

Combining Agent-Based and Input–Output Modeling in Economics: The Multi-Agent Input–Output (MAIO) Framework

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1. The research question

Understanding how investment shocks propagate through the economy and affect heterogeneous agents requires modeling tools that simultaneously capture inter-sectoral interdependencies, behavioral heterogeneity, and endogenous demand formation. Input–Output (IO) analysis provides a rigorous accounting structure for tracing how an exogenous demand impulse activates upstream supply chains and generates multiplier effects on output, value added, and employment. However, IO models usually treat final demand as exogenous and describe average sectoral behavior, abstracting from heterogeneous decisions of firms and households. Agent-Based Models (ABMs), conversely, represent bounded rationality, heterogeneous strategies, and out-of-equilibrium dynamics, yet often lack the sectoral accounting discipline ensuring consistency between production, intermediate consumption, and final demand. This tension is especially acute for structural transformation policies—such as the energy and digital transitions—where capital investment shocks propagate through production networks while distributive consequences depend on the behavioral responses of diverse agents.

Recent work has explored partial integrations of these traditions, however, to the best of our knowledge, no framework fully integrates inter-sectoral IO accounting with a multi-agent structure featuring heterogeneous households, endogenous demand, and empirical calibration on harmonized IO tables—a combination necessary to trace the chain from investment impulse to sectoral propagation to distributive outcomes.

2. The method used: the MAIO framework

The Multi-Agent Input–Output (MAIO) framework addresses this gap by embedding an agent-based architecture within a fully calibrated IO accounting structure. It extends the multi-sector agent-based model by Noddu et al. (2025), which demonstrates analytically and computationally that aggregated-agent representations fail when shocks trigger structural regime shifts. The MAIO model anchors this agent-based engine to real-world inter-industry data from multi-regional IO databases such as EXIOBASE or Eurostat Supply-and-Use Tables.

The model populates this IO structure with multiple types of agents. Firms, one per sector, each own a Kind-of-Activity Unit (KAU) that plans output on the basis of demand expectations, purchases intermediate inputs according to technical coefficients, invests in capital goods, and hires labor. Multiple heterogeneous household groups, stratified by income and wealth, determine consumption endogenously: each group computes its spending budget as a function of disposable income and the gap between current and target wealth-to-income ratios, with differentiated propensities calibrated on survey data. A government collects taxes and provides transfers; a banking sector supplies credit; and a Rest of the World agent represents foreign trade. Production follows a Leontief technology, and all monetary flows are tracked within a stock-flow consistent framework ensuring that every monetary unit spent by one agent is received by another and that financial stocks evolve consistently with flows.

3. The novelty of the research

Endogenous demand formation is the key methodological departure from standard IO analysis. Incomes generated along supply chains—wages, profits, dividends, transfers—feed back into household consumption, which activates further inter-sectoral demand through the technical coefficients. This creates a genuine income-expenditure multiplier operating within the IO production

network, a channel that traditional IO captures only by assuming exogenous spending profiles. Moreover, firms adjust production plans, inventories, and investment in response to observed demand, generating endogenous business-cycle dynamics and potential rationing episodes absent from equilibrium-based approaches.

The MAIO framework is designed to address a broad class of policy-relevant questions where sectoral propagation and distributive effects are jointly important. Natural applications include: the assessment of large-scale public investment programs (energy transition plans, infrastructure packages, industrial policy), where the analyst traces how capital expenditure shocks propagate through supplier industries and how resulting income flows affect heterogeneous households; the evaluation of structural change scenarios, such as the progressive substitution of fossil-fuel electricity with renewable sources, incorporating time-varying technical coefficients and demand reallocation.

Nieddu, M., Raberto, M. & Teglio, A. (2025). The importance of being many: dynamics, interactions and aggregation in a multi-sector economy. Available at SSRN: <http://dx.doi.org/10.2139/ssrn.5564190>