Research in International Business and Finance 30 (2014) 312–335

Contents lists available at ScienceDirect

Research in International Business and Finance

journal homepage: www.elsevier.com/locate/ribaf

Social networks, social interaction and macroeconomic dynamics: How much could Ernst Ising help DSGE?

Shu-Heng Chen[a,*], Chia-Ling Chang[a], Yi-Heng Tseng[b]

[a] AI-ECON Research Center, Department of Economics, National Chengchi University, Taipei 116, Taiwan
[b] College of Management, Yuan Ze University, Chung-Li 32003, Taiwan

A R T I C L E I N F O

Article history:
Received 25 February 2012
Accepted 6 August 2012
Available online 23 August 2012

JEL classification:
C02
C73
D64

Keywords:
New Keynesian DSGE (dynamic stochastic general equilibrium) model
Adaptive belief system
Social network
Ising model
Market sentiment

A B S T R A C T

In this paper, two different versions of the agent-based DSGE (dynamic stochastic general equilibrium) model are studied in comparison The first version is the mesoscopic modeling of market sentiment using the Brock–Hommes adaptive belief system (ABS). The second version is the microscopic modeling of market sentiment by applying the Ising model to different social networks. The issue is to examine whether the distribution of market sentiment generated by the ABS machine can emerge from some kinds of local mimetic interactions, and hence the macroeconomic behavior of the two versions will be essentially the same. Our simulation results show that it is rather hard to have the equivalence of these two versions in the Kolmogorov–Smirnov sense. Hence, directly incorporating social networks and social interactions into microscopic modeling has its own values and may not be replaced or simplified by the mesoscopic counterpart.

1. Motivation

The New Keynesian DSGE (dynamic stochastic and general equilibrium) models have been widely used by central banks for policy analysis; however, despite this dominant position in macroeconomics, the DSGE model has received intensive criticisms during and after financial crises (Colander et al., 2008; Colander, 2010; Solow, 2010; Velupillai, 2011). Partially motivated by these criticisms, some modified or extended versions are, therefore, proposed. In actual fact, one recent form of progress

* Corresponding author.
E-mail address: chen.shuheng@gmail.com (S.-H. Chen).

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http://dx.doi.org/10.1016/j.ribaf.2012.08.004

associate with the DSGE model is that it has been endowed with the three most criticized missing elements, namely, bounded rationality, heterogeneity and interactions (Orphanides and Williams, 2007; Branch and McGough, 2009; Milani, 2009; Chen and Kulthanavit, 2010). More specifically, one major implementation has been to introduce the adaptive belief system (Brock and Hommes, 1997, 1998) to the DSGE model and attempts to formulate the DSGE model in the agent-based fashion (Bask, 2007; De Grauwe, 2010a,b; Lengnick and Wohltmann, 2010; Assenza et al., 2011).

The adaptive belief system (ABS) is basically a stochastically discrete choice model. Unlike the normal discrete choice model which is to be applied to each individual, the ABS machine is used to describe the evolution of the mesoscopic structure of individuals. For example, in a two-type agent-based model (Chen et al., 2012), it is used to model the fractions of fundamentalists and chartists or the factions of optimists and pessimists.

However, in using the agent-based model, one can actually go down one level further and model the social interaction at the individual level with an explicitly embedded social network. If we do so, very naturally, we will encounter the consistency issue, i.e., whether the mesoscopic structure as described by the ABS machine can be generated bottom up. This inquiry is related to Kampouridis et al. (2011, in press), who use genetic programming and self-organizing maps to generate a mesoscopic structure of traders (fractions of different types of traders) bottom up, and is even more closely related to Chen et al. (2010), who use agent-based financial market simulation to show that the well-known *elasticity puzzle* is mainly a result of the micro-macro inconsistency.

In this paper, we study the possible effects of the social network and social learning on the *distribution of market sentiment* (optimism vs. pessimism), also called *fraction distribution* (Chen et al., 2012), within the context of a stylized New Keynesian DSGE model.[1] We want to examine whether the direct application of the stochastic choice model or the ABS machine at the mesoscopic level can emerge bottom up through the *mimetic effects* operated in some familiar classes of network topologies. In addition, since we are getting to each of the individuals and their interaction with neighbors, we need to first describe the interaction model among them. It is at this point that we introduce the famous Ising model, invented by the physicist Ernst Ising in his PhD thesis in 1924, as our model for interacting agents. In sum, we study an "agent-based version" of the DSGE model bottom up by allowing for individuals' mimetic effects, through Ising's model, under different network topologies. We then statistically examine how well these bottom-up settings can fit the mesoscopic structure generated by the direct high-level modeling using the discrete choice model or the ABS machine.

A highlight of our results is briefly given here. In general, we fail to find a good bottom-up match to the ABS-generated fraction distribution. This indicates two possibilities: first, we have not sampled enough of the network topologies, or, second, the use of the ABS machine directly at the aggregate level may not be a good approximation to any macroeconomic model which takes the social network into explicit account. While the first possibility is certainly an issue left for further study, it is the second possibility which motivates a theoretical inquiry into the appropriateness of the use of the discrete choice model at the mesoscopic level when individual interactions are completely governed by the embedded social networks.

The rest of the paper is organized as follows. Section 2 gives an introduction to the DSGE models, including the *standard* New Keynesian version as well as the *agent-based extension* of it proposed by De Grauwe, when the homogeneous rational expectations in the former are replaced by the heterogeneous boundedly rational expectations using Brock–Hommes' adaptive belief systems. Section 3 introduces the social networks employed in this study, mainly the fully-connected network, regular network, small-world network and scale-free network. Section 4 gives a brief review of the Ising model and its incorporation into our agent-based version of the DSGE model. Simulations of both agent-based versions of the DSGE models and the comparative analysis of the simulation results are given in Section 5, followed by the concluding remarks in Section 6.

[1] The fraction distribution gives the distribution of the portfolio of market beliefs. In the statistical-physical macroeconomic model (Aoki and Yoshikawa, 2006), it is a pivotal variable because various types of aggregate behavior will be fundamentally determined by and fed back to it. When there are only two types of agents, say, optimists and pessimists, the fraction distribution is simply the distribution of the share of the optimists in the market.