Why?

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

by

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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

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

  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 utility $U(C_t, C_{t+1}, \ldots)$ and a distribution $F(w_t, d_t | w_{t-1}, d_{t-1}, \ldots)$, 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

$$\mathcal{E}_0\left(\sum_{t=0}^{\infty}\beta^t C_t^{-\gamma}\right)$$

- $F(w_t, d_t | w_{t-1}, d_{t-1}, \ldots)$ 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: $\mathcal{E}_0\left(\sum_{t=0}^{\infty}\beta^t U(C_t, C_{t+1}, \ldots)\right)$ nonparametric (sieve).
- Driving processes: $(w_t/w_{t-1}, d_t/d_{t-1}, \ldots)$ 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`
- 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

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