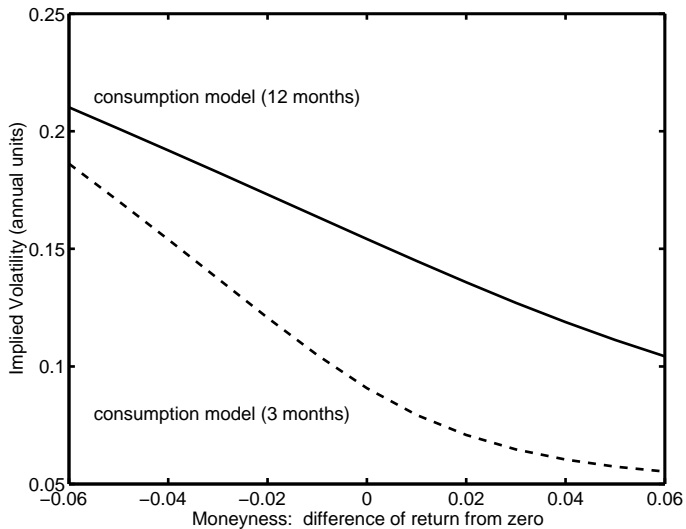


# Disasters Implied by Equity Index Options

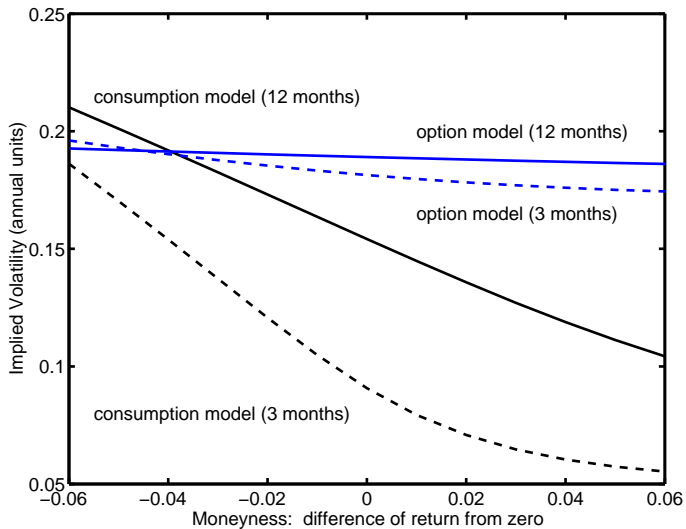
David Backus (NYU), Mikhail Chernov (LBS),  
and Ian Martin (Stanford)

American Economic Association | Atlanta | January 3, 2010

# Option prices



# Option prices



# Outline

How disasters affect asset prices

Disasters in macroeconomic data

Disasters in options data

Extensions

# Entropy and cumulants

Entropy: for  $x > 0$

$$L(x) \equiv \log Ex - E \log x \geq 0$$

Alvarez-Jerman bound

$$L(m) \geq E (\log r^j - \log r^1)$$

Zin's "never a dull moment" conjecture

$$L(m) = \underbrace{\kappa_2(\log m)/2!}_{(\log)\text{normal term}} + \underbrace{\kappa_3(\log m)/3! + \kappa_4(\log m)/4! + \dots}_{\text{high-order cumulants (incl disasters)}}$$

## Macro disasters: overview

No dynamics: iid consumption growth

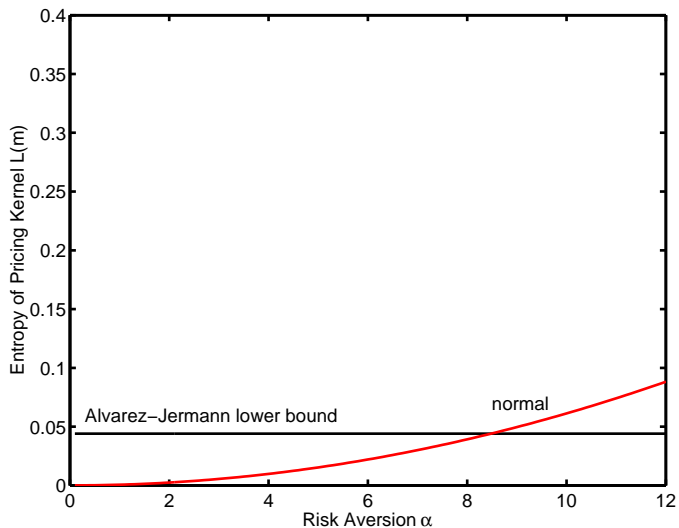
Tight link between consumption growth and equity returns

$$\begin{aligned}g_{t+1} &= c_{t+1}/c_t \\d_t &= c_t^\lambda \\ \log r_{t+1}^e &= \text{constant} + \lambda \log g_{t+1}\end{aligned}$$

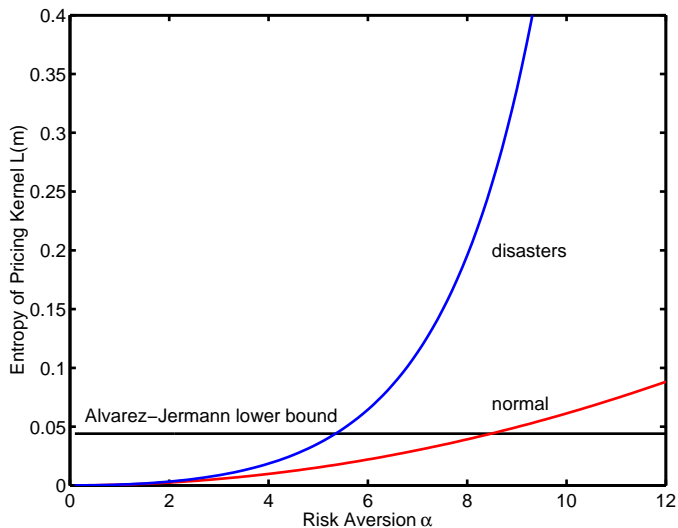
Representative agent with power utility

$$\begin{aligned}\log m_{t+1} &= \log \beta - \alpha \log g_{t+1} \\ \kappa_j(\log m)/j! &= \underbrace{\kappa_j(\log g)(-\alpha)^j/j!}_{\text{"Yaron's bazooka"} }\end{aligned}$$

# Macro disasters: entropy

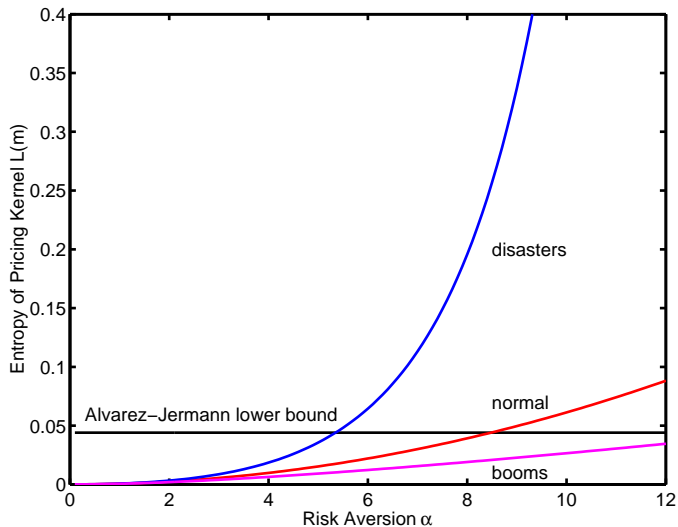


# Macro disasters: entropy

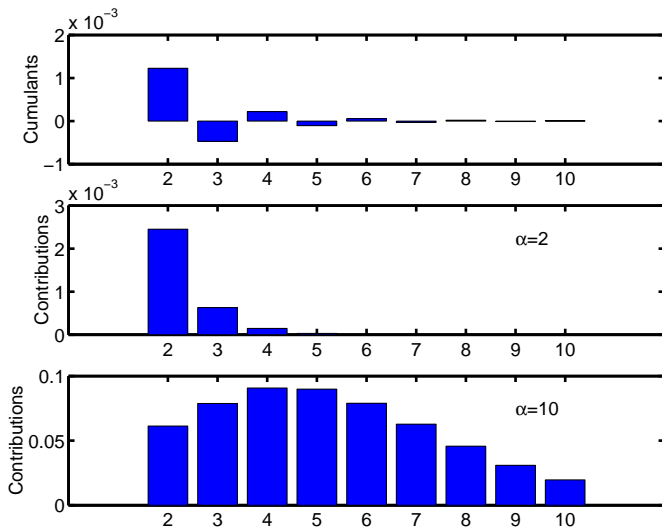




# Macro disasters: entropy



## Macro disasters: cumulants



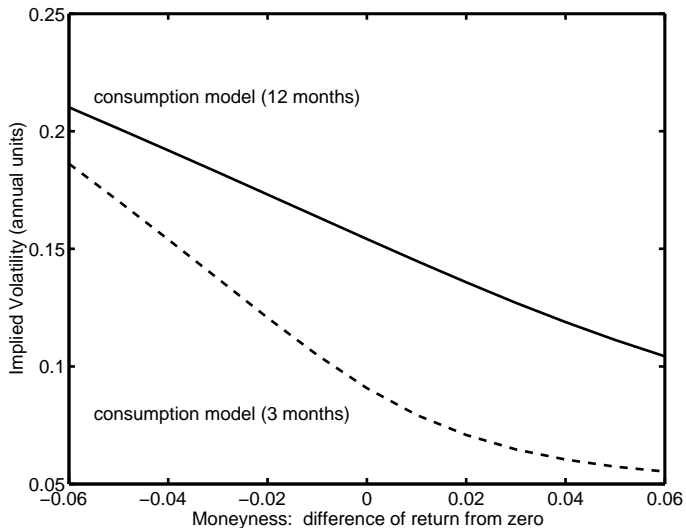
# Option disasters: overview

Option prices an obvious source of information

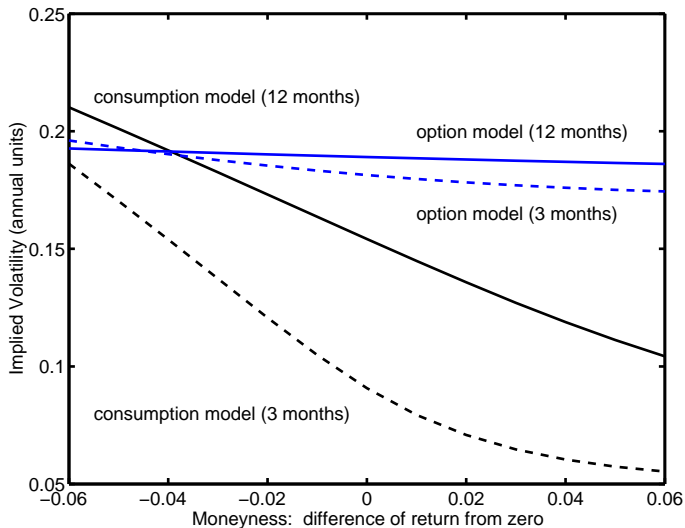
Put options are bets on low returns

Parameters from Broadie, Johannes, and Chernov (JF, 2007)

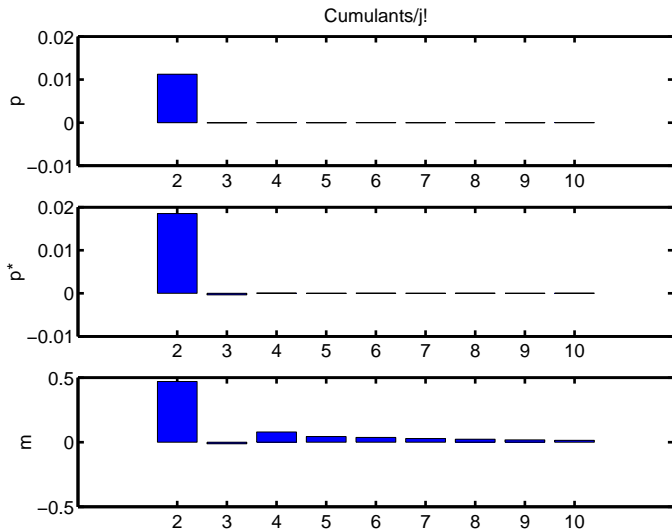
## Option disasters: option prices



## Option disasters: option prices



## Option disasters: cumulants



## Option disasters: components of entropy

Model	Entropy	Variance/2	High-Order Cumulants	
			Odd	Even
<i>Consumption-based model</i>				
Poisson ( $\alpha = 5.38$ )	0.0449	0.0177	0.0173	0.0099
<i>Option-based model</i>				
Option model	<b>0.7647</b>	0.4699	<b>0.1130</b>	<b>0.1819</b>

## Option disasters: consumption implied by options

	Cons Growth Process Based on	
	Macro Data	Option Prices
Skewness	-11.02	-0.31
Excess Kurtosis	145.06	0.87
Tail prob ( $\leq -3$ st dev)	<b>0.0090</b>	<b>0.0086</b>
Tail prob ( $\leq -5$ st dev)	<b>0.0079</b>	<b>0.0002</b>



# Bottom line

Barro, Longstaff & Piazzesi, Rietz

- ▶ Disasters contribute to equity premium, entropy
- ▶ Evident in macro data

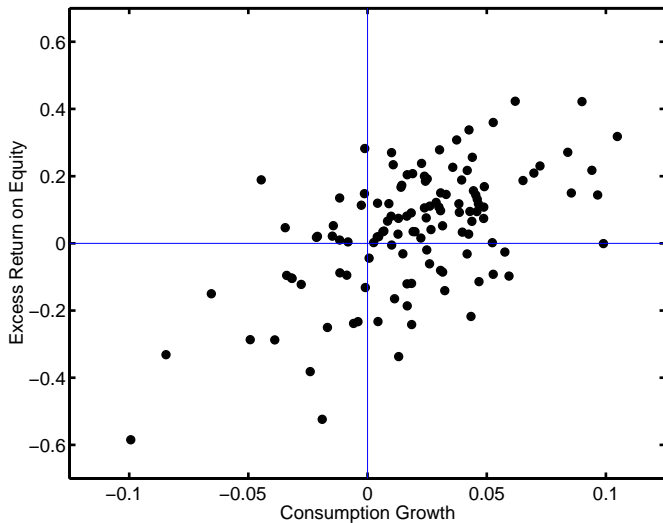
We look at options

- ▶ Smile/smirk suggests something like disasters
- ▶ More modest than macro data
- ▶ High entropy suggests it's not enough to match equity premium

Extensions: reconsider

- ▶ Tight link between consumption growth and equity returns
- ▶ Power utility
- ▶ Consumption growth iid

# Consumption growth and equity returns



# Implied “risk aversion” in the option model

