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Visualization of Chaos for Finance Majors

Adelaide University Working Paper No. 00-7

31 Pages

Posted: 7 Jan 2001

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Date Written: November, 2000

Abstract


Efforts to simulate turbulence in the financial markets include experiments with the logistic equation: $x(t)=\kappa x(t-1)[1-x(t-1)]$, with $0 < x(t) < 1$ and $0 = < \kappa < 4$. Visual investigation of the logistic equation show the various stability and instability regimes for the various value of the Feigenbaum number κ . Visualizations for $t=20$ observations provide clear demonstrations of the stability regimes. We visually investigate these regimes in more detail in the $t=101-110$ range. For $0 < \kappa < 3$, the process settles to a unique stable equilibrium. For $3 = < \kappa < 3.6$ the process bifurcates, or, as colored visualization shows but not black-and-white, its pitchfork bifurcation branches "bang-bang" switch between two regimes. For $3.6 = < \kappa = < 4.0$ the process becomes chaotic, i.e., deterministically random. In this regime are windows of stability, e.g., at $\kappa=3+2\sqrt{2}=3.8284$. At $\kappa=4$, pure chaos, the process is extremely sensitive to initial values, as visually is clearly demonstrated. We increase the number of observations to $t=1000$ and compute the homogeneous Hurst exponent of the process at $\kappa=4$: $H=0.004$, indicating that $x(t)$ is blue noise, i.e., extreme anti-persistent. A histogram shows a highly platykurtic distribution of $x(t)$, with an imploded "mode," with extremely fat tails higher than the "mode," against the reflecting values at $x=0$ and $x=1$. Several plots of the state directory of the system in the $(x(t), x(t-1))$ -space trace out the parabolic strange attractor. Although the strange attractor is a well-defined parabole, the points on the attractor set are deterministically random and unpredictable.

Keywords: Logistic Equation, Visualization, Strange Attractor, Chaos, Hurst Exponent

JEL Classification: C15, C19, C33, C49

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