Models of Financial Markets with Linkages to the Macroeconomy

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OUTLINE

- Characterizing asset pricing dynamics in dynamic stochastic equilibrium models through valuation accounting.
- Fragility in beliefs, ambiguity and robustness.
- Shocks and transmission mechanism in macroeconomic models with financing constraints.
- Systemic risk measurement.

Models of asset valuation

Two channels:

- Stochastic growth modeled as a process $G = \{G_t\}$ where G_t captures growth between dates zero and t.
- Stochastic discounting modeled as a process $S = \{S_t\}$ where S_t assigns risk-adjusted prices to cash flows at date t.

Date zero prices of a payoff G_t is

$$\pi_0 = E\left(S_t G_t | X_o\right)$$

where X_0 captures current period information.

Illustrative Setup

Suppose X is first-order Markov, and W is an iid sequence of multivariate, standard normally distributed random vectors.

- Conditional Gaussian model in logarithms:

$$Y_t = \sum_{s=0}^{t-1} \left[\beta \left(X_s \right) + \alpha \left(X_s \right) \cdot W_{s+1} \right].$$

- Levels $M_t = \exp(Y_t)$. Examples of M include a macroeconomic growth functional G such as consumption or capital and a stochastic discount factor functional S used to price assets.

SINGLE-PERIOD ASSET PRICING

Suppose that

$$\log G_1 = \beta_g(X_0) + \alpha_g(X_0) \cdot W_1$$
$$\log S_1 = \beta_s(X_0) + \alpha_s(X_0) \cdot W_1$$

$$R_1 = \frac{G_1}{E(S_1 G_1 | X_0)}$$

Logarithm of the expected return is:

$$\log E(G_1 | X_0 = x) - \log E(S_1 G_1 | X_0 = x) =$$
$$- \beta_s(x) - \alpha_g(x) \cdot \alpha_s(x) - \frac{|\alpha_s(x)|^2}{2}$$

Then $-\alpha_s$ is the risk-price vector for exposure to the components of W_1.

Asset-pricing puzzles

The magnitude of the risk price vector $|\alpha_s|$ is challenging to explain.

- Recursive utility, habit persistence and other models of investor preferences typically still appeal to large risk aversion on the part of investors.
- Alternative literature explores implications of solvency constraints, idiosyncratic shocks that cannot be fully diversified, or private information.

Alternative derivation

Compute elasticities.

- Consider a parameterized family of payoffs.

$$\log H_1(\mathsf{r}) = \mathsf{r}\alpha_h(X_0)\cdot W_1 - \frac{r^2}{2}|\alpha_h(X_0)|^2$$

  where

$$E[|\alpha_h(X_0)|^2] = 1.$$

  Then α_h gives an exposure direction and $H_1(\mathsf{r})$ has conditional expectation equal to one.

- Form $G_1 H_1(\mathsf{r})$ where

$$\log G_1 + \log H_1(\mathsf{r}) = [\alpha_g(X_0) + \mathsf{r}\alpha_h(X_0)]\cdot W_1 + \beta_g(X_0) - \frac{(\mathsf{r})^2}{2}|\alpha_h(X_0)|^2$$

Parameterized family of asset payoffs to be priced.

Elasticities

- Compute expected return:

$$\log E[G_1 H_1(\mathsf{r}) | X_0 = x] - \log E[S_1 G_1 H_1(\mathsf{r}) | X_0 = x]$$

- Differentiate:

$$\frac{d}{d\mathsf{r}} \log E[G_1 H_1(\mathsf{r}) | X_0 = x]|_{\mathsf{r}=0} - \frac{d}{dr} \log E[S_1 G_1 H_1(\mathsf{r}) | X_0 = x]|_{\mathsf{r}=0}$$

- Component elasticities:

  1. shock-exposure elasticity:

$$\varepsilon_g(x) = \frac{d}{d\mathsf{r}} \log E[G_1 H_1(\mathsf{r}) | X_0 = x]|_{\mathsf{r}=0} = \alpha_g(x) \cdot \alpha_h(x)$$

  2. shock-value elasticity:

$$\varepsilon_v(x) = \frac{d}{dr} \log E[S_1 G_1 H_1(\mathsf{r}) | X_0 = x]|_{\mathsf{r}=0} = \alpha_s(x) \cdot \alpha_h(x) + \alpha_g(x) \cdot \alpha_h(x)$$

  3. shock-price elasticity:

$$\varepsilon_p(x) = \varepsilon_g(x) - \varepsilon_v(x) = -\alpha_s(x) \cdot \alpha_h(x)$$

EXTENDING THE INVESTMENT HORIZON

- Construct payoff: $G_t H_1(\mathsf{r})$.
- Compute price: $E\left[S_t G_t H_1(\mathsf{r}) | X_0 = x\right]$
- Form elasticities:

1. shock-exposure elasticity for horizon t:

$$\varepsilon_g(x, t-1) = \frac{d}{d\mathsf{r}} \frac{1}{t} \log E[G_t H_1(\mathsf{r}) | X_0 = x]|_{\mathsf{r}=0}$$

2. shock-value elasticity for horizon t and (and shock date one):

$$\varepsilon_v(x, t-1) = \frac{d}{dr} \frac{1}{t} \log E[S_t G_t H_1(\mathsf{r}) | X_0 = x]|_{\mathsf{r}=0}$$

3. shock-price elasticity for horizon t:

$$\varepsilon_p(x, t-1) = \varepsilon_g(x, t-1) - \varepsilon_v(x, t-1).$$

Representations

Let M be a multiplicative functional (either G or SG). Then

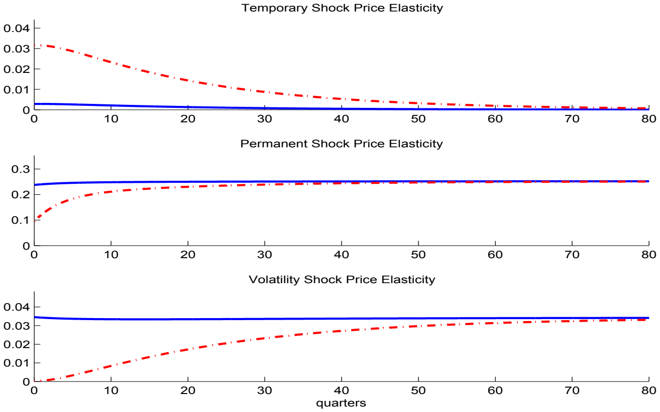
$$\varepsilon_m(x,t) = \alpha_h(x) \cdot \frac{E\left(M_t W_1 | X_0 = x\right)}{E\left(M_t | X_0 = x\right)}$$

Observations

- When M is log-linear, essentially recovers the impulse response function for $\log M$ in response to a shock $\alpha_h \cdot W_1$. Shock exposure elasticities reflect impulse response functions for $\log G$, shock-price elasticities reflect impulse response functions for $-\log S$
- With stochastic volatility and other sources of nonlinearity, the choice of G matters for computing the shock-price elasticities.
- The elasticities are inputs into valuation accounting.

Provide basic tools for exploring asset pricing dynamics and understanding the components of risk premia.

SHOCK-PRICE TRAJECTORIES FOR POWER AND RECURSIVE UTILITY



Stochastic volatility is incorporated. Volatility state set at its unconditional mean.

Pricing comparisons

- External habit models large shock price elasticities initially and then collapse to power utility model with modest risk aversion. Backward-looking channel in which risk aversion is large in bad times.
- Recursive utility models with long-run risk components in consumption have flat trajectories with moderately large risk aversion because of a forward-looking channel in valuation. The long-run risk components implies that the shock price elasticities eventually become large for the power utility model, but not initially.

Two questions:

1. What macroeconomic shocks are priced?
2. Are they structural models?

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Skepticism: Voltaire 1776

Le doute n'est pas une condition agréable, mais la certitude est absurde.

Translation: Doubt is not a pleasant condition, but certainty is absurd.

Economic Agents as Econometricians

Opportunities that investors face depend on the underlying macroeconomy. When making their investment decisions they confront macroeconomic uncertainty about future growth prospects.

- Some components of the macroeconomy may be sufficiently subtle that they are hard to isolate from historical data
- Study pricing in such an environment when investors are skeptical of their model of the macroeconomy and of their historical estimates of model parameters.
- This skepticism generates learning-induced fluctuations in compensations that investors must receive because of exposure to macroeconomic uncertainty.
- Confront an empirical challenge to get movements over time in risk prices - (Campbell and Cochrane, JPE).
- Use models of robust decision-making or ambiguity aversion in conjunction with learning.

Sentiments and uncertainty

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ROBUST DECISION THEORY

- Do not "separate" statistical inference from the decision problem.
- Explore consequence to objectives for alternative specifications of probability distributions (subject to penalization.)
- Dynamic setting with learning two channels (Hansen and Sargent, JET):
    - Misspecified state dynamics - forward looking
    - Misspecified solution to estimation or filtering - backward looking

Long-Run Risk Model

- Extend calculations from Hansen (AER) and Hansen and Sargent (QE)
- Explore a model motivated by Bansal and Yaron.

$$\begin{aligned} Y_{t+1} - Y_t &= \mu + X_t + GW_{t+1} \\ X_{t+1} &= AX_t + BW_{t+1} \end{aligned}$$

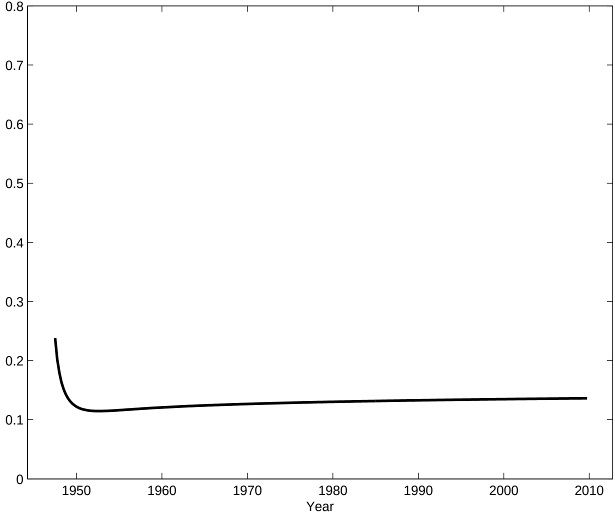
where X is a scalar hidden state and μ an unknown parameter but G, A and B are known. This can be viewed as a state space system when written as:

$$\begin{aligned} Y_{t+1} - Y_t &= \mu + X_t + GW_{t+1} \\ \begin{bmatrix} X_{t+1} \\ \mu \end{bmatrix} &= \begin{bmatrix} A & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} X_t \\ \mu \end{bmatrix} + \begin{bmatrix} B \\ 0 \end{bmatrix} W_{t+1}. \end{aligned}$$

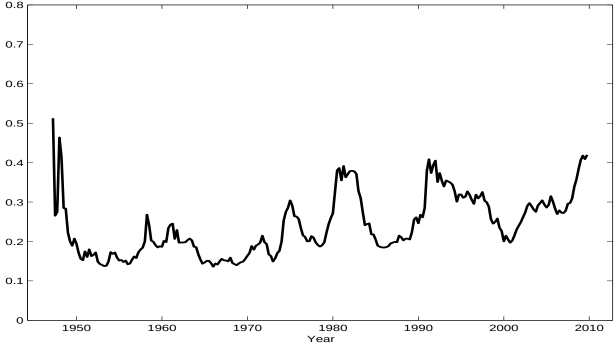
In this system $Y_{t+1} - Y_t$ is the growth rate of consumption. The learning problem is solved by the Kalman filter.

MARKET PRICE OF UNCERTAINTY, μ UNKNOWN

Differences in the conditional mean for consumption divided by the conditional variance.



Market Price of Uncertainty, A, B and μ unknown



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CURRENT QUANTITATIVE MACRO MODELS

Used to identify shocks and support the analysis of monetary policy.

- Typically include a large number of shocks even before the crisis. Econometric identification is tenuous.
- Since the financial crisis, new shocks have now emerged. Examples:
  - Fraction of the capital stock disappears;
  - Fraction of resources that can be confiscated under a threat of default increases.
- New mechanisms feature the link to financial markets:
  - Pricing differences among state-contingent loans depending on collateral requirements.
  - Limited commitment supported by the threat to confiscate a fraction of the capital stock.
- Stochastic volatility has been incorporated but typically modeled as additional exogenous processes.

FURTHER EXTENSIONS REQUIRED FOR POLICY RELEVANCE

- Models are typically solved using local perturbation methods and thus may misrepresent the transition mechanisms germane for large shocks.
- How do we interpret the shocks? Exogenous impulses or "wedges" omitted from the model development.
- Need to understand and model better the sources of volatility variation including linkages to macroeconomic policy.
- Fiscal policy and the associated challenges must play a more central role - sovereign risk.
- Distributional impacts are largely abstracted from. Very limited forms of heterogeneity in financial and nonfinancial sectors in part because of the challenges in model solution and transparency in the model predictions.

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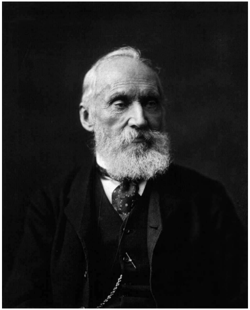
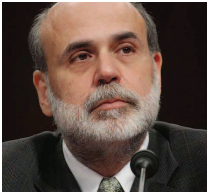
SYSTEMIC RISK

New regulatory "slogan".



Lord Kelvin's dictum: "I often say that when you can measure something that you are speaking about, express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of the meagre and unsatisfactory kind: it may be the beginning of knowledge, but you have scarcely, in your thoughts advanced to the stage of *science*, whatever the matter might be."

WHY MEASURE SYSTEMIC RISK?



Bernanke: ... much work remains to better understand sources of systemic risk, to develop improved monitoring tools, and to evaluate and implement policy instruments to reduce macroprudential risks. These are difficult challenges, but if we are to avoid a repeat of the crisis and its economic consequences, these challenges must be met.

What is the systemic risk measurement agenda?

- Seek quantification that supports informed discussion of system-wide risks to the economy at large and provide input into the monitoring and regulation of financial markets.
- Fuel the analysis by new data and evidence.
- Assemble rich new data sets in thoughtful ways to engender a durable research program with exciting and productive outcomes.

Statistical Approaches

- Distinguish small shocks and large shocks from financial data using statistical methods.
- Interpretations:
  - Small macroeconomic shocks are systematic. They are nondiversifiable macro economic shocks that are commonly "priced" by standard asset pricing models.
  - Large shocks are systemic. They require special attention by policy makers.
- Much of the existing statistical work focus on very short time horizons with implicit or explicit extrapolation.

This form of analysis is interesting, revealing and to be encouraged but....

Potential pitfalls with current approaches

- Measurement without theory - Koopmans' challenge to Burns and Mitchell's attempts to measure business cycles.
- Leaving the term "systemic risk" purposefully vague becomes a justification for regulatory discretion. Regulators pretend "to know it when they see it" (like Justice Potter Stewart said about pornography?).
- Exclusivity of data limits the ability for critiques and replication - will requirements of confidentiality prohibit external researchers from challenging measurements and assertions in meaningful ways?
- Pre-ordained or even inadvertent support for policies such as too big (or too something) to fail.
- Exclusive focus on quick answers - answers that skirt the identification needed for informed policy discussion.
- All large systemic shocks treated the same.

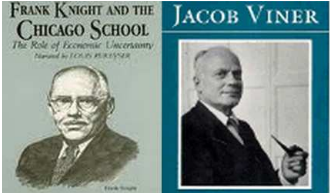
Systemic uncertainty

- How do we best express skepticism in our probabilistic measurement of systemic risk?
- This skepticism when expressed appropriately can have important consequences for policy design.

Related research contributions.

- Network models with lack of full knowledge of financial positions of firms with indirect linkages (neighbors of neighbors).
- Models of when skepticism is reflected in market valuations in pronounced ways (fragile beliefs).

Kelvin Dictum Revisited



Chicago economists responses to the Kelvin Dictum:

- Knight

  > *If you cannot measure a thing, go ahead and measure it anyway.*

- Viner's proposed amendment to the Kelvin Dictum

  > *... and even when we can measure a thing, our knowledge will be meager and unsatisfactory.*

Detective work: Merton, Sills and Stigler, The Kelvin Dictum and Social Science: an Excursion into the History of an Idea, 1984