Giacomo Vaccario

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▬▬▬ Education and key qualifications

2015–2019	**Doctorate of Science**, ***ETH Zürich***, Switzerland.
2015	**ERASMUS+**, ***Universitè Pierre-et-Marie-Curie***, France.
2012–2015	**Msc. in Physics**, ***summa cum laude***, **Università La Sapienza**, Italy.
2011–2012	**MASt in Mathematics**, ***Univesity of Cambridge***, UK.
2008–2011	**BSc. in Physics**, ***Università La Sapienza***, Italy.
2011	**ERASMUS**, ***Queen Mary University of London***, UK.

▬▬▬ Employment

2023–Current   **Senior Researcher**, ***ETH Zürich***, *Chair of Ecosystem Management*, Switzerland.
Responsibilities: Research, supervision, lecturer and proposal writing
Topic: Data-driven models for socio-ecological systems
Group leader: Prof. Jaboury Ghazoul

2015–2024   **Senior Researcher**, ***ETH Zürich***, *Chair of Systems Design*, Switzerland.
Responsibilities: Research, supervision, lecturer and proposal writing
Topic: Data-driven modelling of socio-economic systems
Promotions: PhD (2019), Post-Doc (2021)
Group leader: Prof. Frank Schweitzer

2015   **Research Fellow**, ***Universitè Pierre-et-Marie-Curie***, *LPTMC*, France.
Responsibilities: Research
Topic: Modelling diffusion processes in heterogeneous spatial system
Supervisor: Dr. Julian Talbot

2014   **Data scientist**, *AGT Engineering S.R.L.*, Rome, Italy.
Topic: Data-driven models for consumer behavior in energy grids
Team leader: Ing. Filippo Ugolini

▬▬▬ Projects

2024– Ongoing   **TIMBERHAUS: Climate-smart, circular, and sustainable solutions for use of wood in the construction sector**, *funded by Horizon Europe and SERI*.
Main Contact: Dr. Anders Kjellow

2024– Ongoing   **MainWood: Scaling Up in Wood Construction**, *funded by ETH Board*.
PI: Prof. Dr. Jaboury Ghazoul

2020–2024   **AlpHorn: Signed Relations and Structural Balance: From Data to Models**, *funded by SNF*.
PI: Prof. Dr. Dr. Frank Schweitzer and Prof. Janus Hołyst

2015–2018 **Structure and Dynamics of Collaborative Information Spaces**, *funded by SERI*.
PI: Prof. Dr. Dr. Frank Schweitzer

▬▬▬ Background and experience

I started my career as a physicist and now focus on tackling societal issues, such as the ***emergence and stability of collaboration***, and the ***sustainability and resilience of social, economic, and ecological systems***. My work is grounded in ***systems thinking and complexity***, and I combine this holistic perspective with ***data-driven*** models to provide a ***quantitative understanding*** of the world we live in. I am currently working on the MainWood project, which focuses on developing the scientific foundation for sustainably increasing the use of wood in the construction sector. This involves ***collaborating with stakeholders*** across the entire wood supply chain – from forest managers and sawmills to construction companies – to develop a shared understanding the ***socio-ecological system*** and identify pathways for transitioning to a bioeconomy. In addition to my research, I actively contribute to the academic community as an ***editor*** for Social Network Analysis and Mining, a ***reviewer for for national research foundations and multiple journals***, including EPJ Data Science and Advances in Complex Systems. Furthermore, I have been committed to spreading my research and passion through organizing workshops, teaching courses, and ***guiding over 20 student projects at Bachelor, Master, and PhD levels***.

▬▬▬ Research Achievements

I have a track record of successful scientific output: to date, I have published **23 works** subdivided into **17 peer-reviewed journal articles**, 1 PhD Thesis, 1 patent, 4 pre-print under-review. My work has been recognized as widely **interdisciplinary**, with publications in top journals such as PNAS and Science Advances, and specialized journals in the fields of economics, data science, and complexity. Also, I have been invited to present my work at international conferences and in seminar of top European universities. Below, I grouped relevant publications for the project. In all these publications, I have been prominently involved in the formulation of the scientific idea, work, results, and paper writing. For most papers, there is also an author contribution statement available. Furthermore, I had also a leading and supervising role many of these publications, as they are the result of Master and PhD thesis.

Bridging bottom-up and top-down modelling of socio-economic systems. Social and economic organisations are complex systems whose systemic properties, such as resilience and efficiency, depend on the interactions of their constituting elements [1]. *The properties of these systems can rarely be designed top-down, they instead emerge bottom-up.* Agent-based models offer valuable tools to explore the mechanisms behind the emergence of socio-economic systems and their properties [2]. These models can be calibrated and validated using empirical data [3], enhancing their relevance for real-world applications. Furthermore, they provide regulators and policymakers with quantitative tools to understand the dynamics of socio-economic systems, identify optimal points of intervention, and design policies [4, 5]. These works are examples of my track records in modelling socio-economic systems, showcasing five fundamental skills needed for the project: 1) modelling **interactions of heterogeneous stakeholders** (from individuals to firms, from distributors to central authorities), 2) formalizing **decision-making** of stakeholders, 3) how they interact with available **tangible and intangible resources**, 4) how decision-making and interactions shape the **system dynamics and its emerging properties**, and 5) how to **calibrate and validate models** with empirical data.

[1] Schweitzer, F., Andres, G., Casiraghi, G., Gote, C., Roller, R., Scholtes, I., **Vaccario, G.** & Zingg, C. (2022). Modeling social resilience: Questions, answers, open problems. Advances in Complex Systems, 25(08), 2250014 (doi:

10.1142/S021952592250014X)

[2] Amico, A., **Vaccario, G.**, Schweitzer, F. (2024). Efficiency and resilience: key drivers of distribution network growth. EPJ Data Science, 13(1), 52 (10.1140/epjds/s13688-024-00484-z).

[3] Tomasello, M. V., **Vaccario, G.**, & Schweitzer, F. (2017). Data-driven modeling of collaboration networks: a cross-domain analysis. EPJ Data Science, 6(1), 22.(doi: 10.1140/epjds/s13688-017-0117-5).

[4] Amico, A., Verginer, L., Casiraghi, G., **Vaccario, G.**, Schweitzer, F. (2024). Adapting to disruptions: Managing supply chain resilience through product rerouting. Science Advances, 10(3), eadj1194 (doi: 10.1126/sciadv.adj1194).

[5] Schweitzer, F., Verginer, L., & **Vaccario, G.** (2020). Should the government reward cooperation? Insights from an agent-based model of wealth redistribution. Advances in Complex Systems, 23(07) (doi: 10.1142/S0219525920500186).

Modelling complex multi-agent interactions. Social and economic organizations are composed of heterogeneous actors with diverse interactions. These interactions are rarely limited to two individuals; they often involve multiple actors, requiring methods that go beyond pairwise relationships. This is where hypergraphs come in, modeling group interactions and reproducing patterns like consensus, polarization, or fragmentation [1, 2]. Signed networks further enrich this topic by modeling both positive and negative relations, representing cooperation and conflict. These relations in combination of agent-based models allowed us to model the competing mechanisms arising from status and structural balance, which are prominent theories for the relational changes [3]. This combination also allows for capturing the coexistence of hierarchies and collaboration observed within real-world social network [3]. Note that inferring from data group interactions and signed relations poses significant challenges, and I have co-developed tools to overcome this hurdle [4,5]. These works showcase other three fundamental skills for the success of the project: 1) modelling **complex interactions driving social dynamics**, 2) modelling **hierarchies and its interplay with other mechanisms** and 3) how to **leverage data to empirical inform models**.

[1] Papanikolaou, N., **Vaccario, G.**, Hormann, E., Lambiotte, R., & Schweitzer, F. (2022). Consensus from group interactions: An adaptive voter model on hypergraphs. Physical Review E, 105(5), 054307 (doi: 10.1103/PhysRevE.105.054307).

[2] Papanikolaou, N., Lambiotte, R., & **Vaccario, G.** (2023). Fragmentation from group interactions: A higher-order adaptive voter model. Physica A: Statistical Mechanics and its Applications 630, 129257, (doi: 10.1016/j.physa.2023.129257)

[3] Górski, P., Sulik, A., Andres, G., **Vaccario, G.**, & Hołyst, J. (2024). Co-existence of balance and hierarchies: an ego perspective to explain empirical networks (Under review)

[4] Andres, G., Casiraghi, G., **Vaccario G.**, & Schweitzer, F. (2023). *Reconstructing signed relations from interaction data*. Scientific Reports 13 (1), 20689

[5] Andres, G., **Vaccario G.**, & Schweitzer, F. (2024). *Stochastic Modelling of Hypergraphs: Zero-inflation to counteract the curse of dimensionality*. (ArXiv).

▬▬▬ Supervision and mentoring in complexity and systems thinking

From 2015 to 2024, I made significant contributions and designed courses at ETH Zürich. These include the courses of "System Dynamics and Complexity," "Complex Networks," and "Agent-Based Modeling" offered by the Chair of Systems Design, ETH Zürich, [1] and the course of "Understanding Complexity through System approaches" offered by the Chair of Ecosystem Management [2]. My involvement encompassed creating and delivering lectures and engaging exercise sessions. These activities allowed me to attract many excellent students for their master thesis and semester projects, and a large fraction of them was motivated to continue their academic education with a PhD and are succeeding in this. **I have supervised 20 students at the Bachelor, Master, and PhD levels, with very different break ground from mathematics to environmental science,from physics to management.** I had to guid them through the process of formulating a research question,

developing a research plan, and executing it, keeping a truly **interdisciplinary perspective**. The result of their work reflected an spectacular diversity from conceptual agent-based models of to system dynamic models of fresh waters ecosystem. This exchange of knowledge and experience has been a rewarding experience for me, and I am proud of the achievements of my students. I am currently qualified to supervise Bachelor's, Master's, and PhD students at ETH Zurich.

[1] https://www.sg.ethz.ch/teaching
[2] https://ecology.ethz.ch/education.html

━━━ Other contributions to the academic community

Scientometrics and Informetrics. I am careful and proficient expert of scientometric indicators, i.e., metrics to evaluate the impact of scientific work. I have contributed to the ongoing discussion of the limitations of existing metrics and developed new outlines. In particular, I have developed statistical tools to verify the **fairness of metrics** used to rank publications or scientists, and way **suppress biases in rankings** [1]. Moreover, I have illustrated limitations of existing network-based metrics to rank journals and proposed new ones based on data-driven paradigm [2, 3]. My work has been recognized and published in top journals of the scientometric and informetric community. I have also **organized a satellite and a topical issue** on Success in Science [4], touching important societal issues like gender bias in the scientific community.

[1]**Vaccario, G.**, Medo, M., Wider, N., & Mariani, M. S. (2017). Quantifying and suppressing ranking bias in a large citation network. Journal of informetrics, 11(3), 766-782. (doi: 10.1016/j.joi.2017.05.014)
[2] **Vaccario G.**, Verginer L., *When standard network measures fail to rank journals: A theoretical and empirical analysis.* Quantitative Science Studies, 3(4)
[3] **Vaccario, G.**, Xu, S., Mariani, M. S., & Medo, M (2024). The quest for an unbiased scientific impact indicator remains open. Proceedings of the National Academy of Sciences of the United States of America, 121(41), e2410021121. (doi: 10.1073/pnas.2410021121)
[4] Verginer, L., **Vaccario, G.**, & Petersen, A. M. (2021). Foreword to the special issue on success in science. Advances in Complex Systems, 24(3-4), (doi: 10.1142/s021952592102001x)

Academic services. I have been a strong contributor to the academic community. I have served as reviewer for a national research foundation and multiple journals, including EPJ Data Science and Advances in Complex Systems. Also, I have an editor for Social Network Analysis and Mining, a flagship journal in at the cross section between network, social and computer science. I have been actively involved in the organization of workshops [1, 2] and conferences [3] of complexity and data-science. I am also a member of the Complex Systems Society and of the DPG (German Physical Society), division of socio-economic physics. Many of may works have been presented and discussed at the yearly conference of these communities.

[1] "Signed Relations and Structural Balance" workshop at Conference on Complex System 2022, Palma de Mallorca https://sites.google.com/view/relations-balance-satellite/
[2] "Signed Relations and Structural Balance", ETH workshop organized by the Chair of System Design https://www.sg.ethz.ch/events/workshop-structural-balance-may-2024/
[3] ASONAM 2022 – The 2022 IEEE/ACM International Conference on Advances in Social Network Analysis and Mining https://asonam.cpsc.ucalgary.ca/2022/