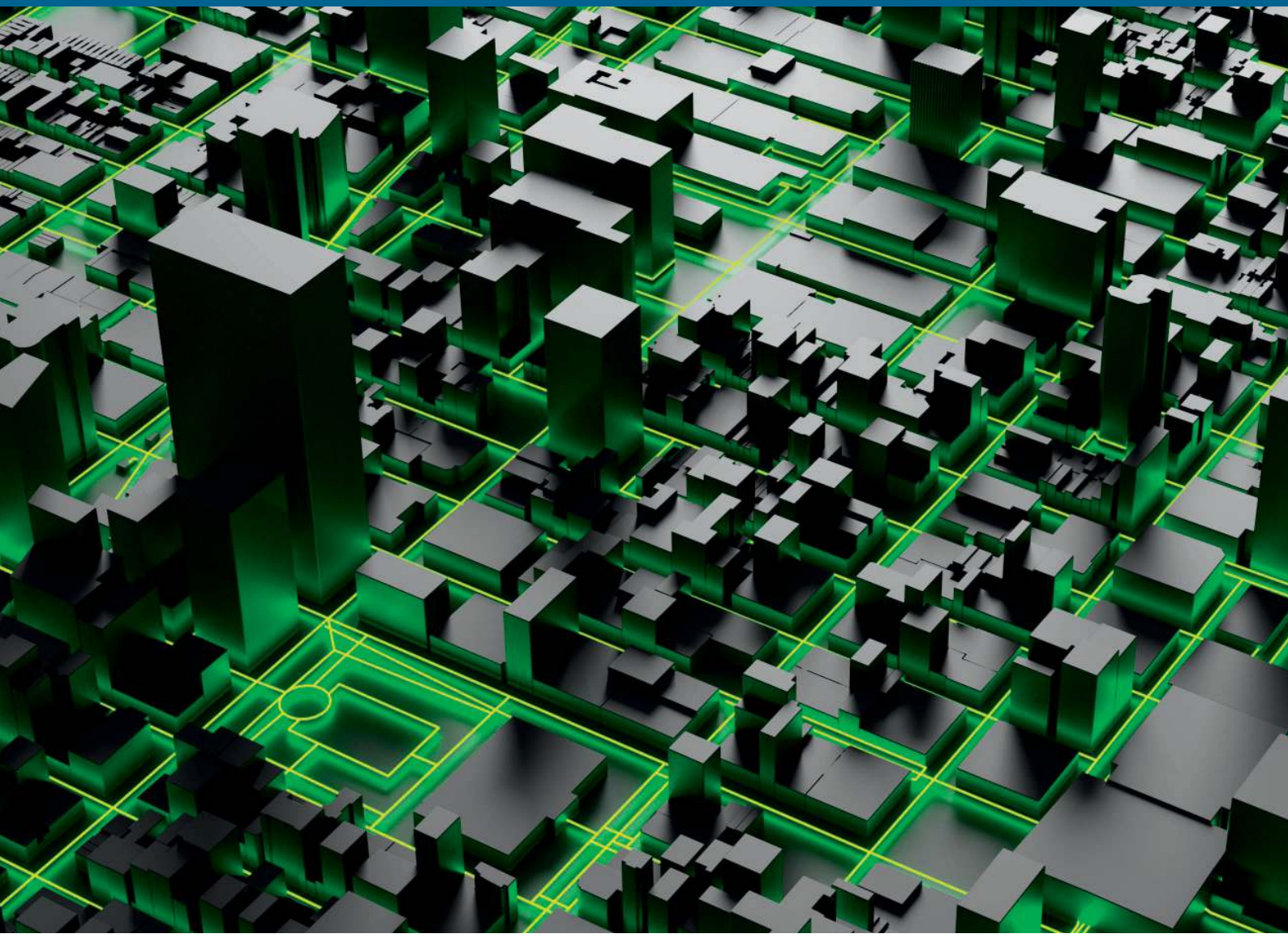
NEWS SPRING 2021

COMPLEXITY SCIENCE HUB VIENNA



The geometry of cities determines urban scaling laws. © Shutterstock

Dear friends of the Hub!

These are strange times. Since last year, there hasn't been much physical interaction happening at the Hub—no live workshops, talks, or conferences, no foreign visitors, no teatime or cheerful beer rounds in the evening. Yet, so much is happening at the Hub...

We are very proud to have attracted two top-notch researchers who start(ed) working with us: Fariba Karimi already switched from GESIS – the Leibniz Institute for the Social Sciences in Germany to the Hub in March, and Frank Neffke is about to leave the US and Harvard Kennedy School. The two of them will contribute new research directions to the Hub (i.e., fairness and bias in Artificial Intelligence and new approaches to the science of cities). In addition, a whole bunch of new, young(er) researchers will support the Hub crowd in the future. In 2021 alone, we grew by nine people. You'll find some of these faces on the last page of this Newsletter.

In May we are also celebrating our fifth anniversary. Hard to believe: Five years have already passed since we started operations in 2016 with a large opening conference and garden party... This year, I am afraid, we won't be able to party. But hope never dies that we'll be able to catch up with it one day.

Until then, we do what the CSH was founded for: science.

Verena Ahne
Knowledge Transfer & Dissemination

VISIONS FOR COMPLEXITY

The city formula

CSH researchers derive scaling laws in cities from 3D city geometry.
When complex systems double in size, many of their parts do not. Some aspects will grow by about 80 percent, others by around 120. The astonishing uniformity of these two growth rates is called "scaling laws."
A multitude of examples show the presence of scaling laws everywhere in the world. In cities, for instance, much of the infrastructure—like the number of gas stations, energy consumption, land coverage—shows a sub-linear growth rate of about 0.80 for every doubling in population size. Socially driven contexts, on the other hand, will grow super-linearly by around 120 percent: People in larger cities earn consistently more money for the same work, make more phone calls, and even walk faster than small town inhabitants.
While we find hundreds of such scaling laws, the big question remains open: Why do they emerge? For cities, Carlos Molinero and Stefan Thurner now provide a simple explanation: They derive them from 3D city geometry.

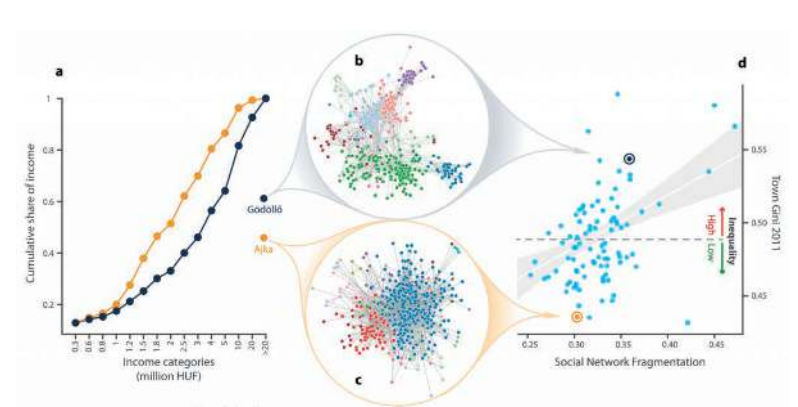
It's all in the (fractal) geometry
"Cities are always built in a way that infrastructure and people meet," says Carlos, an urban science expert, who left the Hub last September. "We therefore think that scaling laws must emerge from the interplay between where people live, and the spaces they use to move through a city."
"The innovative idea here is how the spatial dimensions of a city relate to each other," adds Stefan.
To come to their conclusion, the scientists first mapped thee-dimensionally where people live with the help of open data for the height of buildings in more than 4,700 European cities. They assigned a dot to every person living in a building; together, these dots form a sort of "human cloud" of a city. Clouds are fractals; that is, they are self-similar: If you zoom in, their parts look very similar to the whole. Based on the human cloud, Carlos and Stefan determine the fractal dimension of a city's population: a number that describes the human cloud of each particular city. Similarly, they calculate the fractal dimension of cities' road networks.
"Although these two numbers vary widely from city to city, we discovered that the ratio between the two is a constant," Stefan says—the "sublinear scaling exponent."

A formula for sustainable urban planning
Aside from the mathematical elegance, the finding also has potential practical value. "At first sight, the appearance of such a constant looks like magic," says Stefan. "But it makes perfect sense if one takes a closer look: It's this scaling exponent that determines how the properties of a city change with its size." This is relevant because many cities around the world are expected to double their populations within the next 50 to 80 years. "Scaling laws show us what this doubling means in terms of wages, crime, inventiveness, or resources needed per person—all of this important information for urban planners," Stefan points out.
To know the scaling exponent of a city could help keep the gigantic resource demands of urban growth at bay. "We can now think specifically about how to get this number as small as possible, for example, through clever architectural solutions and radically different approaches to mobility and infrastructure construction: The smaller the scaling exponent, the higher the resource efficiency of a city will be."

→ The paper "How the geometry of cities determines urban scaling laws" appeared in the Journal of The Royal Society Interface.

City shape & inequality

Building cities in a way that fragments social networks is a root cause for inequality.
And another city story (quite a focus topic this time): A research team including CSH's Johannes Wachs and János Kertész showed that urban planning directly influences the formation of social networks in a city and subsequently the socio-economic equality (or inequality) of its citizens.
Social relations provide individuals with essential access to resources, information, economic opportunities, and other forms of support. The study shows that in towns with more evenly distributed social networks, economic inequality tended to be much lower than in towns with highly fragmented social networks. It even becomes a vicious cycle: the higher the fragmentation of social networks, the higher the income inequality in a town over time.
The researchers argue that a root cause for this fragmentation lies in geography. To test their hypothesis, they used a large dataset retrieved from iWiW, a once-popular social media platform used by nearly 40 percent of Hungarians. It includes data of two million individuals from about 500 towns.
"It was impressive to see evidence of strong physical boundaries in a city just by looking at its social network," Johannes emphasizes.



Income inequality correlates with social network fragmentation in towns.

City design and income go hand in hand
The findings confirm that geography and income inequality are strongly related. "If valuable ideas and information cannot float freely through a city because of its physical fragmentation—which causes social fragmentation—there will be inequality," says Johannes.
Of course, social networks do not form in a vacuum. A lot of different mechanisms influence with whom we are in regular contact. For instance, humans tend to befriend similar people ("homophily"). Friends of friends also show the tendency to become friends ("triadic closure").
Yet, the iWiW data found geographic indicators of towns as an additional strong predictor of fragmentation in social networks.
City planners, listen up: "While you can hardly change social networks directly via public policy, your decisions about the built environment in a city designed to facilitate people meeting and interacting will lead to fewer problems with inequality in the future," Johannes concludes.

→ The publication "Inequality is rising where social network segregation interacts with urban topology" appeared in Nature Communications.

CCCSL: A great project ...

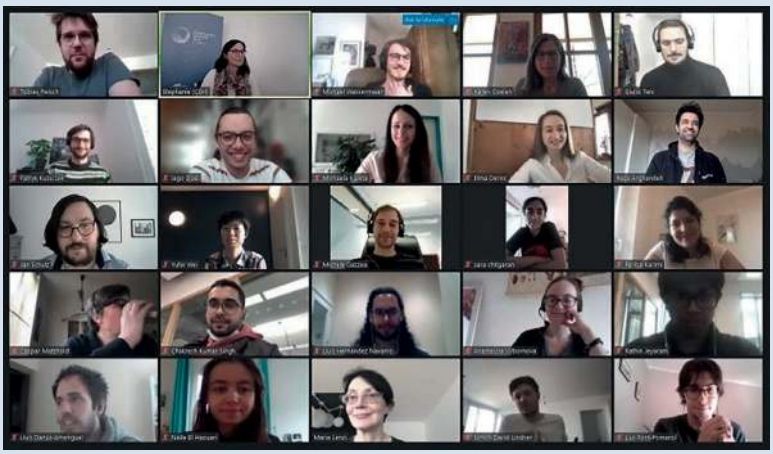
... becomes part of something even bigger.
Do you remember the CCCSL—the CSH Covid-19 Control Strategies List? We started building this comprehensive open-access dataset a year ago, in March 2020. In the emergency phase (from March to August), over 40 volunteers and researchers tirelessly documented governmental interventions in response to COVID-19, coordinated by our never-sleeping wonder woman Amélie Desvars-Larrive.

Amélie Desvars-Larrive, our tireless CCCSL project leader. (c) Verena Ahne

But the Hub was not the only one doing so. All over the world, other groups were tracking measures too. The largest of these projects, CoronaNet at TU Munich, eventually thought of bringing all the policy trackers to one table: The idea for a big data tracker conference was born. The Hub co-hosted this two-part COVID-19 PHSMs Data Coverage Conference. In several intensive workshops and discussions on February 10 and 11, the trackers discussed challenges they face, how data collection on health equity measures can be improved, and how public health responses to future pandemics could build upon the lessons learned. The results and outlooks were shared with international organizations, journalists, and policy makers in a public online conference on March 3.

Enabling better response to this—and future—pandemics
With over 300 registrants and more than 100 representatives of over 50 policy trackers during the first two days, the virtual gathering was a huge success. It considerably boosted communication, cooperation, and the already great spirit of the community. Right after the conference, the first *COVID-19 Public Health and Social Measures Data Coverage Network* was established, a pioneering platform for discussion, collaboration, and cooperation of corona trackers. A joint statement proposing a reflection and a framework for high quality data collection for public policy and possible future pandemics will soon be published.

A project ends, the data lives on
And the CCCSL? After a year of literally day and night work and the collection of 11,512 government interventions in 57 countries, the project has ceased. However, the precious data won't be lost. Currently, Amélie is about to explore a collaborative approach aiming to integrate the CCCSL into CoronaNet, which comprises more than 60,000 measures already (but, as a comparison has shown, not very much overlap). The two teams are working on an algorithm that will enable our dataset to be recoded with the CoronaNet taxonomy. As the algorithm can be used in both ways, this would be a win-win process.



From the Alps to Zoom

In spring 2021, the Hub held its first virtual Winter Lecture Series.
As the Winter School could not take place, we offered our successful 2021 Winter School applicants (plus some additional listeners) the opportunity to participate in four days of high-quality complexity online science lectures with 16 hours of live academic Zoom sessions. But how can the flair of a live event that fosters engagement, networking, and direct dialogue with the speakers be mimicked? The solution was "Wonder": The funky tool allows people to move freely from "table to table" as avatars, join the groups they are interested in, and start a discussion with speakers and other participants. Everyone enjoyed this very much—and the snowy summit picture as a backdrop even gave the networking sessions some alpine flair...

We had great speakers, too: **Simon DeDeo** (Carnegie Mellon University, Santa Fe Institute & CSH External Faculty) provided an insight into cultural data science. **Fariba Karimi** (CSH & Central European University) discussed current advances in computational social science. **Vittorio Loreto** (CSH & SONY-CSL Paris) explored the dynamics of novelty and innovation. **Renaud Lambiotte** (University of Oxford & CSH ExtF) discussed the dynamics and modularity of network science and higher order networks. And **Andrea Rapisarda** (University of Catania & CSH ExtF) explored the beneficial role of randomness. The 39 extremely engaged winter school participants and 18 listeners, spanning from the US East Coast to India and Australia, awarded the virtual event top marks. They praised the variety and interdisciplinary of the lectures and the great interaction with the speakers. Some even formed a *Telegram* group to continue exchanging new ideas gained from the event and, some day, maybe meet in person.
Everybody was happy. And we are sure: It won't be the Hub's last event of this kind.

PUBLICATIONS

The Hub is growing

While most of our "normal" (what's that?) Hub life is still sort of hibernating due to the ongoing pandemic, there's still plenty of activity going on. In fact, we're currently experiencing quite a growth spurt and are excited to welcome some Hub newbies.

Jan Bachmann joined the team focusing on computational social science in April 2021. His research interest lies at the crossing point of data and social science.

Majid Benam has been working as a database manager and research assistant since January 2021. He will be contributing to the creation of a "Crisis Databank" of past societies that went through periods of political turmoil.

Katharina Ledebur is a PhD candidate at the Hub and MedUni Vienna. Her research interests include epidemiology, data analysis, networks, and complex systems.

Eddie Lee left the Santa Fe Institute to work with us as a PostDoc. He studies collective behavior across fields to clarify how patterns in nature reflect universal principles of information and representation.

Bernhard Haslhofer has been a Senior Researcher at the Hub since last November, coordinating research activities in crypto-asset analytics. Bernhard is establishing the new research field of "cryptofinance" together with our member AIT.

Fariba Karimi joined us in March. Her research focuses on computational social science, the emergence of biases and inequality in networks and algorithms, and modeling human behavior. Fariba is also Assistant Professor at the Department of Network and Data Science at the Central European University.

Upcoming

Due to the ongoing pandemic, all our events are still taking place online but we're hoping that this can change soon. To stay updated on what's happening and what's planned, please visit our event calendar:
→ www.csh.ac.at/events

Our next events:

CSH Webtalk by Tom Broekel
→ "Technological complexity and economic growth"
May 7, 2021, 3 p.m.

CSH Webtalk by Leonhard Horstmeyer
→ "Balancing endogenous and exogenous mitigation measures in SIR-type epidemics"
May 14, 2021, 3 p.m.

CSH Talk by Barbara Prainsack
→ "Data ethics: What is it, and who needs it?"
May 28, 2021, 3 p.m.
(will take place at the Hub if possible. Please check online.)

CSH Webtalk by Caspar Matzhold
→ "A systematic approach to analyze the impact of farm-profiles on bovine health"
June 4, 2021, 3 p.m.

This is a selection of publications affiliated to the Hub. Find more at → *www.csh.ac.at/publications*

F. Schweitzer, G. Casiraghi, M. Tomasello, D. Garcia
→ *Fragile, yet resilient: Adaptive decline in a collaboration network of firms*
Frontiers in Applied Mathematics and Statistics 7 (2021) 634006

C. Molinero, S. Thurner
→ *How the geometry of cities explains urban scaling laws and determines their exponents*
Journal of the Royal Society Interface 18 (176) (2021) 20200705

V. Priesemann, et al.
→ *Calling for pan-European commitment for rapid and sustained reduction in SARS-CoV-2 infections* The Lancet 397 (10273) (2020) 469–470

G. Caniglia, et al.
→ *Scientists' Responsibility for Global Futures*
Science & Diplomacy 48 (2021)

J. Korbel, D. Wolpert
→ *Stochastic thermodynamics and fluctuation theorems for non-linear systems*
New Journal of Physics 23 (2021) 033049

G. Tóth, J. Wachs, et al.
→ *Inequality is rising where social network segregation interacts with urban topology*
Nature Communications 12 (2021) 1143

M. Leutner, C. Matzhold, et al.
→ *Major Depressive Disorder (MDD) and Antidepressant Medication Are Over-represented in High-Dose Statin Treatment*
Frontiers in Medicine 8 (2021)

C. Deischinger, E. Dervic, et al.
→ *Diabetes mellitus is associated with a higher relative risk for Parkinson's disease in women than in men*
Journal of Parkinson's Disease 11 (2) (2021)

T. M. Pham, I. Kondor, R. Hanel, S. Thurner
→ *The effect of social balance on social fragmentation*
Journal of the Royal Society Interface 17 (171) (2020) 20200752

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