A Multi-Level Agent-Based Model of Reinsurance

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Abstract:

Advances in agent-based modeling continue to offer new tools and concepts to model and study phenomena involving more complexity. In particular, economic and social issues with different levels of interactions and representations can benefit from frameworks of multi-level agent-based modeling that have successfully simulated other problems sharing similar properties.
We show through our work how reinsurance fits into this category of complex multi-level problems, how we adapted recent concepts with recent tools to go through the modeling obstacles of this issue to come up with a model that confirms the results of other renowned works and surpasses them in terms of analysis depth and assumptions flexibility.

Keywords: reinsurance; agent-based modeling; power and shubik law; multi-level; computational economics

JEL Classification: C63; C92; G2

Introduction

Agent-based modeling is an approach where computer experiments are conducted by defining basic behavior of agents to understand the dynamics of a resulting complex phenomena where computational mathematical decomposition shows its limitations or can't explain empirical reality. Multi-level modeling addresses the issue when interactions of agents occur in different levels that influence each other but also where entities have interactions zones that make each level look as a separate model, such as cells versus tissues in biology or producers/consumers versus economic sectors (Camus, Bourjot, Chevrier 2013, 15–22).

Research in multi-level agent-based modeling solves the technical and theoretical difficulties arising when trying to include all those interactions in one model, but also offers abstraction layers and domain-specific frameworks for the particular difficulties in some phenomena where either the number of agents are too big or have complex aggregated interactions.

Indeed, we can consider reinsurance one of such problems. The insuring relationship between customer and insurer reappears repetitively between insurer and reinsurer then reinsurer of reinsurer thus defining a hierarchy which where elements play different simultaneous roles that makes a direct definition of agents actions too complex. This kind of complexity with the adaptive nature of the agents makes reinsurance an appropriate application case calling for both agent-based modeling and multi-level concepts.

While there are many models in the literature that study different insurance problems from optimal prices to market cycles and stability (Hjorth, Brady, Head, Wilensky 2016, 282-289) no similar experimental approach has been undertaken to explore the dynamics of reinsurance, which is also a starting point of our study.

In section 2, we review the theoretical background and literature related to our subject, then in section 3 we describe our model and approach in detail to finally analyze and discuss the findings in section 4.

Conclusion

We consider our model to be an important application of multi-level agent-based modeling and a new framework for the study of reinsurance. We demonstrated how a recursive definition and a synchronization using multi-level frameworks makes the experimental study of complex reinsurance configurations possible, and allows more flexibility in hypotheses to filter the unnecessary ones from the computational model of reference. The model is also an experimental proof of Power and Shubik law and we showed new dynamics of the law is our analysis. Further work can calibrate the model on an existing reinsurance market specially to have more realistic price adjusting procedures. Other laws between probability loss and optimal number of levels can be explored using data science techniques. For this purpose, the model must benefit from research in large scale modeling to be able to execute with higher numbers of levels.

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