Fragile Beliefs
and the
Price of Uncertainty

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Insights from Three Disciplines

Macroeconomics - studies sources (represented as impulses or shocks) of aggregate fluctuations and the consequences as they play out over time.

Asset pricing - characterizes market compensations for exposures to macroeconomic shocks; these are shocks that cannot be diversified.

Statistics - provides methods for assessing the extent of our knowledge based on existing evidence; supports a decision theory that allows us to account for uncertainty.

The interplay between these three areas of research is what I find fascinating.

Frank Knight and Uncertainty
Risk, Uncertainty, and Profit, 1921

"We must infer what the future situation would be without our interference, and what changes will be wrought by our actions. Fortunately, or unfortunately, *none* of these processes is *infallible*, or indeed ever *accurate* and *complete*."

Probability meets Social Science

Jacob Bernoulli (1713) (left)
Law of Large Numbers

Camille Pissarro (1898) (right)
Old Marketplace in Rouen

Dual Roles for Statistics in Economic Analysis

- Outside a model

  Given a dynamic economic model, researchers:

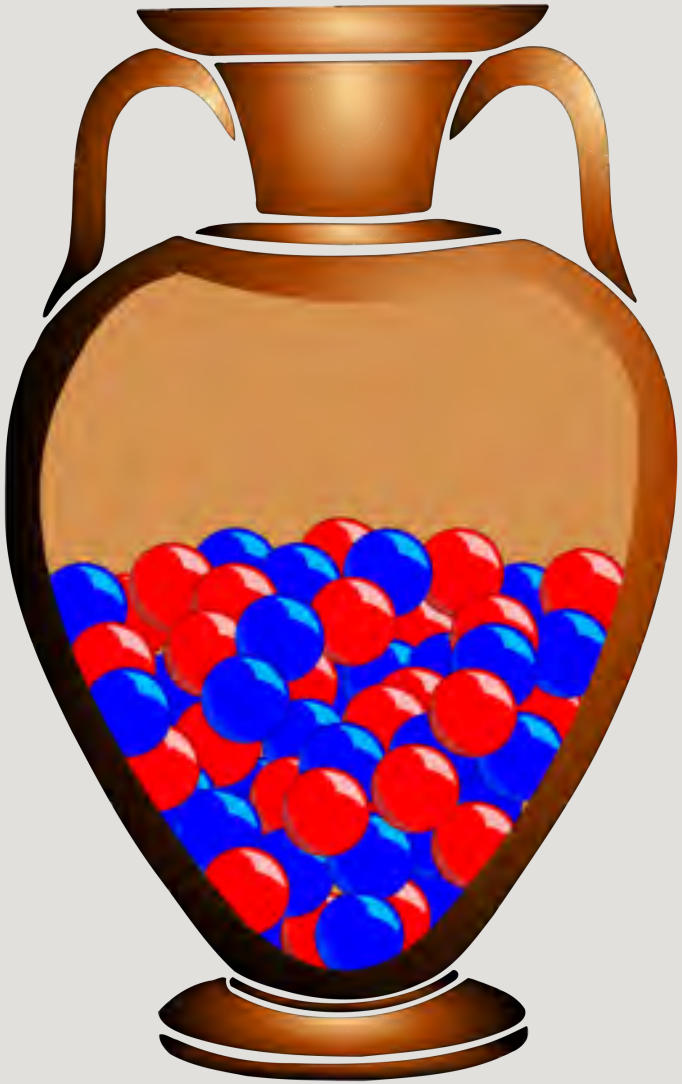
  - estimate unknown parameters
  - assess model implications

- Inside a model

  When *constructing* a dynamic economic model, researchers:

  - depict economic actors (consumers, enterprises) as they cope with uncertainty
  - deduce the consequences for market outcomes and resource allocations

Uncertainty can be *risk*



50 Red Balls

50 Blue Balls

Uncertainty can be *ambiguity*

? Red Balls

? Blue Balls

Uncertainty can *change over time*

? Red Balls

? Blue Balls

Multiple Components to Uncertainty

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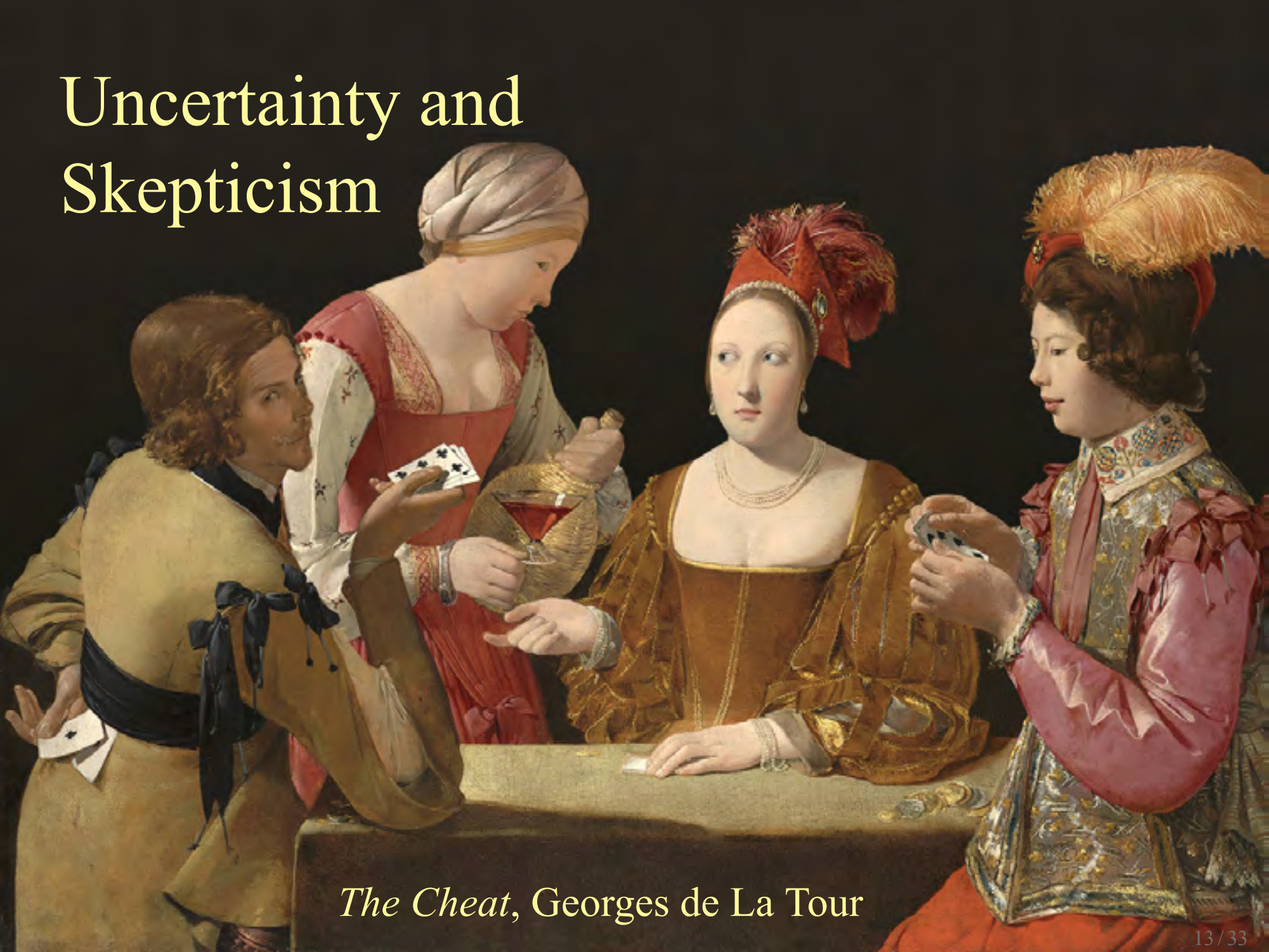
- Model *ambiguity* - how much confidence do we place in each model?
- Model *misspecification* - how do we use models that are not perfect?

Robustness

Hansen and Sargent bookcover

Uncertainty and Skepticism



The Cheat, Georges de La Tour

Statistical complexity

- When is it challenging to learn and draw inferences?
- When is there more scope for behavioral distortions?
- When does statistical uncertainty induce fluctuations in market prices and impact resource allocation?

Take a broader perspective on uncertainty than is typical in economic analyses.

Uncertainty Can Be Complex

Las Meninas, Diego Velázquez

Placing Uncertain Investors Inside an Economic Model

When *constructing* a dynamic economic model, researchers:

- depict economic actors (consumers, enterprises) as they cope with uncertainty when making economic decisions with future consequences
- deduce the resulting market responses and consequences for resource allocations

Rational Expectations inside an Economic Model

Muth (1961) and Lucas (1972): Economic actors (investors) use *long histories* of data to infer the model, including its parameters.

- ▷ Yields a stochastic notion of *equilibrium* with expectations determined *inside the model*
- ▷ Gives a coherent approach to *policy analysis*

Influential, but *neglects* some components of uncertainty by featuring only *risk*. Statistical challenges are off the table.

Long-term Macroeconomic Uncertainty

Joel Mokyr

"There are a myriad of reasons why the future should bring more technological progress than ever before – perhaps the most important being that technological innovation itself creates questions and problems that need to be fixed through further technological progress." (2013)

Robert Gordon

"…the rise and fall of growth are inevitable when we recognize that progress occurs more rapidly in some time periods than others…The 1870-1970 century was unique: Many of these inventions could only happen once, and others reached natural limits." (2016)

An Asset Pricing Perspective on Impulses and Propagation

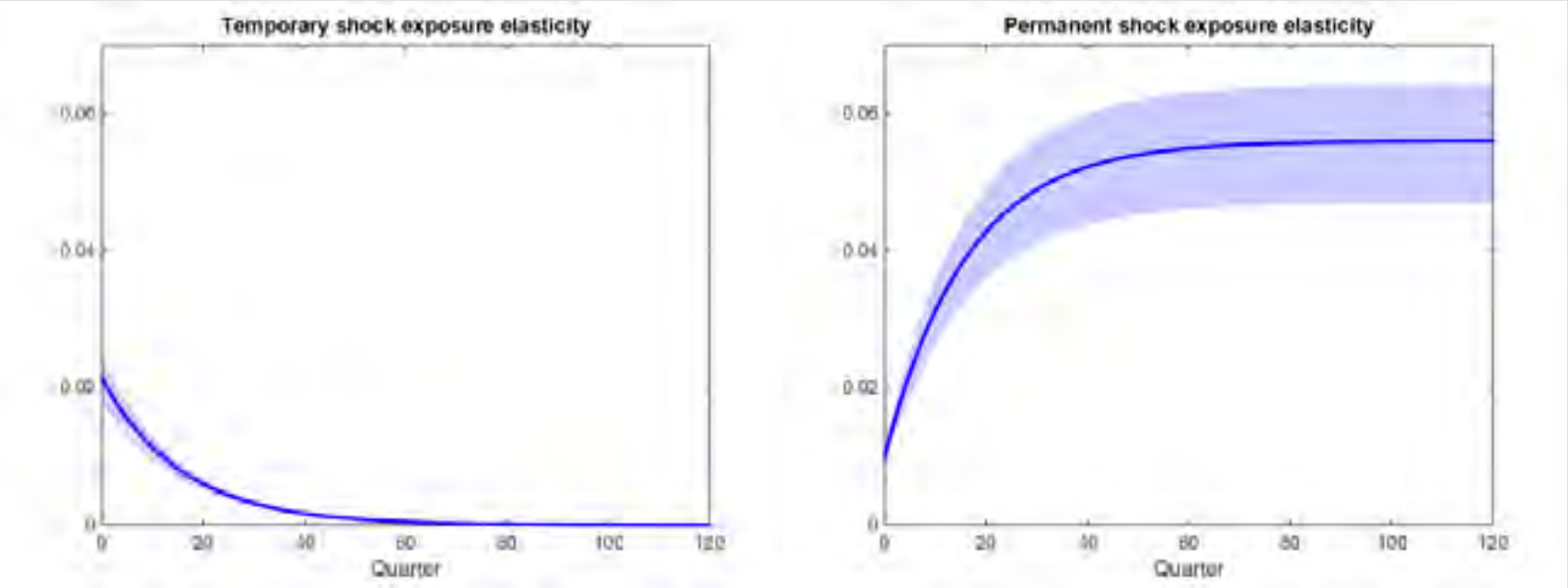
Imagine an impulse or shock W_{t+1} that happens tomorrow.

- ▷ This shock has an impact on a macro time series or a cash flow at future times $t+1$, $t+2$, ...
- ▷ Exposure in the future of the underlying time series to this shock requires compensation today, say time t. The magnitude of the compensation or price depends on the date of the cash flow.
- ▷ Alternative shocks require different compensations or "prices".

Dynamic macroeconomic models imply impulse responses

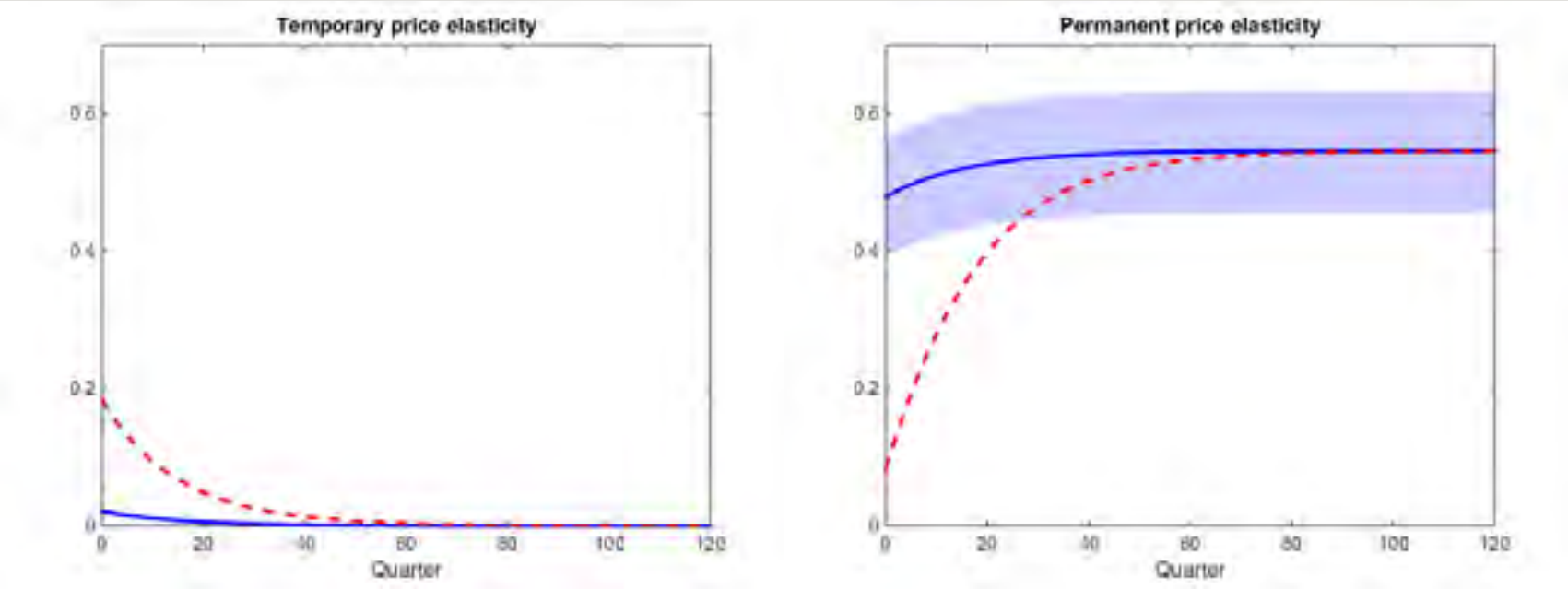
Dynamic models of asset prices imply compensations to shock exposures.

Impulse Responses



Bands depict .1 and .9 deciles.

Shock-Price Elasticities



Recursive utility and Power utility. Bands depict .1 and .9 deciles.

Risk Inside the Model

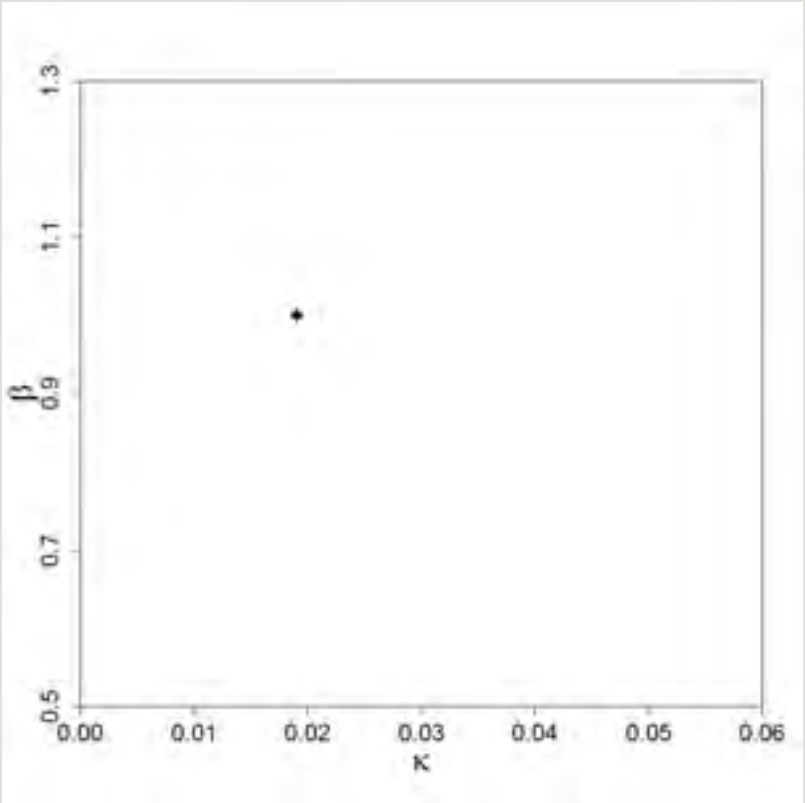
- Recent empirical successes in macro-finance rely on endowing investors with knowledge of potentially statistically subtle components of the macro time series. Where does this confidence come from?
- Imposes stochastic volatility exogenously.
- Imposes large risk aversion.

Success?

Slope Uncertainty

$$Y_{t+1} - Y_t = \alpha_y + \beta Z_t + \sigma_y \cdot W_{t+1} \qquad \text{macro evolution}$$

$$Z_{t+1} = \alpha_z + (1-\kappa) Z_t + \sigma_z \cdot W_{t+1} \qquad \text{growth evolution}$$



Sets of parameter values (β, κ) constrained by relative entropy.

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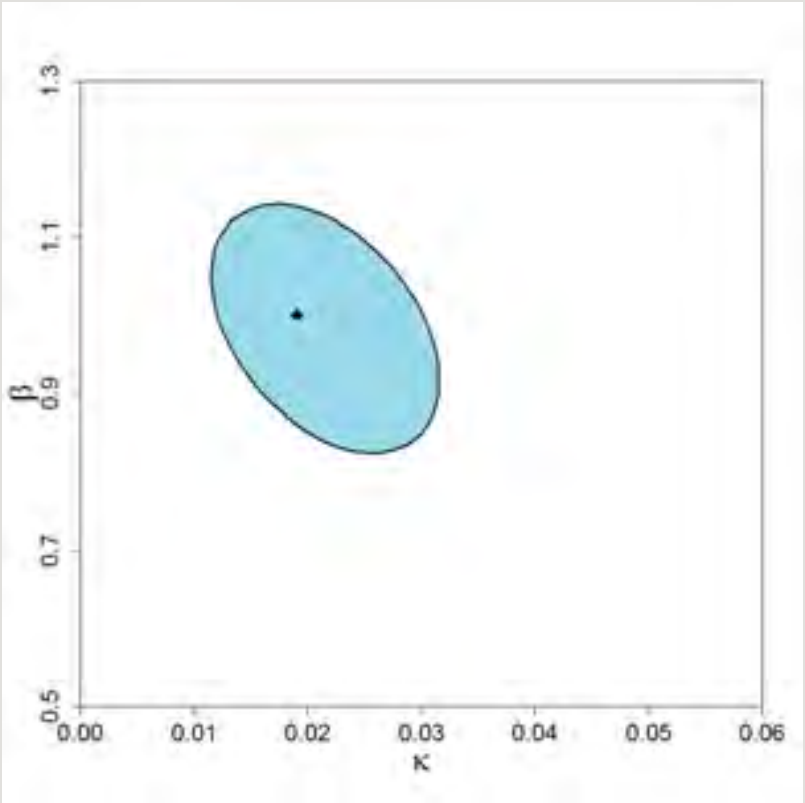

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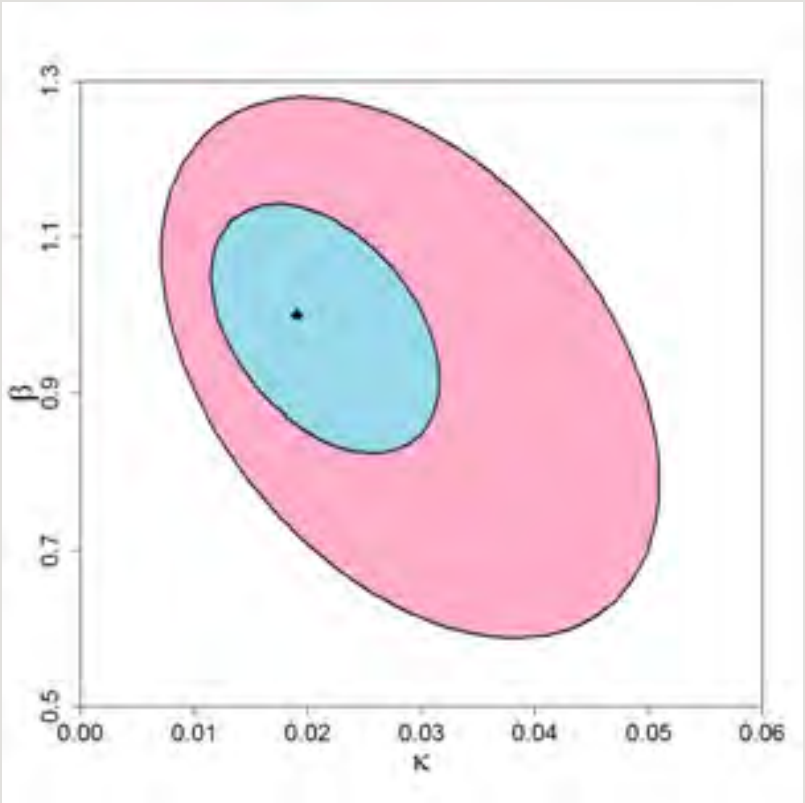

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Model Misspecification and Ambiguity Aversion

Statistical models we use in practice are misspecified.

- Aim of robust approaches:
  - use models in sensible ways rather than discard them
  - use probability and statistics to provide tools for assessing sensitivity to potential misspecification
- Ambiguity aversion - averse to uncertainty about probabilities over future events
- Outcome - target the uncertainty with the most adverse consequences for the decision maker.

Uncertainty and Financial Markets

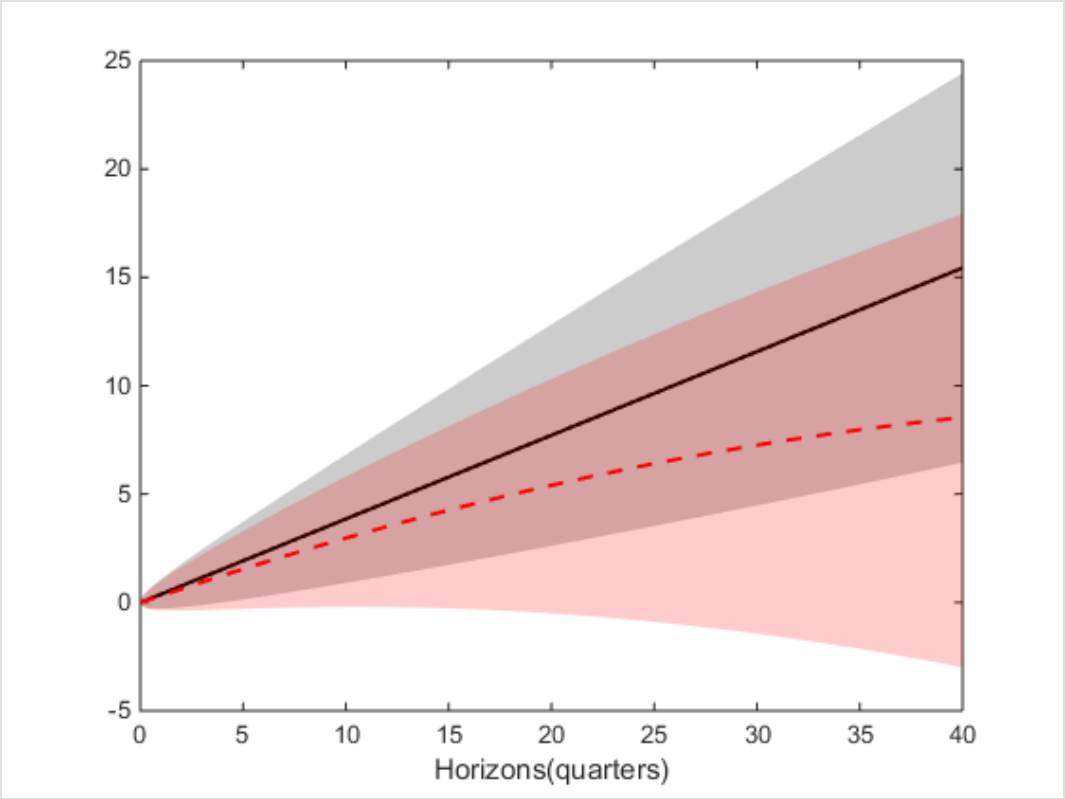
Bear Bull Rumble, Adrian deRooy

Market Adjustments for Uncertainty

Suppose the private sector is uncertain about future macroeconomic growth rates

- Investors fear persistence in bad times and fear the lack of persistence in good times
- Induces fluctuations in the market price of uncertainty

Market Adjustments for Uncertainty



The **black** solid line depicts the median under the baseline model and the shaded region gives the .1 and .9 deciles. The red dashed line is the median under the worst-case model and the red shaded region gives the .1 and .9 deciles. Source: Hansen and Sargent.

What We Have Achieved

- tractable approach for confronting uncertainty
- a mechanism for inducing fluctuations in asset values
- investors fear persistence in bad times and fear the lack of persistence in good times

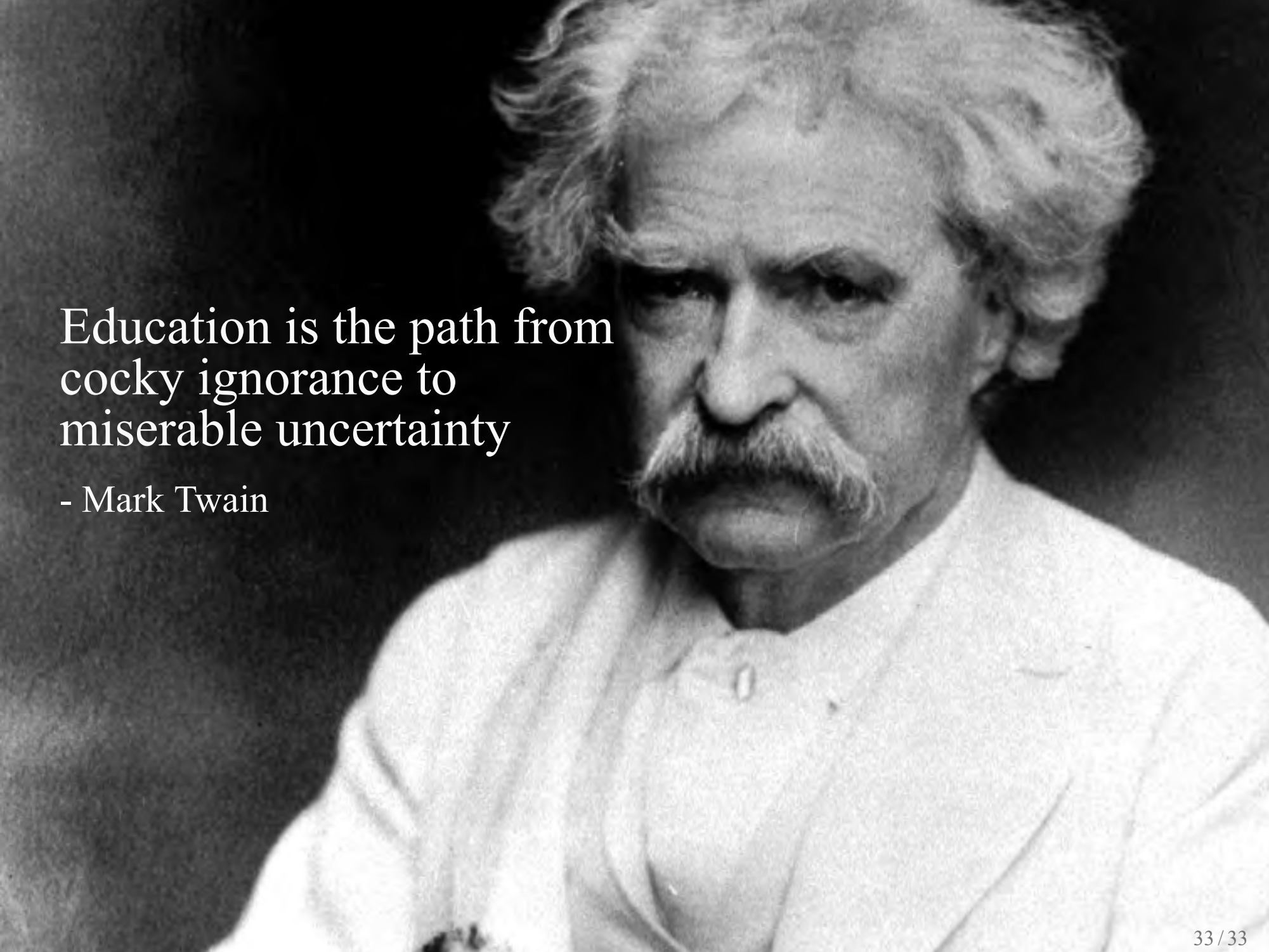
Broader Perspective

- difficult to disentangle risk aversion from belief distortions
- belief distortions are more compelling in environments in which uncertainty is complex
- statistical tools provide valuable ways to assess environmental complexity
- value to pushing beyond the risk model commonly embraced in economics and finance

Friedrich Hayek (1974)

"Even if true scientists should recognize the limits of studying human behaviour, as long as the public has expectations, there will be people who *pretend* or *believe* that they can do more to meet *popular demand* than what is really in their power."
(From Hayek's Nobel address)

See: "Uncertainty in Economic Analysis and the Economic Analysis of Uncertainty," forthcoming in *KNOW* for more discussion.


Education is the path from
cocky ignorance to
miserable uncertainty
- Mark Twain