

# Why?

Discussion of Rob Engle's  
"Models of Dynamic Uncertainty"

by

A. Ronald Gallant  
Duke University  
Fuqua School of Business  
Durham NC 27708-0120 USA

[www.duke.edu/~arg](http://www.duke.edu/~arg)

## What We Have Seen Is Bizarre

Because daily returns on a financial time series are the sum of many trades and arbitrage ought to force approximate independence, one would expect daily returns to be roughly NID.

Instead we see:

- Fat tails.
- Correlations that wax and wane.
- Conditional heteroskedasticity: ARCH, GARCH, etc.
- Conditional skewness and shape dependence of all sorts.

## Why Does This Happen?

## Mechanistic Explanation: Stochastic Volatility

- Price changes  $\Delta p_\tau = \log(P_\tau) - \log(P_{\tau-1})$  occur when new information causes traders to change their valuations.
- If  $I_t$  is the number of information packets that arrive today, then  $R_t = \sum_{\tau=1}^{I_t} \Delta p_\tau$ .
- If a CLT holds, then returns are a scale mixture of normals  $R_t = \sqrt{I_t} \left( \frac{1}{\sqrt{I_t}} \sum_{\tau=1}^{I_t} \Delta p_\tau \right) = \sqrt{I_t} Z_t$ .
- This is the stochastic volatility model;  $I_t$  is called the directing process.
- Tauchen, G., and Pitts, M. (1983). "The Price Variability-Volume Relationship on Speculative Markets," *Econometrica* 51, 485–505.

## Stochastic Volatility?

- If the model is to hold, then the directing process  $I_t$  must be bizarre indeed.
- Gallant, A. Ronald, David A. Hsieh, and George E. Tauchen (1991), “On Fitting a Recalcitrant Series: The Pound/Dollar Exchange Rate, 1974–83,” in Barnett, William A., James Powell, and George E. Tauchen, eds. (1991), *Nonparametric and Semiparametric Methods in Econometrics and Statistics*, Cambridge University Press, Cambridge, Chapter 8, 199–240.

## Stochastic Volatility?

- Internet traffic is about as bizarre as the behavior that Rob Engle has described.
- Hernandez-Campos, F., J.S. Marron, S.I. Resnick, and K. Jeffay (2005) “Extremal Dependence: Internet Traffic Applications,” *Stochastic Models*, forthcoming.
- If internet traffic represents what information flow looks like, then maybe bizarre  $I_t$  is plausible.

# Stochastic Volatility?

- However, what has to be done to generate all the behavior that Rob Engle has described is pretty extreme.
  1. Two volatility factors.
  2. Jumps.
  3. Correlations and feedback.
- Chernov, Mikhail, A. Ronald Gallant, Eric Ghysels, and George Tauchen (2003), "Alternative Models for Stock Price Dynamics," *Journal of Econometrics* 116, 225–257 .
- One becomes skeptical that reduced form models of such complexity have any scientific content at all.
- Not very intellectually satisfying.

## Macroeconomic Explanation: Consumption Based Asset Pricing

- Individuals maximize

$$\mathcal{E}_0 \left( \sum_{t=0}^{\infty} \beta^t U(C_t, C_{t+1}, \dots) \right)$$

subject to a budget constraint  $C_t + P_t Q_t = W_t + (P_t + D_t) Q_{t-1}$ .

- Income  $W_t$  and dividends  $D_t$  are the driving processes and  $\mathcal{E}_t$  denotes expectation with respect to their past.
- If one chooses a distribution  $F(w_t, d_t | w_{t-1}, d_{t-1}, \dots)$  and utility  $U(C_t, C_{t+1}, \dots)$ , then one can solve for the security price  $P_t$ .
- Lucas, R. E., Jr. (1978), "Asset Prices in an Exchange Economy," *Econometrica* 46, 1429–1445.

# Consumption Based Asset Pricing?

- Early attempts to fit the model to data were disappointing
- Utility specification

$$E_0 \left( \sum_{t=0}^{\infty} \beta^t C_t^{-\gamma} \right)$$

- $F(w_t, d_t | w_{t-1}, d_{t-1}, \dots)$  unspecified.
- Hansen, L. P., and K. J. Singleton (1982), “Generalized Instrumental Variable Estimation Estimators of Nonlinear Rational Expectations Models,” *Econometrica* 50, 1269–1286.

# Consumption Based Asset Pricing?

- But there was some early evidence that the model could be made to work.
- Utility specification:  $\mathcal{E}_0 \left( \sum_{t=0}^{\infty} \beta^t U(C_t, C_{t+1}, \dots) \right)$  nonparametric (sieve).
- Driving processes:  $(w_t/w_{t-1}, d_t/d_{t-1}, \dots)$  stationary, nonparametric (sieve).
- Estimation method: limited information maximum likelihood.
- Gallant, A. Ronald, and George Tauchen (1989), “Seminonparametric Estimation of Conditionally Constrained Heterogeneous Processes: Asset Pricing Applications,” *Econometrica* 57, 1091–1120.

# Consumption Based Asset Pricing?

- Recent attempts have been more successful: Habit persistence, mildly behavioral.
- Utility: One gets habituated to a level of consumption and is reluctant to change it quickly.
- Driving processes: Simple random walk dynamics.
- Estimation method: calibration (non-statistical).
- Campbell, John Y., and John Cochrane (1999) “By Force of Habit: A Consumption-based Explanation of Aggregate Stock Market Behavior,” *Journal of Political Economy* 107, 205–251.

# Consumption Based Asset Pricing?

- Recent attempts: Prospect theory, strongly behavioral.
- Utility: Based on the experimental psychology literature.
  - Asymmetric reactions to changes to wealth and to the history of losses and gains on specific investments.
  - Small groups of teenagers and twentysomethings with no meta analysis. We need some statistical input here.
- Driving processes: Simple random walk dynamics.
- Estimation method: calibration (non-statistical).
- Barberis, Nicholas, Ming Huang, and Tano Santos (2001) “Prospect Theory and Asset Prices,” *The Quarterly Journal of Economics* CXVI, 1–53.

# Consumption Based Asset Pricing?

- Recent attempts: long run risks, mainstream economics.
- Epstein-Zin-Weil utility: When consumption is received matters and timing preferences are cleanly separated from risk aversion.
- Driving processes: The Alan Greenspan world view. Productivity (hence income) fluctuates in slowly changing, long cycles that are extremely difficult to detect statistically.  
*Stochastic volatility.*
- Estimation method: calibration (but at least not openly contemptuous of statistics).
- Bansal, Ravi, and Amir Yaron, (2004) “Risks For the Long Run: A Potential Resolution of Asset Pricing Puzzles”, *Journal of Finance*, 59, 1481–1509.

# Consumption Based Asset Pricing?

- Recent attempts: long run risks, mainstream economics.
- Epstein-Zin-Weil utility: When consumption is received matters and timing preferences are cleanly separated from risk aversion.
- Driving processes: The Alan Greenspan world view. Productivity (hence income) fluctuates in slowly changing, long cycles that are extremely difficult to detect statistically. **No stochastic volatility.**
- Estimation method: mixed calibration and Bayes
- Hansen, Lars Peter, John C. Heaton, Nan Li (2005) "Consumption Strikes Back: Measuring Long Run Risk," Working paper, Department of Economics, University of Chicago.

# What Role Does Statistics Play?

- Not much.
- Journal impact factors for 1999, 2002:
  - Science: 24.595, 26.682
  - Econometrica: 2.206, 2.737
  - Journal American Statistical Association: 1.74, 1.669
  - Annals of Statistics: 1.382, 1.079
  - Biometrika: 1.226, 0.970
- <http://www.sciencegateway.org/impact>
- We seem to be in decline.

# Why Does Statistics Play a Small Role?

- We are trained as reduced form modelers, not structural modelers.
- Data from serious science are usually sparse. Our fanciest nonlinear and nonparametric methods only work well when data are abundant.
- Our methods only work when the model is assumed to be correct. We have next to nothing to offer when the model is admittedly misspecified.
- Our teaching and paradigms are nearly useless when science asks why.

# Some Attempts at Statistics Playing a Role

- A reasonable Bayesian attempt:
  - Gallant, A. Ronald, and Robert E. McCulloch (2004) “On the Determination of General Scientific Models,”  
<http://www.duke.edu/~arg/papers>
  - Software and User’s Guide:  
<ftp://ftp.econ.duke.edu/pub/arg/gsm>
- An as yet inadequate frequentist attempt:
  - Gallant, A. Ronald (2001) “Effective Calibration,”  
<http://www.duke.edu/~arg/papers>
  - Software and User’s Guide:  
[ftp://ftp.econ.duke.edu/pub/arg/emm\\_cpp](ftp://ftp.econ.duke.edu/pub/arg/emm_cpp)
- Both require MCMC methods and strong doses of prior information to work effectively.

## Statistics Day

- Hopefully these remarks will trigger an interest in the  
**WHY OF SCIENCE**
- Hopefully, an interest in the why of science will help  
**REVERSE THE DECLINE OF STATISTICS**

## These Slides

[www.duke.edu/~arg](http://www.duke.edu/~arg)

Click on “working papers”

Download “eng4upslid.pdf”