

The virtues and vices of equilibrium and the future of financial economics

J. Doyne Farmer  John Geanakoplos

First published: 10 November 2008

<https://doi.org/10.1002/cplx.20261>

Citations: 107

Abstract

The use of equilibrium models in economics springs from the desire for parsimonious models of economic phenomena that take human reasoning into account. This approach has been the cornerstone of modern economic theory. We explain why this is so, extolling the virtues of equilibrium theory; then we present a critique and describe why this approach is inherently limited, and why economics needs to move in new directions if it is to continue to make progress. We stress that this shouldn't be a question of dogma, and should be resolved empirically. There are situations where equilibrium models provide useful predictions and there are situations where they can never provide useful predictions. There are also many situations where the jury is still out, i.e., where so far they fail to provide a good description of the world, but where proper extensions might change this. Our goal is to convince the skeptics that equilibrium models can be useful, but also to make traditional economists more aware of the limitations of equilibrium models. We sketch some alternative approaches and discuss why they should play an important role in future research in economics. © 2008 Wiley Periodicals, Inc. Complexity, 2009

REFERENCES

1 Arrow, K. J.; Debreu, G. Existence of an equilibrium for a competitive economy. *Econometrica* 1954, 22, 265–290.

[Web of Science®](#) | [Google Scholar](#)

2 Debreu, G. *Theory of Value*; Wiley: New York, 1959.

[Google Scholar](#)

3 Arrow, J. K. Le role des valeurs boursieres pour la repartition la meilleure des risques. *Econometrie, Colloques Internationaux du Centre National de la Recherche Scientifique* 1953, 11, 41–47.

[Google Scholar](#)

4 D. Kahneman; A. Tversky, Eds. *Choices, Values, and Frames*; Cambridge University Press: Cambridge, 2000.

[Google Scholar](#)

5 Brock, W. A.; Hommes, C. H. Models of complexity in economics and finance. In: *System Dynamics in Economic and Financial Models*; C. Hey; J. Schumacher; B. Hanzon; C. Praagman, Eds.; Wiley: New York, 1997; pp 3–41.

[Web of Science®](#) | [Google Scholar](#)

6 Brock, W. A.; Hommes, C. H. Heterogeneous beliefs and routes to chaos in a simple asset pricing model. *J Econ Dynam Control* 1998, **22**, 1235–1274.

[Web of Science®](#) | [Google Scholar](#)

7 Brock, W. A.; Hommes, C. H. Rational animal spirits. In: *The Theory of Markets*; P. Herings; G. van der Laan; A. Talman, Eds.; North Holland: Amsterdam, 1999; pp 109–137.

[Google Scholar](#)

8 Schleifer, A. *Clarendon Lectures: Inefficient Markets*; Oxford University Press: Oxford, 2000.

[Google Scholar](#)

9 Delong, J. B.; Schleifer, A.; Summers, L. H.; Waldmann, R. J. Positive feedback and destabilizing rational speculation. *J Finance* 1990, **45**, 379–395.

[Web of Science®](#) | [Google Scholar](#)

10 Sargent, T. J. *Bounded Rationality in Macroeconomics*; Oxford University Press: Oxford, 1993.

[Google Scholar](#)

11 Timmermann, A. Structural breaks, incomplete information, and stock prices. *J Business Econ Stat* 2001, **19**, 299–314.

[Web of Science®](#) | [Google Scholar](#)

12 Akerlof, G. The market for “lemons”: Quality uncertainty and the market mechanism. In: *Readings in Social Welfare: Theory and Policy*; R. Kuenne, Ed.; Blackwell: Malden, MA, 2000; pp 488–500.

[Google Scholar](#)

13 Spence, A. *Market signaling: Informational transfer in hiring and related screening processes*; Harvard University Press: Cambridge, 1974.

[Google Scholar](#)

14 Stiglitz, J. Credit rationing in markets with imperfect information. *Am Econ Rev* 1981, **71**, 393–410.

[Web of Science®](#) | [Google Scholar](#)

15 Dubey, P.; Geanakoplos, J.; Shubik, M. Default and punishment in general equilibrium. *Econometrica* 2005, **73**, 1–37.

[Web of Science®](#) | [Google Scholar](#)

16 Geanakoplos, J. Promises, promises. In: *The Economy as an Evolving Complex System, II*; W. B. Arthur; S. N. Durlauf; D. H. Lane, Eds.; Addison-Wesley: Reading, 1997; pp 285–320.

[Google Scholar](#)

17 Geanakoplos, J. Liquidity, default, and crashes: Endogenous contracts in general equilibrium. In: *Advances in Economics and Econometrics: Theory and Applications, Eighth World Congress, Vol. 3*; M. Dewatripont; L. P. Hansen; S. J. Turnovsky, Eds.; Cambridge University Press: Cambridge, 2003; pp 170–205.

[Google Scholar](#)

18 Arrow, K. J. An extension of the basic theorems of classical welfare economics. In: *Proceedings of the Second Berkeley Symposium on Mathematical Statistics*; University of California Press: Berkeley, 1951; pp 507–532.

[Google Scholar](#)

19 Debreu, G. The coefficient of resource utilization. *Econometrica* 1951, **19**, 273–292.

[Web of Science®](#) | [Google Scholar](#)

20 Brock, W.; Hommes, C.; Wagener, F. More hedging instruments may destabilize markets, Tech. rep. University of Amsterdam, 2007.

[Google Scholar](#)

21 Geanakoplos, J.; Polemarchakis, H. Existence, regularity, and constrained suboptimality of competitive allocations when the asset market is incomplete. In: *Essays in Honor of Kenneth J. Arrow; Uncertainty, Information and Communication, Vol. 3*; W. P. Heller; R. M. Starr; D. A. Starrett, Eds.; Cambridge University press: Cambridge, 1986, pp. 65–96.

[Google Scholar](#)

22 Fama, E. F. Efficient capital markets: A review of theory and empirical work. *J Finance* 1970, **25**, 383–417.

[Web of Science®](#) | [Google Scholar](#)

23 Fama, E. F. Efficient capital markets: II. *J Finance* 1991, **46**, 1575–1617.

[Web of Science®](#) | [Google Scholar](#) |

24 Roll, R. Orange juice and weather. *Am Econ Rev* 1984, 861–880.

[Web of Science®](#) | [Google Scholar](#) |

25 Ross, S. *Neoclassical Finance*; Princeton University Press: Princeton, NJ, 2004.

[Google Scholar](#) |

26 Lucas, R. E. *Econometric policy evaluation: A critique*, *Carnegie Rochester Conf Series Public Policy* 1976, vol. 1, 19–46.

[Web of Science®](#) | [Google Scholar](#) |

27 Sims, C. A. Macroeconomics and reality. *Econometrica* 1980, **48**, 1–48.

[CAS](#) | [Web of Science®](#) | [Google Scholar](#) |

28 Berns, G.; Laibson, D.; Loewenstein, G. Intertemporal choice – toward and integrative framework. *Tends Cogn Sci* 2007, **11**, 482–488.

[PubMed](#) | [Web of Science®](#) | [Google Scholar](#) |

29 Barberis, N.; Thaler, R. A survey of behavioral finance. In: *Handbook of Economics and Finance*; G. Constantinides; M. Harris; R. Stultz, Eds.; North Holland: University of Chicago, 2003, pp 1052–1090.

[Google Scholar](#) |

30 Thaler, R. *Advances in Behavioral Economics*; Russel Sage Foundation: New York, 2005.

[Google Scholar](#) |

31 Fisher, F. M. *Disequilibrium Foundations of Equilibrium Economics*; Cambridge University Press: Cambridge, 1983.

[Google Scholar](#) |

32 Ijiri, Y.; Simon, H. A. *Skew Distributions and the Sizes of Business Firms; Studies in Mathematical Economics*; North-Holland: Amsterdam, 1977.

[Google Scholar](#) |

33 Brown, S.; Goetzmann, W. N.; Ross, S. Survival. *J Finance L* 1995, 3, 853–873.

[Web of Science®](#) | [Google Scholar](#)

34 Markowitz, H. Portfolio selection. *J Finance* 1952, 7, 77–91.

[Web of Science®](#) | [Google Scholar](#)

35 Tobin, J. Liquidity preference as behavior towards risk. *Rev Econ Studies* 1958, 25, 65–86.

[Web of Science®](#) | [Google Scholar](#)

36 Lintner, J. The valuation of risky assets and the selection of risky investments in stock portfolios and capital budgets. *Rev Econ Stat* 1965, 47, 13–37.

[Web of Science®](#) | [Google Scholar](#)

37 Sharpe, W. F. Capital asset prices: A theory of market equilibrium under conditions of risk. *J Finance* 1964, 19, 425–442.

[Web of Science®](#) | [Google Scholar](#)

38 Campbell, J. Y.; Shiller, R. J. The dividend-price ratio and expectations of future dividends and discount factors. *Rev Finan Studies* 1989, 1, 195–228.

[Web of Science®](#) | [Google Scholar](#)

39 Sebenius, J. K.; Geanakoplos, J. Dont bet on it—Contingent agreements with asymmetric information. *J Am Stat Assoc* 1983, 78, 424–426.

[Web of Science®](#) | [Google Scholar](#)

40 Shiller, R. J. Do stock prices move too much to be justified by subsequent changes in dividends? *Am Econ Rev* 1981, 71, 421–436.

[Web of Science®](#) | [Google Scholar](#)

41 Shiller, R. J. *Market Volatility*; MIT Press: Cambridge, 1997.

[Google Scholar](#)

42 Odean, T. Do investors trade too much? *Am Econ Rev* 1999, 89, 1279–1298.

[Web of Science®](#) | [Google Scholar](#)

43 Cutler, D. M.; Poterba, J. M.; Summers, L. H. What moves stock prices? *J Portfolio Manage* 1989, **15**, 4-12.

[Web of Science®](#) | [Google Scholar](#)

44 French, K.; Roll, R. Stock return variances: The arrival of information and the reaction of traders. *J Financial Econ* 1986, **17**, 5-26.

[Web of Science®](#) | [Google Scholar](#)

45 Engle, R.; Rangel, J. The spline GARCH model for unconditional volatility and its global macroeconomic causes, Tech. rep., NYU and UCSD, 2005.

[Google Scholar](#)

46 Engle, R. F. Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica* 1982, **50**, 987-1007.

[Web of Science®](#) | [Google Scholar](#)

47 Mandelbrot, B. The variation of certain speculative prices. *J Business* 1963, **36**, 394-419.

[Web of Science®](#) | [Google Scholar](#)

48 Mandelbrot, B. B. A subordinated stochastic process model with finite variance for speculative prices: Comment. *Econometrica* 1973, **41**, 157-59.

[Web of Science®](#) | [Google Scholar](#)

49 Clark, P. K. Subordinated stochastic process model with finite variance for speculative prices. *Econometrica* 1973, **41**, 135-155.

[Web of Science®](#) | [Google Scholar](#)

50 Ane, T.; Geman, H. Order flow, transaction clock, and normality of asset returns. *J Finance* 2000, **55**, 2259-2284.

[Web of Science®](#) | [Google Scholar](#)

51 Gillemot, L.; Farmer, J. D.; Lillo, F. There's more to volatility than volume. *Quant Finance* 2006, **6**, 371-384.

[Web of Science®](#) | [Google Scholar](#)

52 Newman, M. E. J. Power, laws, pareto distributions and zipf's law. *Contemp Phys* 2005, **46**(5), 323-351.

[Web of Science®](#) | [Google Scholar](#)

53 Farmer, J. D.; Geanakoplos, J. Power laws in economics and elsewhere, Tech. rep., Santa Fe Institute, 2005 Unfinished manuscript. www.santafe.edu/~jdfpapers/powerlaw3.pdf.

[Google Scholar](#)

54 Pareto, V. *Cours d'Economie Politique*; Droz: Geneva, 1896.

[Google Scholar](#)

55 Fama, E. F. The behavior of stock-market prices. *J Business* 1965, **38**, 34-105.

[Web of Science®](#) | [Google Scholar](#)

56 Officer, R. R. Distribution of stock returns. *J Am Stat Assoc* 1972, **67**, 807-812.

[Web of Science®](#) | [Google Scholar](#)

57 Akgiray, V.; Booth, G. G.; Loistl, O. Stable laws are inappropriate for describing German stock returns. *Allgemeines Statistisches* 1989, **73**, 115-121.

[Google Scholar](#)

58 Koedijk, K. G.; Schafgans, M. M. A.; de Vries, C. G. The tail index of exchange rates. *J Int Econ* 1990, **29**(1/2), 1-197.

[Google Scholar](#)

59 Loretan, M.; Phillips, P. C. B. Testing the covariance stationarity of heavy-tailed time series: An overview of the theory with applications to several financial datasets. *J Empirical Finance* 1994, **1**, 211-248.

[Google Scholar](#)

60 Mantegna, R. N.; Stanley, H. E. Scaling behavior in the dynamics of an economic index. *Nature* 1995, **376**, 46-49.

[CAS](#) | [Web of Science®](#) | [Google Scholar](#)

61 Longin, F. M. The asymptotic distribution of extreme stock market returns. *J Business* 1996, **69**, 383-408.

[Web of Science®](#) | [Google Scholar](#)

62 Lux, T. The stable paretian hypothesis and the frequency of large returns: An examination of major german stocks. *Appl Financial Econ* 1996, **6**, 463-475.

[Google Scholar](#)

63 Muller, U. A.; Dacorogna, M. M.; Pictet, O. V. Heavy tails in high-frequency financial data. In: *A Practical Guide to Heavy Tails: Statistical Techniques and Applications*; R. J. Adler; R. E. Feldman; M. S. Taqqu, Eds.; Springer-Verlag: Berlin, 1998; pp 55–78.

[Google Scholar](#)

64 Plerou, V.; Gopikrishnan, P.; Amaral, L. A. N.; Meyer, M.; Stanley, H. E. Scaling of the distribution of price fluctuations of individual companies. *Phys Rev E Part A* 1999, **60**, 6519–6529.

[CAS](#) | [PubMed](#) | [Web of Science®](#) | [Google Scholar](#)

65 Rachev, S.; Mittnik, S. *Stable Paretian Models in Finance*; Wiley: New York, 2000.

[Web of Science®](#) | [Google Scholar](#)

66 Goldstein, M. L.; Morris, S. A.; Yen, G. G. Problems with fitting to the power-law distribution. *Eur Phys J B* 2004, **41**, 255–258.

[CAS](#) | [Web of Science®](#) | [Google Scholar](#)

67 Gopikrishnan, P.; Plerou, V.; Gabaix, X.; Stanley, H. E. Statistical properties of share volume traded in financial markets. *Phys Rev E Part A* 2000, **62**, R4493–R4496.

[CAS](#) | [Web of Science®](#) | [Google Scholar](#)

68 Lillo, F.; Mike, S.; Farmer, J. D. Theory for long memory in supply and demand. *Phys Rev E* 2005, **7106**, 066122.

[Web of Science®](#) | [Google Scholar](#)

69 Ding, Z.; Granger, C. W. J.; Engle, R. F. A long memory property of stock returns and a new model. *J Empirical Finance* 1993, **1**, 83–106.

[Web of Science®](#) | [Google Scholar](#)

70 Breidt, F. J.; Crato, N.; de Lima, P. J. F. Modeling long-memory stochastic volatility, *Journal of Econometrics*, Vol. **83**, issues 1–2, March–April 1998 pp. 325–346.

[Google Scholar](#)

71 Harvey, A. C. Long-Memory in Stochastic Volatility, Working paper; London School of Economics, 1993.

[Google Scholar](#)

72 Baillie, R. T. Long-memory processes and fractional integration in econometrics. *J Econometrics* 1996, **73**, 5–59.

73 Bollerslev, T.; Mikkelsen, H.-O. Modeling and pricing long-memory in stock market volatility. *J Econometrics* 1996, **73**, 151–184.

74 Lobato, I. N.; Velasco, C. Long-memory in stock-market trading volume. *J Business Econ Stat* 2000, **18**, 410–427.

75 Bouchaud, J.-P.; Mezard, M.; Potters, M. Statistical properties of the stock order books: Empirical results and models. *Quant Finance* 2002, **2**, 251–256.

76 Zovko, I.; Farmer, J. D. The power of patience; a behavioral regularity in limit order placement. *Quant Finance* 2002, **2**, 387–392.

77 Mike, S.; Farmer, J. An empirical behavioral model of liquidity and volatility. *J Econ Dynam Control* 2008, **32**, 200–234.

78 Bouchaud, J.-P.; Gefen, Y.; Potters, M.; Wyart, M. Fluctuations and response in financial markets: The subtle nature of “random” price changes. *Quant Finance* 2004, **4**, 176–190.

79 Bouchaud, J.-P.; Kockelkoren, J.; Potters, M. Random walks, liquidity molasses and critical response in financial markets. *Quant Finance* 2006, **6**, 115–123.

80 Lillo, F.; Farmer, J. D. The long memory of the efficient market. *Studies Nonlinear Dynam Econometrics* 2004, **8**, 1226.

81 Farmer, J.; Gerig, A.; Lillo, F.; Mike, S. Market efficiency and the long-memory of supply and demand: Is price impact variable and permanent or fixed and temporary? *Quant Finance* 2006, **6**, 107–112.

82 Stanley, M. H. R.; Amaral, L.; Buldyrev, S.; Havlin, S.; Leschhorn, H.; Maass, P.; Salinger, M.; Stanley, H. Scaling behavior in growth of companies. *Nature* 1996, **379**, 804–806.

[CAS](#) | [Web of Science®](#) | [Google Scholar](#) |

83 Amaral, L. A. N.; Buldyrev, S. V.; Havlin, S.; Leschhorn, H.; Maass, P.; Salinger, M. A.; Stanley, H. E.; Stanley, M. H. R. Scaling behavior in economics. I. Empirical results for company growth. *Physica A* 1997, **244**, 1–24.

[Web of Science®](#) | [Google Scholar](#) |

84 Plerou, V.; Amaral, L. A. N.; Gopikrishnan, P.; Meyer, M.; Stanley, H. E. Similarities between growth dynamics of university research and of competitive economic activities. *Nature* 1999, **400**, 433–437.

[CAS](#) | [Web of Science®](#) | [Google Scholar](#) |

85 Lillo, F.; Farmer, J. D.; Mantegna, R. N. Master curve for price impact function. *Nature* 2003, **421**, 129–130.

[CAS](#) | [PubMed](#) | [Web of Science®](#) | [Google Scholar](#) |

86 Durlauf, S. N. Complexity in economics. Working paper 03-02-014; Santa Fe Institute, 2003.

[Google Scholar](#) |

87 Calvet, L.; Fisher, A. Forecasting multifractal volatility. *J Econometrics* 2002, **105**, 27–58.

[Web of Science®](#) | [Google Scholar](#) |

88 Calvet, L.; Fisher, A. How to forecast long-run volatility: Regime-switching and the estimation of multifractal processes. *J Finan Econometrics* 2004, **2**, 49–83.

[Google Scholar](#) |

89 Embrechts, J. P.; Kluppelberg, C.; Mikosch, T. *Modeling Extremal Events for Insurance and Finance*; Springer-Verlag: Berlin, 1997.

[Google Scholar](#) |

90 Clauset, A.; Shalizi, C.; Newman, M. Power law distributions in empirical data, Tech. Rep. 07-12-049, Santa Fe Institute, 2007.

[Google Scholar](#) |

91 Farmer, J. D.; Shubik, M.; E., S. Is economics the next physical science? *Phys Today* 2005, **58**, 37–42.

[Web of Science®](#) | [Google Scholar](#) |

92 Farmer, J. D. Market force, ecology and evolution. *Ind Corp Change* 2002, **11**, 895–953.

[Web of Science®](#) | [Google Scholar](#) |

93 Khandani, A.; Lo, A. What happened to the quants in august 2007? Tech. rep., MIT, 2007.

[Google Scholar](#) |

94 Fostel, A.; Geanakoplos, J. Emerging markets in an anxious global economy, Tech. Rep. 1646, Cowles Foundation Discussion Paper, 2008.

[Google Scholar](#) |

95 J. H. Kagel; A. E. Roth, Eds. *The Handbook of Experimental Economics*; Princeton University Press: Princeton, NJ, 1995.

[Google Scholar](#) |

96 Shefrin, H. Behavioral Finance, Volumes I-III; Edward Elgar: Northampton, MA, 2001.

[Google Scholar](#) |

97 Shefrin, H. *A Behavioral Approach to Asset Pricing*; Elsevier: Amsterdam, 2005.

[Web of Science®](#) | [Google Scholar](#) |

98 Krugman, P. What economists can learn from evolutionary theorists. a talk given to the European Association for Evolutionary Political Economy 1996, posted at <http://www.pkarchive.org>.

[Google Scholar](#) |

99 Helbing, D. Traffic and related self-driven many-particle systems. *Rev Mod Phys* 2001, **73**, 1067–1141.

[Web of Science®](#) | [Google Scholar](#) |

100 Nagel, K.; Wagner, P.; Woesler, R. Still flowing: Approaches to traffic flow and traffic jam modeling. *Operat Res* 2003, **51**, 681–710.

[Web of Science®](#) | [Google Scholar](#) |

101 Helbing, D.; Johansson, A.; Al-Abideen, H. The dynamics of crowd disasters: An empirical study. *Phys Rev E* 2007, **75**, 046109.

[CAS](#) | [PubMed](#) | [Web of Science®](#) | [Google Scholar](#) |

102 Dragulescu, A.; Yakovenko Victor, M. Exponential and power-law probability distribution of wealth and income in the united kingdom and the united states. *Physica A* 2001, **299**(1/2), 213–221.

[Web of Science®](#) | [Google Scholar](#)

103 Yakovenko, V. Statistical mechanics approach to econophysics. In: *Springer Encyclopedia of Complexity and System Science*; Springer Verlag: Berlin, 2007.

[Google Scholar](#)

104 Champernowne, D. A model of income distribution. *Econ J* 1953, **63**, 318–351.

[Web of Science®](#) | [Google Scholar](#)

105 Simon, H. A. On a class of skew distribution functions. *Biometrika* 1955, **42**(3/4), 425–440.

[Web of Science®](#) | [Google Scholar](#)

106 Malcai, O.; Biham, O.; Solomon, S. Power-law distributions and Levy-stable intermittent fluctuations in stochastic systems of many autocatalytic elements. *Phys Rev E* 1999, **60**, 1299–1303.

[PubMed](#) | [Web of Science®](#) | [Google Scholar](#)

107 Sornette, D.; Cont, R. Convergent multiplicative processes repelled from zero: Power laws and truncated power laws. *J de Physique I* 1997, **7**, 431–444.

[Web of Science®](#) | [Google Scholar](#)

108 Levy, M. Market efficiency, the pareto wealth distribution, and the distribution of stock returns. In: *The Economy as an Evolving Complex System III*; S. N. Durlauf; L. E. Blume, Eds.; Oxford University Press: Oxford, 2005.

[Google Scholar](#)

109 Zipf, G. *Selective Studies and the Principle of Relative Frequency in Language*; Harvard University Press: Cambridge, 1932.

[Google Scholar](#)

110 Zipf, G. *Human Behavior and the Principle of Least Effort*; Addison-Wesley: Cambridge, 1949.

[Google Scholar](#)

111 Gabaix, X. Zipf's law for cities: An explanation. *Quart J Econ* 1999, **114**, 739–768.

[Web of Science®](#) | [Google Scholar](#)

112 Axtell, R. L. The emergence of firms in a population of agents: Local increasing returns, unstable Nash equilibria, and power law size distributions, Tech. Rep. 03-019-99, Santa Fe Institute, 1999.

[Google Scholar](#)

113 Axtell, R. Zipf distribution of U. S. firm size. *Science* 2001, **293**, 1818–1820.

[CAS](#) | [PubMed](#) | [Web of Science®](#) | [Google Scholar](#)

114 Glosten, L. R.; Milgrom, P. R. Bid, ask and transaction prices in a specialist market with heterogeneously informed traders. In: *Financial Intermediaries*; M. K. Lewis, Ed.; Edward Elgar: Aldershot, UK, 1995; pp 174–203.

[Google Scholar](#)

115 Sandas, P. Adverse selection and comparative market making: empirical evidence from a limit order market. *Rev Financial Studies* 2001, **14**, 705–734.

[Web of Science®](#) | [Google Scholar](#)

116 Becker, G. Irrational behavior and economic theory. *J Pol Econ* 1962, **70**, 1–13.

[Web of Science®](#) | [Google Scholar](#)

117 Gode, D. K.; Sunder, S. Allocative efficiency of markets with zero-intelligence traders: Market as a partial substitute for individual rationality. *J Pol Econ* 1993, **101**, 119–137.

[Web of Science®](#) | [Google Scholar](#)

118 Mendelson, H. Market behavior in a clearing house. *Econometrica* 1982, **50**, 1505–1524.

[Web of Science®](#) | [Google Scholar](#)

119 Cohen, K. J.; Conroy, R. M.; Maier, S. F. Order flow and the quality of the market. In: *Market Making and the Changing Structure of the Securities Industry*; Y. Amihud; T. Ho; R. A. Schwartz, Eds.; Rowman and Littlefield: Lanham, 1985; pp 93–110.

[Google Scholar](#)

120 Domowitz, I.; Wang, J. Auctions as algorithms: Computerized trade execution and price discovery. *J Econ Dynam Control* 1994, **18**, 29–60.

[Web of Science®](#) | [Google Scholar](#)

121 Bak, P.; Paczuski, M.; Shubik, M. Price variations in a stock market with many agents. *Physica A-Stat Mech Appl* 1997, **246**, 430–453.

[Web of Science®](#) | [Google Scholar](#)

122 Bollerslev, T.; Domowitz, I.; Wang, J. Order flow and the bid-ask spread: An empirical probability model of screen-based trading. *J Econ Dynam Control* 1997, **21**, 1471–1491.

[Web of Science®](#) | [Google Scholar](#)

123 Eliezer, D.; Kogan, I. I. Scaling laws for the market microstructure of the interdealer broker markets, Tech. rep., available at: <http://www.arxiv.org/abs/cond-mat/9808240>, 1998.

[Google Scholar](#)

124 Maslov, S. Simple model of a limit order-driven market. *Physica A-Stat Mechan Appl* 2000, **278**(3/4), 571–578.

[Web of Science®](#) | [Google Scholar](#)

125 Slanina, F. Mean-field approximation for a limit order driven market model. *Phys Rev E Part 2*, **64** 2001, article no.056136.

[Web of Science®](#) | [Google Scholar](#)

126 Challet, D.; Stinchcombe, R. Analyzing and modeling 1+1d markets. *Physica A* 2001, **300**,(1/2) 285–299.

[Web of Science®](#) | [Google Scholar](#)

127 Daniels, M. G.; Farmer, J. D.; Gillemot, L.; Iori, G.; Smith, D. E. Quantitative model of price diffusion and market friction based on trading as a mechanistic random process. *Physical Review Letters* 2003, **90**, 108102–108104.

[CAS](#) | [PubMed](#) | [Web of Science®](#) | [Google Scholar](#)

128 Chiarella, C.; Iori, G. A simulation analysis of the microstructure of double auction markets. *Quant Finance* 2002, **2**, 346–353.

[Google Scholar](#)

129 Smith, E.; Farmer, J. D.; Gillemot, L.; Krishnamurthy, S. Statistical theory of the continuous double auction. *Quant Finance* 2003, **3**, 481–514.

[Web of Science®](#) | [Google Scholar](#)

130 Farmer, J. D.; Patelli, P.; Zovko, I. The predictive power of zero intelligence in financial markets. *Proc Natl Acad Sci U S A* 2005, **102**, 2254–2259.

[CAS](#) | [PubMed](#) | [Web of Science®](#) | [Google Scholar](#)

131 Wyart, M.; Bouchaud, J.-P.; Kockelkoren, J.; Potters, M.; Vettorazzo, M. Relation between bid-ask spread, impact and volatility in double auction markets, Tech. rep., 2006.

[Google Scholar](#)

132 Grossman, S. J.; Stiglitz, J. E. On the impossibility of informationally efficient markets. *Am Econ Rev* 1980, **70**, 393-408.

[Web of Science®](#) | [Google Scholar](#)

133 Geanakoplos, J.; Milgrom, P. A theory of hierarchies based on limited managerial attention. *J Japan Int Econ* 1991, **5**, 205-225.

[Web of Science®](#) | [Google Scholar](#)

134 LeBaron, B. Agent-based computational finance: suggested readings and early research. *J Econ Dynam Control* 2000, **24**(5-7), 679-702.

[Web of Science®](#) | [Google Scholar](#)

135 Tesfatsion, L. Agent-based computational economics: A brief guide to the literature, Tech. rep., 1999.

[Google Scholar](#)

136 Tesfatsion, L. Agent based computational economics. Growing economies from the bottom up, Tech. rep., 2005.

[Google Scholar](#)

137 Beja, A.; Goldman, M. B. On the dynamic behavior of prices in disequilibrium. *J Finance* 1980, **3**, 235-248.

[Web of Science®](#) | [Google Scholar](#)

138 Brock, W. A.; LeBaron, B. A dynamic structural model for stock return volatility and trading volume. *Rev Econ Stat* 1996, **78**, 94-110.

[Web of Science®](#) | [Google Scholar](#)

139 Caldarelli, G.; Marsili, M.; Zhang, Y.-C. A prototype model of stock exchange. *Europhys Lett* 1997, **40**, 479-484.

[CAS](#) | [Web of Science®](#) | [Google Scholar](#)

140 Chiarella, C. The dynamics of speculative behavior. *Ann Operat Res* 1992, **37**, 101-123.

[Google Scholar](#)

141 Chiarella, C.; He, X. Asset price and wealth dynamics under heterogeneous expectations. *Quant Finance* 2001, **1**, 509–526.

[Google Scholar](#)

142 Day, R. H. Bulls, bears and market sheep. *J Econ Behav Organ* 1990, **14**, 299–329.

[Web of Science®](#) | [Google Scholar](#)

143 Farmer, J. D.; Joshi, S. The price dynamics of common trading strategies. *J Econ Behav Organ* 2002, **49**, 149–171.

[Web of Science®](#) | [Google Scholar](#)

144 Kirman, A. Epidemics of opinion and speculative bubbles in financial markets. In: *Money and Financial Markets*; M. Taylor, Ed.; Blackwell: Oxford, 1991; pp 354–368.

[Google Scholar](#)

145 Kirman, A. Ants, rationality and recruitment. *Quarterly Journal of Economics* 1993, **108**, 137–156.

[Web of Science®](#) | [Google Scholar](#)

146 Lux, T. Time variation of second moments from a noise trader/infection model. *J Econ Dynam Control* 1997, **22**, 1–38.

[Web of Science®](#) | [Google Scholar](#)

147 Lux, T. The socio-economic dynamics of speculative markets: Interacting agents, chaos, and the fat tails of return distributions. *J Econ Behav Organ* 1998, **33**, 143–165.

[Web of Science®](#) | [Google Scholar](#)

148 Lux, T.; Marchesi, M. Scaling and criticality in a stochastic multi-agent model of a financial market. *Nature* 1999, **397**, 498–500.

[CAS](#) | [Web of Science®](#) | [Google Scholar](#)

149 Rieck, C. Evolutionary simulation of asset trading strategies. In: *Many-agent Simulation and Artificial Life*; E. Hillebrand; J. Stender, Eds.; IOS Press: Amsterdam, 1994; pp 112–136.

[Google Scholar](#)

150 Arthur, W. B.; Holland, J. H.; LeBaron, B.; Palmer, R.; Tayler, P. Asset pricing under endogenous expectations in an artificial stock market. In: *The Economy as an Evolving Complex System II*; W. B. Arthur; S. N. Durlauf; D. H. Lane, Eds.; Addison-Wesley: Redwood City, 1997; pp 15–44.

[Google Scholar](#)

151 Challet, D.; Marsili, M.; Zhang, Y.-C. *Minority Games*; Oxford University Press: Oxford, 2005.

[Google Scholar](#)

152 Giardina, I.; Bouchaud, J.-P. Bubbles, crashes and intermittency in agent based market models. *Eur Phys J B* 2003, **31**, 421–437.

[CAS](#) | [Web of Science®](#) | [Google Scholar](#)

153 Johnson, N. F.; Jeffries, P.; Hui, P. M. *Financial Market Complexity*; Oxford University Press: Oxford, 2003.

[Google Scholar](#)

154 LeBaron, B.; Arthur, W. B.; Palmer, R. Time series properties of an artificial stock market. *J Econ Dynam Control* 1999, **23**(9/10), 1487–1516.

[Web of Science®](#) | [Google Scholar](#)

155 LeBaron, B. Empirical regularities from interacting long and short memory investors in an agent-based financial market. *IEEE Trans Evolution Comp* 2001, **5**, 442–455.

[Web of Science®](#) | [Google Scholar](#)

156 LeBaron, B. Calibrating an agent-based financial market, Tech. rep., Brandeis Economics Dept., 2003.

[Google Scholar](#)

157 Lux, T. The Markov-switching multifractal model of asset returns: Estimation via GMM estimation and linear forecasting of volatility. *J Business Econ Stat* 2008, **26**(2), 194–210.

[Web of Science®](#) | [Google Scholar](#)

158 Alfarano, S.; Lux, T.; Wagener, F. Empirical validation of stochastic models of interacting agents: A maximally skewed noise trader model. *Eur J Phys-Condensed Matter* 2007, **55**(2), 183–187.

[Web of Science®](#) | [Google Scholar](#)

159 Thomas, B. Alfred marshall on economic biology. *Rev Pol Econ* 1991, **3**, 1–14.

[Google Scholar](#)

160 Foster, J. Economics and the self-organization approach: Alfred marshall revisited? *Econ J* 1993, **103**, 975–991.

[Google Scholar](#)

161 Nelson, R. R.; Winter, S. G. *An Evolutionary Theory of Economic Change*; Harvard University Press: Cambridge, 1982.

[Web of Science®](#) | [Google Scholar](#)

162 R. England, Ed. *Evolutionary Concepts in Contemporary Economics*; University of Michigan: Ann Arbor, 1994.

[Google Scholar](#)

163 Ruth, M. Evolutionary economics at the crossroads of biology and physics. *J Social Evolution Syst* 1996, **19**, 125–144.

[Google Scholar](#)

164 Farmer, J. D.; Lo, A. W. Frontiers of finance: Evolution and efficient markets. *Proc Natl Acad Sci U S A* 1999, **96**, 9991–9992.

[CAS](#) | [PubMed](#) | [Web of Science®](#) | [Google Scholar](#)

165 Lo, A. Market efficiency from an evolutionary perspective, Tech. rep., MIT, 2005.

[Google Scholar](#)

166 Keim, D. B.; Madhavan, A. Anatomy of the trading process: Empirical evidence on the behavior of institutional traders. *J Financ Econ* 1995, **37**, 371–398.

[Web of Science®](#) | [Google Scholar](#)

167 Menkhoff, L. The noise trading approach—Questionnaire evidence from foreign exchange. *J Int Money Finance* 1998, **17**, 547–564.

[Web of Science®](#) | [Google Scholar](#)

168 Lillo, F.; Moro, E.; Vaglica, G.; Mantegna, R. Specialization of strategies and herding behavior of trading firms in a financial market, Tech. rep., University of Palermo 2007.

[Google Scholar](#)

169 Zovko, I.; Farmer, J. D. Correlations and clustering in the trading of members of the London Stock Exchange. In: *Complexity, Metastability and Nonextensivity: An International Conference*; S. Abe; T. Mie;

[Google Scholar](#)

170 Friedman, M. *Essays in Positive Economics*; University of Chicago Press: Chicago, 1953.

[Google Scholar](#)

171 Hens, T.; Schenk-hoppe, K. Evolutionary finance: Introduction to the special issue. *J Mathe Econ* 2005, **41**, 1-5.

[Web of Science®](#) | [Google Scholar](#)

172 Hens, T.; Schenk-hoppe, K. Evolutionary stability of portfolio rules in incomplete markets. *J Mathe Econ* 2005, **41**, 43-66.

[Web of Science®](#) | [Google Scholar](#)

Citing Literature



[Download PDF](#)

ABOUT WILEY ONLINE LIBRARY

[Privacy Policy](#)
[Terms of Use](#)
[About Cookies](#)
[Manage Cookies](#)
[Accessibility](#)

[Wiley Research DE&I Statement and Publishing Policies](#)
[Developing World Access](#)

HELP & SUPPORT

[Contact Us](#)
[Training and Support](#)
[DMCA & Reporting Piracy](#)

OPPORTUNITIES

[Subscription Agents](#)
[Advertisers & Corporate Partners](#)

CONNECT WITH WILEY

[The Wiley Network](#)
[Wiley Press Room](#)

