From micro to meso to macro and back: combining agent-based-modeling and input-output analysis

Topic: Agent-Based Modeling and Input-Output Analysis - I
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This paper discusses the limitations of a static and asymptotic approach used in standard input-output models and in the recent strand of literature on production networks (Acemoglu et al., 2012; Carvalho and Tahbaz-Salehi, 2019) to investigate the influence of the topology of input-output networks on the transmission of shocks and the build-up of macroeconomic volatility.

We present a micro-founded dynamic model in which aggregate volatility materializes in a genuinely dynamic sense and shock emergence and propagation are endogenous processes. This is accomplished through the use of agent-based modeling, which simulates the interactions of boundedly rational and heterogeneous entities in order to produce out-of-equilibrium dynamics. The model takes into consideration the endogenous production of shocks, disequilibrium, and aggregate volatility, as well as processes of convergence toward equilibrium.

We employ computational methods. We numerically apply our model and use Monte-Carlo simulations to examine its characteristics. This is how agent-based algorithmic economics typically operates (see LeBaron and Tesfatsion, 2008). However, the hybrid character of our model is a significant innovation. As is typical in the agent-based literature, some of the dynamics are defined by behavioral rules and local interactions. Other dynamics are defined in a more axiomatic manner by assuming some kind of efficiency, and they are then implemented as solutions to linear programs. This enables us to abstract away from the specifics of processes whose time scale or magnitude are below those of interest in the model, thereby lowering the number of free parameters (this perspective on time scales is akin to the one leading to subscale parameterization in climate modeling, see Edwards, 2010). However, this strategy requires resolving significant and challenging network optimization issues. As a result, it brings up the problem of computational capacity in the context of agent-based computational economics for the first time that we are aware of. Even though none of the simulations presented in this paper involve a sizable number of industries or businesses, they all needed months of computation time.

Unlike most ABM approaches, our model is fully calibrated. Specifically, the model is based on micro and macro data from national accounts, sector accounts, inputâ€“output tables, government statistics, census data, and business demography data. The model parameters are either taken directly from data or are calculated from national accounting identities.

The results confirm the influence of the topology of the production network on aggregate volatility and establish a strong connection between disequilibrium and aggregate volatility, which is absent in input-output and standard production network models.

Our model also identifies financial constraints as an endogenous route to disequilibrium, which impairs the local functioning of markets and generates endogenously micro-economic shocks from which aggregate volatility can emerge. The presence of credit networks and the positive feedback between financial fragility and financial constraints foster the propagation of financial shocks (Delli Gatti et al., 2010; Battiston et al., 2012).

The paper contributes to the literature on the origins of aggregate fluctuations (Bak et al. 1993; Gabaix, 2011) by grounding existing results on the non-diversification of shocks in a dynamical

setting with heterogeneous interacting agents and allowing for the endogenous generation and propagation of shocks via bankruptcies, defaults and network-based financial accelerator mechanisms. The presence of credit networks and the positive feedback between financial fragility and financial constraints foster the propagation of financial shocks.