

Chaos Theory, Is the Future Predictable?

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Presented by:
Charles K. Bobrinsky

An Investor's Tool Box of Ideas

- Charlie Munger's Tool Box: Multiple mental models.
- The Second Law of Thermodynamics.
- Psychology and Confirmation Bias.
- Chaos Theory should be in your tool box.
- Counter to Overconfidence and Planning Fallacy.
- Counter to Determinism!!!
- Can models predict financial future?
- Do forecasts decline in accuracy over time?

- Determinism - philosophical belief every event is inevitable result of preceding events and actions.
- Accurate long-term predictions are possible through the applications of the laws of physics and a precise knowledge of starting conditions.
- Determinism into science, Isaac Newton - Principia Mathematica, 1687.
- Many famous people were Determinists; Newton, Tolstoy, Marx and even Einstein.

The Clockwork Universe

- Since Newton, physics proclaimed absolute law of cause and effect.
- It was always possible to make accurate long-term predictions of any physical system so long as one knows the starting conditions well enough.
- By putting more precise information into Newton's laws, you got more precise output for any later or earlier time.

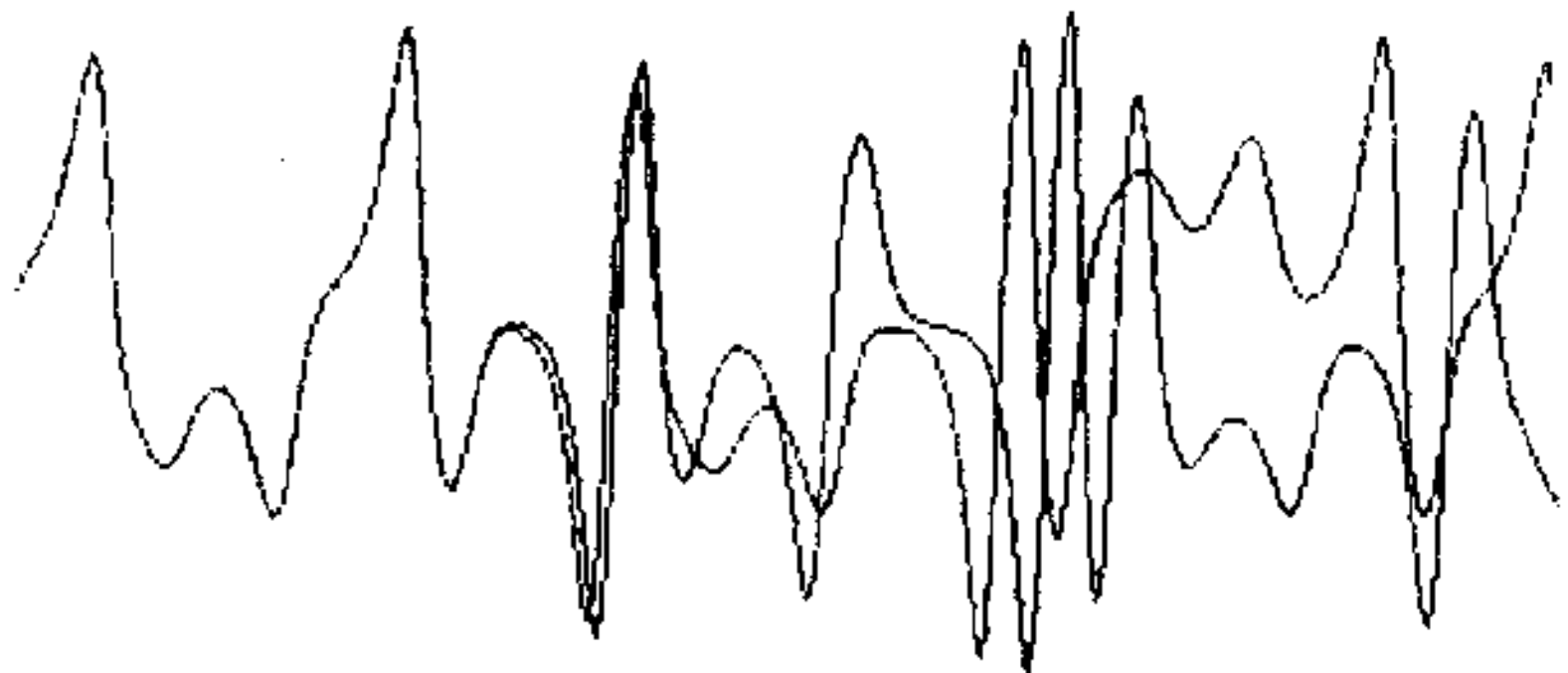
- French mathematician Laplace said:
“If we were to know with precision the positions and speeds of all the particles in the universe, then we could predict the future with certainty.”
- Better predictions come from better measurement of current conditions.
- Marxist’s and dialectic materialism.
- Scientific material forces control history.
- Inescapable.
- Guns, Germs and Steel – Collapse, Jared Diamond

Finance

- Determinism appears in markets through:
 - 1) Quant Investing.
 - 2) *Value At Risk* in Risk Management.
 - 3) Stress tests for banks.
 - 4) Long-range earnings forecast models.
 - 5) Investment banking analysts producing long range pro-forma deal models.

Edward Lorenz and the Butterfly Effect

- Edward Lorenz - Army Corp. of Engineers
Model to predict weather.
- Computer code -12 inputs
Temperature, barometric pressure, humidity,
etc.
- In 1960, computer programs very slow.
- Computer code is absolutely Deterministic.
- Lorenz expected:
Same initial values = Same outputs.
- Lorenz got wildly different outputs!



Lorenz Paper: Does the Flap of a Butterfly's Wings in Brazil set off a Tornado in Texas?

- Weather is a chaotic system.
- Accuracy requires massive measurements.
- Measurement variance between instruments produces uncertainty.

“Small Things Can Have a Big Impact” is Not New

For Want of A Nail

- For want of a nail the shoe was lost.
- For want of a shoe the horse was lost.
- For want of a horse the rider was lost.
- For want of a rider the battle was lost.
- For want of a battle the kingdom was lost.
- And all for the want of a horseshoe nail.

- New!!
- Small changes can affect simple systems!
Even Deterministic systems.
- Before Chaos Theory:
Scientists ignored small errors and assumptions.
- Lorenz: long-term predictions theoretically impossible.
- There is ALWAYS measurement error.

- Quantum Mechanics and Chaos Theory
Dual challenge to Determinism.
- Chaotic systems
 - Any imprecision at all produces uncertainty.
Predictions soon become no better than chance.
 - The extreme "sensitivity to initial conditions"
mathematically present in the systems studied by
Lorenz has come to be called dynamical instability, or
simply **Chaos**.

- Only short-term predictions have any accuracy.
- Chaos Theory shows that using the laws of physics to make precise long-term predictions is impossible, even in theory. Making long-term predictions to any degree of precision at all would require giving the initial conditions to infinite precision.

- 1986 Chair of Cambridge Physics Apology:
“The Recently Recognized Failure of
Predictability in Newtonian Dynamics.”
- Apologized on behalf of “all scientists” for
having “misled the educated public by
spreading ideas about the Determinism of
systems satisfying Newton’s laws of motion
that after 1960 were proved to be incorrect.”

When is the World Not Chaotic?

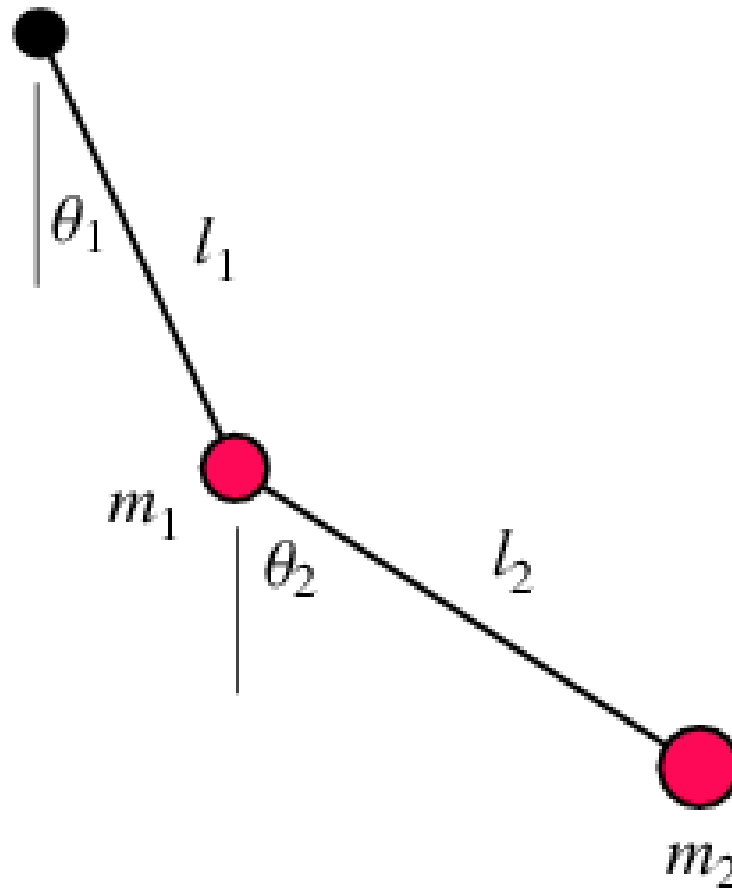
- Butterfly Effect NOT everywhere.
- Systems in equilibrium.
- Periodic motion.
- DOES apply in Deterministic systems.
- Does the Butterfly Effect mean Deterministic systems are not predictable at all? NO!
- Predictable in the short-run BECAUSE Deterministic.
- Period predictable is:
HORIZON OF PREDICTABILITY.
- Horizon of Predictability is time required for Small errors to compound and become large.
- For the Weather; 7 to 10 days.

- For an electrical circuit, a few thousandths of a second.
- For the solar system, about 5 million years.
- How long is the Horizon of Predictability for the earnings of our portfolio companies?

Johnson & Johnson versus Netflix

- JNJ 2017 EPS estimate as of July 2016 = 7.10
Actual 2017 EPS = 7.30 = 2.8% of error
- NFLX 2017 EPS estimate as of July 2016 = 0.89
Actual 2017 EPS = 1.25 = 40.4% error
- JNJ 2018 EPS estimate as of July 2016 = 7.58
Current 2018 EPS estimate = 8.12 = 7.1%
increase
- NFLX 2018 EPS estimate as of July 2016 = 1.78
Current 2018 EPS estimate = 2.86 = 60.7%
increase

Double Pendulum



A double pendulum consists of one pendulum attached to another. Double pendula are an example of a simple physical system which can exhibit chaotic behavior. Consider a double bob pendulum with masses and attached by rigid mass less wires of given lengths and angles.

This Leads to Hamilton's Equations

$$\dot{\theta}_1 = \frac{\partial H}{\partial p_{\theta_1}} = \frac{l_2 p_{\theta_1} - l_1 p_{\theta_2} \cos(\theta_1 - \theta_2)}{l_1^2 l_2 [m_1 + m_2 \sin^2(\theta_1 - \theta_2)]}$$

$$\dot{\theta}_2 = \frac{\partial H}{\partial p_{\theta_2}} = \frac{l_1(m_1 + m_2)p_{\theta_2} - l_2 m_2 p_{\theta_1} \cos(\theta_1 - \theta_2)}{l_1 l_2^2 m_2 [m_1 + m_2 \sin^2(\theta_1 - \theta_2)]}$$

$$\dot{p}_{\theta_1} = -\frac{\partial H}{\partial \theta_1} = -(m_1 + m_2)g l_1 \sin \theta_1 - C_1 + C_2$$

$$\dot{p}_{\theta_2} = -\frac{\partial H}{\partial \theta_2} = -m_2 g l_2 \sin \theta_2 + C_1 - C_2,$$

where

$$C_1 \equiv \frac{p_{\theta_1} p_{\theta_2} \sin(\theta_1 - \theta_2)}{l_1 l_2 [m_1 + m_2 \sin^2(\theta_1 - \theta_2)]}$$

$$C_2 \equiv \frac{l_2^2 m_2 p_1^2 + l_1^2 (m_1 + m_2) p_2^2 - l_1 l_2 m_2 p_1 p_2 \cos(\theta_1 - \theta_2)}{2 l_1^2 l_2^2 [m_1 + m_2 \sin^2(\theta_1 - \theta_2)]^2} \sin[2(\theta_1 - \theta_2)].$$

Horizons of Predictability

- What is within the Horizon of Predictability?
 - Earnings a quarter ahead?
 - Earnings a year ahead?
 - Earnings two years ahead?
- Precise forecasts may be impossible, but trends may not be.

Final Thoughts

- 1987 Goldman/Salomon LBO of Southland (7-Eleven) Complex 10-year financial projections Southland to repay 50% of its debt by year 5.
 - Southland never repaid any debt and was bankrupt by year 3.
- December 2007, AIG Value at Risk (VAR) of \$150 million. VAR is a complex quantitative model Estimate of maximum loss in a given period.
 - In 2008, AIG lost \$62 billion.
- “The volatility of our portfolio is...”
- “Plans are useless, but planning is everything” Dwight Eisenhower.