

# Modern Tools for Agent-Based Model Sensitivity Analysis

Matteo Ottaviani<sup>1</sup>, Francesco Lamperti<sup>2,3</sup>, Amir Sani<sup>2,4</sup>, Andrea Roventini<sup>2,5</sup>

<sup>1</sup> Scuola Normale Superiore, Pisa [matteo.ottaviani@sns.it](mailto:matteo.ottaviani@sns.it)

<sup>2</sup> Institute of Economics, Scuola Superiore Sant'Anna, Pisa

<sup>3</sup> Fondazione Eni Enrico Mattei, Milano

<sup>4</sup> Simudyne Ltd, London

<sup>5</sup> OFCE - Sciences Po, Nice

Since the eighties of the last century, agent-based modeling has become both a complement and a substitute for more traditional economic-modeling methodologies. In macroeconomics, for example, agent-based models (ABMs) are nowadays considered as a valid and effective competitor of standard Dynamic Stochastic General Equilibrium (DSGE) models [1]. Likewise, ABMs of financial markets are often considered better than traditional models based on the efficient-market hypothesis in explaining the statistical properties of buy-and-sell high-frequency dynamics [2].

Sensitivity analysis (SA) constitutes an open challenge for ABMs in economics and finance. SA is central to effective model design and intuitive evaluation, where one aims to rank parameter importance when explaining output variance or "sensitivity" to changes in the input parameters (or initial conditions) of the model. This sensitivity to input parameters represents a response for how the model (approximately) behaves when input parameters are changed. Understanding the models response to (possibly joint) changes in parameter values forms the basis for assessing model robustness and drawing robust implications from policy exercises [3]. Unfortunately, as ABMs become more realistic, they require an increasing number of parameters. This results in highly prohibitive computational costs when assessing ABM sensitivities. Surrogate meta-models offer a solution to this computational burden [4].

We propose a wide sensitivity analysis of the Brock and Hommes asset-pricing model [5] and the Franke and Westerhoff limit-order book model [2] directly and on a variety of surrogate meta-models using two well-known approaches to SA and a recently introduced game-theoretic algorithm for "model explanation" from the machine learning literature.

Novel methods for assessing the importance of each parameter in explaining both the variance and some moment-independent measures of the output are performed [6; 7]; they are as well compared to other ones previously employed (in literature) with the same purposes [8]. In particular, it's shown the output response of the two models employed varying one or more parameters through SA methods (e.g. first and second orders Sobol's indices); moreover, it's highlighted how changing bounds can heavily impact the sensitivity analysis and how the modeler can use their intuition for how the sensitivity should rank to find bounds that reflect this. Furthermore, it's debated how variation plots can be used to show how a user can work with a proper agreed calibration in exploring specific parameter variations.

In the end, it is proposed a computationally cheap and very effective procedure to follow, for macro and financial agent-based models, in order to obtain reasonable and meaningful outputs and, in particular, combining them with calibrating features in all-in-one way. Moreover, a useful and quick cost function is shown as well. The effective tools presented for tuning parameters are crucially worthwhile in a policy-making perspective. The paper particularly focus on failures and positive aspects of global sensitivity measures compared to local ones; steady and non-steady state regimes analysis is performed. Global against Local SA comparison is performed and the use-cases where they are useful and when they fail is correctly explained.

## References

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