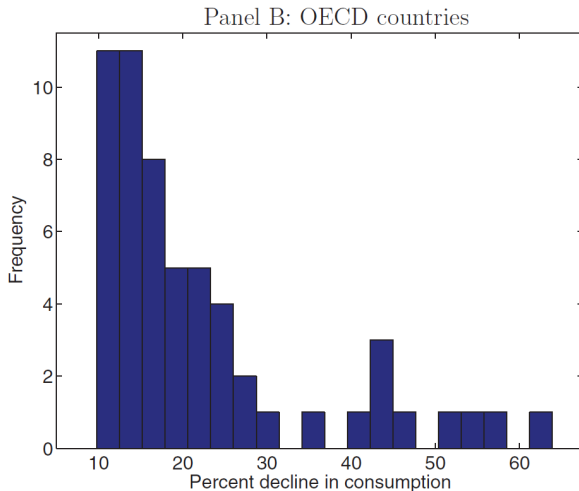


Agenda

- 1 Option Pricing in Partial Equilibrium
- 2 General Equilibrium Asset Pricing
- 3 Habit Formation and Asset Pricing
- 4 Recursive Utility
- 5 Long-Run Risk and Asset Pricing
- 6 Disaster Risk and Asset Pricing**
 - Motivation and Model Setup
 - Asset Pricing

- In reality, consumption and stock market dynamics are not as smooth as the Lucas model suggests.
- The frameworks we have studied so far do not take into account the possibility of rare disasters that hit the economy with a slam.
- Examples:
 - Corona Crash of Spring 2020
 - Financial Crisis of 2008
 - Wall Street Crash of 1929
 -
- All these crashes destroyed a lot of money within some few trading days and had a significant impact on consumption.
- We study a simple model with instantaneous disaster shocks following Rietz (1998), Barro (2006, 2009).



Selected disasters in history, see Wachter (2013), original data from Barro and Ursua (2008).

- Endowment economy with **disaster risk component**

$$\Delta c_{t+1} = \mu_c + \sigma_c \eta_{c,t+1} + \nu_{t+1}$$

- $\eta_{c,t+1} \sim \mathcal{N}(0, 1)$, i.i.d. and ν_{t+1} satisfies

$$\mathbb{P}(\nu_{t+1} = \log(1 - b_{t+1})) = p, \quad \mathbb{P}(\nu_{t+1} = 0) = 1 - p$$

where b_{t+1} is i.i.d.

- Disaster probability: p
- Loss if a disaster hits the economy: b_{t+1}

$$C_{t+1} = C_t e^{\mu_c + \sigma_c \eta_{c,t+1} + \nu_{t+1}}$$
$$= \begin{cases} C_t e^{\mu_c + \sigma_c \eta_{c,t+1}}, & \text{in normal times} \\ C_t e^{\mu_c + \sigma_c \eta_{c,t+1}} (1 - b_{t+1}), & \text{if a disaster hits} \end{cases}$$

- Expected consumption growth

$$\mathbb{E}_t \left[\frac{C_{t+1}}{C_t} \right] = \mu_c + \frac{1}{2} \sigma_c^2 - p \mathbb{E}_t [b_{t+1}]$$

- Rare but heavy disasters: Barro (2006, 2009) uses
 - expected growth rate without disasters $\mu_c = 2.5\%$
 - consumption volatility in normal times $\sigma_c = 2\%$
 - disaster probability $p = 1.7\%$
 - expected disaster size $\bar{b} = \mathbb{E}_t [b_{t+1}] = 29\%$
- Therefore, expected growth rate is $\mathbb{E}_t \left[\frac{C_{t+1}}{C_t} \right] \approx 2\%$.
- Alternative calibrations can be found in Wachter (2013), Barro and Jin (2011), among others.

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- Consider an investor with CRRA utility (Barro 2006):

$$u(C) = \frac{1}{1-\gamma} C^{1-\gamma}.$$

- Consumption growth is i.i.d., so wealth-consumption ratio constant, and everything works along the lines of Section 2.
- Standard Procedure
 - Write down the Euler equation and determine the pricing kernel
 - Derive the risk-free interest rate.
 - Derive the equity premium.
 - Determine the wealth-consumption ratio.
- This procedure also works for recursive utility (Barro 2009).

- Euler Condition remains unchanged in the CRRA case,

$$\mathbb{E}_t \left[e^{-\delta} \frac{u_c(C_{t+1})}{u_c(C_t)} R_t \right] = 1.$$

- For the risk-free asset

$$e^{-r_t^f} = \mathbb{E}_t \left[e^{-\delta} \frac{u_c(C_{t+1})}{u_c(C_t)} \right]$$

- Exploiting a first order approximation ($e^{-p} \approx 1 - p$):

$$r_t^f = \delta + \gamma \mu_c - \frac{1}{2} \gamma^2 \sigma_c^2 - p (\mathbb{E}_t [(1 - b_{t+1})^{1-\gamma}] - 1)$$

- **blue terms:** standard
- **red terms:** disaster risk reduces the interest rate

- Equity premium

$$rp_t^i = \gamma\sigma_c^2 + p\mathbb{E}_t[b_{t+1}((1 - b_{t+1})^{1-\gamma} - 1)]$$

- **blue terms:** standard
- **red terms:** disaster risk boosts the equity premium
- The benchmark calibration generates a high equity premium and a low real interest rate even with CRRA utility and a moderate degree of risk aversion in the range between $\gamma = 3$ and $\gamma = 4$.

- The model is still very simplistic.
 - equity premium is constant.
 - interest rates is constant.
 - financial crises are point events.
 - CRRA implies that an increase in uncertainty (σ , ρ , or b_{t+1}) for given expected consumption growth implies a higher price-dividend ratio.
- It can be adjusted in various dimension to account for
 - recursive preferences (e.g., Barro 2009; Barro and Jin 2011)
 - long-run risk and stochastic volatility (as in Bansal and Yaron 2004)
 - time-varying disaster risk (e.g., Wachter 2013)
 - periods of crisis (e.g., Branger et al. 2016)
 - climate-induced disaster shocks (e.g., Hambel et al. 2020)
 - ...

Possible Model Extensions

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