



BANCA D'ITALIA  
EUROSISTEMA

AAAI Bridge FINST  
**February 8**, 2023

# BLACK-IT DEMO: CALIBRATING MULTI-AGENT SYSTEMS TO MIMIC FINST REALITIES \*

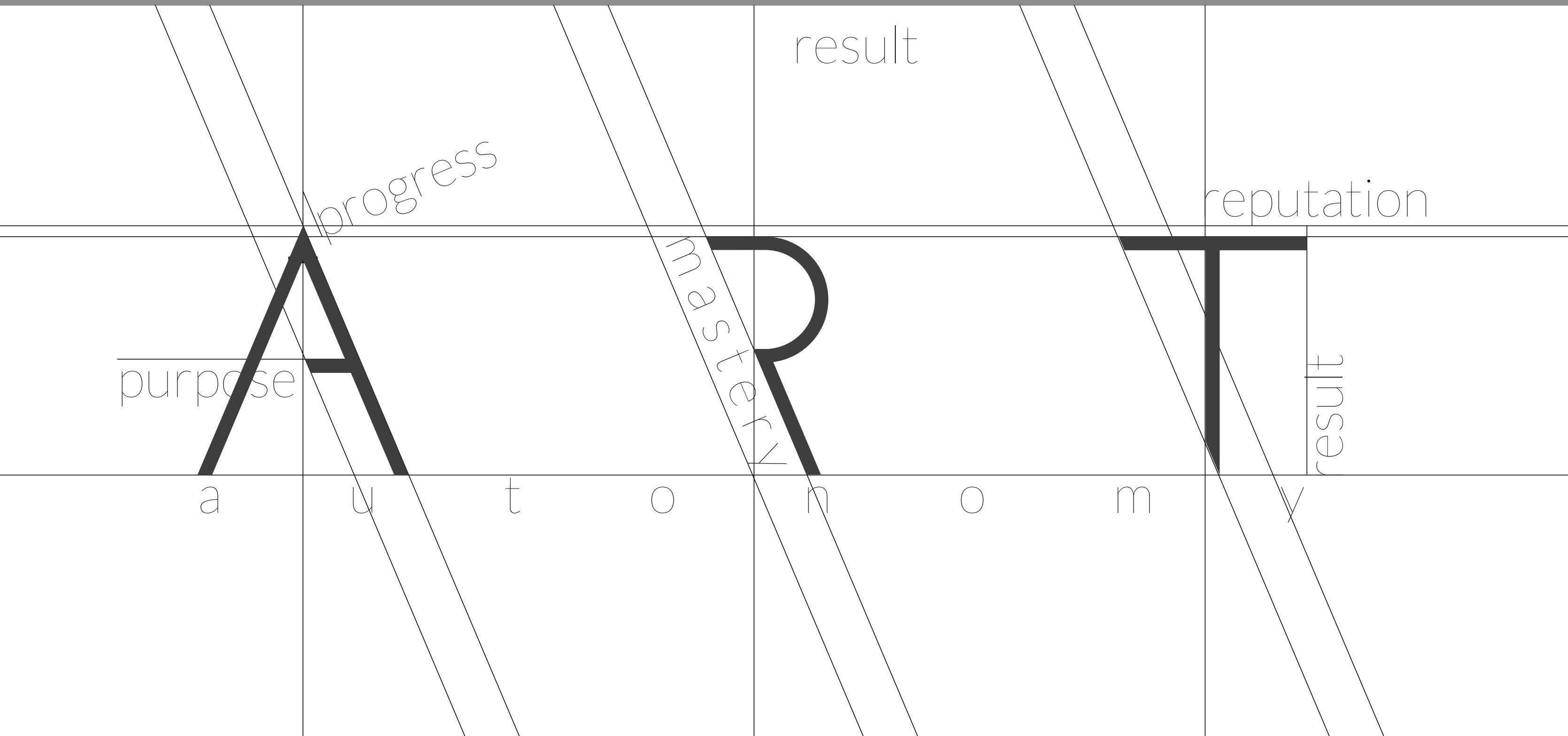
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**Applied Research Team (ART)**

aka "Divisione Ricerca sulle Tecnologie Avanzate - DRTA" (**Bank of Italy**)



# AMBS AND CENTRAL BANKS

ABMs and  
central banks

ABM  
calibration

Key  
features

Extensive  
documentation

High modelling **flexibility**  
Intrinsically **non-equilibrium**

heterogeneity  
bounded rationality

**Complementary** to DSGE modelling

Published on 12 August 2008

Working Paper No. 352  
By Marco Galbiati and Kimmo Soramäki

This paper lays out and simulates a multi-agent, multi-period model of an RTGS payment system. At the beginning of the day, banks choose how much costly liquidity to allocate to the settlement process. Then, they use it to execute an exogenous, random stream of payment orders. If a bank's liquidity stock is depleted, payments are queued until new liquidity arrives from other banks, imposing costs on the delaying bank. The paper studies the equilibrium level of liquidity posted in the system, performing some comparative statics and obtaining: i) a liquidity demand curve which links liquidity to delay costs and ii) insights on the efficiency of alternative system configurations.

An agent-based model of payment systems



2008

No. 686 - Exploring agent-based methods for the analysis of payment systems: A crisis model for StarLogo TNG



Temi di Discussione

(Working Papers)

by Luca Arciero, Claudia Biancotti, Leandro D'Aurizio, Claudio Impenna  
August 2008

Share

2008

Payment systems



Staff Working Paper No. 619  
Macroprudential policy in an agent-based model of the UK housing market

Rafa Baptista, J Doyne Farmer, Marc Hinterschweiger, Katie Low, Daniel Tang and Arzu Uluc

October 2016

No. 1338 - Macroprudential policy analysis via an agent-based model of the real estate sector



Temi di Discussione

(Working Papers)

by Gennaro Catapano, Francesco Franceschi, Michele Loberto and Valentina Michelangeli  
June 2021

2021

Housing market

CANVAS: A Canadian Behavioral Agent-Based Model

by Cars Hommes,<sup>1</sup> Mario He,<sup>2</sup> Sebastian Poledna,<sup>3</sup> Melissa Siqueira<sup>4</sup> and Yang Zhang<sup>2</sup>



INTERNATIONAL MONETARY FUND  
**To Demand or Not to Demand: On Quantifying the Future Appetite for CBDC**

2022-2023

Macro and CBDC

# ABM CALIBRATION

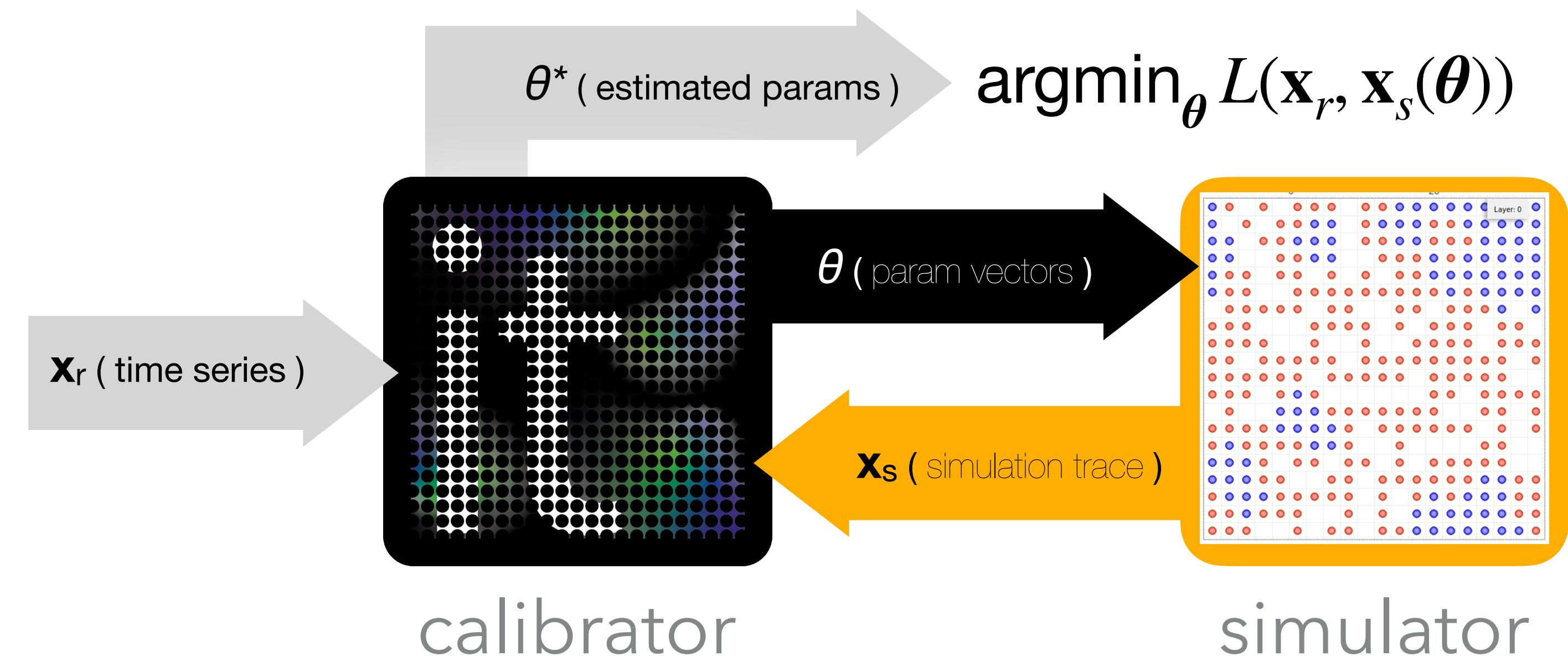
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A software capable of finding the **ABM parameters** that **best fit real data**



# ABM CALIBRATION

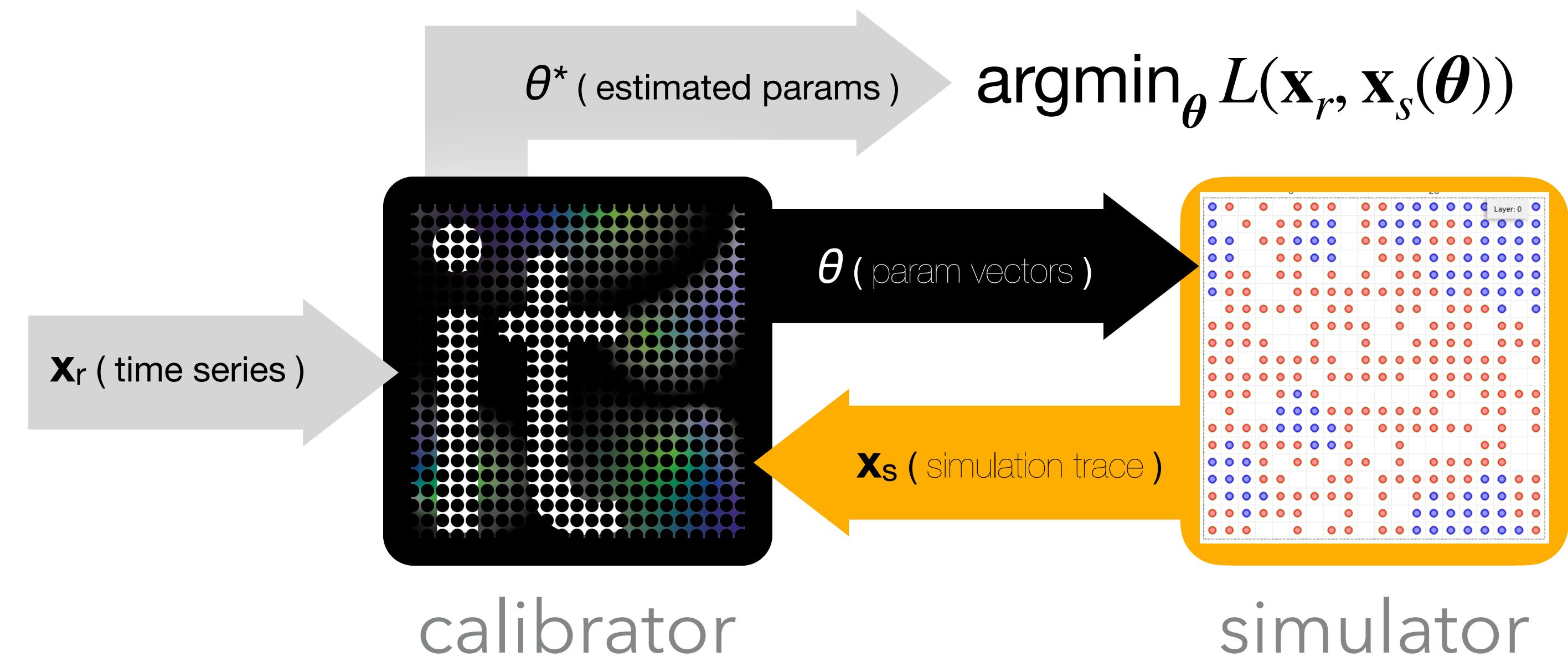
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A software capable of finding the **ABM parameters** that **best fit real data**



In a typical scenario, for **20 free parameters**,  
you would need  $20^{20} \sim 10^{26}$  combinations

# ABM CALIBRATION

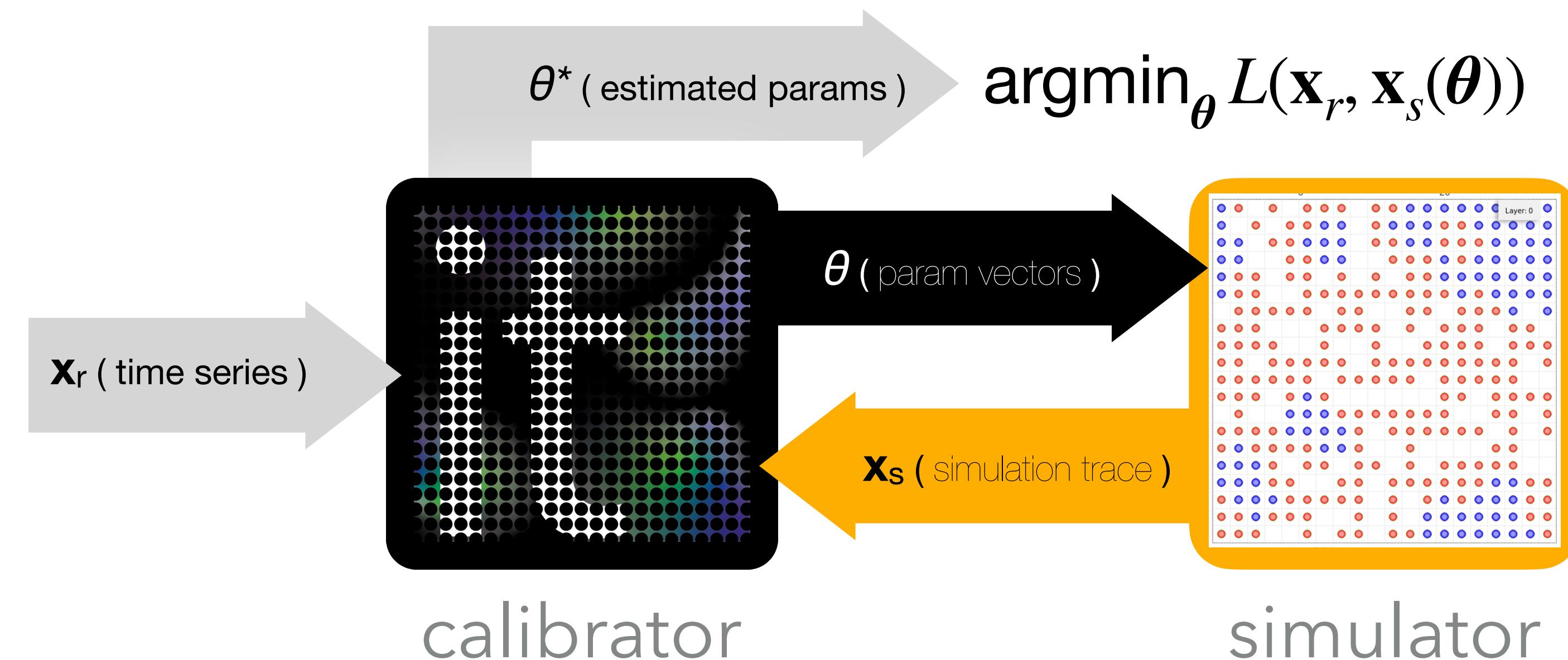
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A software capable of finding the **ABM parameters** that **best fit real data**



👉 Need for efficient calibration strategies

In a typical scenario, for **20 free parameters**, you would need  $20^{20} \sim 10^{26}$  combinations

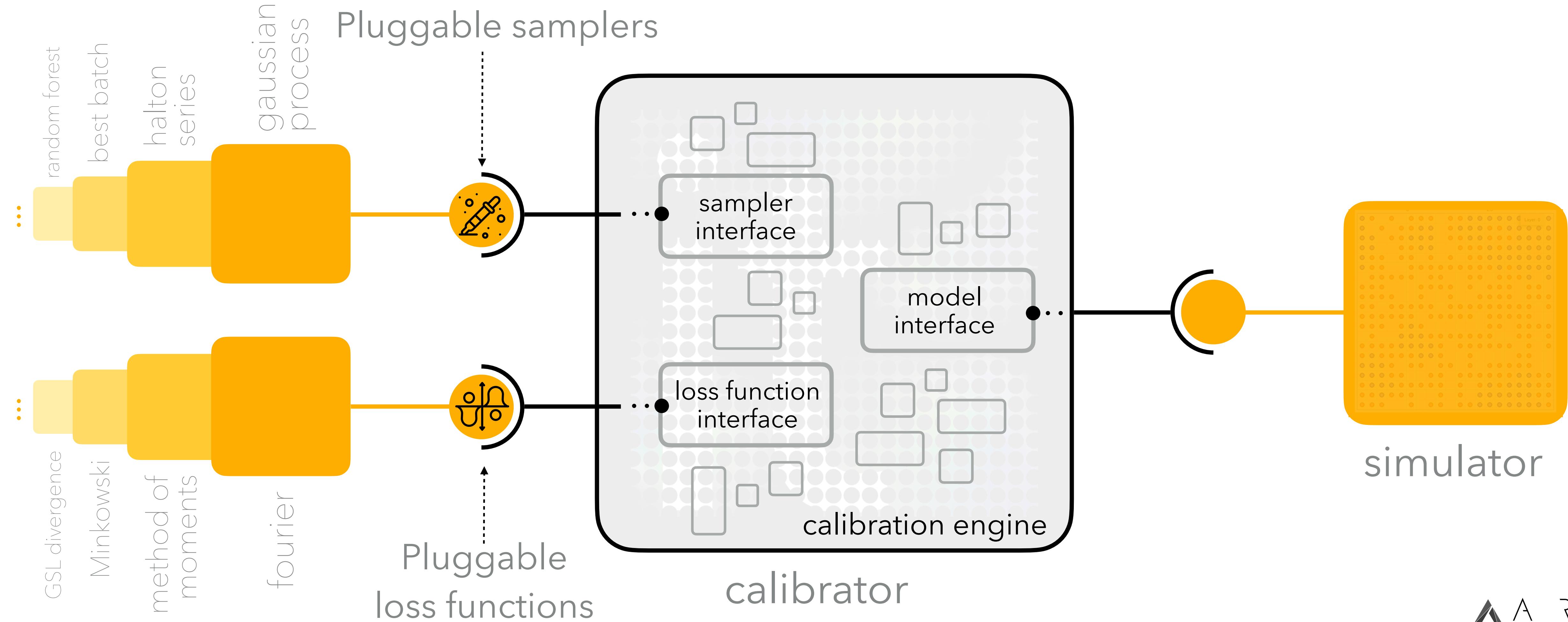
# KEY FEATURES

ABMs and  
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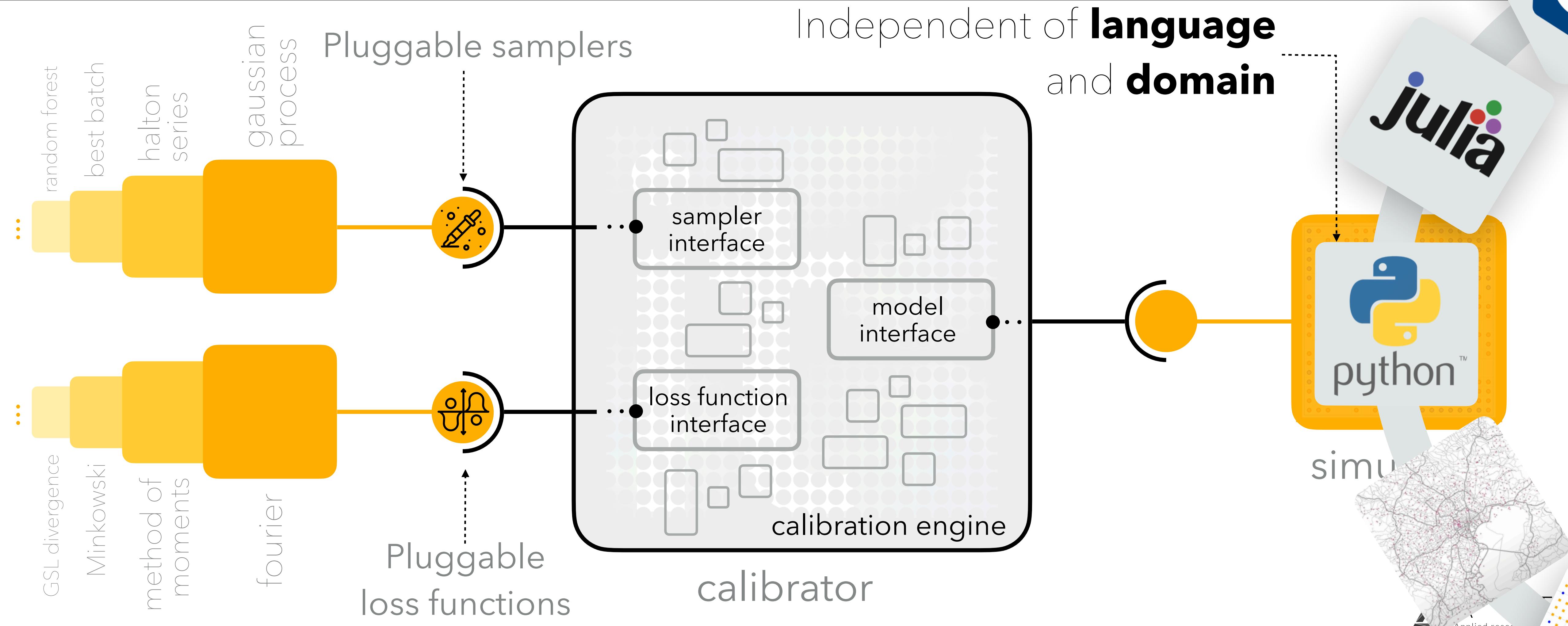
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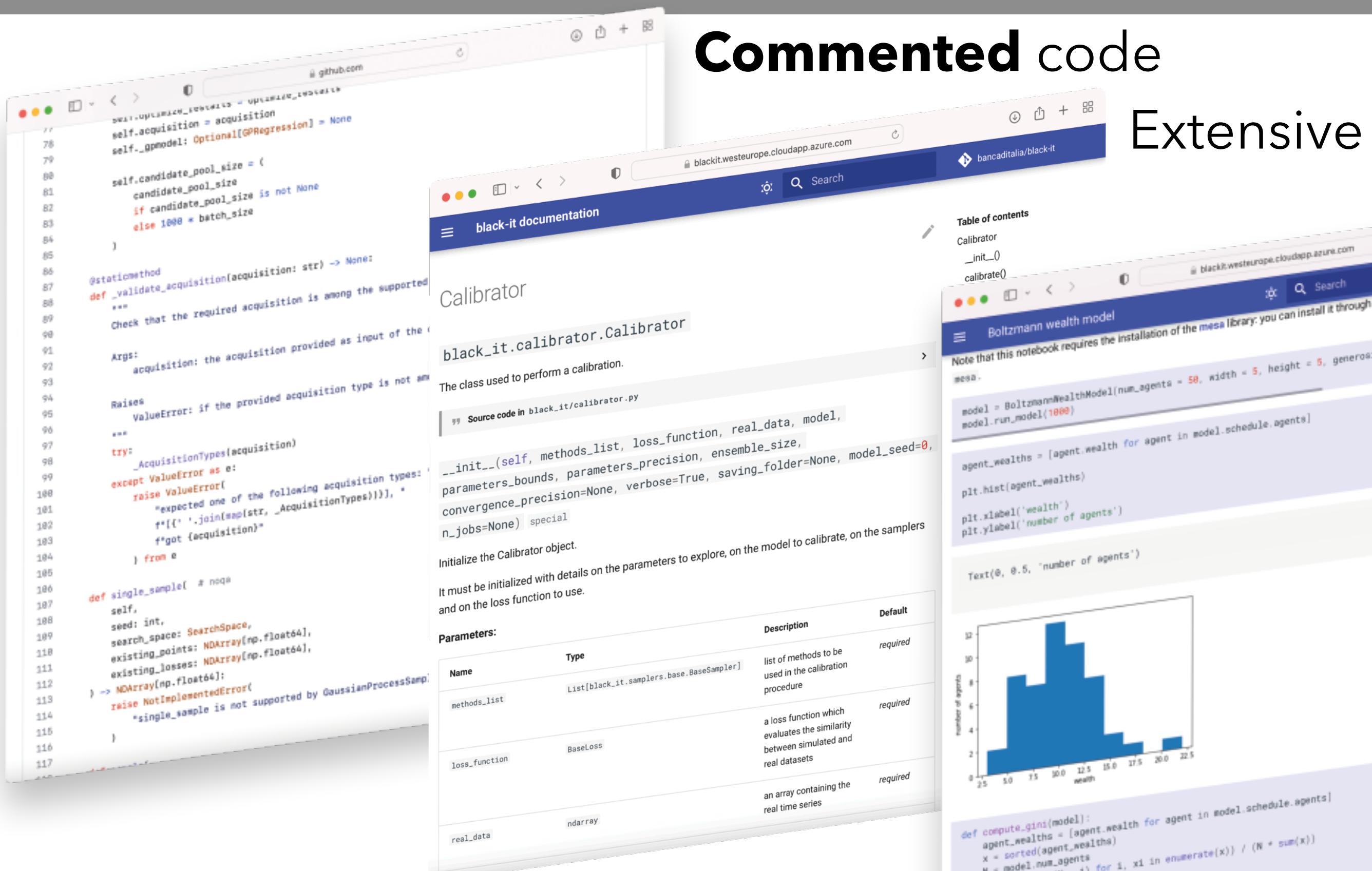
# EXTENSIVE DOCUMENTATION

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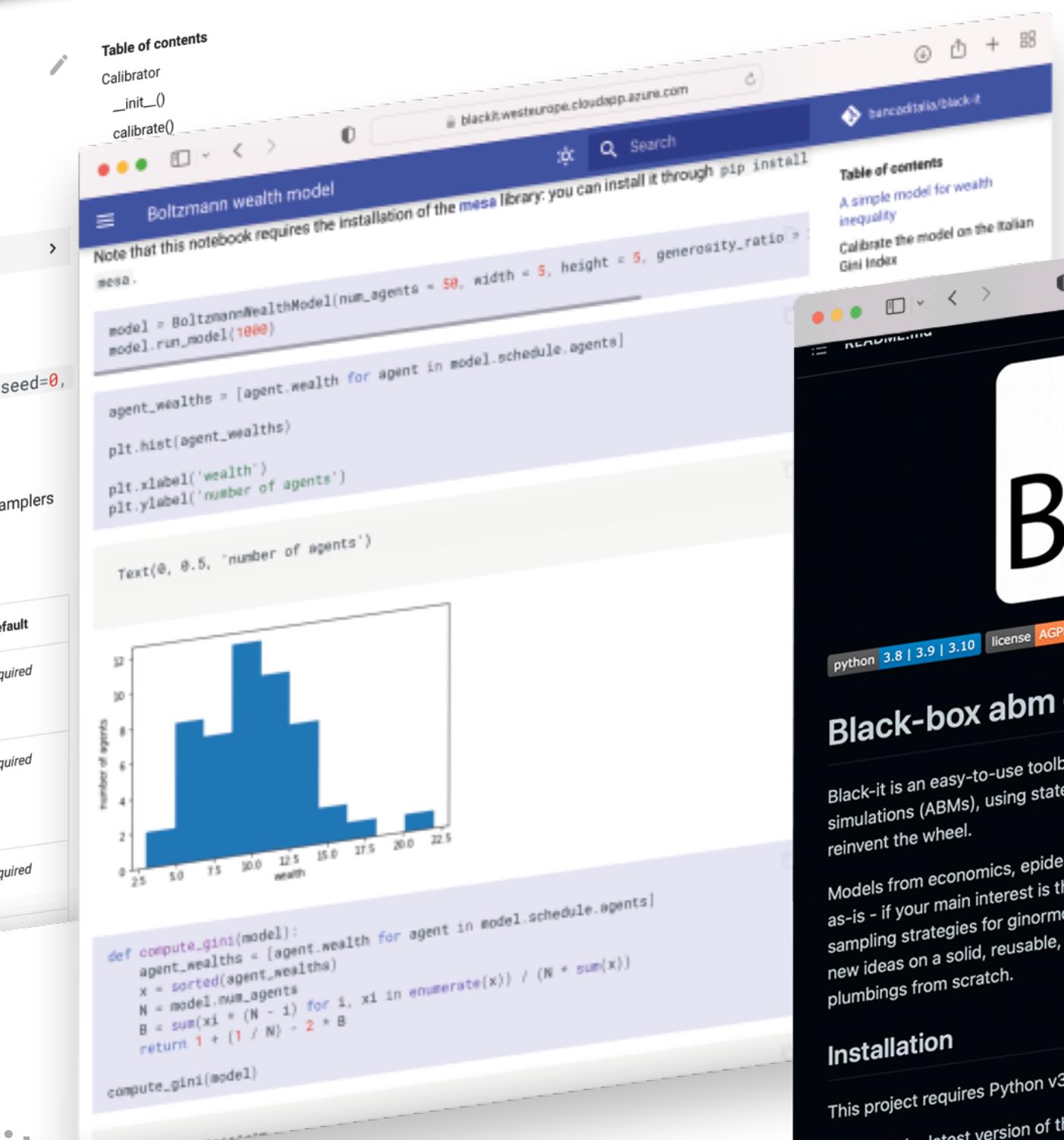


The screenshot shows a GitHub repository page for `black-it/calibrator.py`. The code is well-commented, explaining the purpose of each method and parameter. It includes a table of parameters with their types, descriptions, and default values.

Name	Type	Description	Default
<code>methods_list</code>	<code>List[black_it.samplers.base.BaseSampler]</code>	list of methods to be used in the calibration procedure	<code>required</code>
<code>loss_function</code>	<code>BaseLoss</code>	a loss function which evaluates the similarity between simulated and real datasets	<code>required</code>
<code>real_data</code>	<code>ndarray</code>	an array containing the real time series	<code>required</code>

## Commented code

Extensive online **reference manual**



The screenshot shows a Jupyter notebook cell with Python code for a Boltzmann wealth model. It includes a histogram of agent wealth distribution and a calculation of the Gini coefficient.

```

model = BoltzmannWealthModel(num_agents = 50, width = 5, height = 5, generosity_ratio = 0.5)
model.run_model(1000)

agent_wealths = [agent.wealth for agent in model.schedule.agents]
plt.hist(agent_wealths)
plt.xlabel('wealth')
plt.ylabel('number of agents')

Text(0, 0.5, 'number of agents')

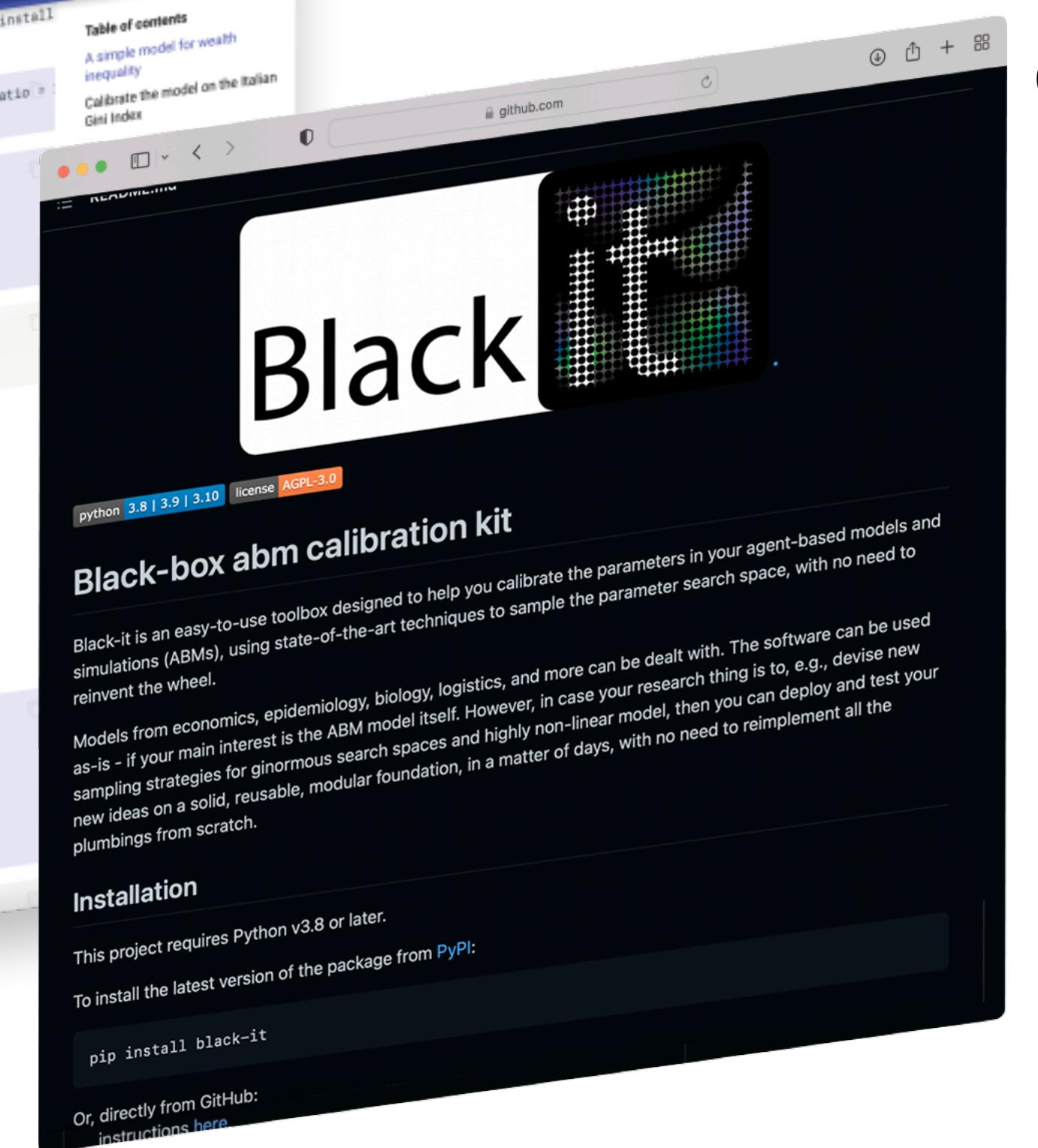
def compute_gini(model):
    agent_wealths = [agent.wealth for agent in model.schedule.agents]
    x = sorted(agent_wealths)
    N = model.num_agents
    B = sum(x[i] * (N - i) for i, xi in enumerate(x)) / (N * sum(x))
    return 1 + (1 / N) - 2 * B

compute_gini(model)

```

Examples and Jupyter **tutorials**

**GitHub** page



The screenshot shows the GitHub page for Black-it. It features a large logo, a histogram of agent wealth, and sections for installation and documentation.

**Black-box abm calibration kit**

Black-it is an easy-to-use toolbox designed to help you calibrate the parameters in your agent-based models and simulations (ABMs), using state-of-the-art techniques to sample the parameter search space, with no need to reinvent the wheel.

Models from economics, epidemiology, biology, logistics, and more can be dealt with. The software can be used as-is – if your main interest is the ABM model itself. However, in case your research thing is to, e.g., devise new sampling strategies for ginormous search spaces and highly non-linear model, then you can deploy and test your new ideas on a solid, reusable, modular foundation, in a matter of days, with no need to reimplement all the plumbing from scratch.

**Installation**

This project requires Python v3.8 or later.  
To install the latest version of the package from PyPI:

```
pip install black-it
```

Or, directly from GitHub: [instructions here](#)

► **GitHub** page: [github.com/bancaditalia/black-it](https://github.com/bancaditalia/black-it)

► **Documentation** page: [bancaditalia.github.io/black-it/](https://bancaditalia.github.io/black-it/)



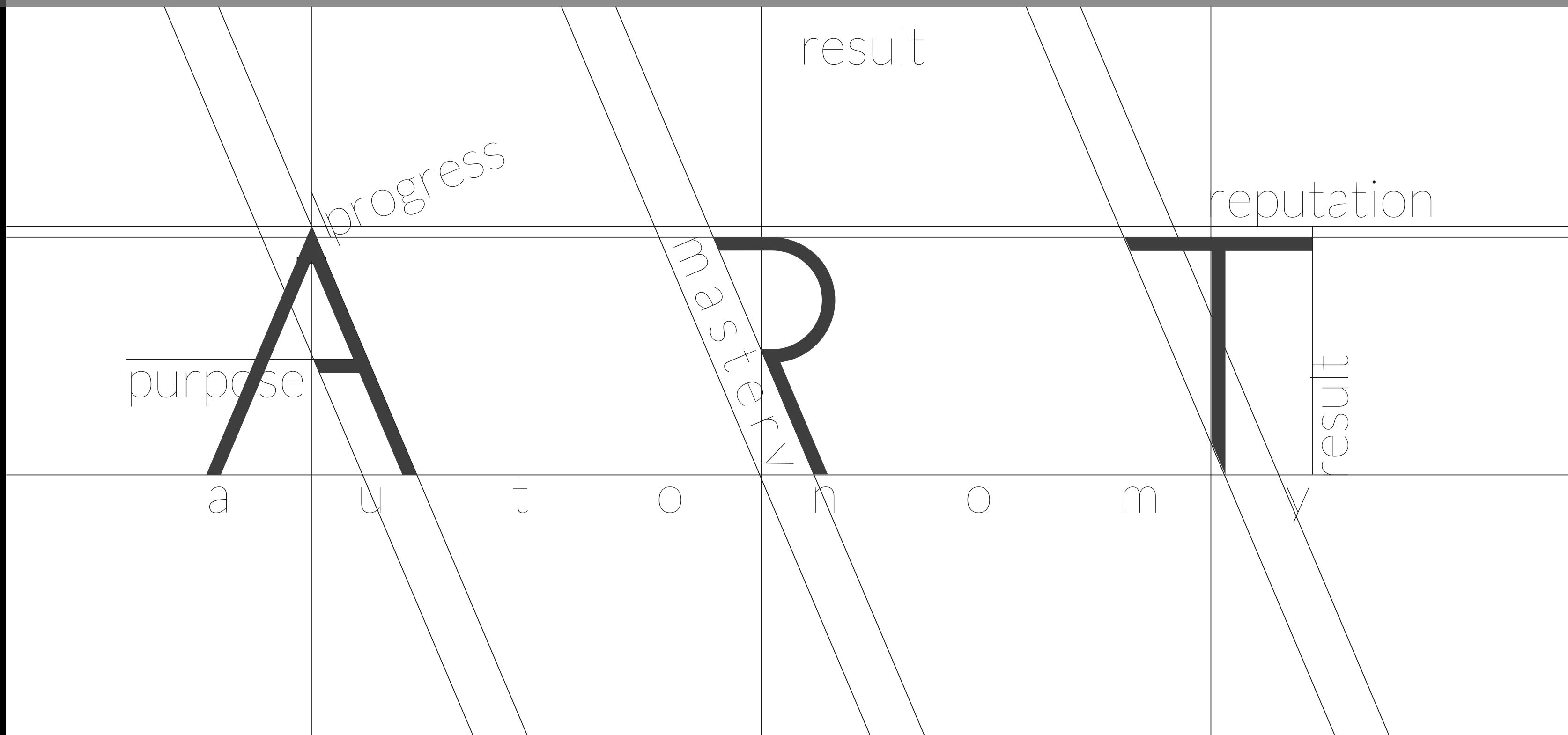
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**Thank you for your attention!**

Time for a **Q&A** session: Any **Question**?



\*All views and opinions are those of the speaker(s)  
and do not necessarily reflect the position of Bank of Italy