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A Nonlinear Stochastic Differential Equation Model for Financial Bubbles and Crashes with Finite-Time Singularities

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Abstract : We propose and solve exactly a class of non-linear generalization of the Black-Scholes process of stochastic differential equations describing price bubble and crashes dynamics. As a result of nonlinear positive feedback, the faster-than-exponential price positive growth (bubble forming) and negative price growth (crash forming) are found to be the power-law finite-time singularity in which bubbles and crashes price formation ending at finite critical time tc. While most literature on the market bubble and crash process focuses on the nonlinear positive feedback mechanism aspect, very few studies concern the noise level on the same process. The present work adds to the market bubble and crashes literature by studying the external sources noise influence on the critical time tc of the bubble forming and crashes forming. Two main results will be discussed: (1) the analytical expression of expected value of the critical time <tc> is found and unexpected critical slowing down due to the coupling external noise is predicted; (2) numerical simulations of the nonlinear stochastic equation is presented, and the probability distribution of Prob(tc) is found to be the inverse gamma function.

Keywords : bubble, crash, finite-time-singular, numerical simulation, price dynamics, stochastic differential equations
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