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The dynamics of leverage in a demand-driven model with heterogeneous firms☆

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ABSTRACT

This paper introduces heterogeneous microeconomic behavior into a demand-driven macroeconomic model in order to study the joint dynamics of leverage and capital accumulation. By identifying the links between firm level variables and aggregate quantities, the paper contributes toward a reformulation of the Minskyan formal analysis that explicitly considers the role of microeconomic factors in generating macroeconomic instability. The aggregation of heterogeneous agents is not only performed numerically, as in traditional agent-based models, but also by means of an innovative analytical methodology, originally developed in statistical mechanics and recently imported into macroeconomics. The distinctive feature is in that the joint analysis of the numerical and analytical solutions of the model sheds light on the effects of financial fragility at the firm level on the dynamics of the macroeconomy. In particular, the analysis of steady-state and stability properties of the system provide additional insights on the role of behavioral and size heterogeneity of firms for the stocks of aggregate debt and capital.

1. Introduction

The 2008 financial turmoil itself, and the process of de-leveraging by the private sector observed in the following years, have drawn the attention to the crucial role of credit as a factor leading both to the instability of the system and to a strengthening of real-financial linkages in the economy. This view, which was central to the work of Hyman Minsky, is also supported by the vast historical evidence presented in Schularick and Taylor (2012), which highlights that credit booms tend to be followed by deeper recessions when compared to other financial crises episodes.

A formal investigation of these phenomena from a Minskyan standpoint requires the integration of the financial and economic systems in a demand-driven macroeconomic model. A seminal formalization of a Minsky crisis generated by self-fulfilling expectations was made by Taylor and O'Connell (1985) using a Kaleckian model, but without dealing explicitly with the role of debt. Delli Gatti et al. (1993) and Fazzari et al. (2008), among others, have used aggregative dynamical models to represent the interaction between business debt and aggregate fluctuations, while Chiarella and Di Guilmi (2011) and Lima

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and Meirelles (2007) introduced a micro-level analysis that explicitly considers leverage heterogeneity.[1] An alternative, which has received renewed attention after the crisis (Khalil and Kinsella, 2011; Bezemer, 2010), builds on the traditions of Tobin (1969) and Godley and Lavoie (2007) to take into account all flows of income between sectors in the economy, as well as their accumulation into financial and tangible assets in a Keynesian setup. Besides allowing for formal Minskyan analyses of corporate debt and financial fragility (Dos Santos, 2005), the so-called Stock-Flow Consistent (SFC) models have recently been used to study the macroeconomic effects of shareholder value orientation and financialization (Van Treeck, 2009), household debt accumulation (Kim and Isaac, 2010), and other related issues.

The traditional limitation of this type of models, however, is that of dealing with economic behavior only in aggregative terms, thus excluding the heterogeneity of agents as a source of financial instability. The relevance of a microeconomic analysis in modeling financial fragility was stressed by Minsky himself: "*an ultimate reality in a capitalist economy is the set of interrelated balance sheets among the various units*" (Minsky, 2008, 116). Taylor and O'Connell (1985) remark that "*shifts of firms among classes as the economy evolves in historical time underlie much of its cyclical behavior. This detail is rich and illuminating but beyond the reach of mere algebra*". It is thus for understanding the economy as an "out-of-equilibrium" system while allowing for heterogeneous microeconomic behavior, that the literature based on the so-called agent-based models (ABMs) has proven to be so useful for the analysis of financial instability (Delli Gatti et al., 2005, 2010; Dosi et al., 2013, among others). The numerical methods allows for a higher degree of complexity in the model, at least to a certain extent,[2] while keeping track of the evolution of the single agents. Nevertheless, for using a fully bottom-up approach, this type of models often lack a clear macroeconomic closure and are hard to connect to other macro analyses.

The starting point of this paper is to see agent-based, SFC and, more generally, Keynesian–Kaleckian macroeconomic approaches as complementary in their understanding of the crucial role of real-financial linkages for the instability of the economic system, as well as its macroeconomic dynamics.[3] Moreover, from a methodological point of view, we aim to enhance the standard analysis the SFC and ABM approaches, which fully relies on numerical and computational solutions, in order to clearly identify the relationships between macro and micro-variables, as well as the causality links within the system.

In order to provide a few analytical insights that will add to the numerical simulations of the model, we perform an aggregation of heterogeneous agents by means of an innovative analytical methodology originally developed in statistical mechanics and recently imported into macroeconomics (see Alfarano et al., 2008; Aoki and Yoshikawa, 2006; Di Guilmi, 2008; Foley, 1994; Landini et al., 2014; Weidlich, 2000, among others). This modeling approach builds from the idea that, as the economy is populated by a very large number of dissimilar agents, an analytical model cannot keep track of the conditions of every single agent at each point in time. As Aoki and Yoshikawa (2006) remark: "*the point is that precise behavior of each agent is irrelevant. Rather we need to recognize that microeconomic behavior is fundamentally stochastic*." Therefore, a microfounded analytical model should look at how many agents are in a certain condition, rather than at which agents, and represent their evolution in probabilistic terms. This approach is particularly suitable to microfound macroeconomic models, since it is able to endogenously derive the macro-equations and the dynamics of flows from the microeconomic behavioral rules, without imposing ad-hoc constraints.

Hence, the contributions of this paper are basically three. The first is mainly methodological, and consists in the integration of the numerical and analytical solutions of an ABM, further developing the insights provided by Chiarella and Di Guilmi (2011) who show that the master equation solution can replicate the results of the simulations of a multi-agent model. Here we take the integration of the numerical and analytical approaches a step further, using the steady state solution of the analytical model to investigate and explain the outcomes of the Monte Carlo numerical simulations. Besides helping us opening the "black box" of the simulations, the analytical approach allows for a few generalizations and a better assessment of the role of heterogeneity in levels and dimensions in relation to a more homogeneous microeconomic setup.

The second contribution, also methodological, concerns the innovative approach to the microfoundation of stock-flow consistent modeling. The macro-equations of the aggregate model are here generated endogenously in a bottom-up approach, starting from the behavioral equation for agents. Consequently, the steady-state analysis is able to assess the impact of the balance sheet structures of firms on the macroeconomy.

The third contribution is to explore micro and macroeconomic aspects leading to the emergence of short-run fluctuations and long-run instability of the economic system. In particular, the paper shows how the diverse financial structures of firms can determine the evolution of the economy, as stressed in Minsky's narrative. As the objective is not to fully represent the behavior of any particular economy over time, but rather to provide a few methodological and theoretical insights for the analysis of leverage and financial instability, the model we present is particularly simple and stylized, but it is still able to point toward the usefulness of the method for more realistic settings.

[1] See Chiarella and Di Guilmi (2012) and Lavoie (2009) for more exhaustive surveys of the Minskyan formal analysis.

[2] Lengnick (2013), among others, warns about the risk that in large ABMs the causal chain of events and the connections between the micro and the macro dynamics may become hard to identify.

[3] Such complementarities are clear in Godin and Kinsella (2012), which combines the two approaches in a study of the interaction of banks and firms in the leverage cycle. A dynamic micro-macro analysis is also developed in the work by Dosi et al. (2013), which builds an agent-based Keynesian model for the study of interactions between income distribution and monetary and fiscal policies.