Understanding the complex dynamics of financial markets through microsimulation

Qiu, G.

Publication date
2011

Citation for published version (APA):
## Contents

1 Introduction ............................................. 1
   1.1 Complexity of financial markets ................. 1
       1.1.1 Financial markets as complex systems ...... 1
       1.1.2 The complex dynamics of financial markets ... 5
   1.2 Motivation and methodology ...................... 7

2 Empirical Observations and Limitations of Traditional Economic Theories 9
   2.1 Stylized facts observed in financial markets .... 9
       2.1.1 Stock markets ................................ 10
       2.1.2 Options markets .............................. 13
   2.2 Empirically consistent models .................. 18
       2.2.1 Models of price dynamics ................... 18
       2.2.2 Option pricing models ....................... 19
   2.3 Problems of standard financial theories .......... 25
       2.3.1 Adoption of unrealistic assumptions ........ 26
       2.3.2 Evasion of endogenous mechanisms .......... 29

3 Modern Approaches to Financial Modeling: Heterogeneity, Irrationality and Interactions 32
   3.1 Behavioral finance ................................ 32
       3.1.1 Stock markets ............................... 36
       3.1.2 Options markets ............................ 36
   3.2 Agent-based simulation ......................... 37
       3.2.1 Stock markets ............................... 40
## CONTENTS

3.2.2 Options markets .................................. 43
3.3 Econophysics ........................................ 45

4 Understanding Stock Market Dynamics 49
4.1 A cellular automaton model of stock markets .......... 50
  4.1.1 Level I model .................................. 51
  4.1.2 Level II model .................................. 52
  4.1.3 Level III model ................................ 53
  4.1.4 Rule of price updating ........................... 55
4.2 Simulation results .................................... 57
  4.2.1 Simulation results of the Level I model .......... 57
  4.2.2 Simulation results of the Level II model .......... 58
  4.2.3 Simulation results of the level III model .......... 58
4.3 Discussion: The market dynamics revealed by the model 63
  4.3.1 Long-range interactions can emerge from local interactions 65
  4.3.2 Price and volatility are mean-reverting ........... 67
  4.3.3 Heavy tails due to large price variations are caused by imitations 69
  4.3.4 Volatility clustering is related to the evolution of trading activity 71
  4.3.5 The regularity can be identified in some other microsimulation models 73
4.4 Conclusions ......................................... 74

5 Why Do Options Markets Smile? 76
5.1 A microsimulation model of options markets ........... 77
  5.1.1 S model: The market consists of only speculators .... 78
  5.1.2 SA model: The market consists of both speculators and arbitrageurs 79
  5.1.3 SAL model: Difference in liquidity is included .... 80
5.2 Simulation results ................................... 81
  5.2.1 Shapes of the implied volatility curves ........... 81
    5.2.1.1 Implied volatility curves from the S model .... 82
    5.2.1.2 Implied volatility curves from the SA model .... 82