Frequent Once-in-a-Lifetime Crises

Dr. Randal Allen, Lone Star Analysis

Agenda

- Introduction
- Modeling Rare Events
- Measurement of Risk
- Exposing Black Swans
  - Tornado charts
  - Percent point functions
  - Stochastic optimization
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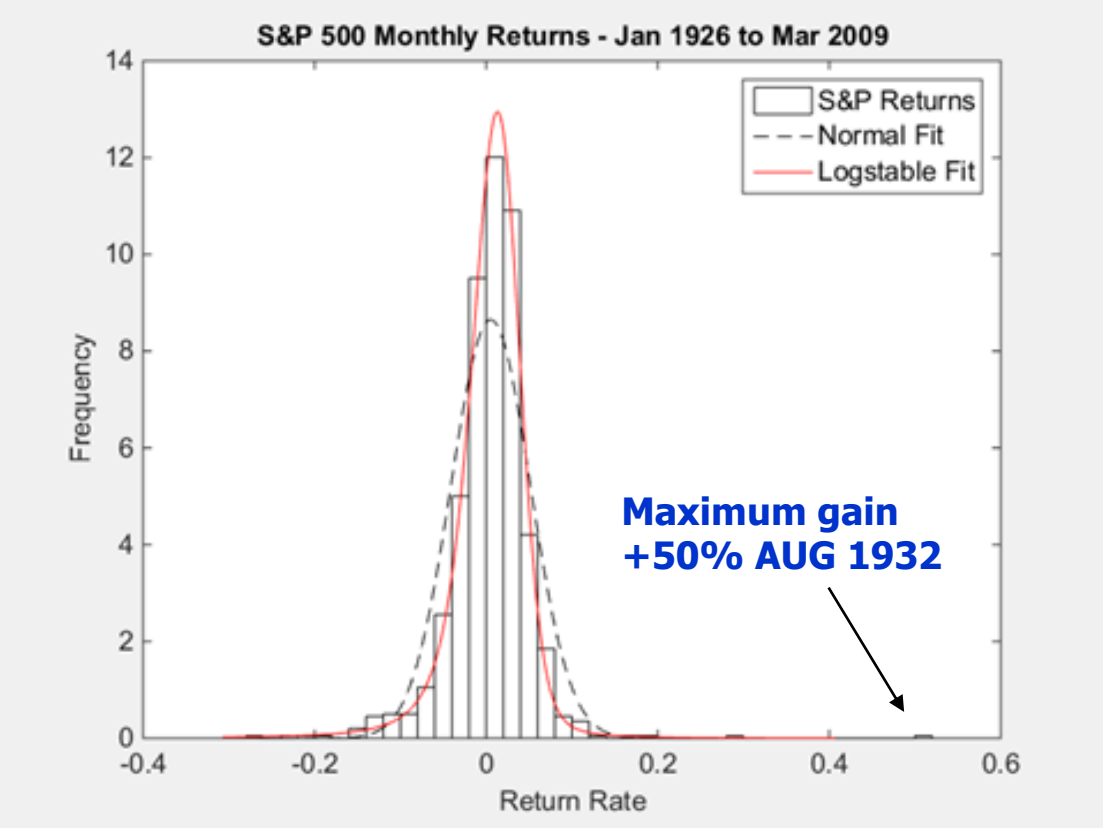
- Summary

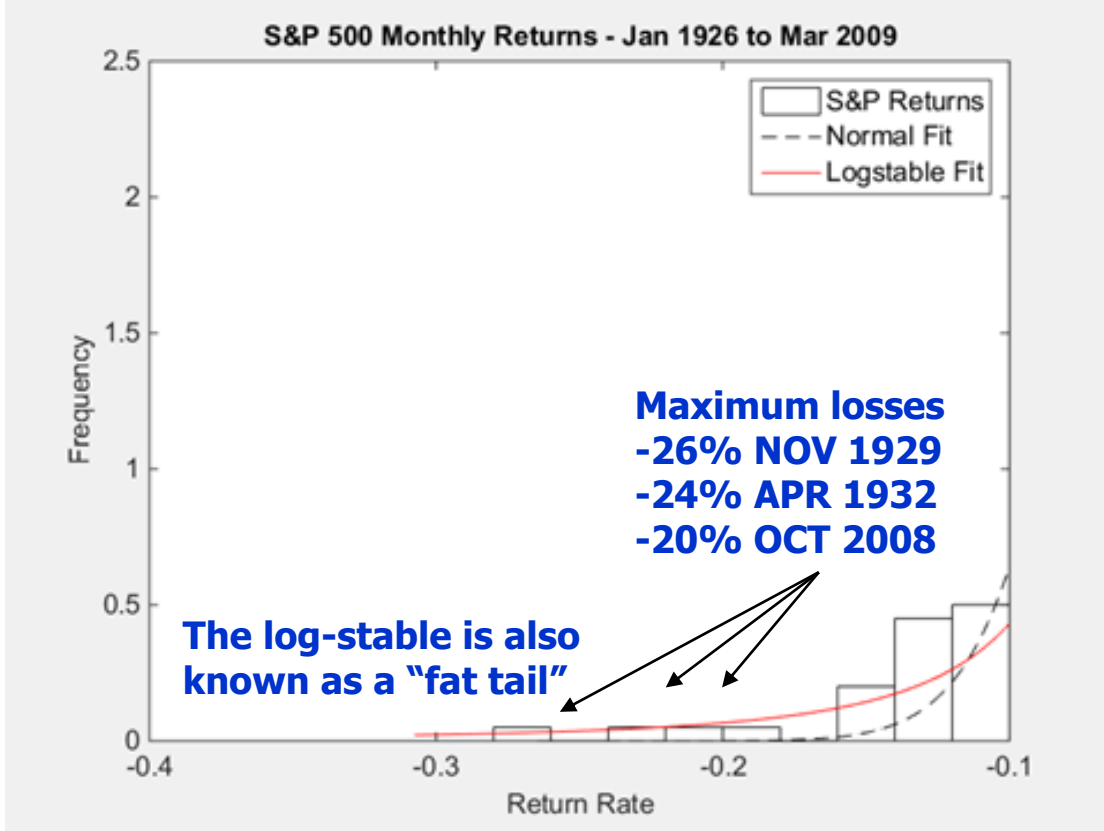
Introduction

- **Black Swan (Nassim Taleb)**
  - Improbable event with colossal consequences
- **Gray Swan (Benoit Mandelbrot)**
  - Predicting some behavior of a black swan
- **Modeling & Simulation Probabilistic Tools**
  - Tornado charts (specialized bar charts)
  - Percent Point Functions (a variation on the cumulative distribution function)
  - Stochastic optimization
- **2015 I/ITSEC Black Swan Kickoff Questions**
  - How can M&S be used to analyze and prepare or create a Black Swan?
  - Can we develop complex adaptive models and simulation tools that will enable the analysis?

Modeling Rare Events

- Leveraging the financial markets for analogy…



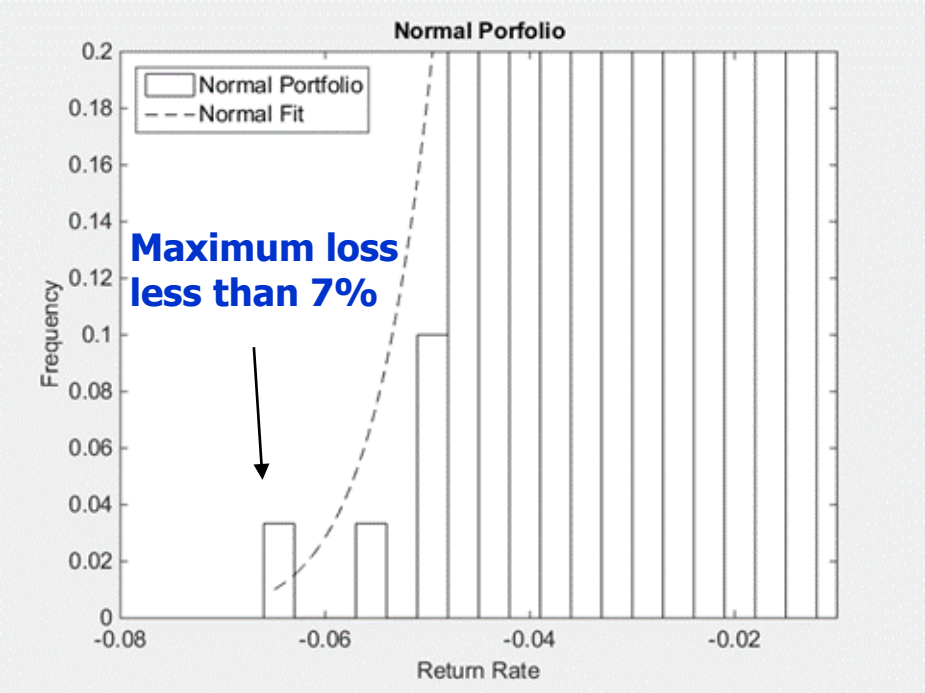


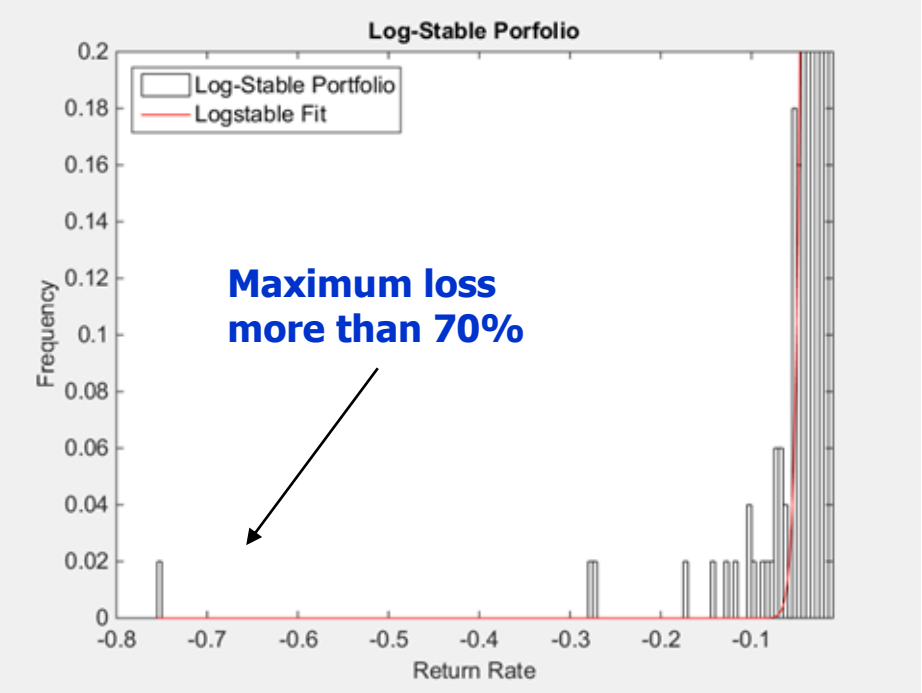
- …normal fit suggests *zero* probability of losses beyond 16%.

Measurement of Portfolio Risk

- **Leveraging the financial markets for analogy…**

Asset Class	Allocation
Small Cap Stocks	20%
Mid Cap Stocks	15%
Large Cap Stocks	5%
Int'l Developed Stocks	5%
Int'l Emerging Stocks	10%
Corporate Bonds	15%
Government Bonds	10%
Real Estate	10%
Commodities	10%





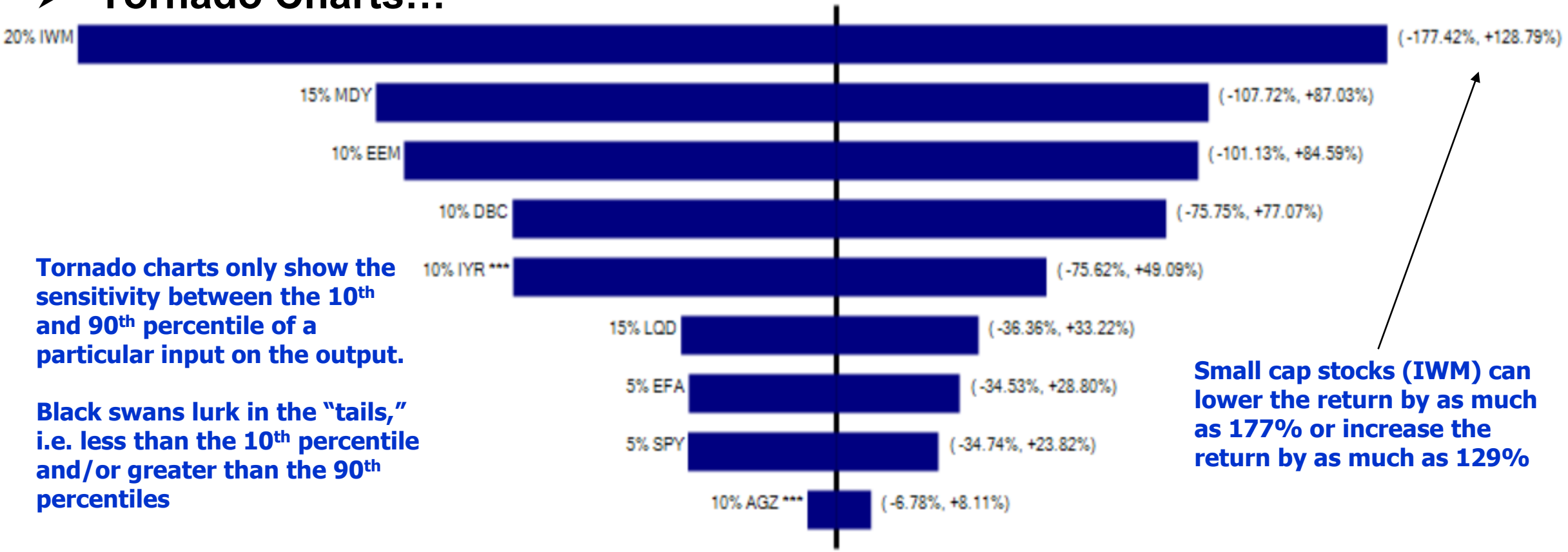
- **…the log-stable portfolio fit shows losses could be as much as an order of magnitude higher!**

Exposing Black Swans

- What if the model architecture contains thousands of influential nodes?
- How does one expose the potential (needle in the haystack) black swan?
- Tools
  - Tornado charts
  - Percent point functions
  - Stochastic optimization

Exposing Black Swans

- **Tornado Charts…**



Tornado charts only show the sensitivity between the 10th and 90th percentile of a particular input on the output.

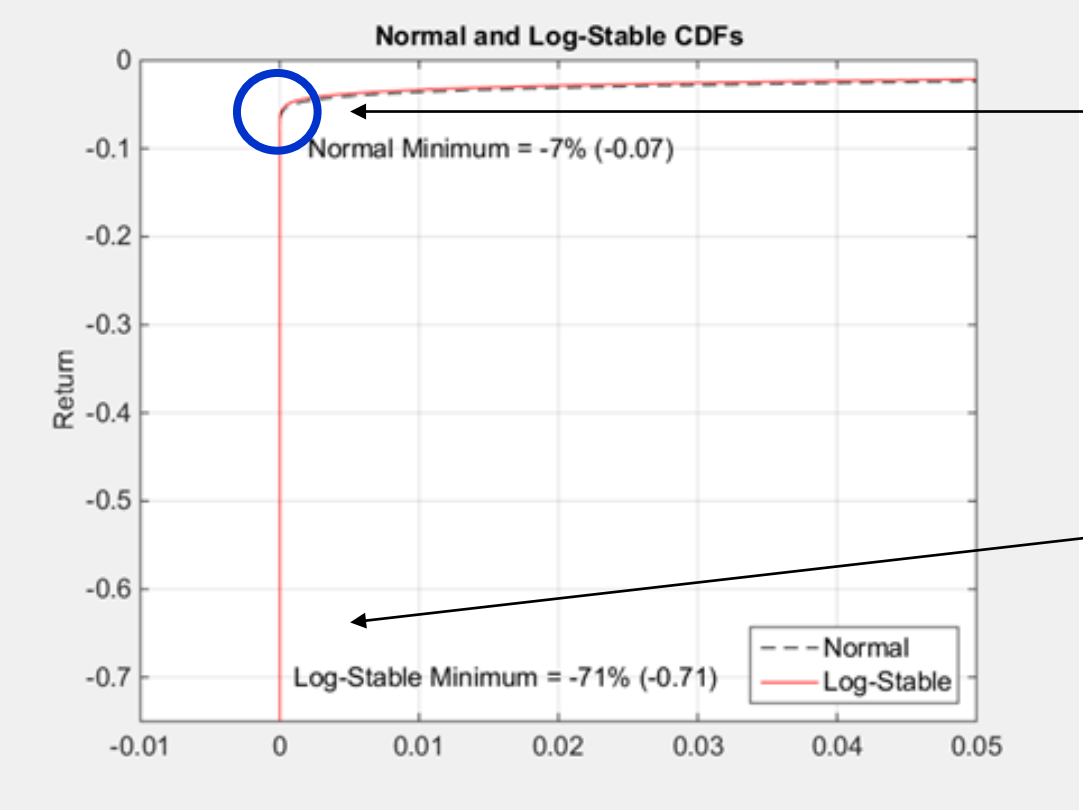
Black swans lurk in the "tails," i.e. less than the 10th percentile and/or greater than the 90th percentiles

Small cap stocks (IWM) can lower the return by as much as 177% or increase the return by as much as 129%

- **…fall short from inspecting the tails of distributions.**

Exposing Black Swans

- **Percent point functions…**



When the portfolio is fit with a normal distribution, the tail ends near -7%.

When fit with a log-stable distribution, the tail continues down to -71%.

The log-stable distribution exposes larger risk.

- **...facilitate inspection of tails to see if potential rare events might be lurking.**

Exposing Black Swans

- **Stochastic optimization…**
  - **Random variable inputs**
  - **Random objective function**
  - **Random iterates**

ETF	Allocation	Minimum	Maximum
IWM	20%	-24%	14%
MDY	15%	-24%	14%
SPY	5%	-18%	10%
EFA	5%	-23%	12%
EEM	10%	-29%	16%
LQD	15%	-11%	13%
AGZ	10%	-2%	4%
IYR	10%	-38%	26%
DBC	10%	-29%	15%
	Portfolio	-21.9%	14.1%

Stochastic optimization is overkill for this example, but makes the point.

All inputs will be selected from their range in order to minimize or maximize the result.

For a portfolio with thousands of random inputs and complex interconnections, it soon becomes intractable to perform these calculations with a spreadsheet, let alone by hand.

- **…lists all the input values, chosen so as to achieve minimum return.**

Exposing Black Swans

- **Tornado charts**
  - **Show how input variation impacts the output (between 10th and 90th percentile).**
- **Percent Point Function (PPF)**
  - **Show how much impact rare events could have (<10th percentile tail, >90th percentile tail).**
- **Stochastic optimization**
  - **Shows the values each input must be to achieve output extrema (min or max).**
- **Together, these tools and their insights reduce the surprise of a black swan, rendering it gray.**

Training and Simulation Applications

- **Acquisition**
  - Random inputs modeled as log-stable (fat tail) distributions could expose exorbitant costs, extreme impacts of schedule slippage, and/or poor performance.
- **Training proficiency**
  - Baseline effectiveness, time, number of iterations, media factors, instructional quality factors, and skill decay could all be modeled with fat tails to see if there are any substantial impacts to proficiency.
- **Strategic multi-layer assessment**
  - Numerous inputs to organizational, social network, time influence network, information diffusion, and text analysis models should leverage fat tail distributions to expose any potential black swan events.

Summary

- It's possible to identify potential black swans and in doing so, render them gray. Thus we can prepare, organize, train and equip for black swan resiliency.
- The log-stable distribution is superior to the normal distribution when it comes to modeling data that includes rare events lying far from the mean.
- Three tools (Tornado charts, PPFs, and stochastic optimization) and their insights can reduce the surprise of a black swan, rendering it gray.

Acknowledgements

- I'd like to thank my co-author John Volpi (CTO of Lone Star Analysis) for his assistance in preparing this paper and presentation.

- We thank Dr. Paul Kaplan (Morningstar) and Dr. John Nolan (University of Virginia) for personal email correspondence.

- We recognize Investools / TD Ameritrade from which we were able to obtain historical monthly data for each asset class.