Frequency-Magnitude Relations

Earthquakes
Moment (Richter) Magnitude

\[ M = \frac{2}{3} \log_{10} W - 6.0 \]

\( W = \) Seismic Moment
\( = \) Energy Released

California-NV Region
\( b \sim 0.9 \)

\( \text{Slope} = -b \)

S&P 500 Quakes
\( M=4 \) means \( \sim 4\% \) move in SPX
(either up or down)

\[ M_F = 100 \left| \log_e \frac{P_i}{P_{i-1}} \right| \]

\( P_i = \) Closing Price, Day \( i \)

Gutenberg–Richter Relation

Financial (Stock/Bond) Quakes

S&P 500
\( b \sim 0.25 \)

\( \text{Slope} = -b \)

Catalog: ANSS_2010-08-12.Ca-NV.29.0.42.0.Lat._127.-113.Long.catalog

Catalog: SPX_File.txt
Dynamics of Financial Markets

Investors are arrows:

\[ \text{↑ Owns only Govt. bonds} \quad \text{↓ Owns only stocks} \]

\( \phi \) is the fraction of total money deployed in Govt bonds

\( f \) is the real Fed funds rate

Volatility \( V \) plays the role of “temperature”

For example, we might have \( V \propto (VIX) \)

Investors “interact” with neighbors, strength \( J \)

Market Potential \( U[\phi] \)
Transitions in Financial Markets

First order phase transitions – metastability, nucleation, hysteresis

\[ U[\phi] = \varepsilon \phi^2 + \alpha \phi^4 - f \phi \]

\( f \): Real Fed funds rate
\( V \): Volatility \( \propto (VIX) \)
\( \varepsilon \propto (V - V_C) \)
Phase Transitions and the Markets

Before a 1$^{\text{st}}$ Order Phase Transition

Transition occurs via nucleation and growth of bubbles

Classical: Correlation lengths and times are small
Nonclassical: Correlation lengths and times $\rightarrow \infty$

Large fluctuations (volatility is high) – Ginzburg Criterion

Risk function (of bubble formation):

- Related to nucleation rate of bubbles,
- Lifetime in the metastable state is inverse of nucleation rate

Scaling (fat tail) exponents can be calculated
VOLATILITY & P500 (^VIX) - Chicago Options

Technical Analysis

VOLATILITY & P500 (Chicago Options)
Range: 1d 5d 1m 3m 6m 1y 2y 5y 10y
Moving Avg: 5 | 10 | 20 | 50 | 100 | 200
Indicators: MACD | MFI | ROC | RSI | Slope
Overlays: Bollinger Bands | Parabolic SAR
Compare: ^VIX vs

VOLATILITY & P500

Bust | Metastable Bust | Boom | Metastable Boom | Bust | Metastable Bust | Boom | Metastable Boom

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Federal Funds Rate History
(Effective Rate 1966 - 2012)

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Simple Phase Diagram for the Markets

- **Volatility**
  - **High**: High volatility
  - **Low**: Low volatility

- **Market Cycle**
  - **Boom**: High volatility, $f < 0$
  - **Bust**: High volatility, $f > 0$
  - **Metastable (?) Boom**: Low volatility, $f < 0$
  - **Metastable (?) Bust**: Low volatility, $f > 0$

- **Stimulative Monetary Policy**
  - Easier Credit – Higher Liquidity

- **Restrictive Monetary Policy**
  - Tighter Credit – Lower Liquidity

- **Boom**: Stocks are preferred.
- **Bust**: Govt bonds are preferred.
Attractor for the S&P 500: The dynamics are a bit more complex than a simple Ising model!

This is not random – there is structure here. Time interval = 1970-2012