Chaos and Uncertainty in Disability Experience

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Maine Event

September 27, 2002

Chaos is a name for any order that produces confusion in our minds

George Santayana

Chaos was the law of nature; Order was the dream of man

Henry Brooks Adams

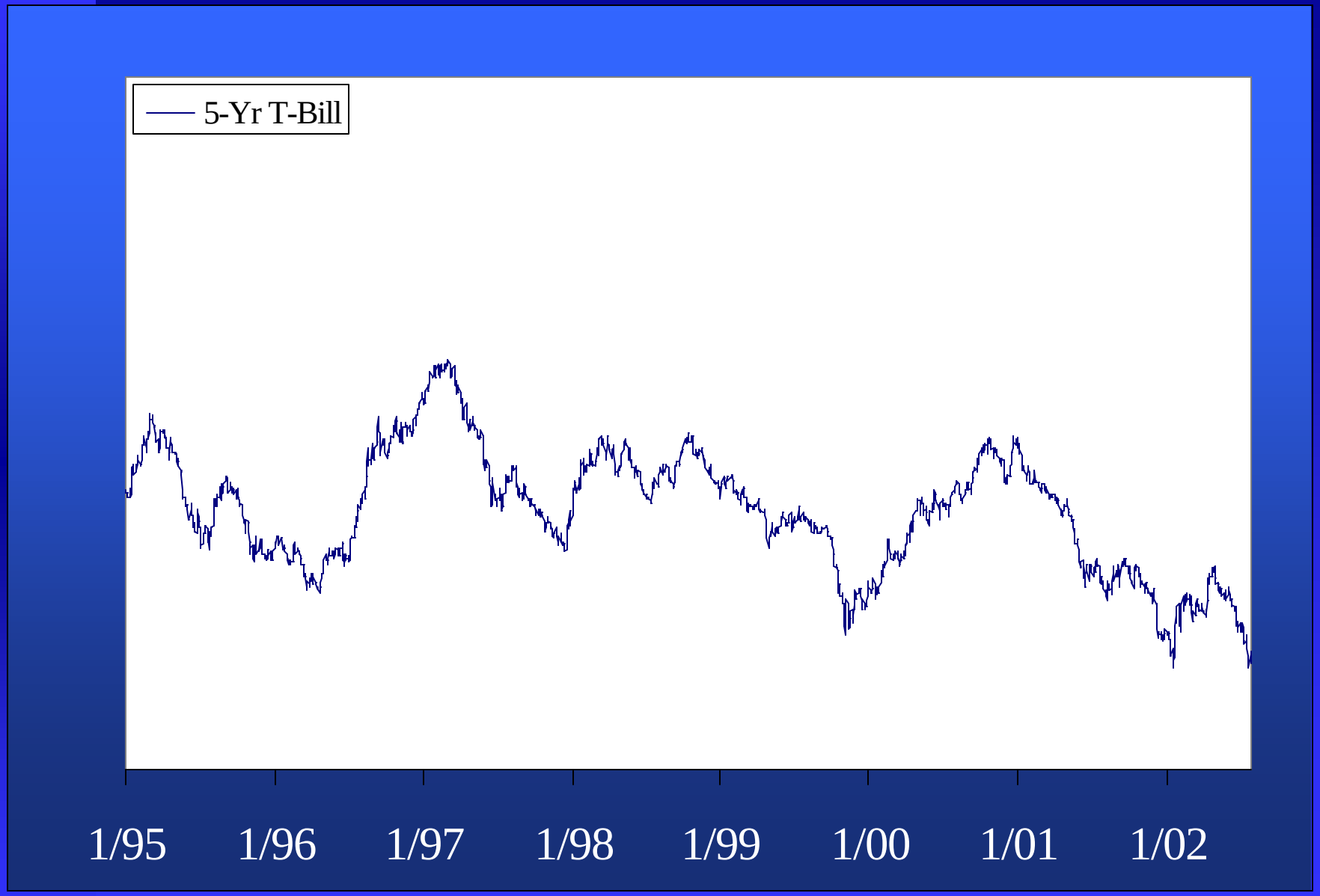
It is an Uncertain World

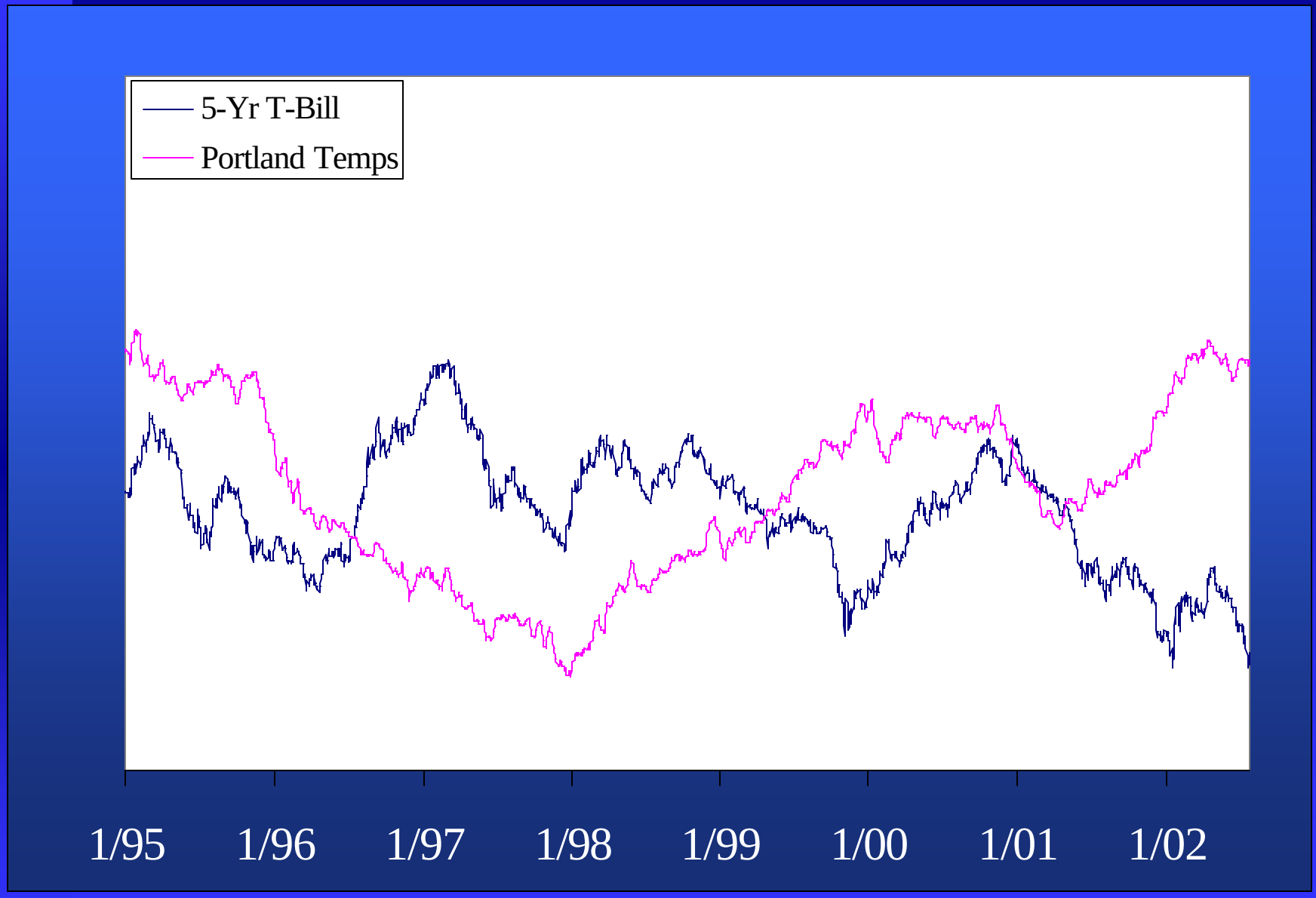
- Five-Year Treasury Yields
- Daily Temperature in Portland
- S&P 500 Index
- Bob Lee's Gambling Experience
- Disability Incidence

Given for one instant an intelligence which could comprehend all the forces by which nature is animated and the respective positions of the beings which compose it, if moreover this intelligence were vast enough to submit these data to analysis, it would embrace in the same formula both the movements of the largest bodies in the universe and those of the lightest atom; to it nothing would be uncertain, and the future as the past would be present to its eyes.

Pierre Simon De Laplace, 1812

The initial conditions predetermine the future


5-Yr T-Bill
1/95
1/96
1/97
1/98
1/99
1/00
1/01
1/02


5-Yr T-Bill
Portland Temps
1/95
1/96
1/97
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1/01
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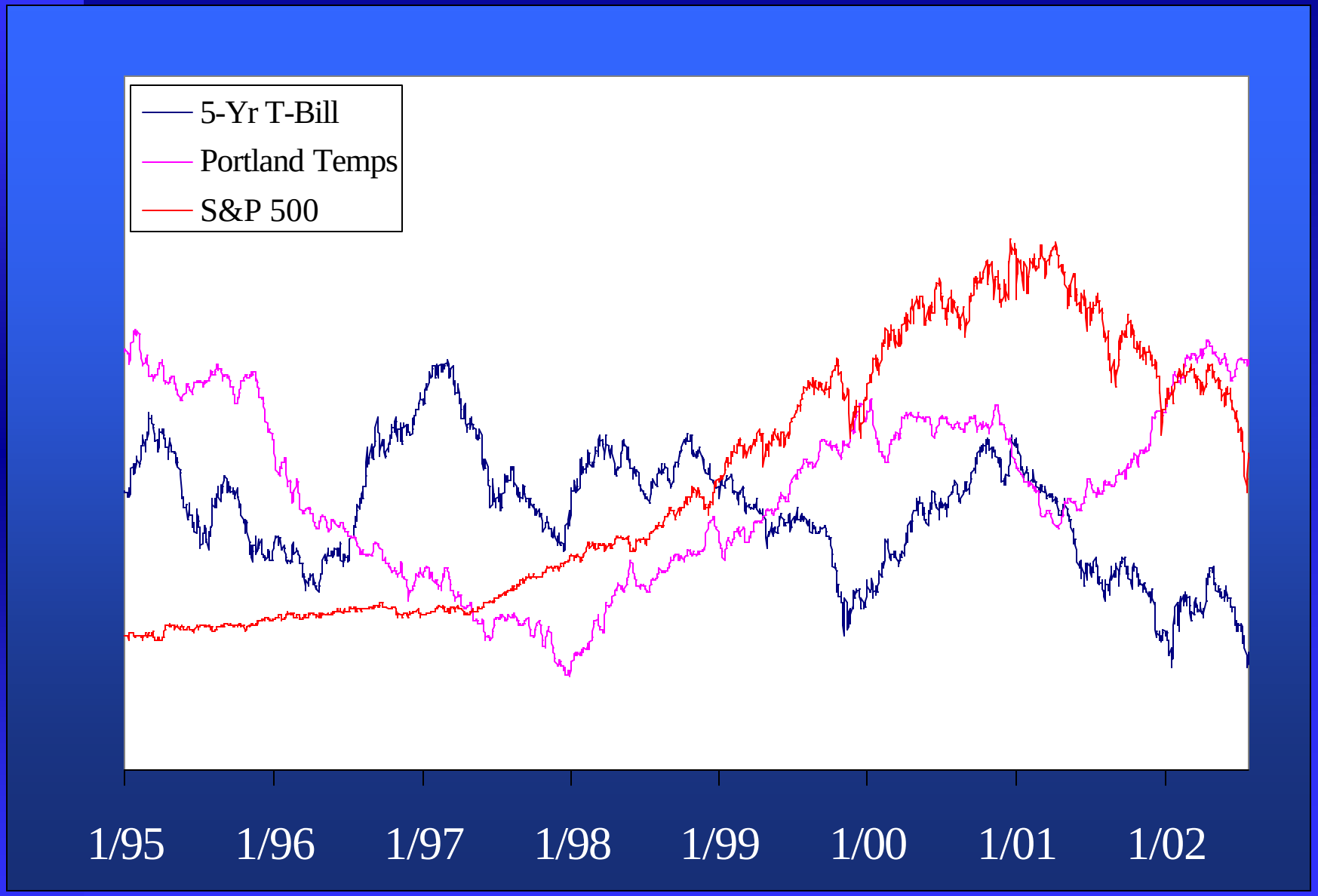
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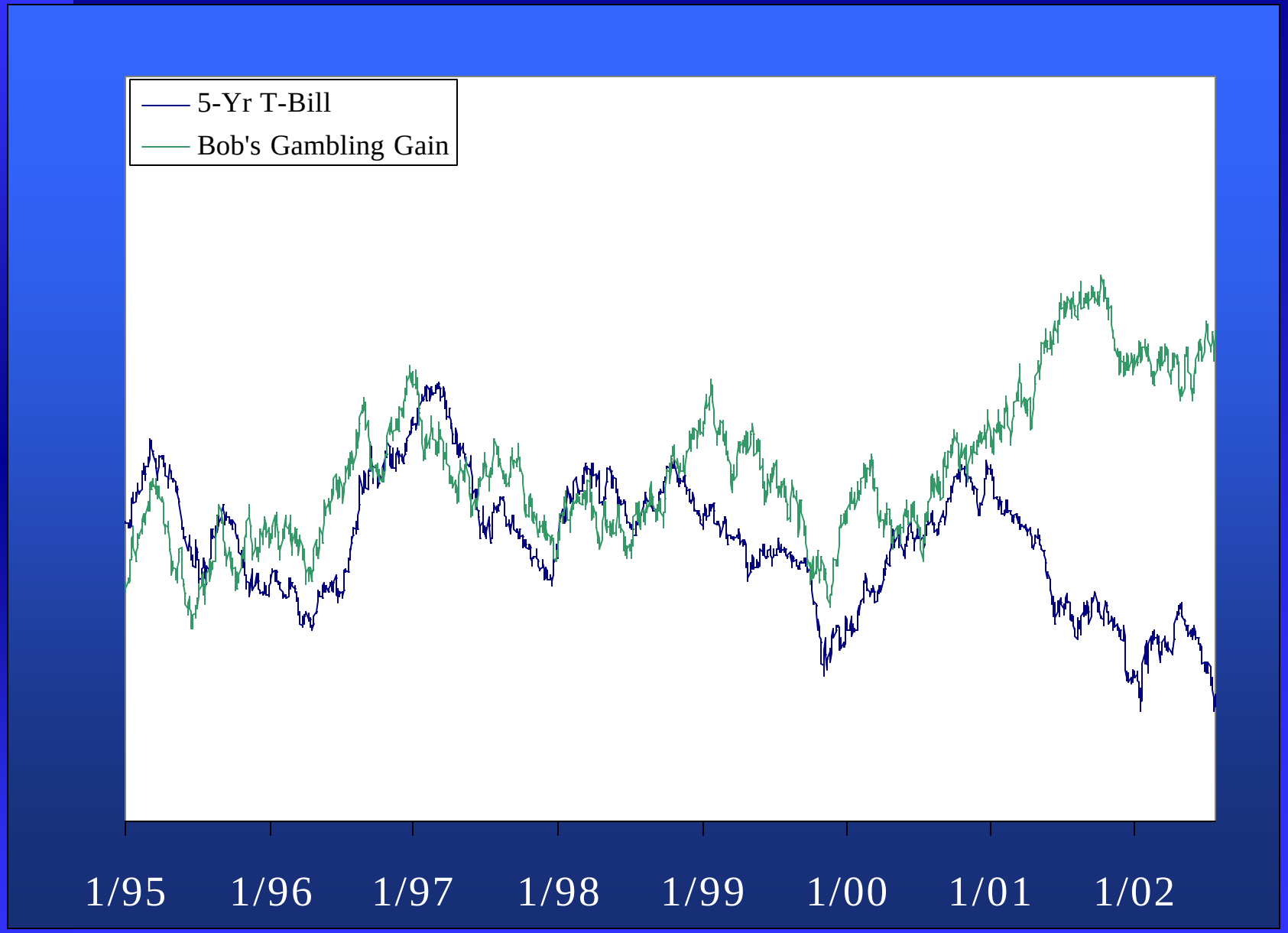
5-Yr T-Bill
Bob's Gambling Gain
1/95
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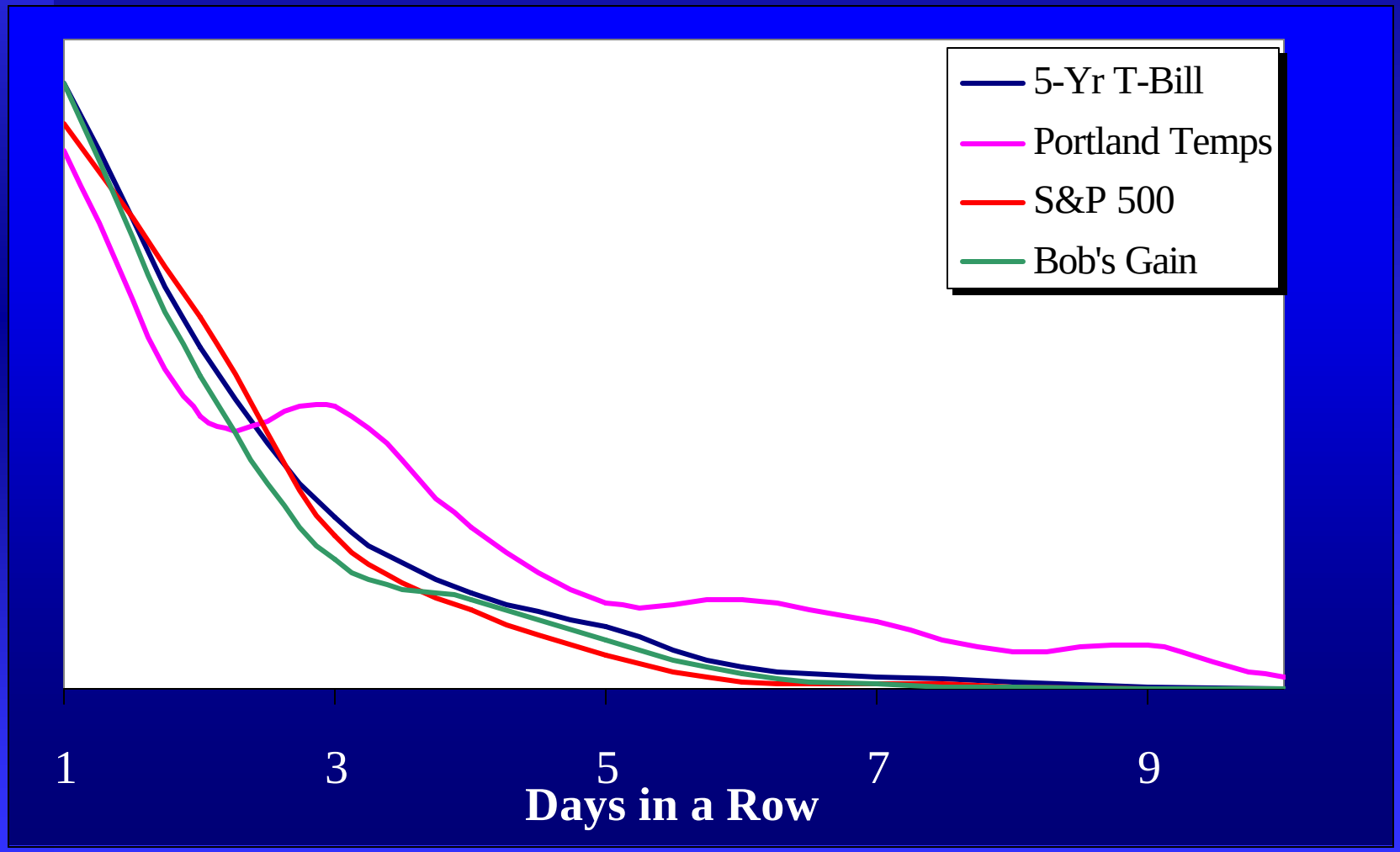
1/01
1/02

Distribution of Streaks

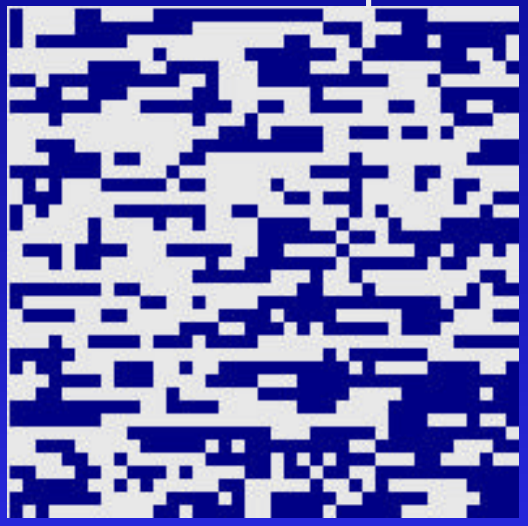


Light = Increase

Dark = Decrease

5-Year Treasury

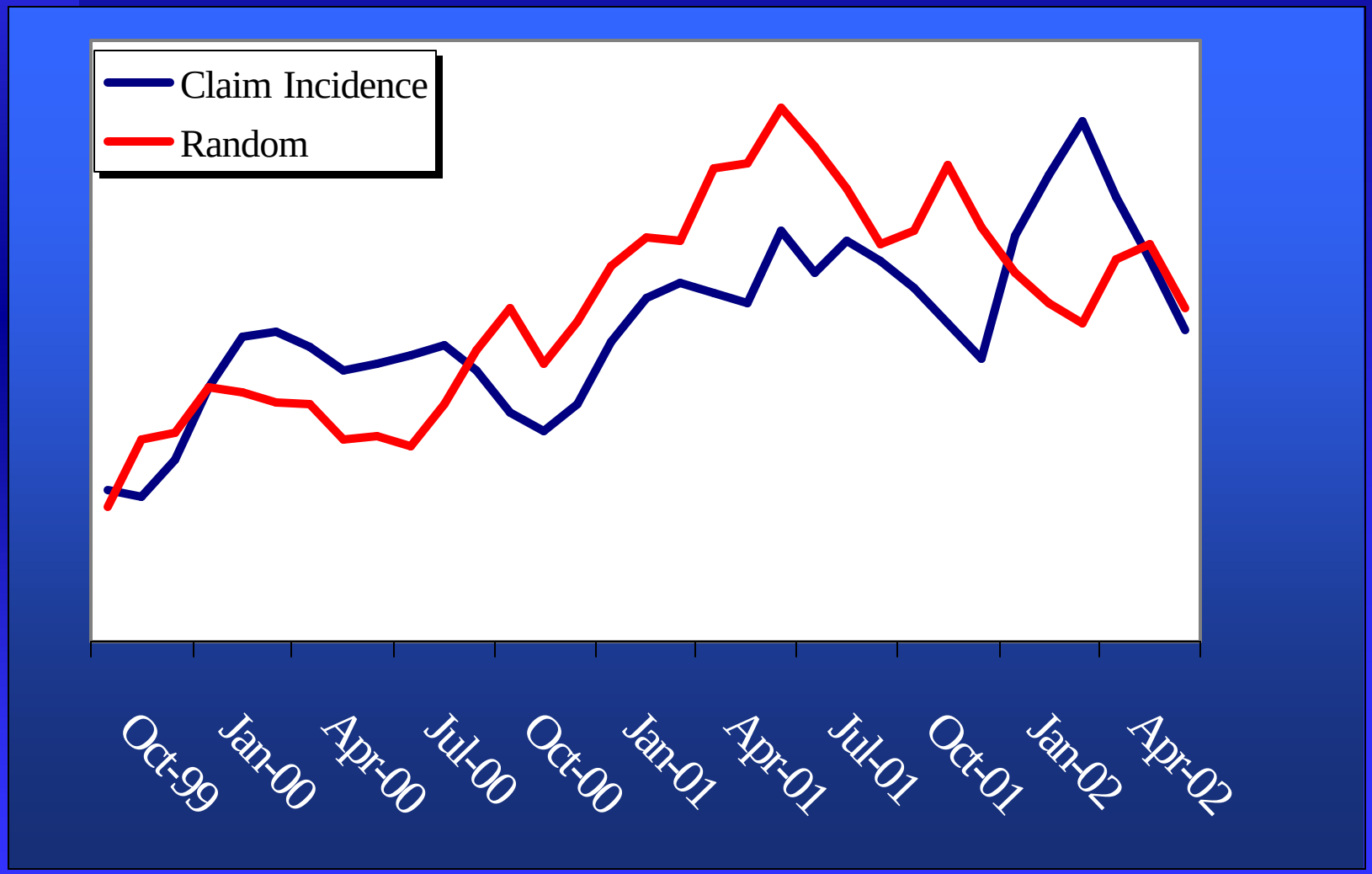
Portland Temperature



S&P 500

Random

How Random is Disability Experience?



Random versus Predictable

Random

Predictable

Roulette

Dice

Cards

Lottery

Stock Market

Interest Rates

Weather

Disability Insurance

Most Human Activity

Physical systems

Planetary Orbits

Structural Load

Technology

Predictability

On April 8th in the year 2024, Burlington Vermont will experience a total eclipse of the sun. This eclipse will be begin at 5:26 pm and last for 3 minutes and 35.9 seconds

Predictability

Simple Population Dynamics

Population Model

N = Population

Max = Maximum Sustainable Population

P = Unknown Parameter

$$N_{t?1} \; ? \; P * N_t * (Max \; ? \; N_t)$$

$$X_{t?1} \; ? \; A * X_t * (1 \; ? \; X_t)$$

Where $X = N / Max$

Simple Population Dynamics

$$Xnew = A * Xold * (1 - Xold)$$

Example:

A = 2.5 X0 = 0.2

X1 = 2.5 * 0.2 * (1 – 0.2) = 0.4

X2 = 2.5 * 0.4 * (1 – 0.4) = 0.6

X3 = 2.5 * 0.6 * (1 – 0.6) = 0.6

Population at 60% of maximum is at equilibrium

Simple Population Dynamics

Equilibrium State

$X = A * X * (1 - X)$

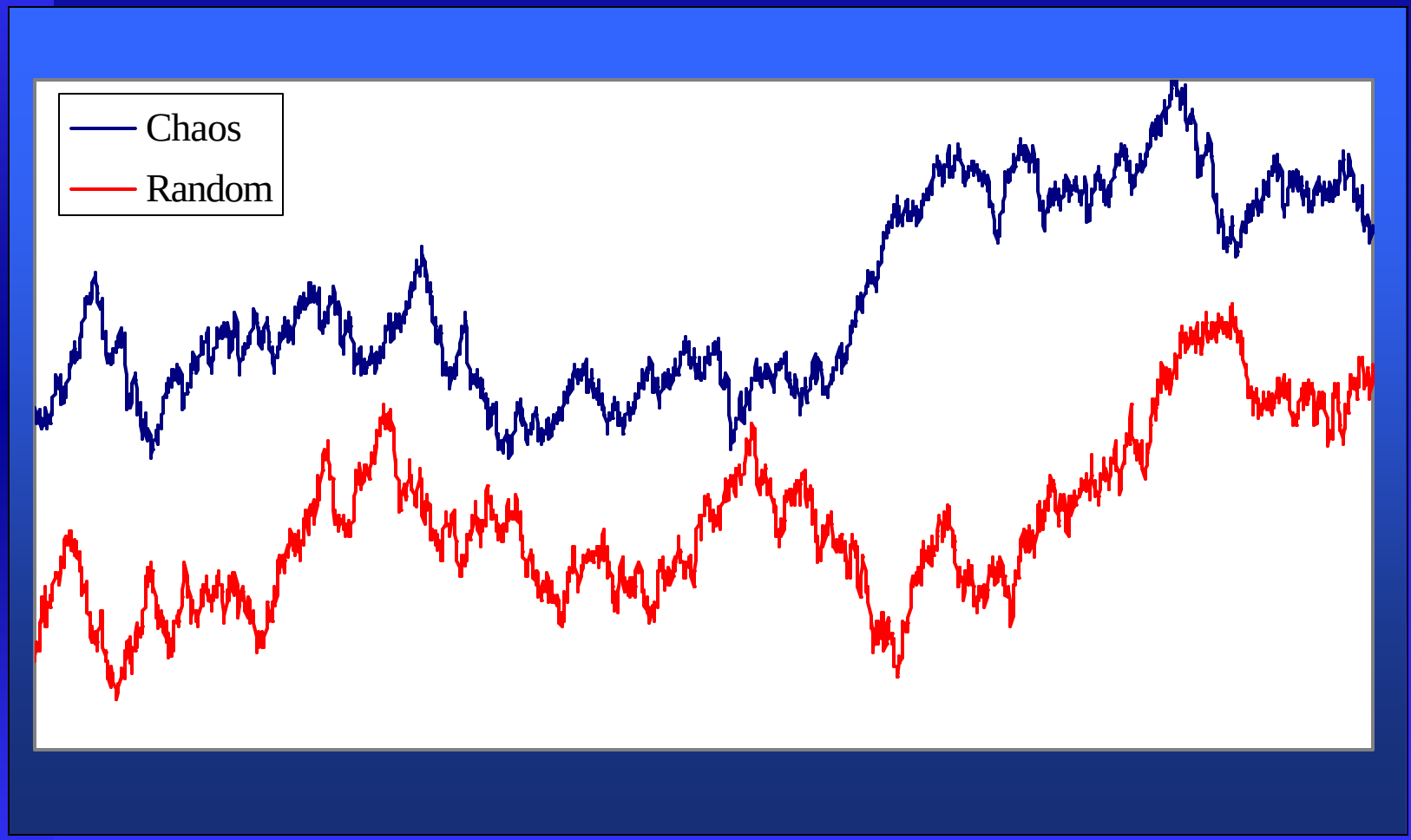
Equilibrium Solution

$X = (A - 1) / A$

Looks like a pretty simple problem

Simple Population Dynamics

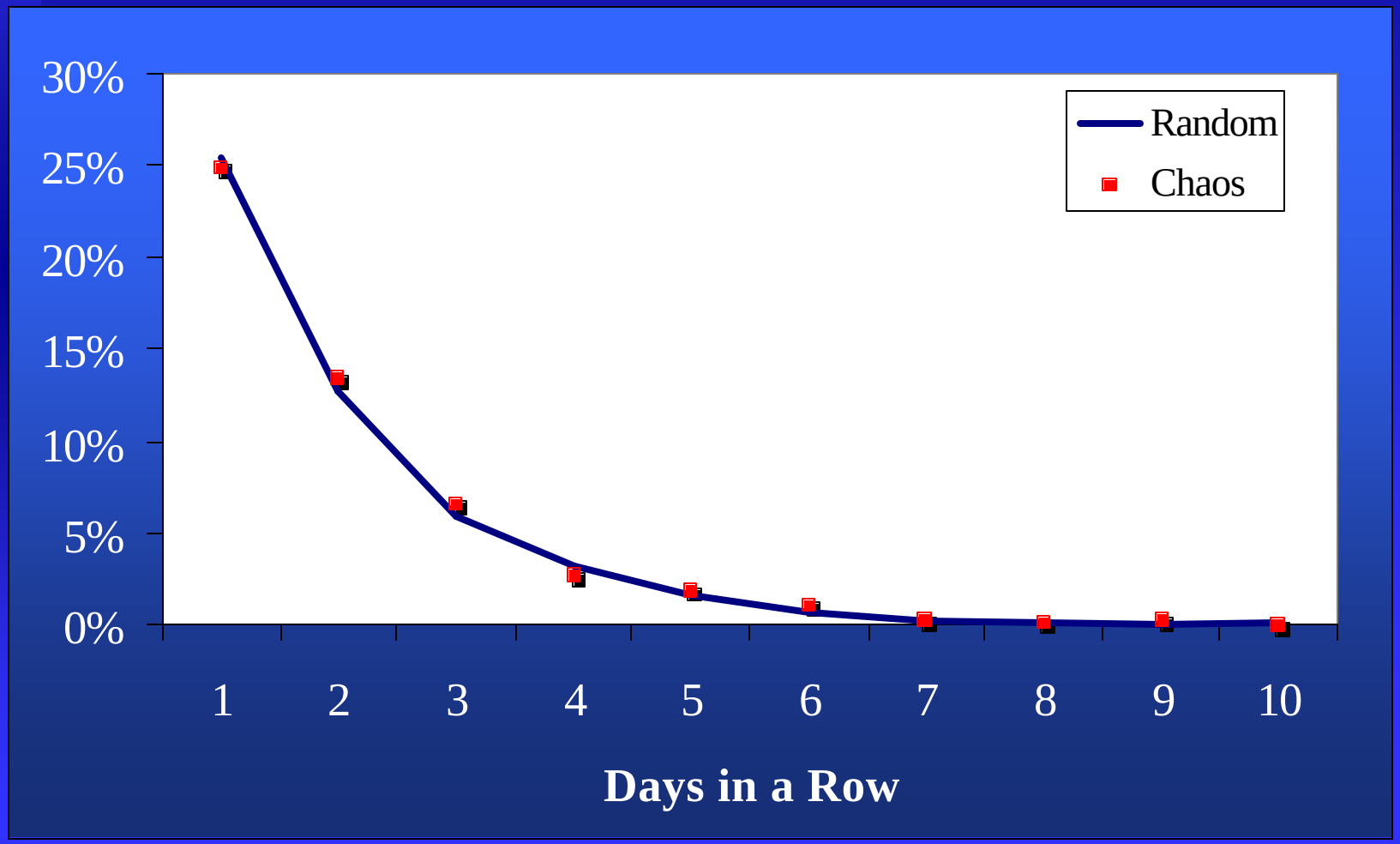
Random versus Chaotic



Chaotic = Simple Population Dynamics

Random versus Chaotic

Distribution of Streaks



Random versus Chaotic

Increase: Dark Decrease: Light

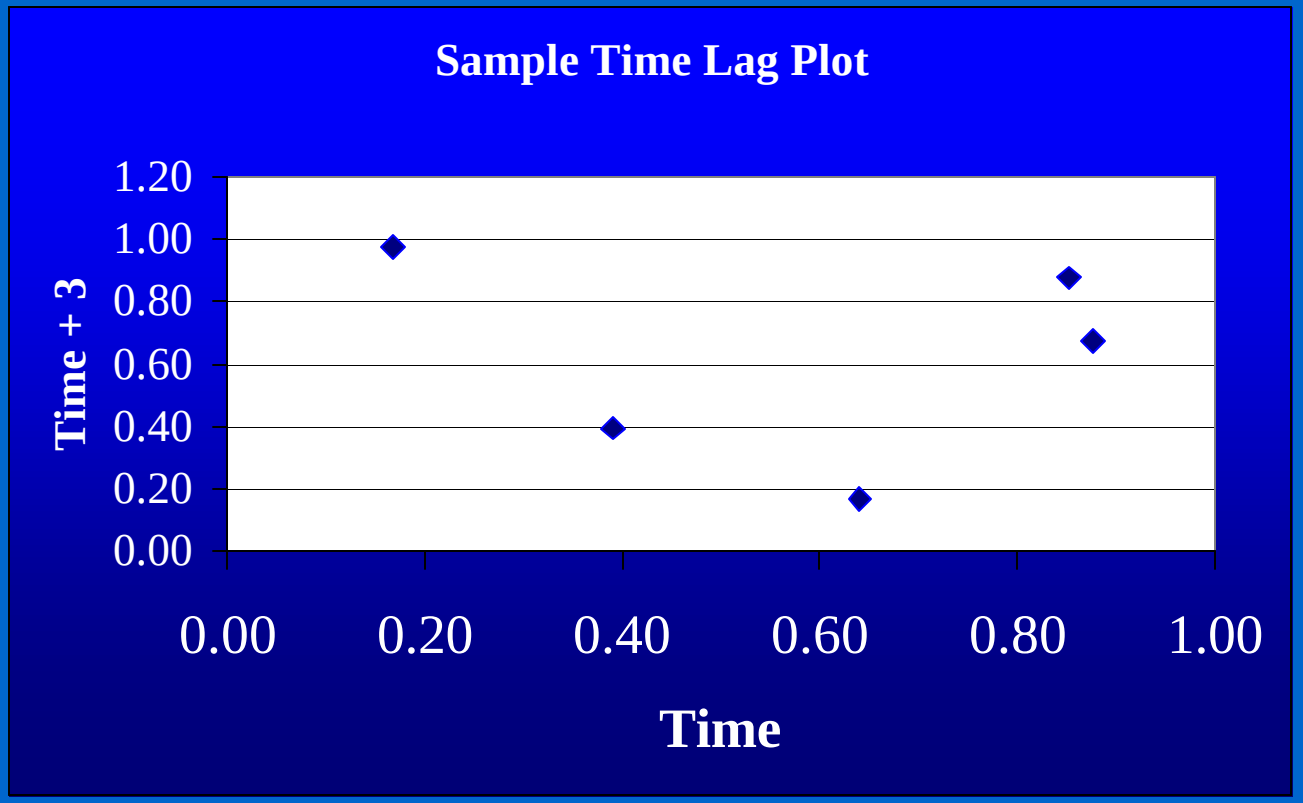
Random

Chaos

Distinguish Random from Chaotic

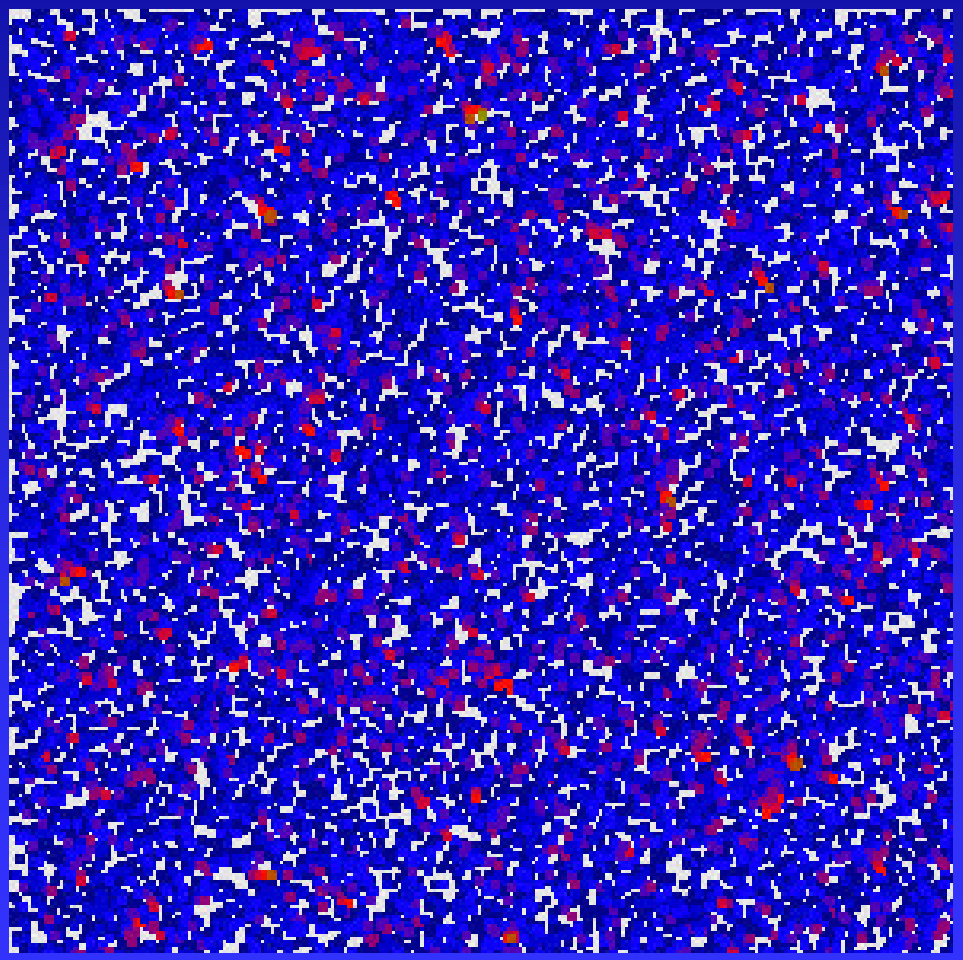
Time-Lagged Plot: Plot value on one axis versus value at a fixed time lag on another axis

Time	Values
1	0.64
2	0.85
3	0.39
4	0.17
5	0.88
6	0.40
7	0.98
8	0.67



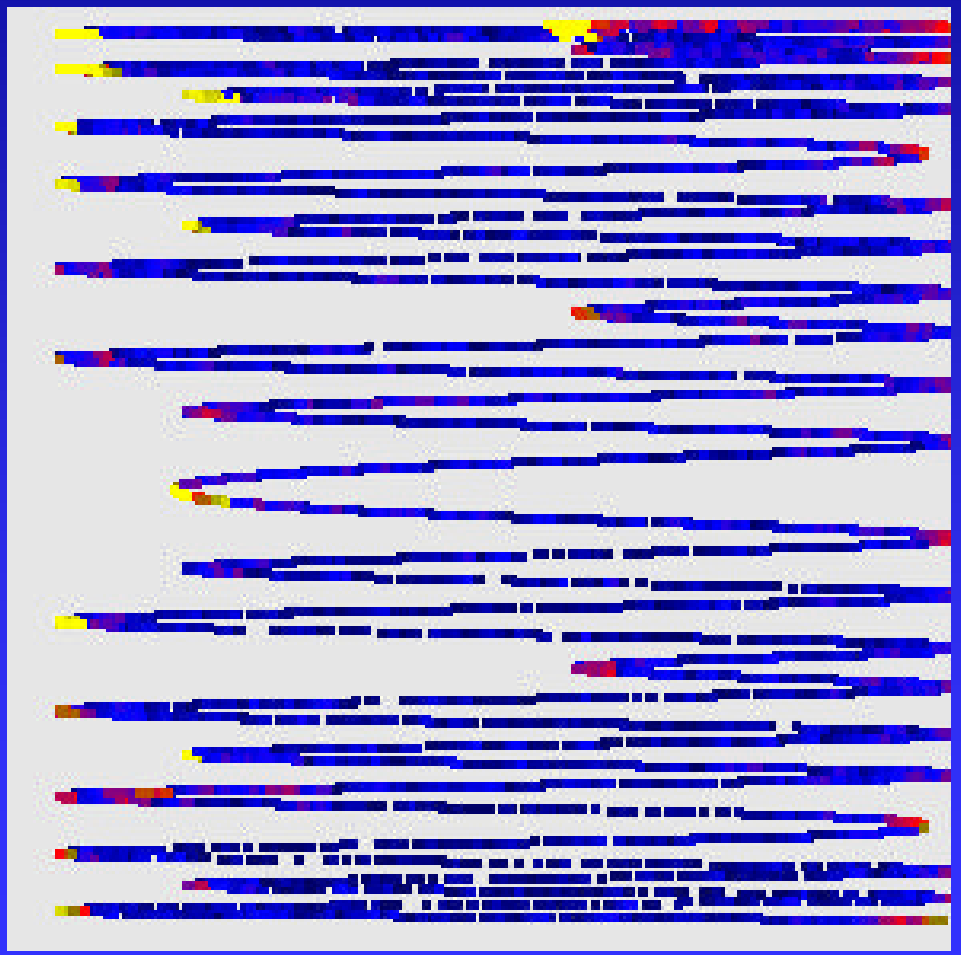
Random Time-Lag Chart

Lag: Seven



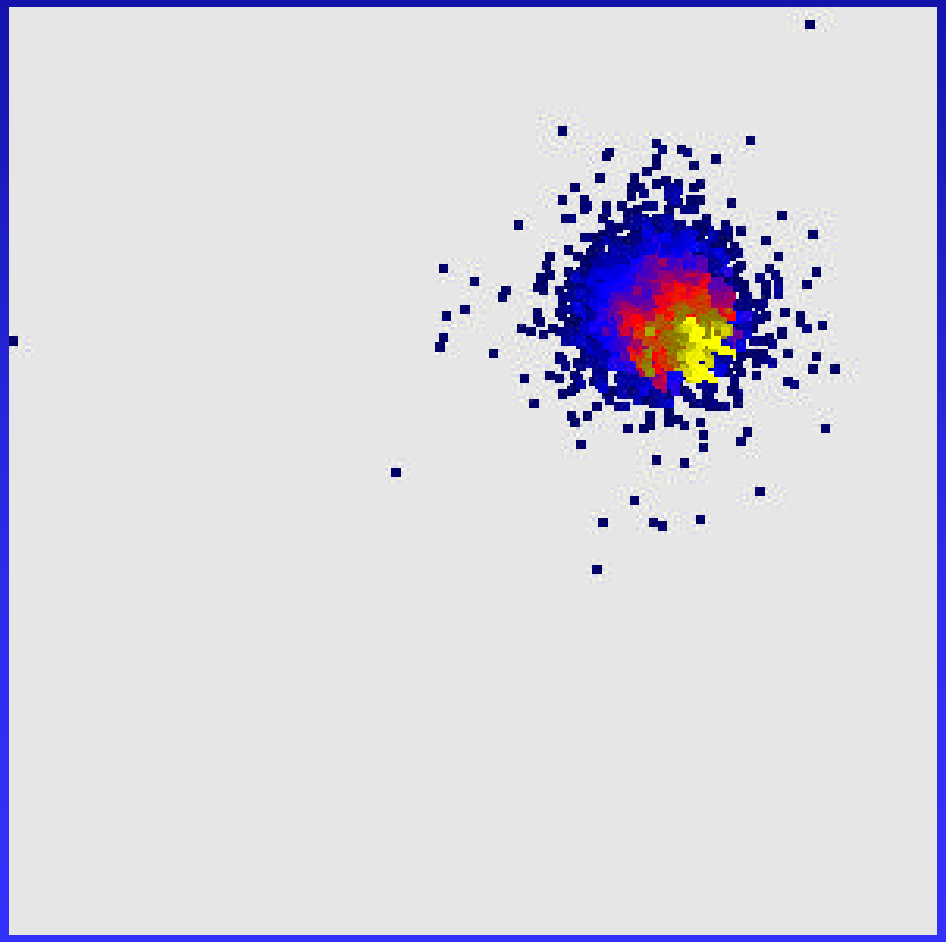
Chaos Time-Lag Chart

Lag: Seven



S&P 500 Time-Lag Chart

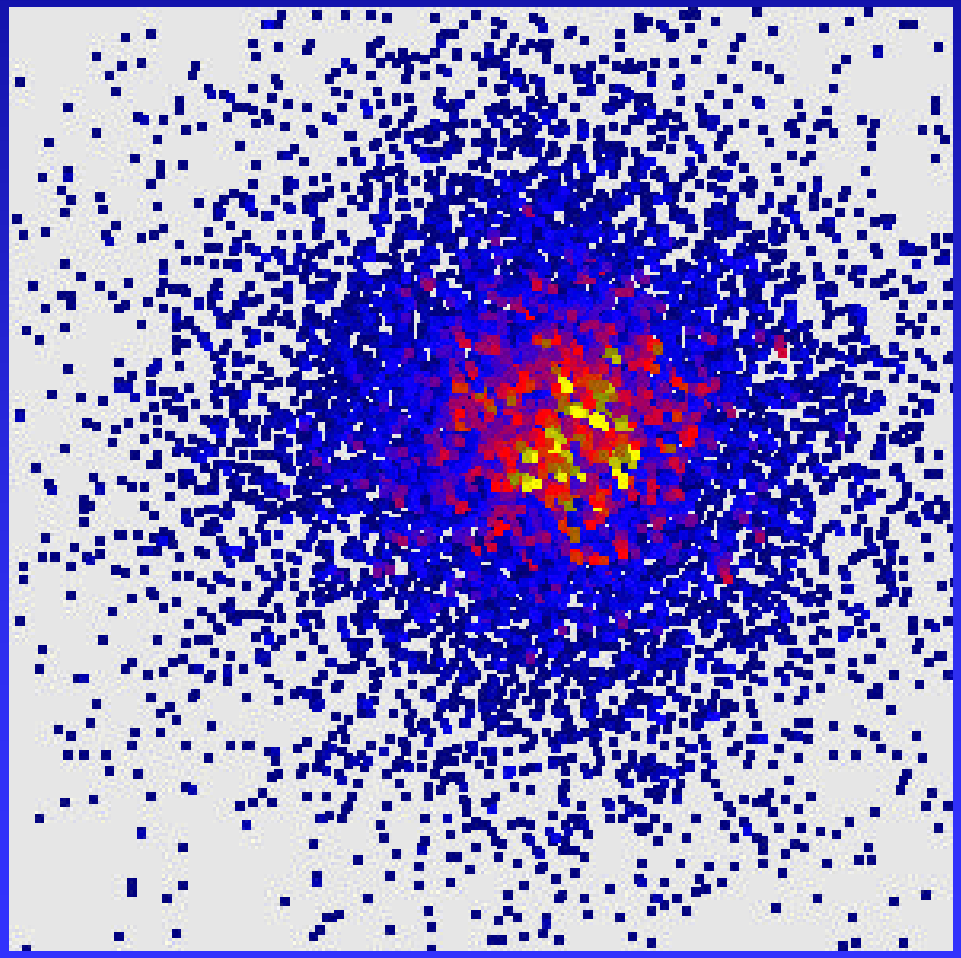
Lag: Seven



S&P 500 Time-Lag Chart

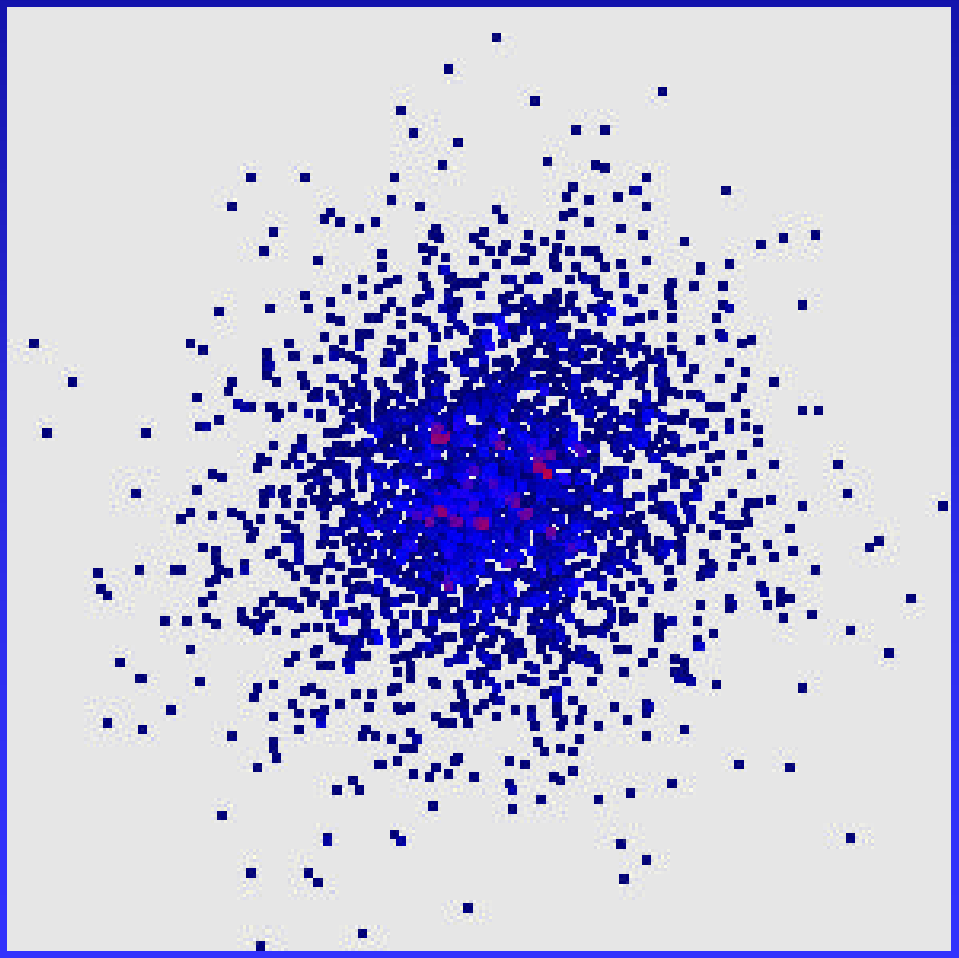
Lag: Seven

Zoomed



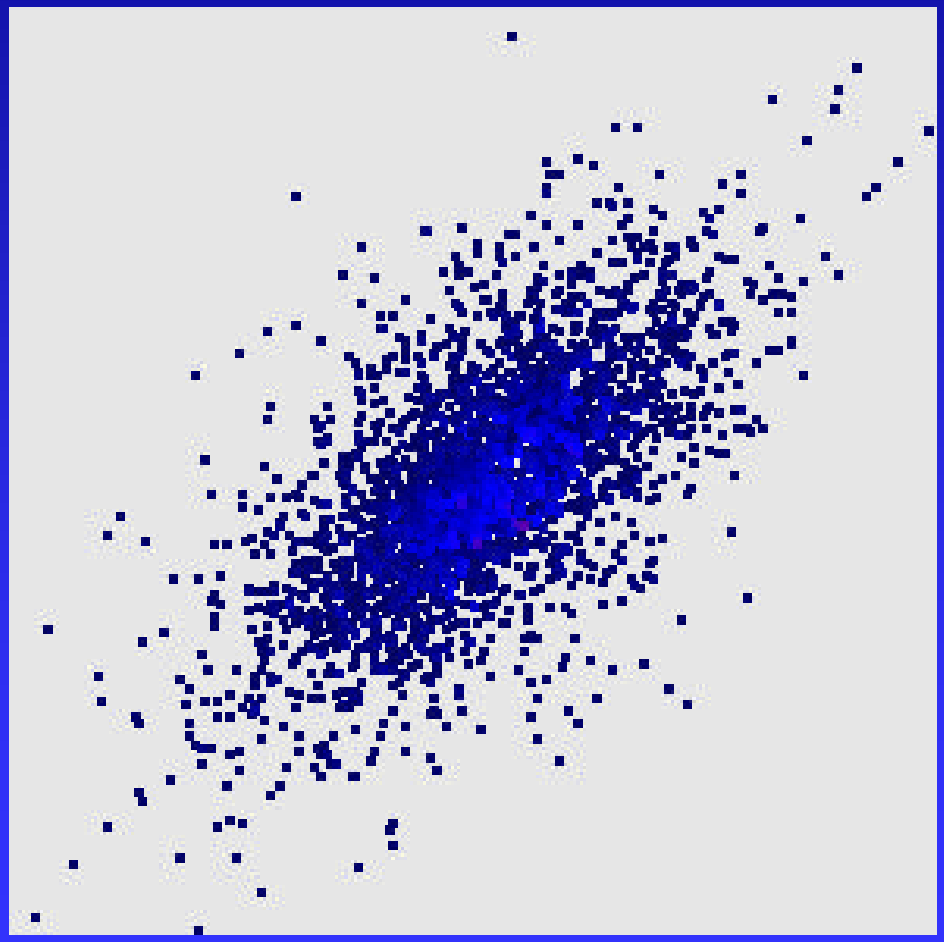
Portland Temps Time-Lag Chart

Lag: Seven



Portland Temps Time-Lag Chart

Lag: One Day



Chaos

Sensitive Dependence on Initial Conditions

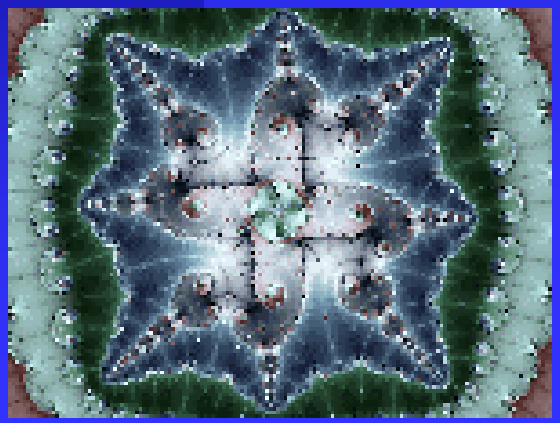
implies
Lack of Predictability

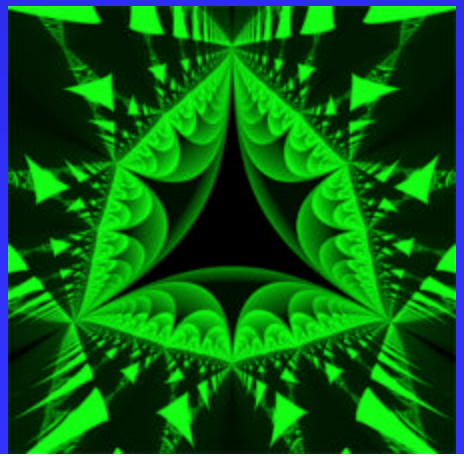
Signatures of Chaos

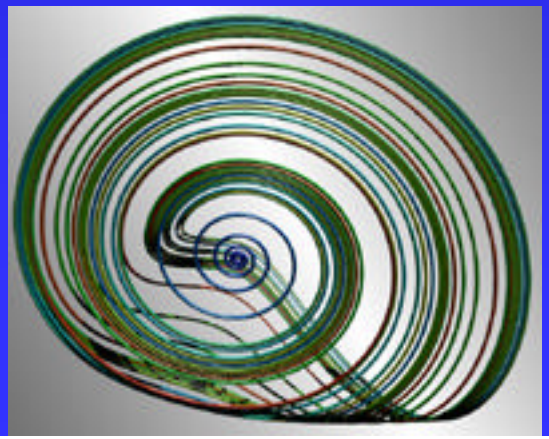
Chaotic Dynamics can result from a simple model, but must involve mechanism for feedback

Dynamics are fully determined, but highly unpredictable due to sensitive dependence on initial conditions

Time lag plots will reveal complicated structure







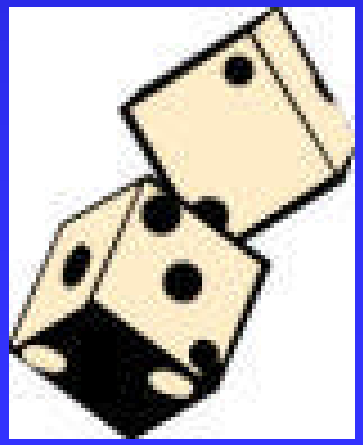
Signatures of Randomness

One observation does not affect the next

Dynamics influenced by many factors

Time lag plots reveal no structure

Aggregate Behavior can be handled through statistics

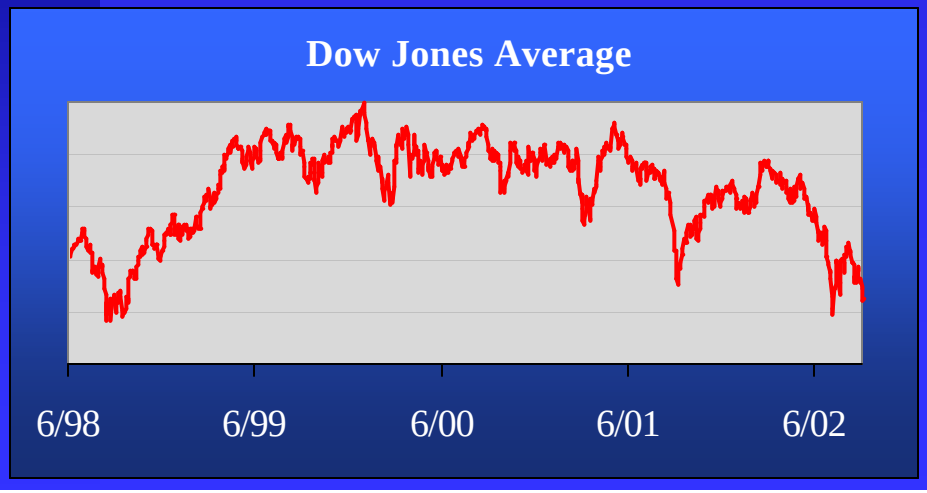


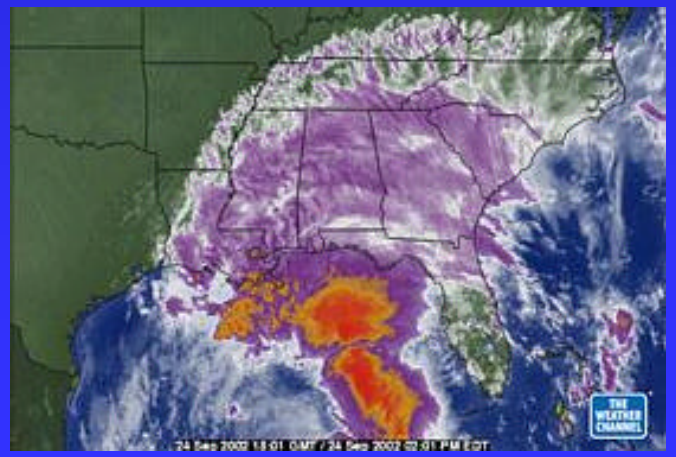
Signatures of Complex Systems

Dynamics are influenced by many variables, some of which may be chaotic

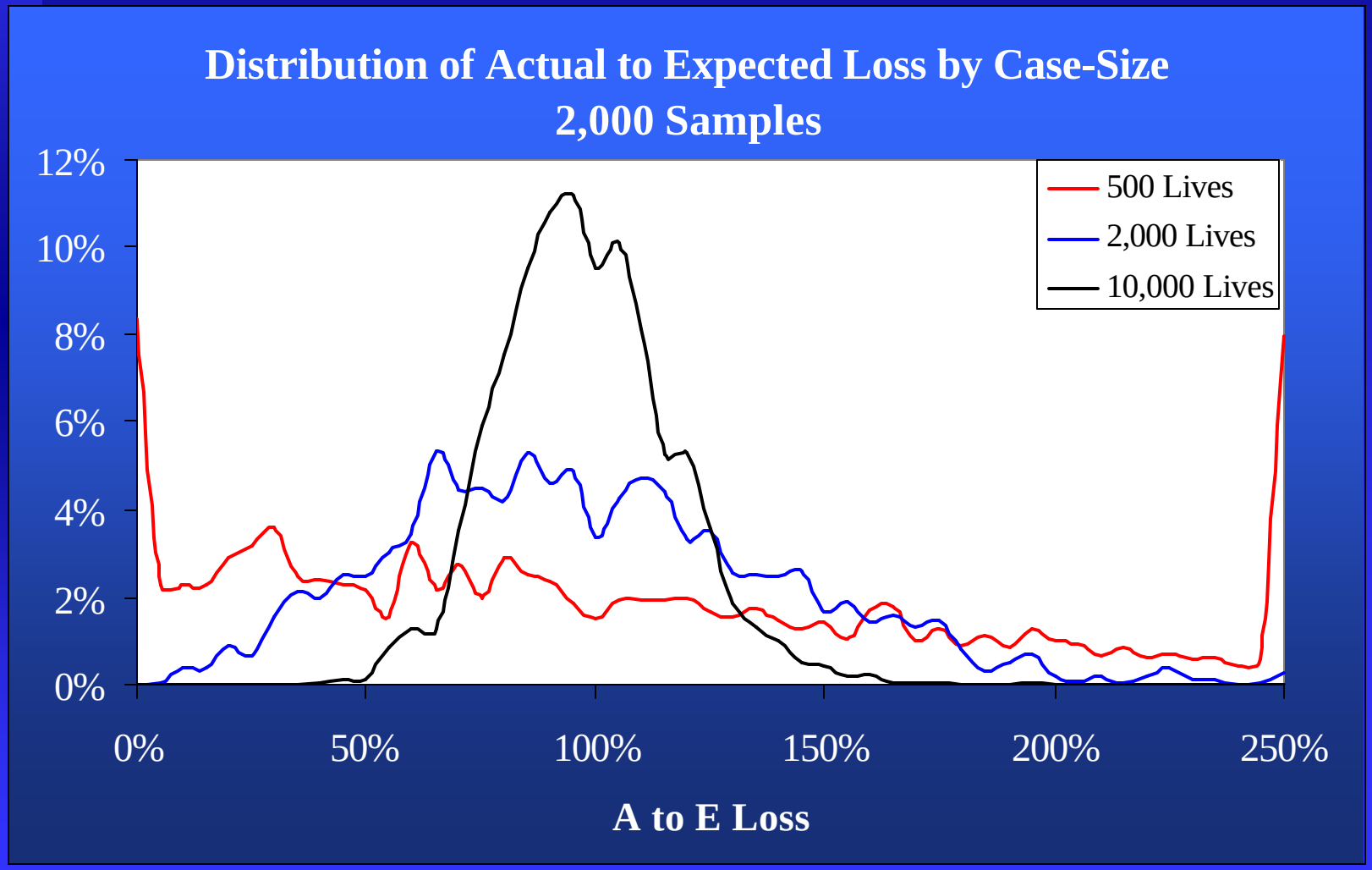
Dynamics resist analysis. Limited utility of computer simulations.

Sensitive Dependence on Initial Conditions
- “the butterfly effect”

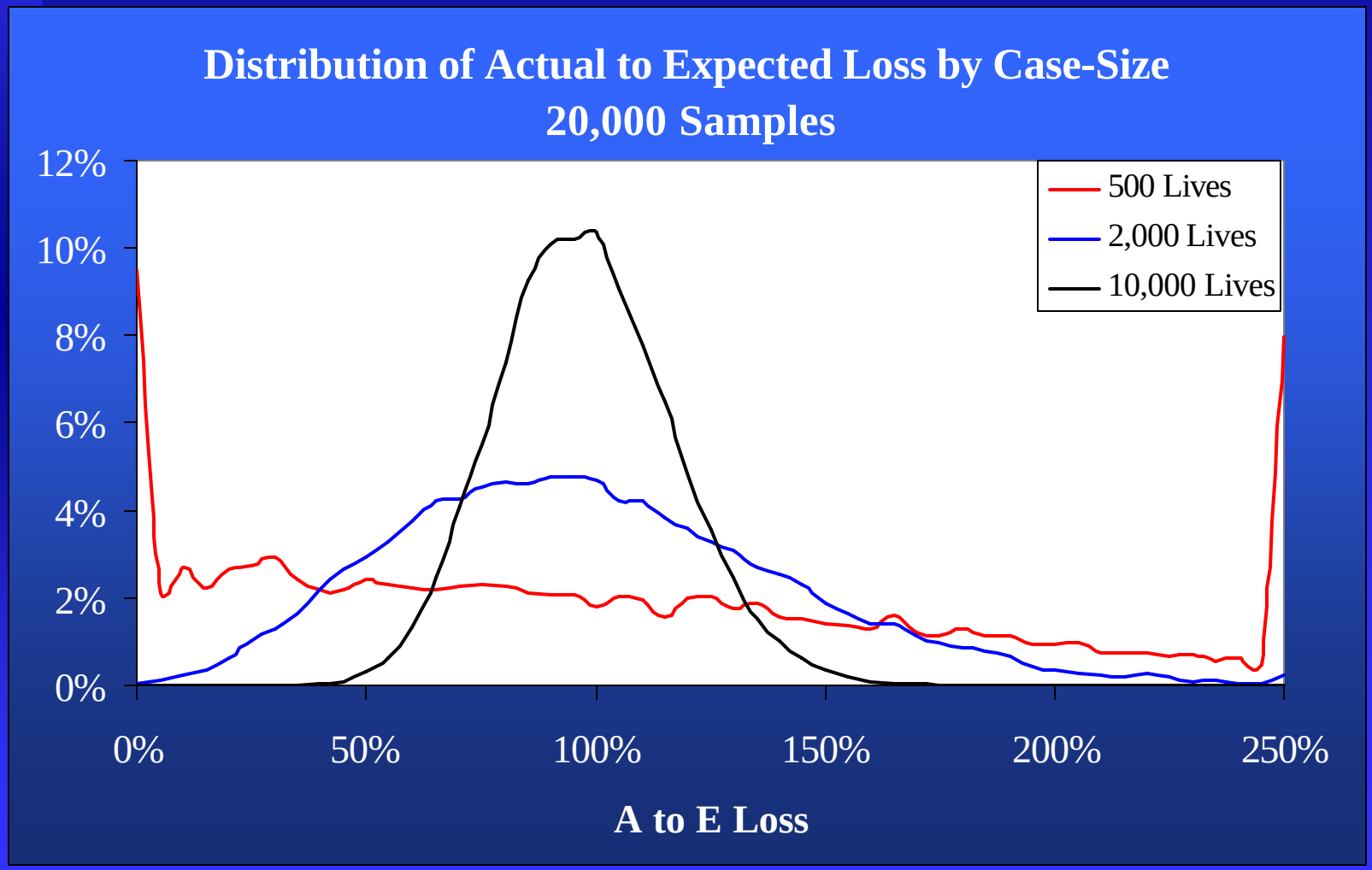




Monte-Carlo Simulations of Disability Experience



Monte-Carlo Simulations



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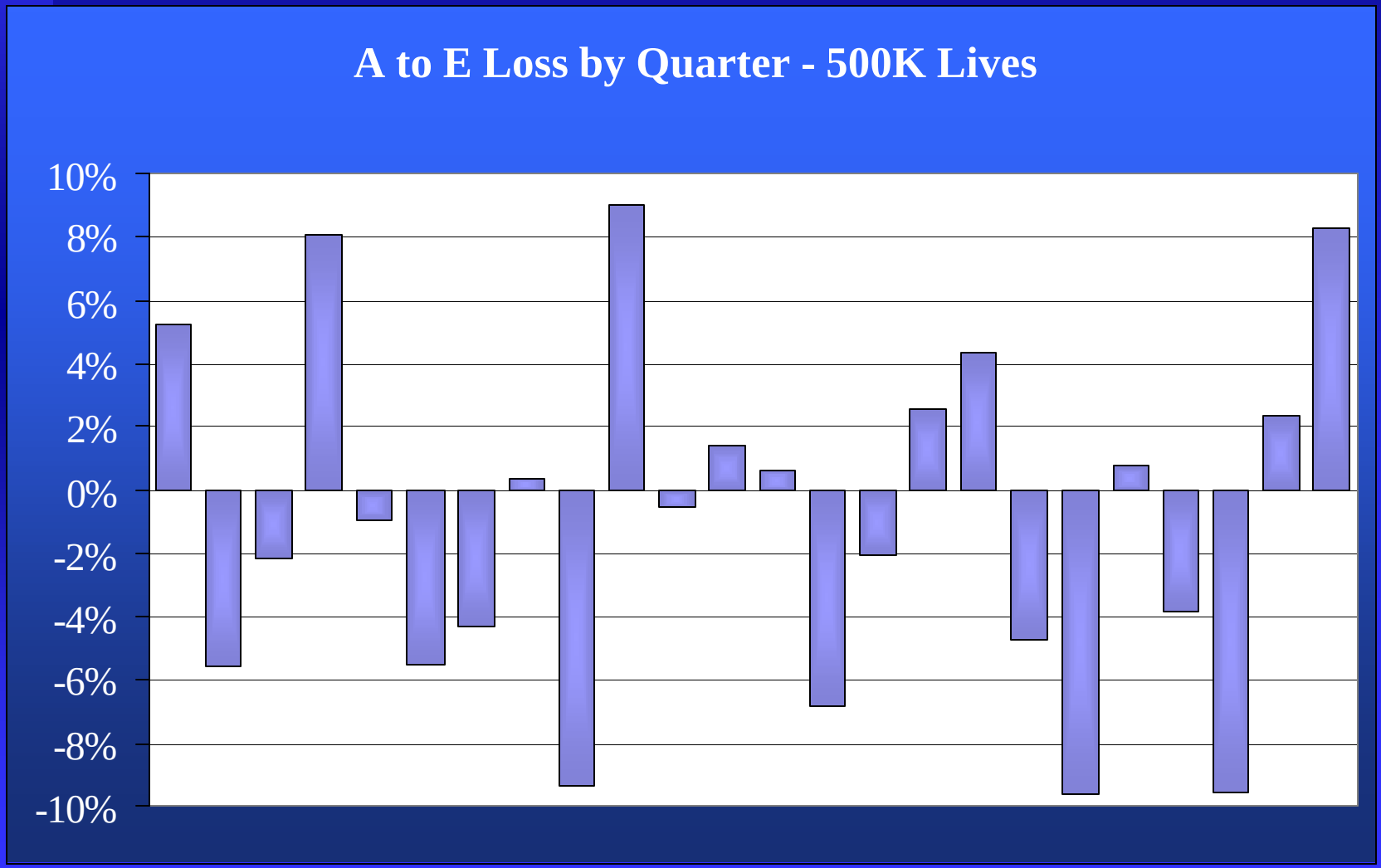
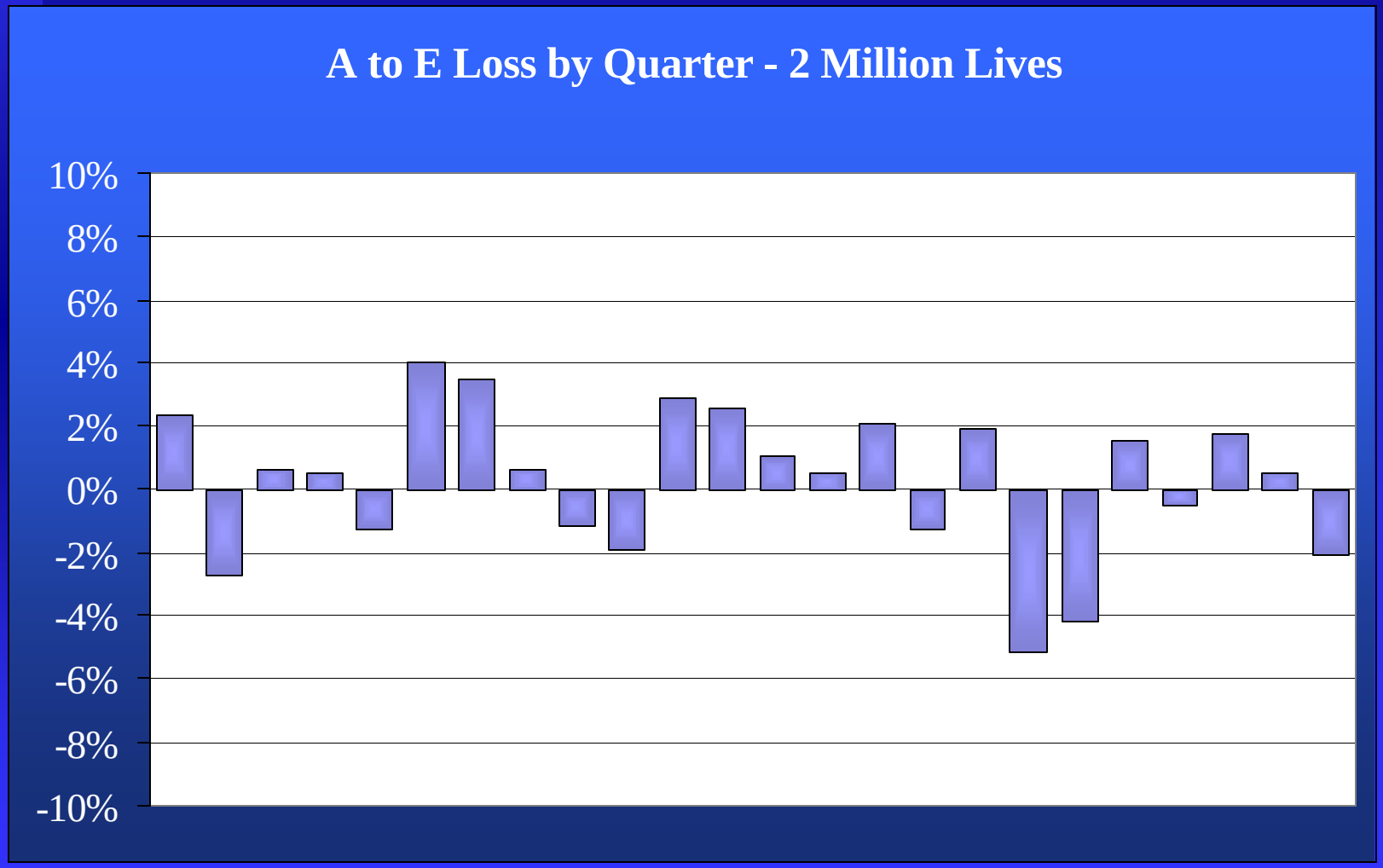


Monte-Carlo Simulations



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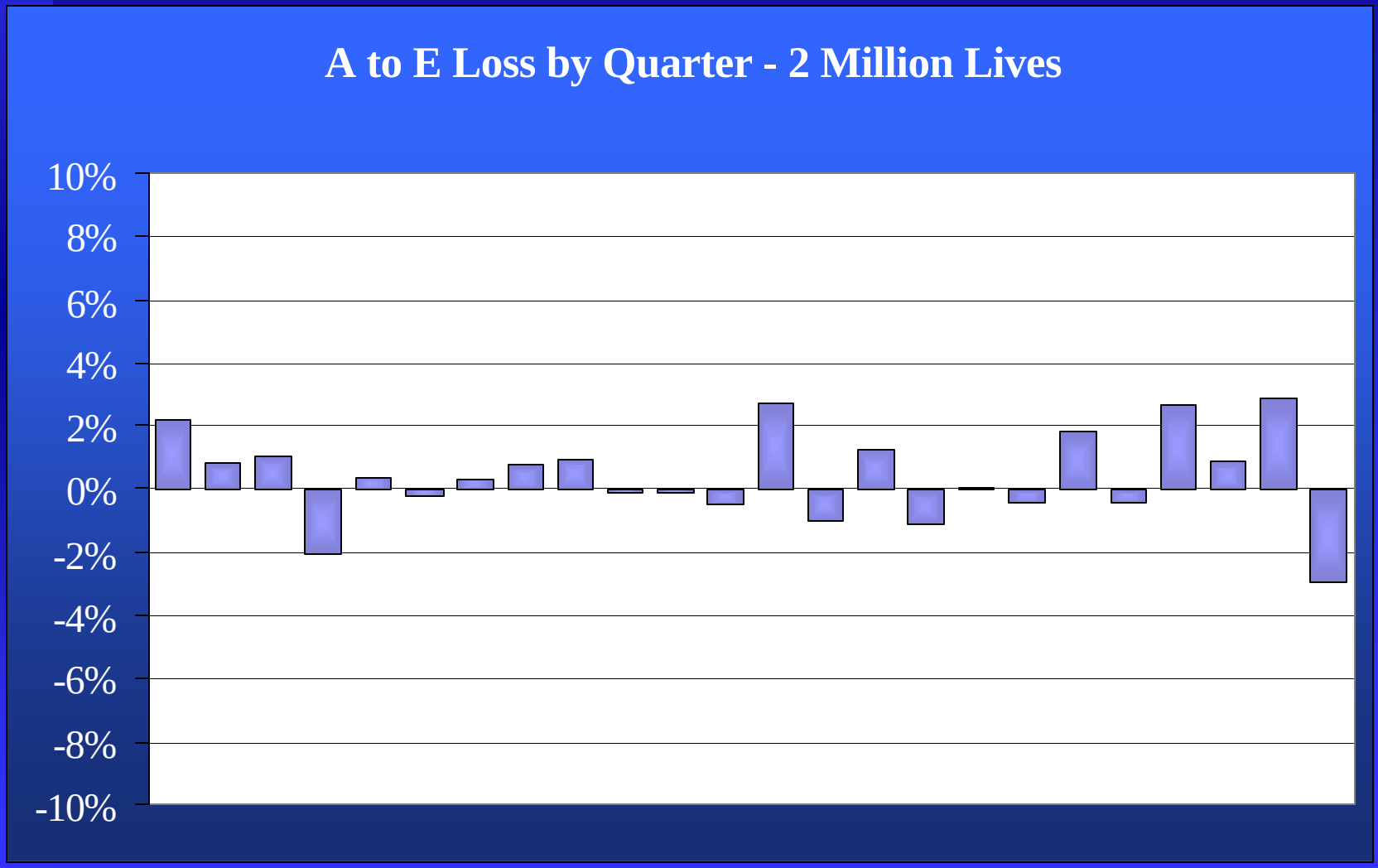

Chaos in Disability Experience?

Disability Experience is unpredictable

Difficult to statistically measure Chaos

Lack of Predictability limits utility

Little impact of feedback mechanism

Disability experience is driven by many external factors, some of which may be chaotic