Horse riding techniques drove the evolution of military technology. Assyrian relief from 8th c. BCE
© British Museum

Dear friends of the Hub!

Over the past months we have all finally returned from working at home to physical tables and rooms in Palais Strozzi—and suddenly palpably sensed how much the CSH has grown. All those faces from Zoom screens suddenly are real figures. Our rooms are filled, team meetings crowded, coffee machines constantly running. Around 60 people are working at the Hub now, and more are to come—a challenge. But also a great joy.

As usual at this time of the year, the new academic season started with a lot of events. A highlight for us will be the visit of **Ricardo Hausmann** later in November. Ricardo is one of the leading figures in economic complexity analysis. **He will give a public lecture on November 23**. For those who cannot attend in person, we plan to stream the event. Stay tuned for (CORONA-driven) updates!

We would also like to use this newsletter to offer some congratulations. Our team leader **Fariba Karimi** was nominated for the **2021 Hedy Lamarr Award** of the City of Vienna, a prize that aims to "recognize Austrian female scientists for their exceptional achievements in the field of information

technology." Our External Faculty member **Roberta Sinatra** received the **Young Scientist Award for Socio- and Econo-physics** of the German Physical Society (DPG), a prize that recognizes "outstanding original contributions that use physical methods to develop a better understanding of socio-economic problems." And, last but not least, CSH President **Stefan Thurner** and our CORONA "media star" **Peter Klimek** received the **2021 Paul Watzlawick Ring of Honor** (one ring each...) from the Vienna Medical Association in October. May the force be with you!

Verena Ahne
Knowledge Transfer & Dissemination

Peter and Stefan with jury president Elisabeth Nöstlinger and Hans-Peter Petutschnig, Deputy Chamber Office Director of the Vienna Medical Association.
© ÄK Wien / Stefan Seelig

VISIONS FOR COMPLEXITY

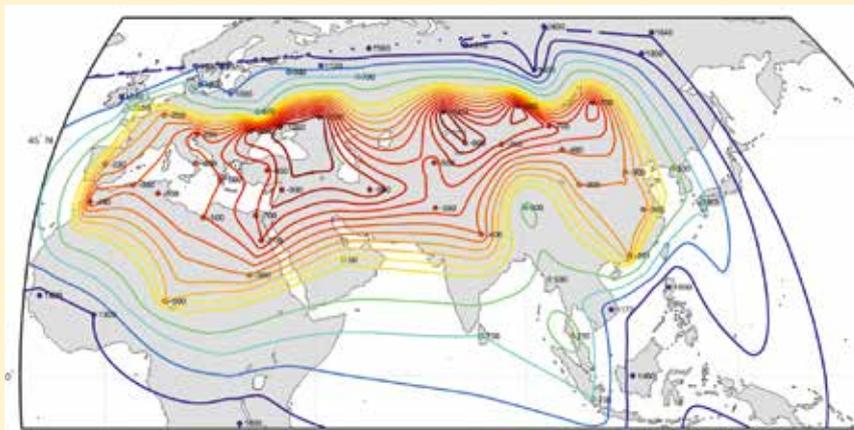## What drove the invention of military technologies?

Big historical data help to understand the evolution of "war machines."

A study just published in *PLoS ONE* had two main goals: "First, we wanted to draw a clear picture of where and when military technologies appeared in pre-industrial societies. Second, we intended to find out why important technologies were developed or adopted in certain places," explains the work's first author **Peter Turchin**.

According to this paper, the strongest influences on the evolution of military technology came from world population size, the connectivity between geographical areas, and advances in critical technologies such as iron metallurgy or horse riding. To the researcher's surprise, state-level factors such as the size of the population, the territory, or the complexity of governance seem not to have played a major role.

study, the researchers show that some military inventions had cascading effects on cultural and social evolution. The invention of the bit and bridle, for example, made it easier to control horses, which led to advances in weapons or the appearance of mounted archers and knights, which again made it necessary to build better fortifications. "We think that this bundle of military technologies was one of the most important factors leading to the rise of mega-empires and of world religions like Christianity, Buddhism, and Islam during the first millennium BCE," Peter points out. Mega-empires are defined as societies with tens of millions of inhabitants and covering millions of square kilometers of territory. According to the Seshat team, they began to appear in different parts of Europe and Asia as part of a process of growing social complexity driven by the connection—and competition—between states with increasingly advanced and dangerous technology.

Questions from the past for our future
Good data, in combination with methods

The study "Rise of the war machines: Charting the evolution of military technologies from the Neolithic to the Industrial Revolution" appeared in October in PLoS ONE.

Signs of massive fraud in Russian elections

The statistical election toolkit developed by Hub scientists indicates huge irregularities in the September Duma elections.

CSH's **Peter Klimek** and **Stefan Thurner** analyzed data from the 2021 Duma elections (Sept. 17–19) in Russia with a statistical forensic toolkit they had published several years ago. They found systematic and highly significant statistical evidence for the presence of ballot-stuffing, i.e., multiple ballots per person during the voting process, and voter rigging: the intimidation and coercion of voters.
Without electoral malpractice, the authors state in a policy brief published in October,
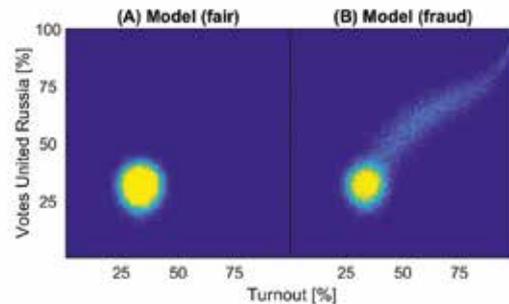
A fair election would lead to a symmetrical vote–turnout distribution (A). To get the shape observed in the 2021 Russian Duma election (B), one has to assume that about 50 % of all electoral districts show an inflated turnout.

The spread of horse-mounted cavalry. Effective horse riding had far-reaching consequences for the evolution of military technologies.

For their analyses, the researchers applied innovative quantitative methods of mathematical modeling and statistical analysis to data from *Seshat: Global History Databank*, a constantly growing collection of historical and archaeological data from across the globe. *Seshat* was developed to distinguish cause and effect in theories of social evolution. To date, it has assembled around 200,000 entries from more than 500 societies, spanning 10,000 years of human history.

Bit and bridle led to mega-empires
"*Seshat* really is a goldmine for the study of cultural evolution," says Peter, who initiated the collection ten years ago. In their new

like the ones used here, offer a fresh perspective on a multitude of open questions, theories, and controversies in various fields, ranging from archaeology, to history, to the social sciences. But a fundamental understanding of social dynamics is not only of academic interest, emphasizes Peter, who leads a team investigating "Social Complexity and Collapse" at the CSH. "We need to know what makes a society thrive or how to recognize early signs of deterioration and societal collapse. Understanding what leads to social transformation and being able to identify 'tipping points' which lead to either the resilience of a society or to catastrophe is crucial for all of us, especially today."

Vladimir Putin's party *United Russia* would have only yielded an overall outcome of around 30 percent—in contrast to the officially postulated 50 percent. Smaller voting stations contributed more considerably to statistical irregularities, which is a strong sign of intimidation and/or ballot-stuffing. "In about half of all voting districts, different degrees of ballot-stuffing have to be assumed to explain the observed statistics," reads the policy brief. "In 49 percent of stations, we find signs for ballot-stuffing."

The CSH Policy Brief 5/2021*, called "Election forensics of the Russia 2021 elections statistically indicate massive election fraud," appeared in October and can be accessed via → www.csh.ac.at/csh-policy-briefs-research-briefs.*

How to manage limited natural resources

What led to the equilibrium in Bali's rice cultivation system? A method from physics helps determine the factors.

Finding efficient ways to jointly manage and optimize water reserves are essential for our future. But how can a well-balanced system be established? To single out relevant parameters, a scientific team including **Stefan Thurner** and **J. Stephen Lansing** (CSH External Faculty) applied a method from physics to a system in equilibrium: the centuries-old rice irrigation practices in Bali. They found that the current equilibrium has self-organized over the course of the past one thousand years, perhaps driven by farmers' conflicting planting schedules.

Balancing conflicting constraints
Balinese rice farmers have always had to deal with two constraints. First, water for paddy irrigation is a limited resource. Intu-

To find patterns in synchronized and unsynchronized farming schedules, the scientists analyzed satellite images of several rice growing regions in Bali and classified which of four characteristic planting patterns—growth, harvest, flood, or drain—occurred when and where. Then they developed a way to relate these patterns to the balance of stresses in Balinese farming.

A formula for an equilibrium
"We present a formula that explains how a balance between water stress and pest stress is realized and how the system eventually reaches an equilibrium," says Stefan. "If the stresses were managed differently, the rice growing regions would look very different from what we observe in reality." It is a razor-sharp balance between different possible states. Just how fast this balance can be lost became apparent in the 1970s, when the so-called Green Revolution made farmers use pesticides and cultivate their paddies without using their traditional ways of synchronization. At first, harvests

increased. But within a few years, farmers reported chaos in water schedules; the number of pests exploded. When too many paddies in higher regions were flooded at the same time, farmers with lower terraces experienced water stress. Disharmony between neighbors grew and disturbed the carefully maintained Balinese culture of social harmony. It was only when the traditional system was reinstated that the equilibrium (mostly) returned.

The paper offers a quite theoretical approach. Yet it could have a practical side in other coupled human–environment ecological systems, Stefan is convinced, as "it allows the relating of easily observable environmental patterns to stress balance and therefore the detection of weak points in their management."

"Bali's Ancient Rice Terraces: A Hamiltonian Approach" appeared in October in the journal Physical Review Letters.

Rice terraces in Bali: A state of equilibrium evolved through efforts to balance water stress and pest stress.
© Shutterstock

itively, one would think that an *unsynchronized* flooding would lead to a fairer water distribution between farmers. Yet, there is also a need to control rice pests such as insects that can easily move between fields. The farmers found out that pest control needs the *synchronized* flooding of neighboring paddies. These two constraints have opposing effects. "The larger the agricultural area that follows the same irrigation schedule, the more water stress appears from the synchronized irrigation cycles," the study reads.

HUB*LiVE*

CSH Public Lecture by Ricardo Hausmann

"The Complexity of Economic Growth"

We are honored to announce that Ricardo Hausmann from the Harvard Kennedy School will give a public lecture live at the Hub.

In his talk, Ricardo will introduce the framework of economic complexity analysis which not only changes how we view the roles of human capital, migration, and foreign direct investment in economic growth, but also helps predict the development trajectories of cities, regions, and countries. Moreover, it offers new answers to old puzzles in economic development: Why did the world experience such rapid economic growth over the past centuries? Why did this growth lead to a massive expansion in inequality in the 18th, 19th, and 20th centuries? Why did this inequality start narrowing

© Harvard University

at the end of the 20th century—and what can we do to support a more inclusive and sustainable growth in the 21st century?

Ricardo Hausmann is the founder and director of Harvard's Growth Lab, one of the most well-regarded and influential hubs for research on international development. Before he joined Harvard University, he was chief economist of the Inter-American Development Bank and Minister of Planning of Venezuela.

→ *CSH Public Lecture:*
Nov. 23, 2021, 5 pm
Registration required!
For your personalized ticket, go to www.csh.ac.at → "News & Events"

UPCOMING

PUBLICATIONS

The comeback of live events at the Hub! These are our next ones:

CSH Talk
Herbert Van de Sompel
→ *"The Web is rotting and what to do about it"*
Nov 10, 2021 | 3 pm–4 pm

Herbert Van de Sompel, a former Los Alamos National Laboratory scientist currently working in The Hague and at Ghent University, will talk about the detrimental effects of when links of web resources break ("link rot") or their content changes ("content drift"). He will assess the extent of these problems for links to web resources in scientific literature by using three vast corpora of publications and a range of public web archives. He will describe the so-called Robust Link approach that offers a proactive, uniform, and machine-actionable way to combat link rot and content drift, and introduce the Robustify web service and API devised to generate links that remain functional over time, with special attention to challenges related to deploying infrastructure that is required to be long-lasting.

CSH Web Talk
Sergey Gavrilets
→ *"Disentangling material, social, and cognitive determinants of human behavior and beliefs"*
Nov 12, 2021 | 3 pm–4 pm

Sergey Gavrilets, University of Tennessee & CSH External Faculty, will live-talk about influences on human decision-making in social situations. Examples are cost–benefit considerations, normative and cultural influences, learning, and conformity with peers or external authorities, as well as dynamically changing personal perceptions of a situation, beliefs about actions and expectations of others, or psychological phenomena such as cognitive dissonance and social projection. Sergey will discuss the results of a long-term experimental economics study—testing, validating, and parameterizing a general model he has developed—within the context of the Common Pool Resources game. The model allows the evaluation and comparison of the importance of different material and non-material factors in both statistical and economically meaningful ways.

CSH Workshop
→ *"Neolithic agricultural productivity and demography estimates"*
Nov 15–16, 2021

The goal of this workshop organized by **Peter Turchin** is to widen the understanding of issues relevant for modeling Neolithic agriculture, before agent-based models with high spatial resolution can be built. After investigating the limitations of modern datasets as the basis of large-scale agricultural productivity estimates, the workshop aims at critically assessing whether current methodologies have technical shortcomings that explain the observed discrepancy among expected population densities. Another focus will be on various agricultural production factors in Neolithic times.

For further talks, workshops, and other events go to
→ www.csh.ac.at/events

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

P. Turchin, et al.
→ Rise of the war machines: Charting the evolution of military technologies from the Neolithic to the Industrial Revolution, *PLoS ONE* (Oct 20) (2021)

Y. Gandica, J.S. Lansing, N.N. Chung,
S. Thurner, L.Y. Chew
→ Bali's Ancient Rice Terraces: A Hamiltonian Approach, *Physical Review Letters* 127 (2021) 168301

T. Reisch, G. Heiler, J. Hurt, P. Klimek,
A. Hanbury, S. Thurner
→ Behavioral gender differences are reinforced during the COVID-19 crisis, *Scientific Reports* 11 (2021) 19241

V. Machàcek, M. Srholec, M.R. Ferreira,
N. Robinson-Garcia, R. Costas
→ Researchers' institutional mobility: bibliometric evidence on academic inbreeding and internationalization, *Science and Public Policy* (2021) scab064

J. Einsiedler, Y. Cheng, F. Papst, O. Saukh
→ Transferable Models to Understand the Impact of Lockdown Measures on Local Air Quality, in: *Proceedings of the 3rd International Workshop on Urban Computing* (UrbCom) (2021)

T.M. Pham, A.C. Alexander, J. Korbel,
R. Hanel, S. Thurner
→ Balance and fragmentation in societies with homophily and social balance, *Scientific Reports* 11 (2021) 17188

B. Monechi, E. Ubaldi, P. Gravino, I. Chabay,
V. Loreto
→ Finding successful strategies in a complex urban sustainability game, *Scientific Reports* 11 (2021) 15765

M. Strauss, T. Niederkrotenthaler,
S. Thurner, A. Kautzky-Willer, P. Klimek
→ Data-driven identification of complex disease phenotypes, Journal of the *Royal Society Interface* 18 (180) (2021) 20201040

A. Pichler, J.D. Farmer
→ Simultaneous supply and demand constraints in input–output networks: the case of Covid-19 in Germany, Italy, and Spain, *Economic Systems Research* (2021)

P. Bello, D. Garcia
→ Cultural Divergence in popular music: the increasing diversity of music consumption on Spotify across countries, *Humanities and Social Sciences Communications* 8 (2021) 182