

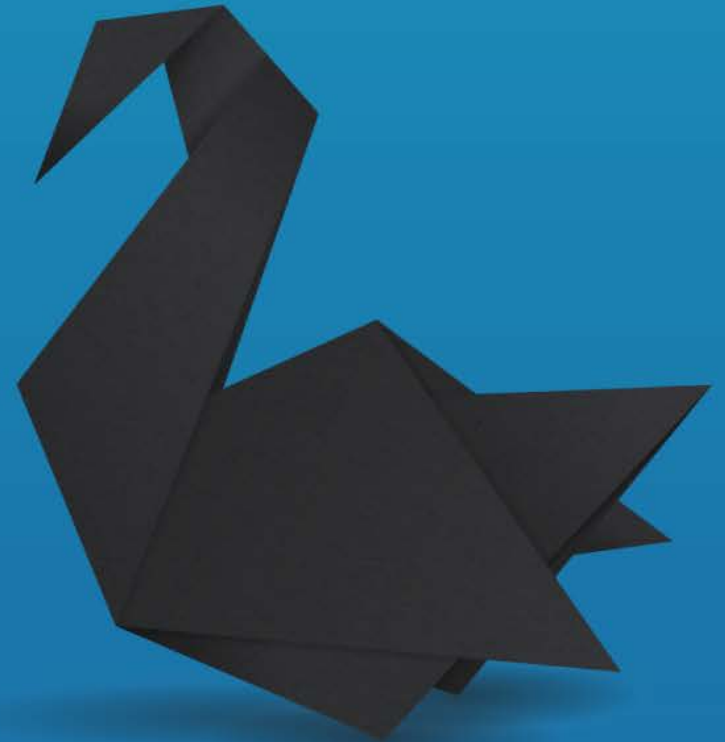
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FROM KNOWN UNKNOWNNS TO BLACK SWANS

How to Manage Risk
in Latin America and the Caribbean

Semiannual Report - Office of the Regional Chief Economist

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Disclaimer



- This report was developed under the leading role of Carlos Vegh, Chief Economist - Latin America and the Caribbean, World Bank.
- I contributed to the report as an external consultant.
- Hence, this presentation do not necessarily reflect the views of The World Bank, its Board of Executive Directors, or the governments they represent.

The Foundations of Risk: Roadmap



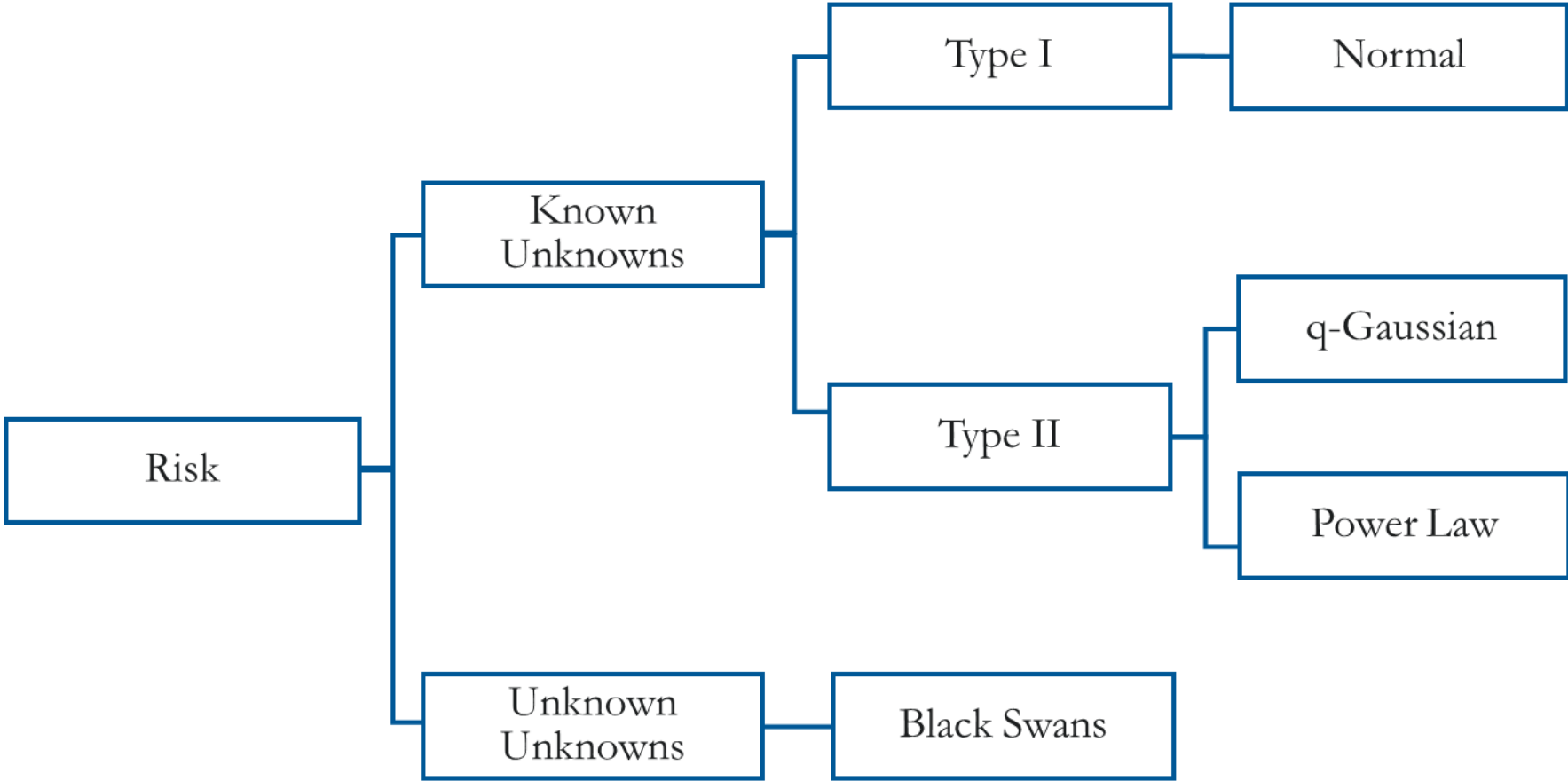
- Why do we care about what type of risk we face?
- What types of risks do we face?
- The curse of the fat tails
- Not all swans are white ...

Why is Knowing the Type of Risk Important for Policy?

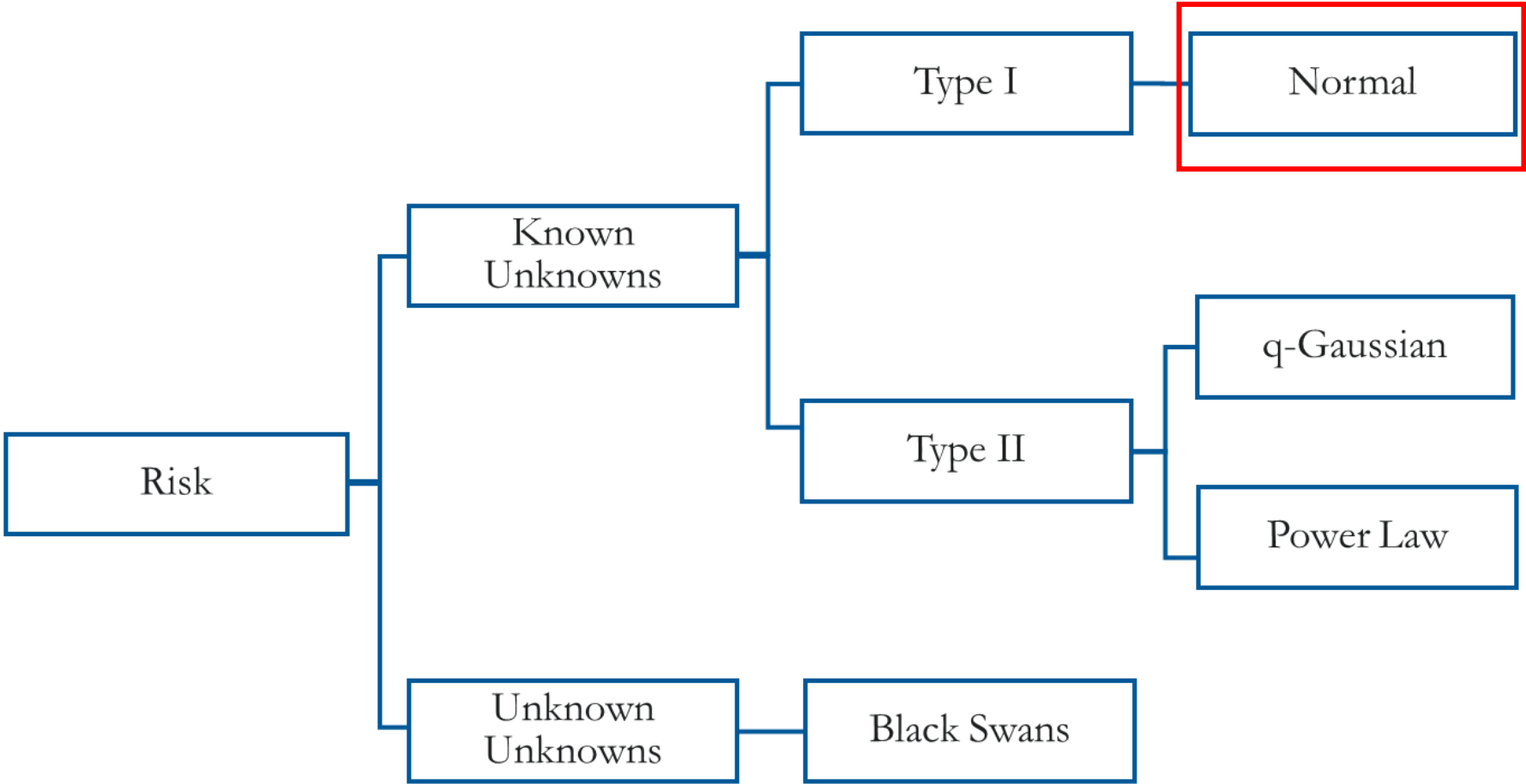


- In a risky world, a country would want to insure/hedge as much as possible
- In an ideal world, you would fully insure against every possible risk, go home, and sleep peacefully!
- In the actual world, the type of risk basically determines a country's ability to insure
- What risks can you insure against?
 - You can fully insure against all Type I risks (normal distribution)
 - You can insure against *some* Type II (fat tails) risks but not all
 - You *cannot* insure against Black Swans

Classification of Risks



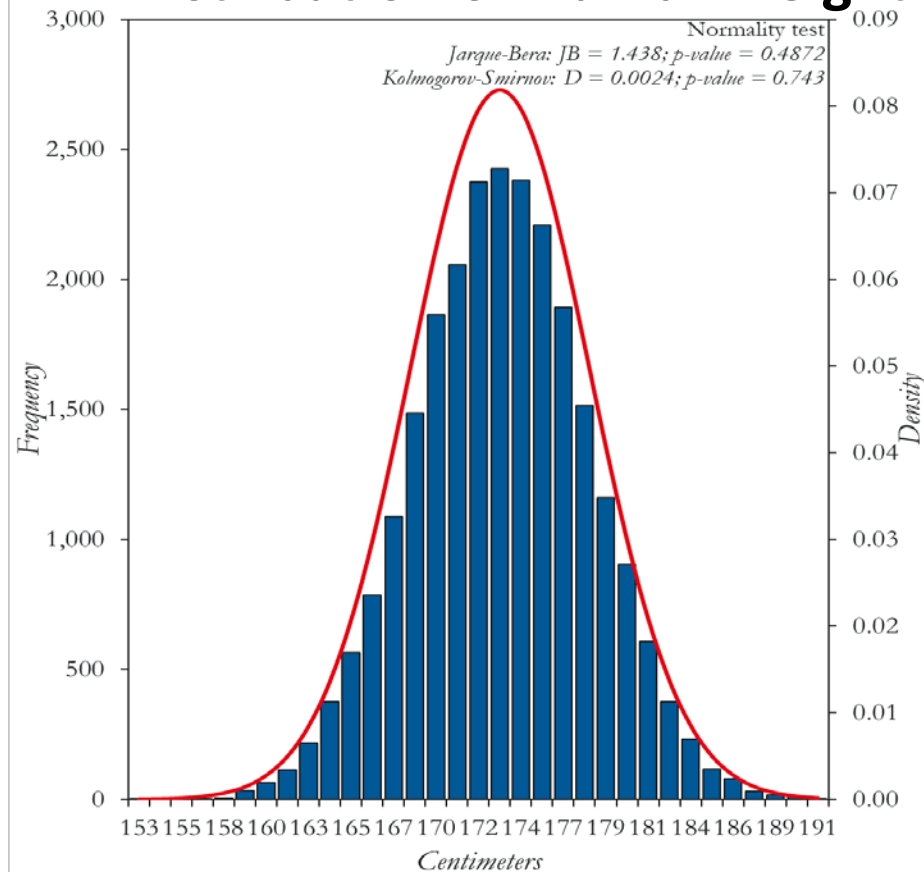
Classification of Risks



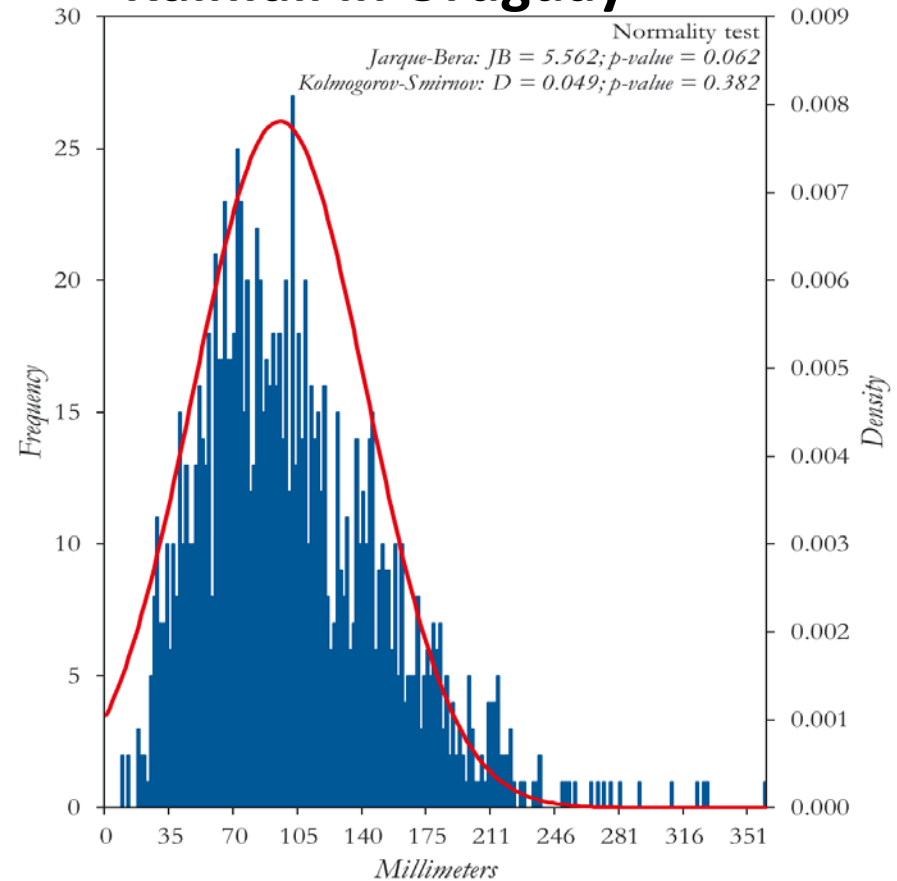
Known Unknowns: Type I Risk, Normal Distributions



Distribution of Human Height

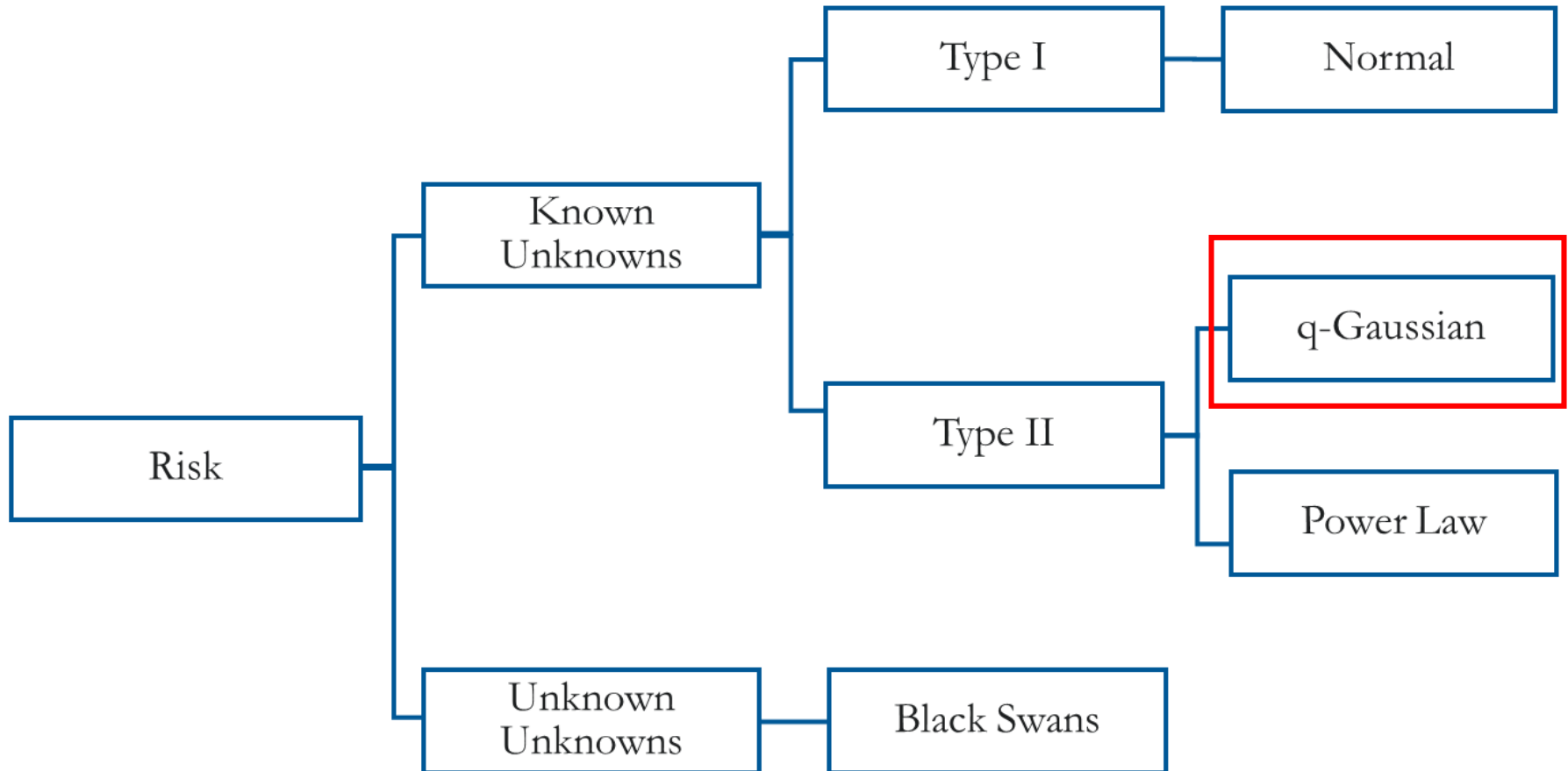


Rainfall in Uruguay



You can fully insure against Type I risks by, for example, using options (priced à la Black-Scholes).
Big problem: In the actual world, most economic and natural risks are *not* Type I!

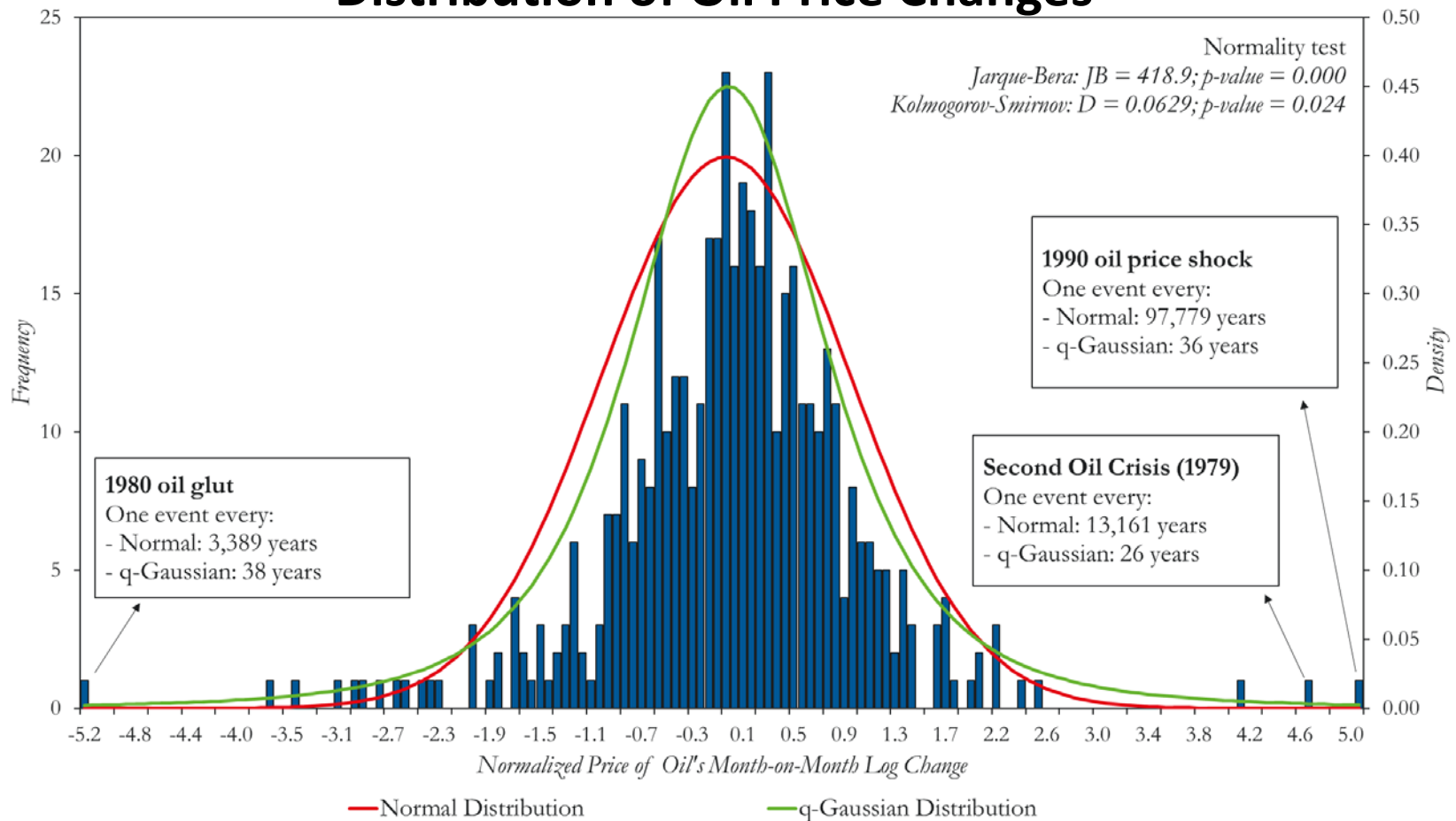
Classification of Risks



Known Unknowns: Type II Risk, q-Gaussian



Distribution of Oil Price Changes

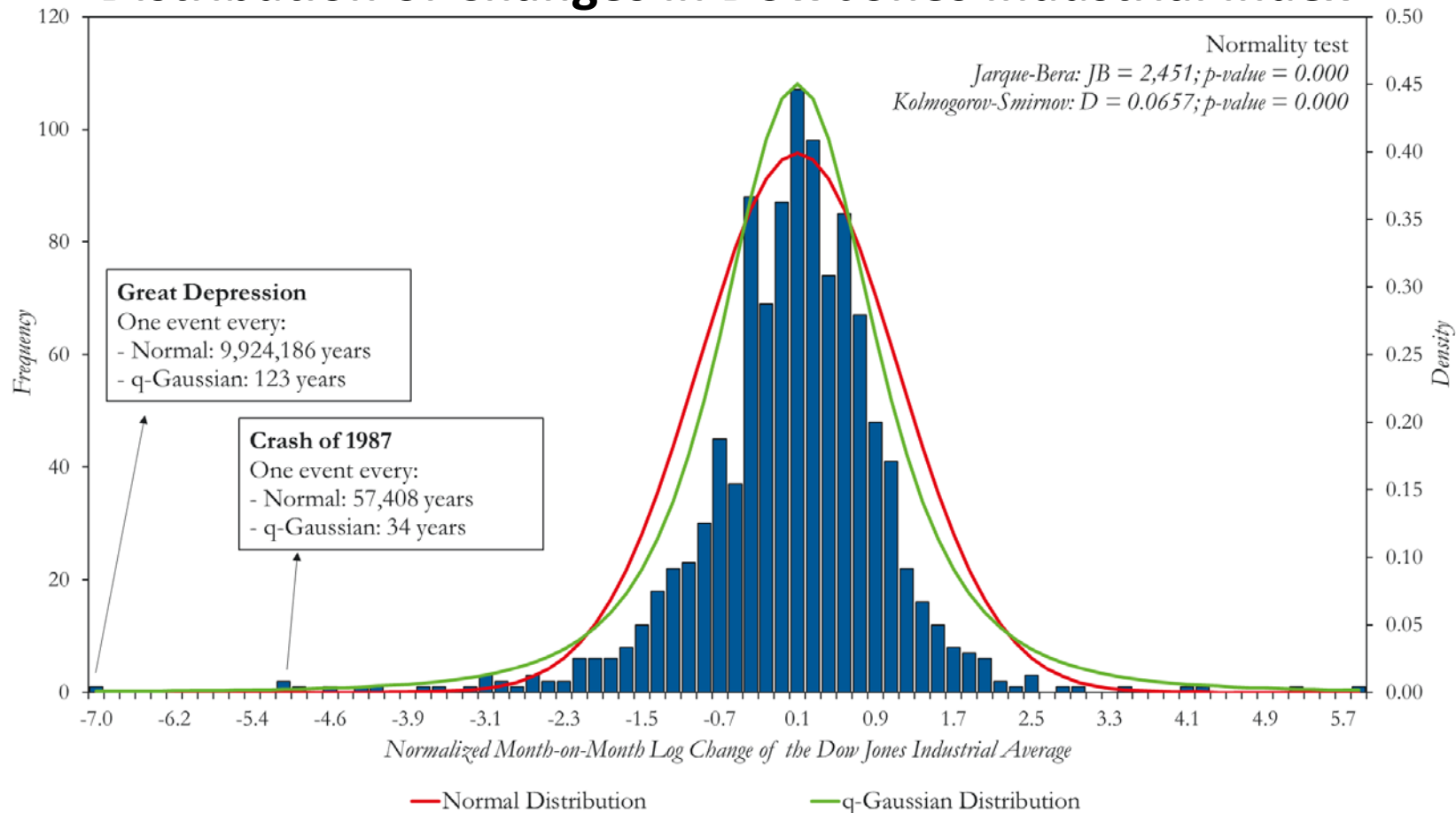


q-Gaussian distributions begin to grow “fat tails.” As long as they are not too “fat,” risk can be priced (with a “premium” over Black-Scholes) and you can insure. Changes in stock prices and many commodities follow q-Gaussians.

Known Unknowns: Type II Risk, q-Gaussian



Distribution of Changes in Dow Jones Industrial Index



q-Gaussian distributions can be mistakenly taken for normal distributions due to their bell-shape form. But because of fatter tails, we can clearly reject normality.

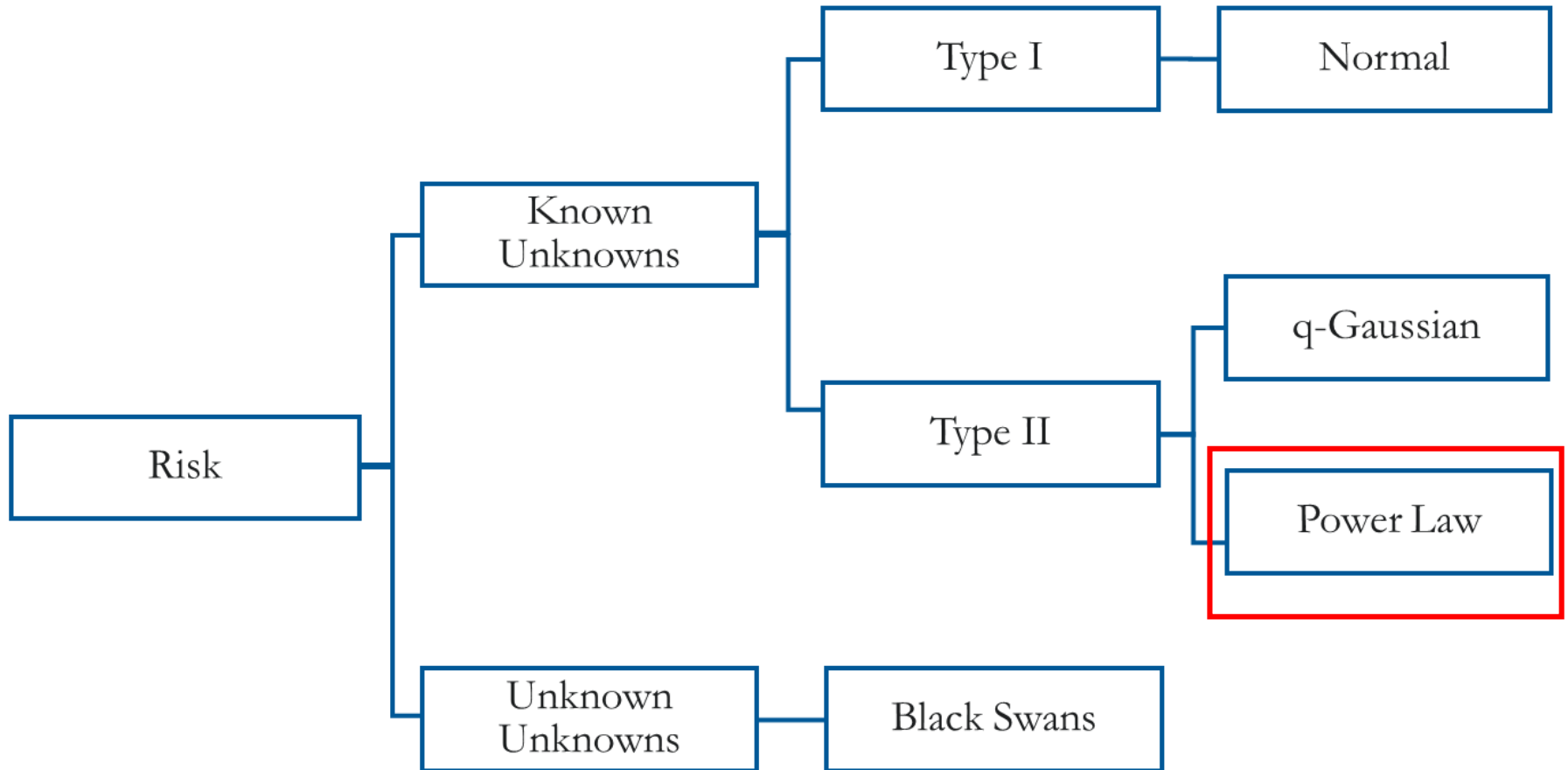


Pricing Options in a General Equilibrium Framework (I)

- If we assume risk neutrality and a normal distribution for the stochastic endowment in the second period, we are able to replicate the Black-Scholes pricing solution for an “option” or claim to future consumption endowment:

$$C(P_0, t) = \overbrace{\underbrace{P_0}_{\text{Today's price}} * \underbrace{N(d)}_{\text{Probability}}}^{\text{GROSS RETURN}} - \overbrace{\underbrace{Ke^{-r(T-t)}}_{\text{PV of strike price}} * \underbrace{N(d)}_{\text{Probability}}}^{\text{COST}}$$

Classification of Risks

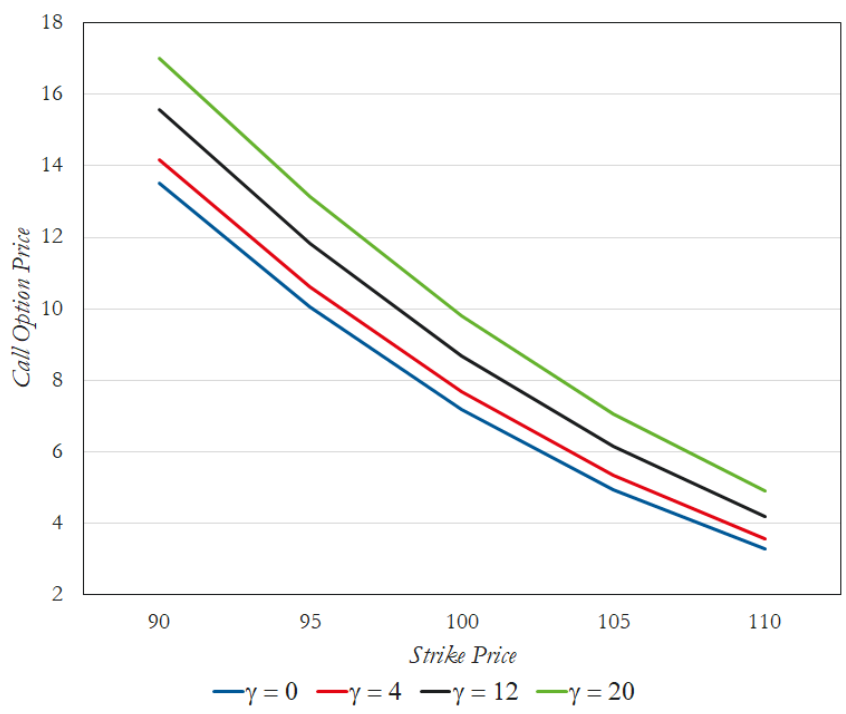




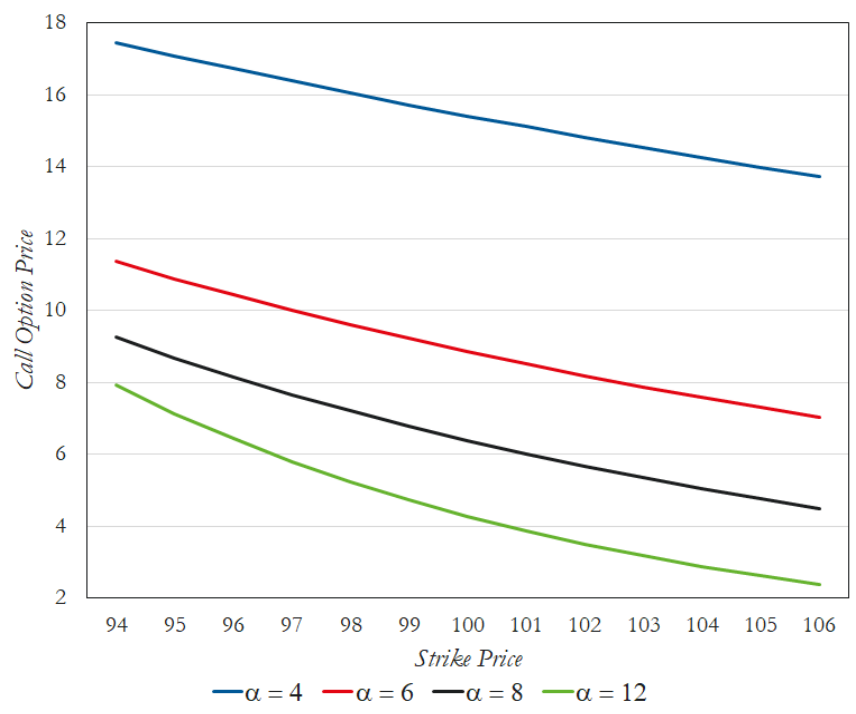
Pricing Options in a General Equilibrium Framework (II)

- Relaxing the assumption of risk neutrality or assuming distributions with fatter tails than a normal distribution results in a premium relative to the standard Black-Scholes pricing

For different levels of risk aversion



For different tails

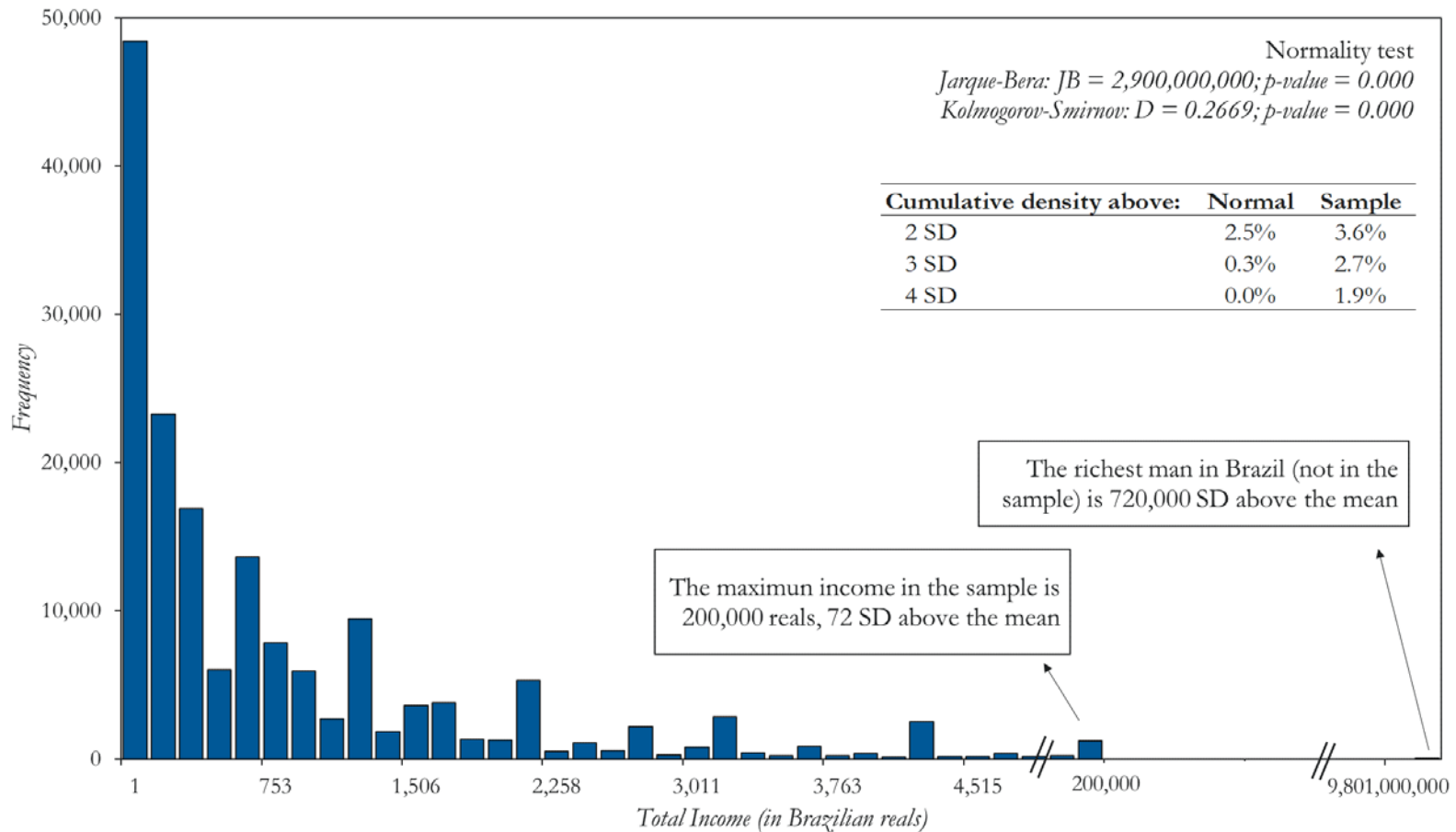


[back to classification](#)

Known Unknowns: Type II Risk, Power Law Distributions



Distribution of Income in Brazil

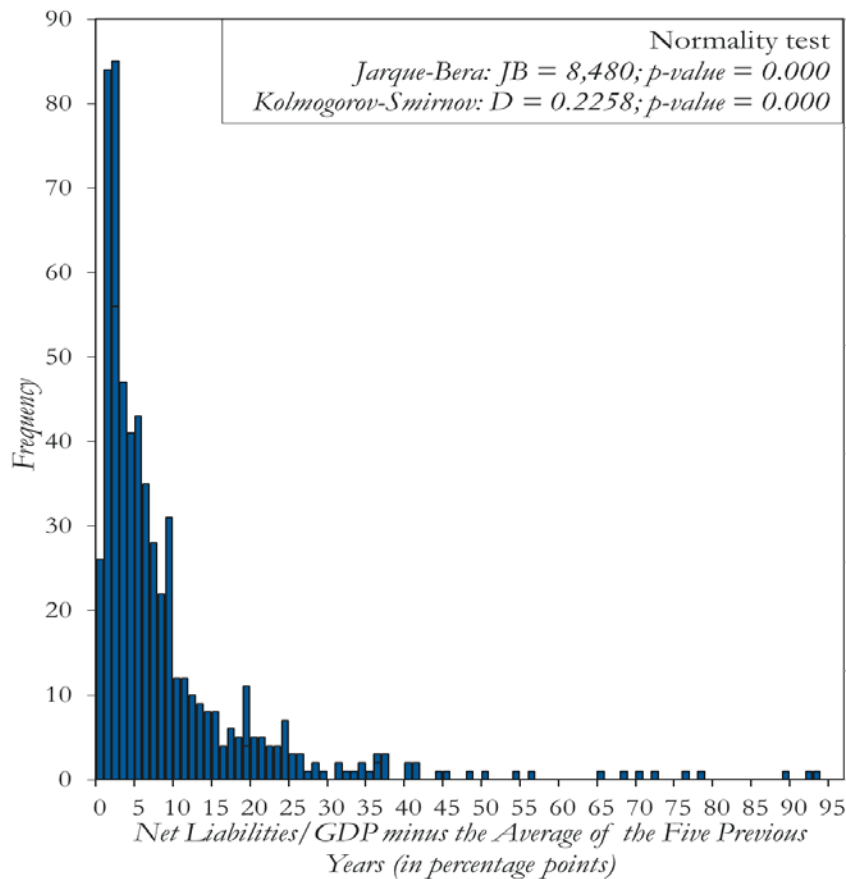


Textbook example of a power distribution. Richest man would be 720,000 standard deviations above the mean!

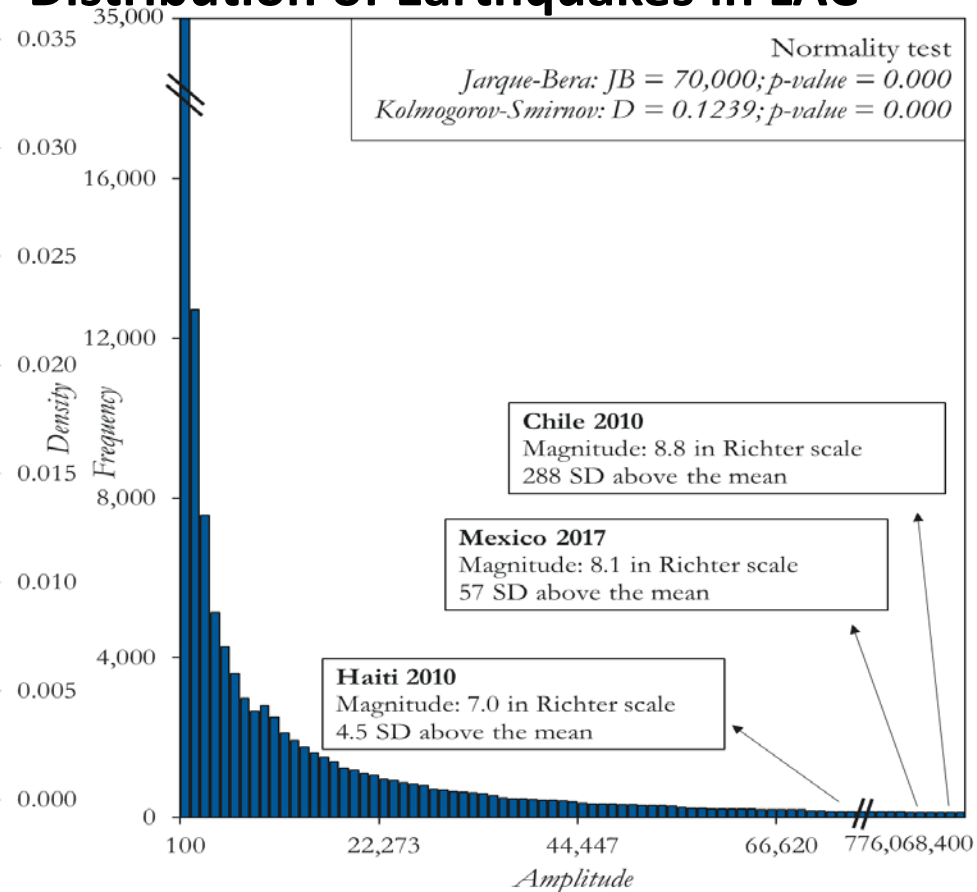


Known Unknowns: Type II Risk, Power Law Distributions

Distribution of Sudden Stops



Distribution of Earthquakes in LAC



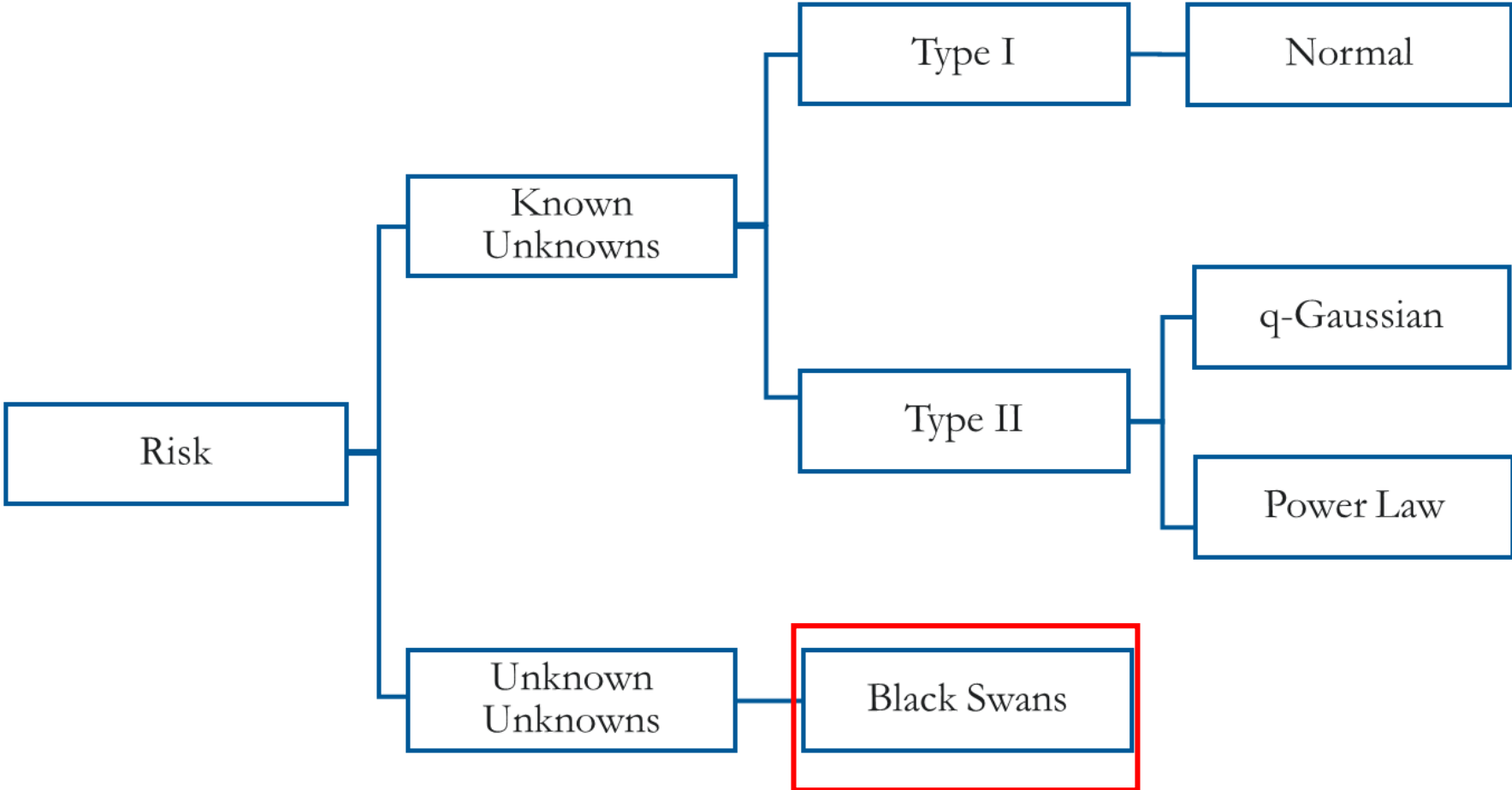
Power distributions have a lot of mass close to zero and long, fat tails. Hard to price because the occurrence of a single “fat tail” event could bankrupt the insurer. Many economic/natural risks follow power distributions.

Pricing Catastrophe Bonds



- The key difficulty in pricing a catastrophe bond is that the underlying process of the cat bond is driven by two distributions:
 - i. the probability of an event occurring
 - ii. the intensity of such event
- Jointly, these distributions determine the probability of the bond being either paid in full to investors or being liquidated to help the insured
- A popular arbitrage-free solution involves a compound doubly-stochastic Poisson distribution to measure the probability of occurrence of the natural disaster

Classification of Risks



Unknown Unknowns: Black Swans (I)



- Until 1697, Europeans thought all swans were white ...



Unknown Unknowns: Black Swans (II)



- And, then, surprise, surprise ... A black swan was spotted in Australia!!



Unknown Unknowns: Black Swans (III)



- A “black swan” is an event that is:
 - Unpredictable
 - Typically “large”
- You cannot insure against a “black swan” because, by definition, they are unpredictable (and hence have not known distribution)
- All you can do is to provide ex-post aid
- Big public policy implication: You cannot insure against everything!

Black Swans in Practice



Black Swan Events

- The Black Death (14th century)
- The Long Depression (1873-1896)
- The Spanish Flu Pandemic (1918-1919)
- World War I (1914-1918)
- The Great Depression (1929-1939)
- First Oil Crisis (1973-1974)
- 9/11 (2001)
- Global Financial Crisis (2008)
- Maracanã 1950: Uruguay beats Brazil

Ex-Post Policy Aid

- None (1/3 of European population dies)
- None (U.S. unemployment rises to 14%)
- None (5% of world population dies)
- None (arguably sows the seeds for WWII)
- New Deal
- None (stagflation followed)
- \$2.8 trillions on counter-terrorist measures
- \$700 billion bail-out plan
- None

Policy Lessons on Foundations of Risk



- Knowing the type of risk is critical
- Type I risks (normal distribution) or close to normal are easy to insure against (and hence should)
- Type II is insurable as long as tails are not too fat (and we can now sell earthquake bonds)
- Key policy implication: The fatter are the tails, the less market insurance will be available, and hence the more important precautionary/ex-post aid becomes

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THANK YOU!

