Financial Time Series, Nobel Prize, and Ecology
Lessons Learned from the 2003 Nobel Prize in Economics

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(http://www.stat.colostate.edu/~rdavis/lectures)

Jeopardy

Hosted

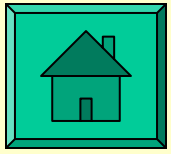
by

Richard Trebeck

Financial Time Series	Nobel Prize	Ecology
100	100	100
200	200	200
300	300	300
400	400	400
500	500	500

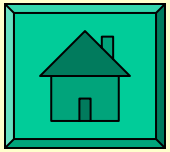
What is the ARCH process?

Name of the model developed by 2003 Nobel Prize winner Engle.



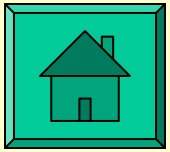
Who is John Nash

Nobel Prize winner whose story was depicted in the movie “A Beautiful Mind”



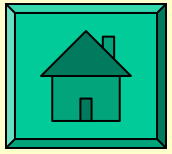
Who is Aldo Leopold?

Considered the father of ecology.



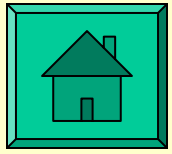
Who is Tim Bollerslev?

This person added the letter G to ARCH.



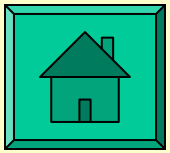
Who are Merton and Scholes?

These Nobel Prize winners developed an innovative theory for pricing derivatives.



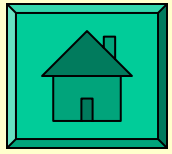
What is ACES?

The Alaska Consortium for Environmental Statistics.



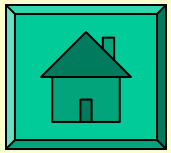
What is long memory?

Another term to describe persistence in volatility.



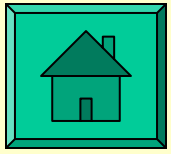
Who are Rob Engle and Clive Granger?

Shared the 2003 Nobel Prize in Economics.



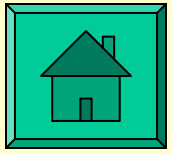
What is PRIMES?

The PRogram for Interdiscplinary Mathematics, Ecology and Statistics at Colorado State University.



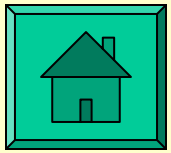
What is cointegration?

The term Granger used to combine two nonstationary time series to form a single stationary process.



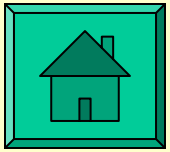
Who are Merton and Scholes?

These 1997 Nobel prize winners were Partners in the hedge fund, Long-Term Capital Management, that ultimately needed a $3.65 billion bailout.



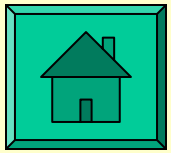
What is the Lotka-Volterra model?

A simple model for predator-prey interactions.



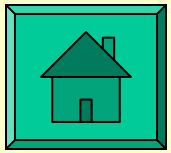
What is geometric Brownian motion?

The process used by Black and Scholes to model asset prices.



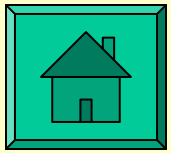
Who is Jan Tinbergen?

This 1969 Nobel Prize winner is known as the father of Econometrics.



Game over?

Bonus



Black-Scholes' Nobel Prize Winning Formula for Pricing Options

- Merton-Scholes won 1997 Nobel Prize (Fischer Black died in 1995).
- tells investors what value to put on a financial derivative

Robert Merton

Myron Scholes

So revolutionary was the very idea that you could use mathematics to price derivatives that initially Black and Scholes had difficulty publishing their work. When they first tried in 1970, Chicago University's *Journal of Political Economy* and Harvard's *Review of Economics and Statistics* both rejected the paper without even bothering to have it refereed.

It was only in 1973, after some influential members of the Chicago faculty put pressure on the journal editors, that the *Journal of Political Economy* published the paper.

Industry was far less shortsighted than the ivory-towered editors at the University of Chicago and Harvard. Within six months of the publication of the Black-Scholes article, Texas Instruments had incorporated the new formula into their latest calculator, announcing the new feature with a half-page ad in *The Wall Street Journal.*
—Keith Devlin

The Formula

$$V(s,T) = s\Phi\left(\frac{\log\frac{s}{K} + (r + .5\sigma^2)}{\sigma\sqrt{T}}\right) - ke^{-rT}\Phi\left(\frac{\log\frac{s}{K} + (r - .5\sigma^2)}{\sigma\sqrt{T}}\right)$$

= value of European call option

σ = volatility

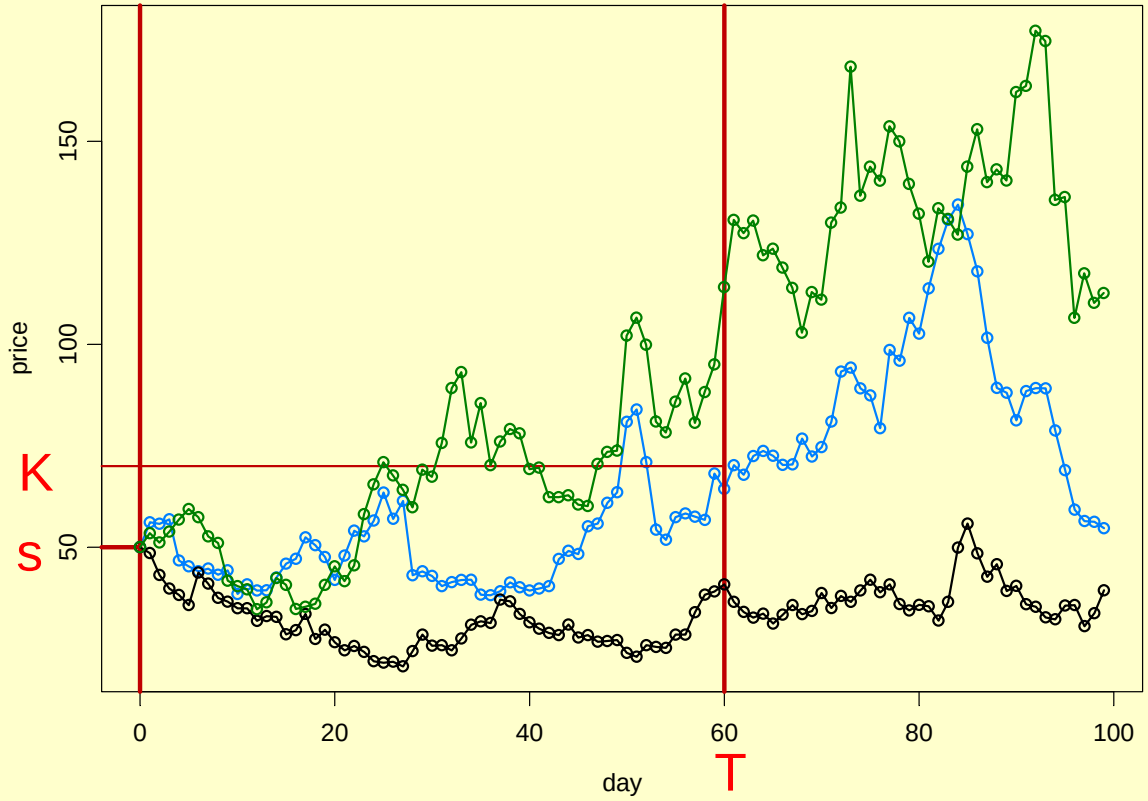
r = risk free bond rate

Φ = std normal cdf.

s = current value 50

T = exercise date 60

K = strike price 70



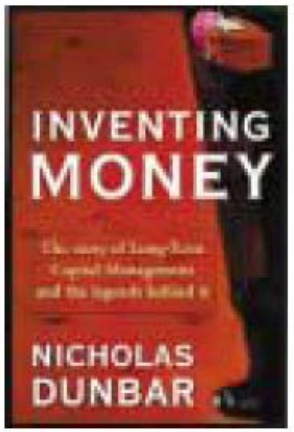
Postscript on Black-Merton-Scholes

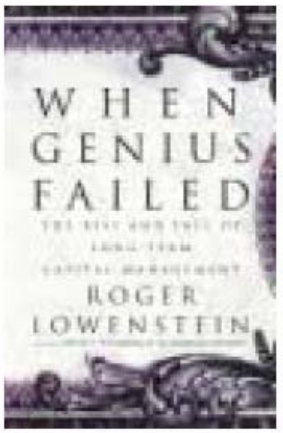
- rejuvenated the field of stochastic differential equations
- created a new field of financial mathematics
- the rise and fall of “Long Term Capital Management” – $3.65 billion bailout by Federal Reserve et al.

BOOKLINKS

Inventing Money: The Story of Long-Term Capital Management and the Legends Behind It
Nicholas Dunbar
John Wiley & Sons, Ltd., 2000

When Genius Failed: The Rise and Fall of Long-Term Capital Management
Roger Lowenstein
Random House, 2000





“once in-a-100-year event to cause LTCM to lose even 25% of its capital.”

Robert Engle and Clive Granger

KUNGL. VETENSKAPSAKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

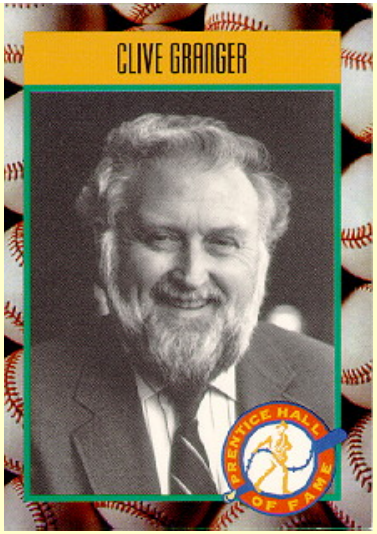
Press Release: The Bank of Sweden Prize in Economic Sciences in memory of Alfred Nobel 2003
8 October 2003

The Royal Swedish Academy of Sciences has decided that the Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel, 2003, is to be shared between

Robert F. Engle
New York University, USA
"for methods of analyzing economic time series with time-varying volatility (ARCH)"
and
Clive W. J. Granger
University of California at San Diego, USA
"for methods of analyzing economic time series with common trends (cointegration)".

Clive Granger (UC San Diego)

- cointegration (common trends)
- long memory

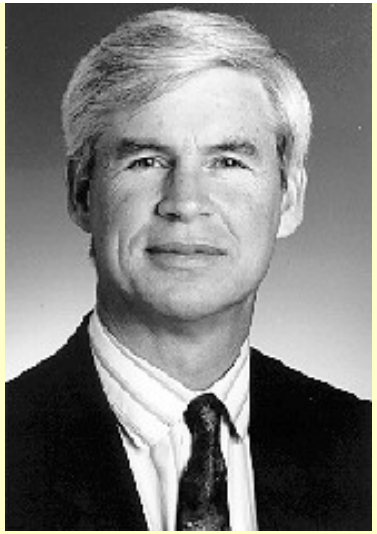


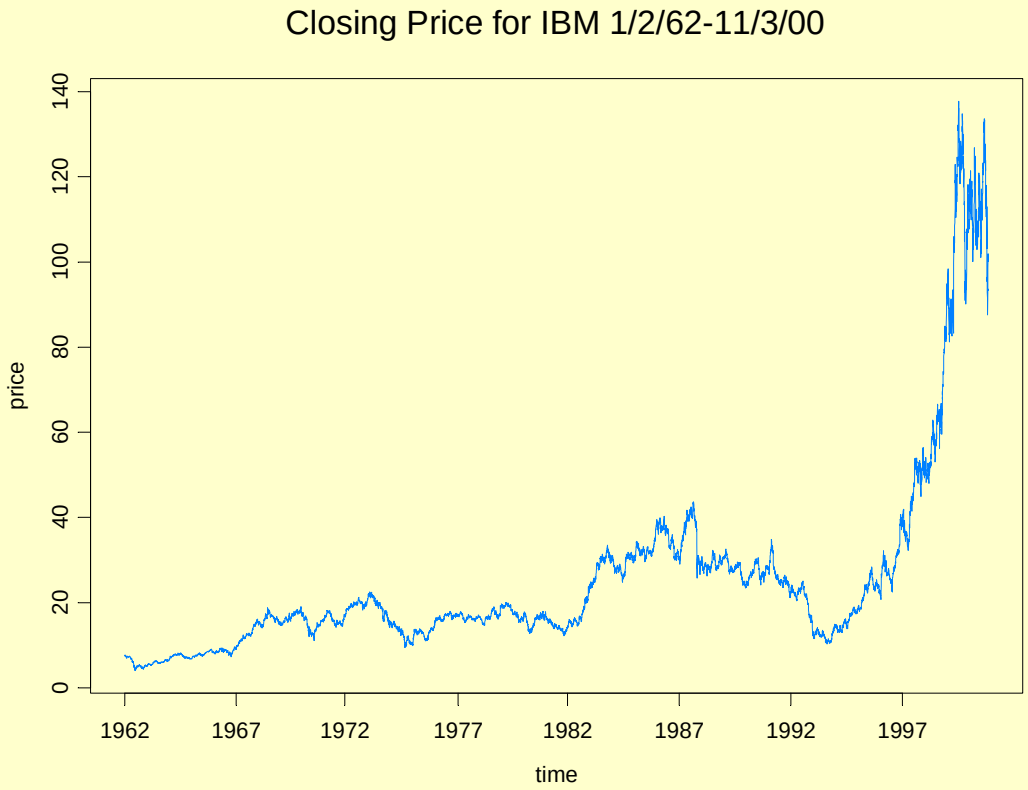
The stock market is like a small row boat on a rough sea, bouncing around as it drifts, whereas the macro economy is like a large ocean liner, very ponderous and difficult to maneuver but without such a rough journey. … I was more concerned with building models that central bankers could use for policy purposes and particularly for long run forecasting. The idea is called "cointegration" and provides ways to discover that two large boats are drifting with the same current or that two macroeconomies are moving together. You will find both of these words [ARCH and cointegration] defined in the Oxford English Dictionary in a few years time!

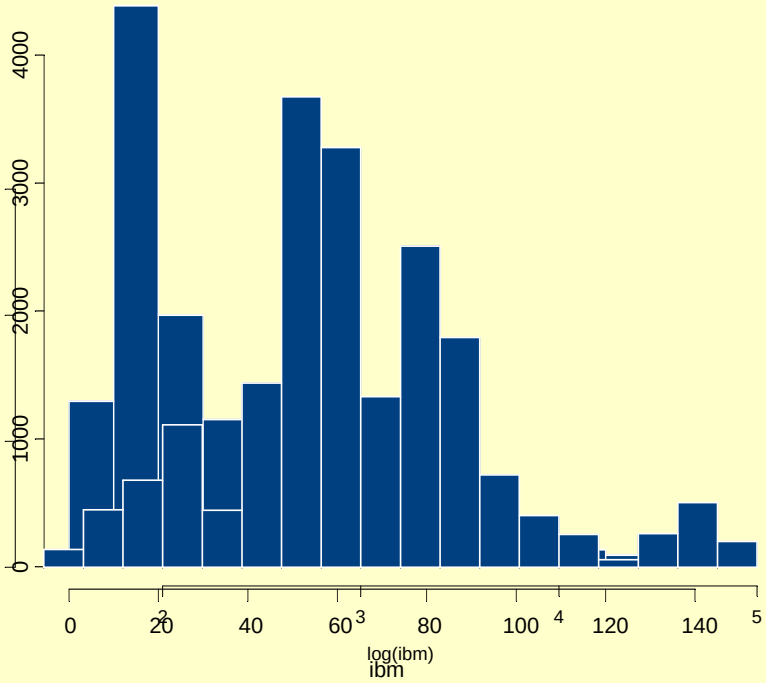
Forecasts vary in horizon, from a few seconds up to a few days in financial markets, compared to from one to several months for macro variables. We have to provide uncertainty intervals around the central forecasts to indicate the extent to which we are unclear about the future. The ARCH models are concerned with variations in the confidence intervals at different horizons while my methods are concerned with coordination of forecasts for several variables. The advantage that I have is that it may take a year or more to show that my forecasts were wrong, whereas Rob's could be found incorrect in about a day! ---banquet speech

Rob Engle (UC San Diego/NYU)

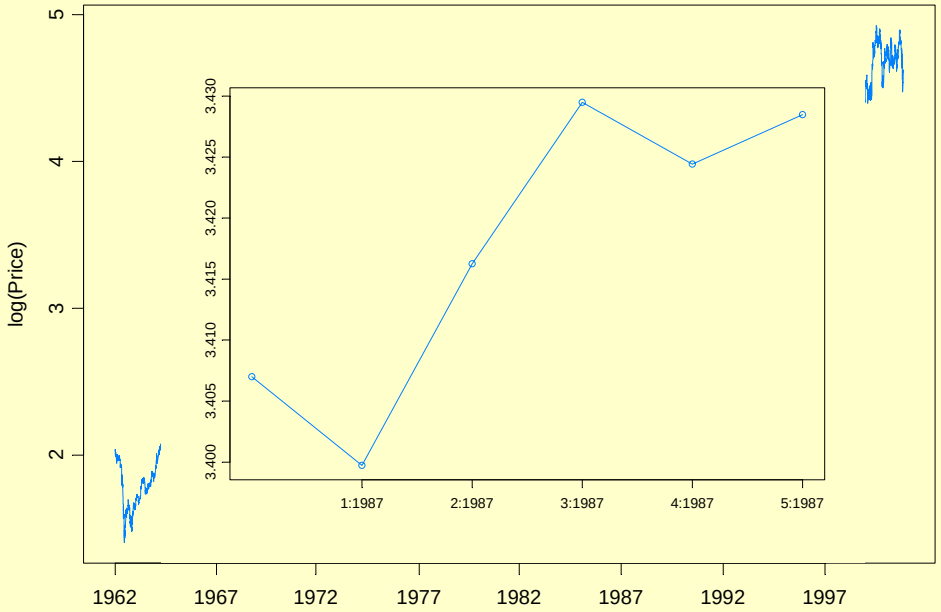
- modeling volatility
- high frequency (tick) data



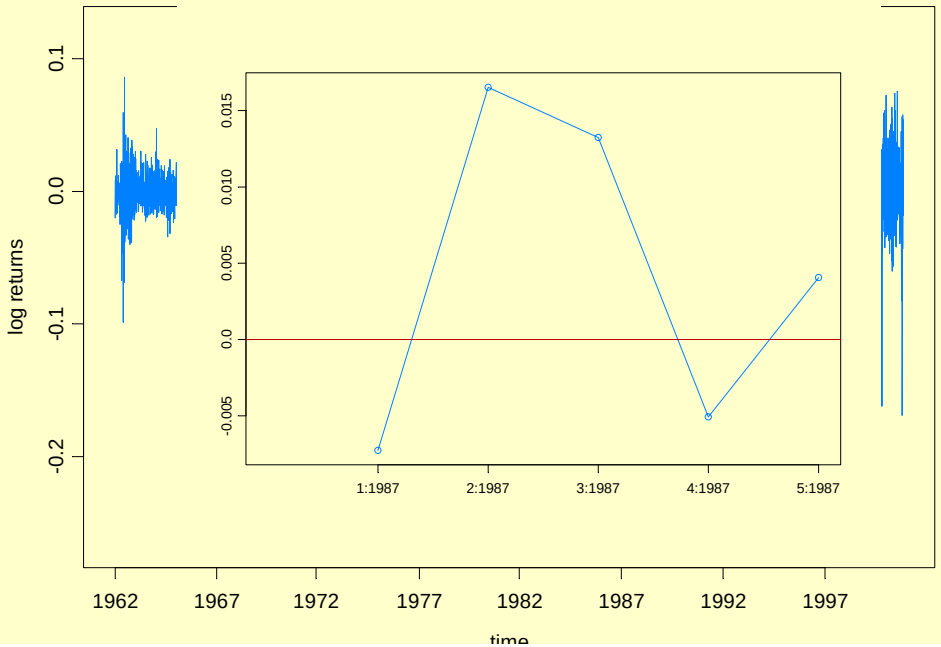


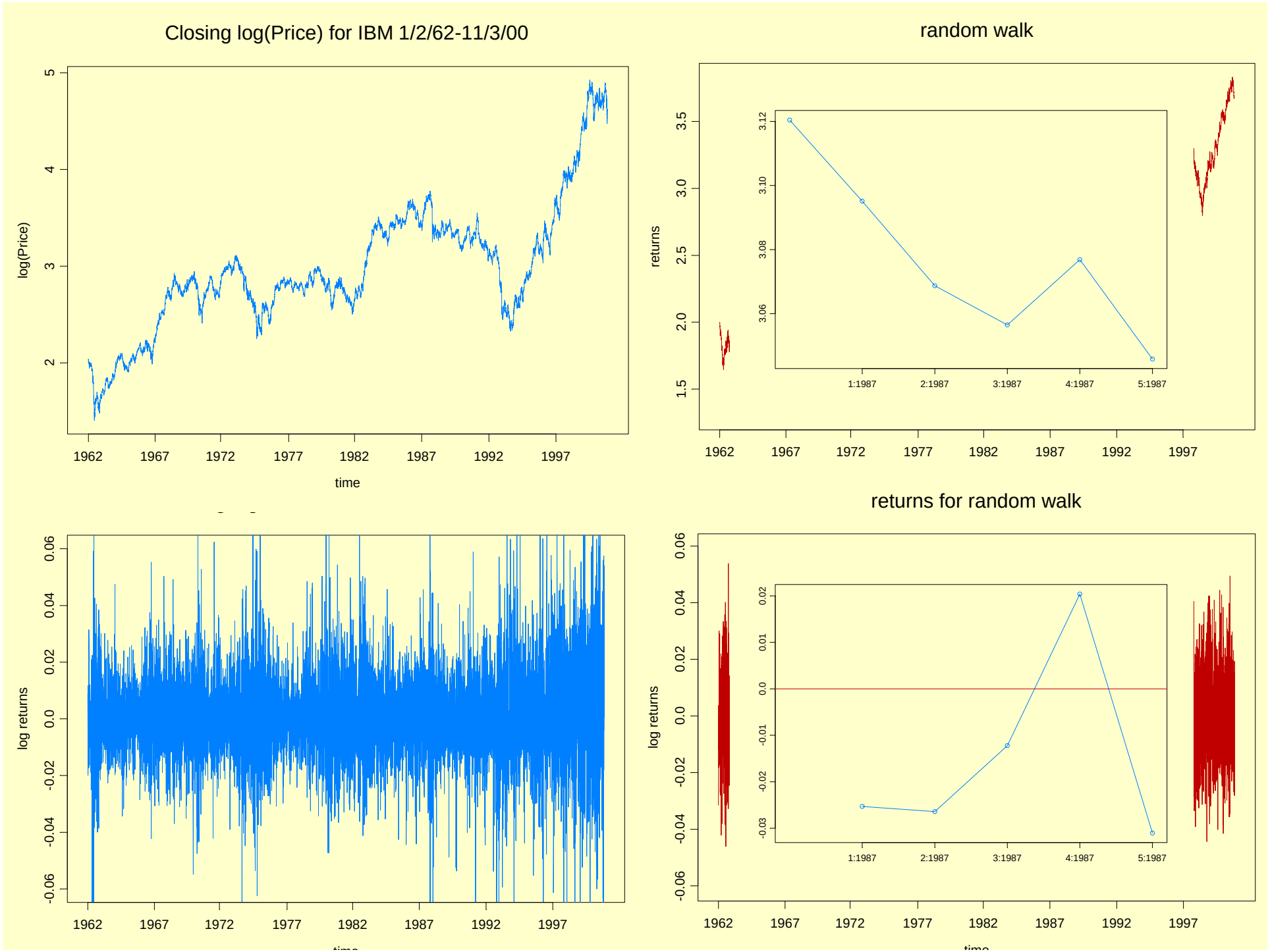


Closing log(Price) for IBM 1/2/62-11/3/00

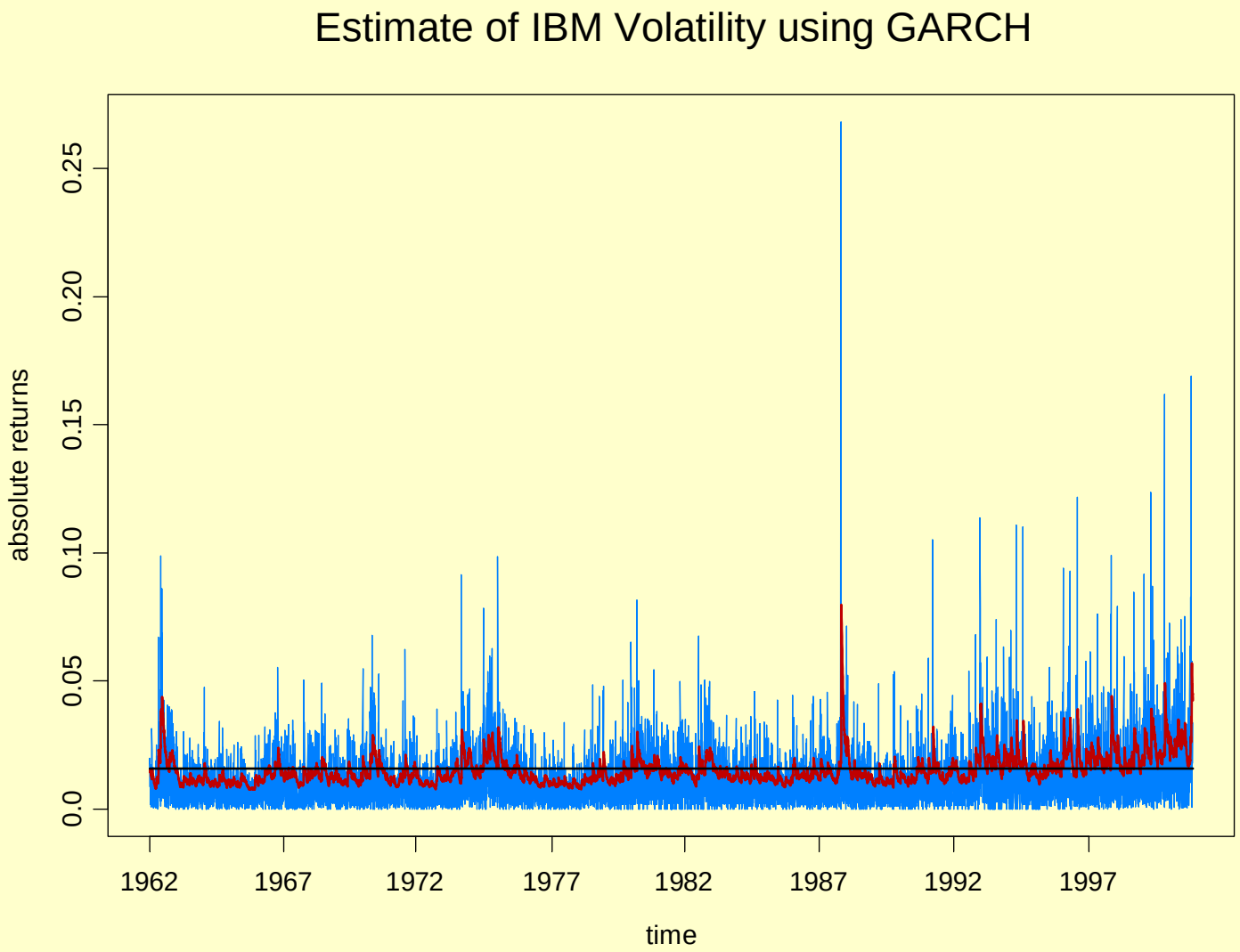


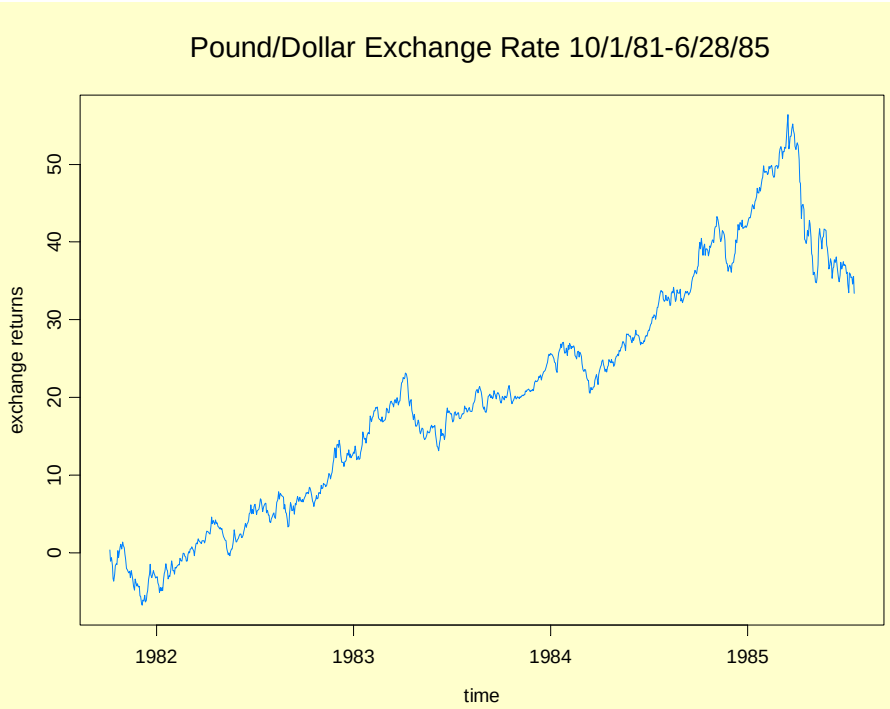
Closing log returns for IBM 1/2/62-11/3/00

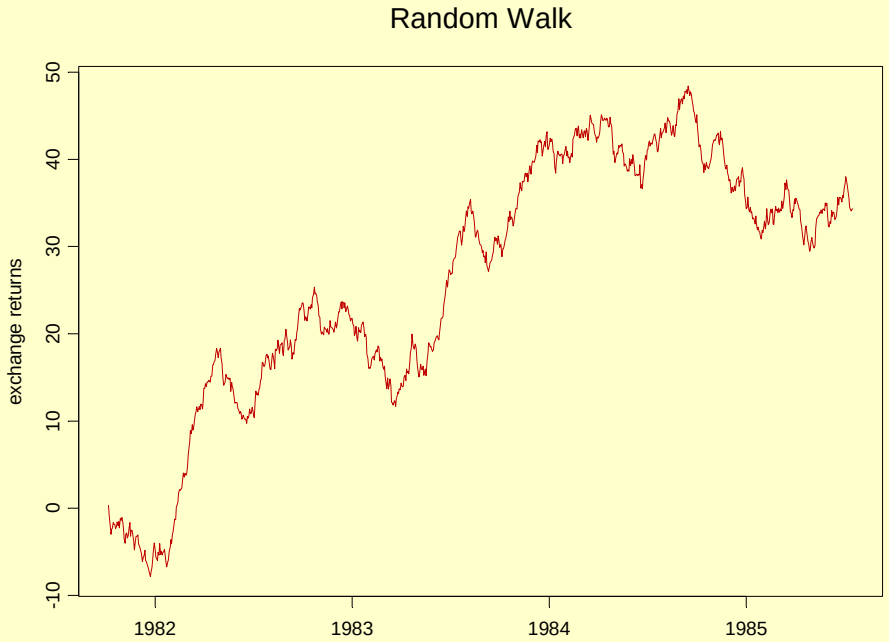


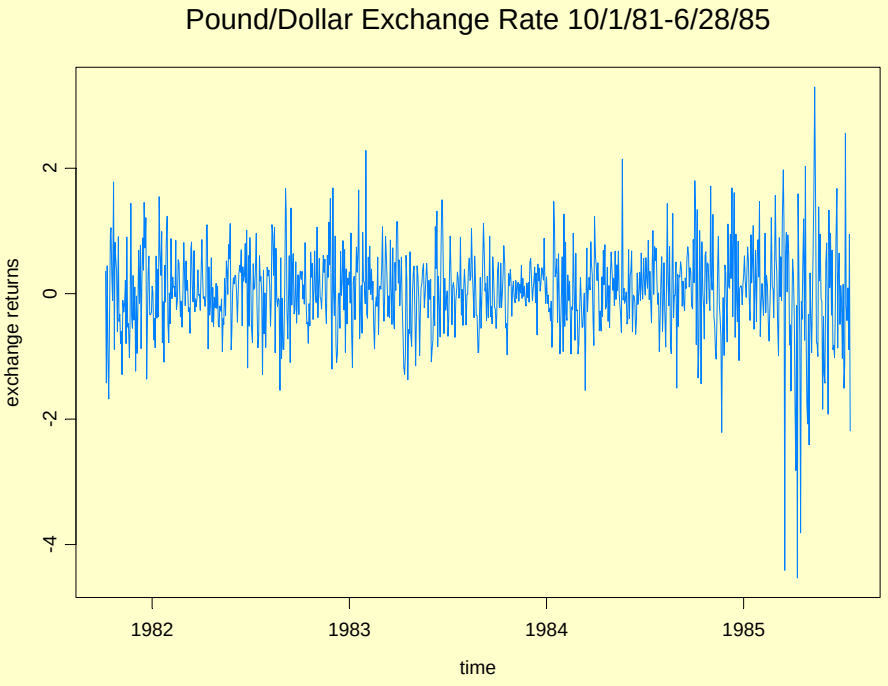

Closing log(Price) for IBM 1/2/62-11/3/00
log(Price)
time
random walk
returns
1:1987
2:1987
3:1987
4:1987
5:1987
log returns
returns for random walk

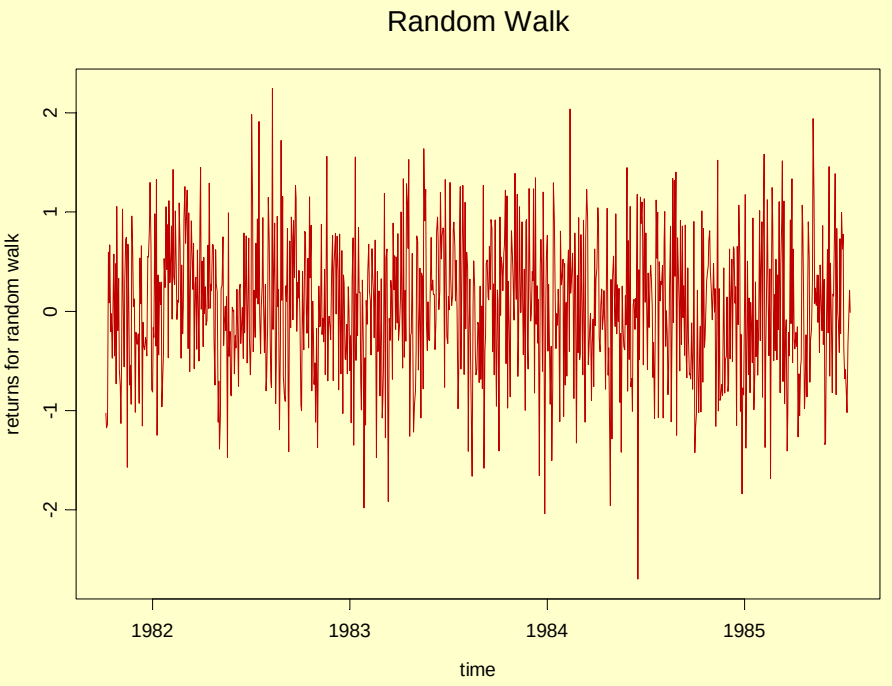
Impact on GARCH modeling



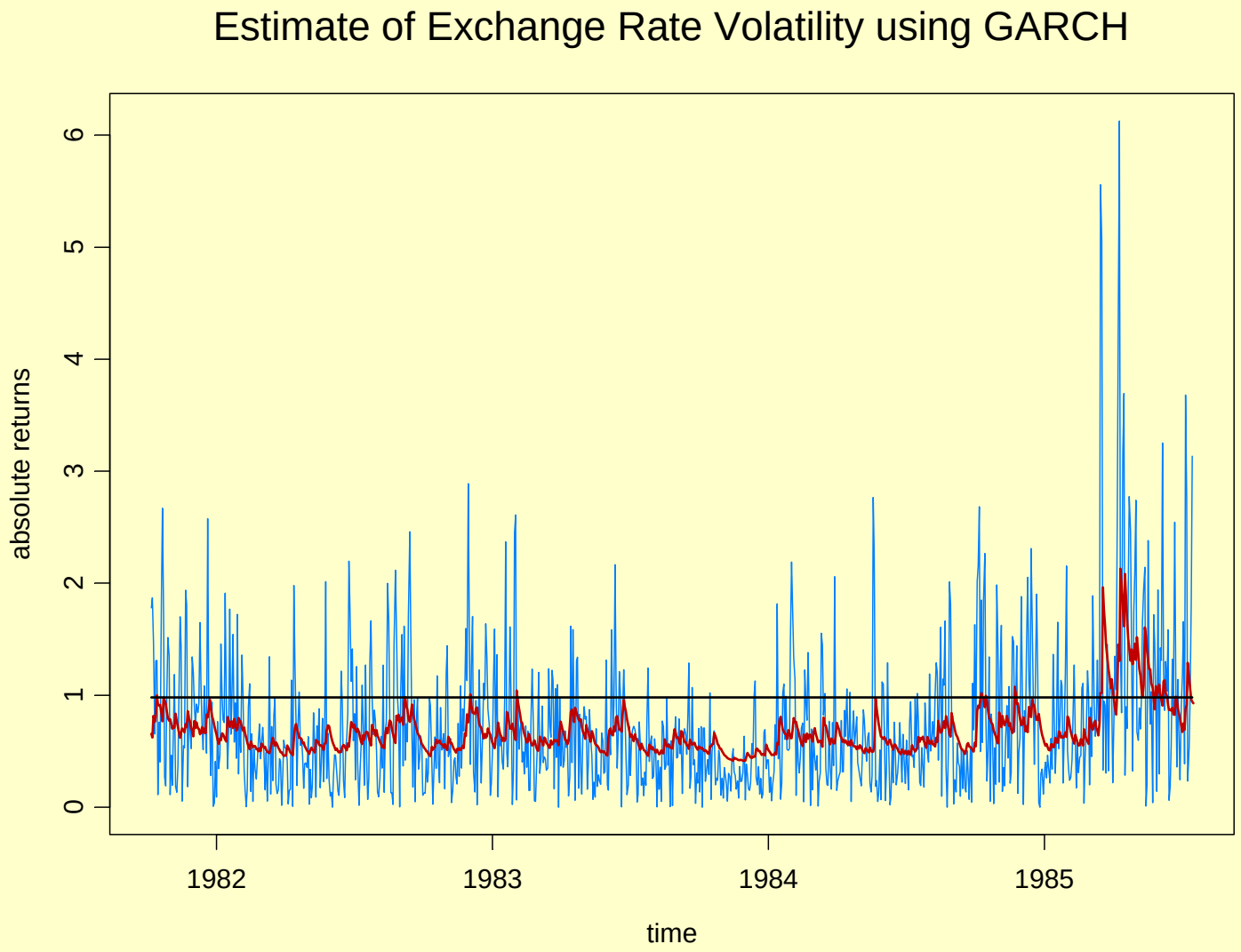

Pound/Dollar Exchange Rate 10/1/81-6/28/85
exchange returns
0
10
20
30
40
50
1982
1983
1984
1985
time


Random Walk
exchange returns
-10
0
10
20
30
40
50
1982
1983
1984
1985


Pound/Dollar Exchange Rate 10/1/81-6/28/85
exchange returns
-4
-2
0
2
1982
1983
1984
1985
time


Random Walk
returns for random walk
-2
-1
0
1
2
1982
1983
1984
1985
time

Impact on GARCH modeling



Application to Ecology

Example: NEE=Net Ecosystem Exchange in Harvard Forest

- About half of the CO_2 emitted by humans accumulates in the atomosphere
- Other half is absorbed by "sink" processes on land and in the oceans

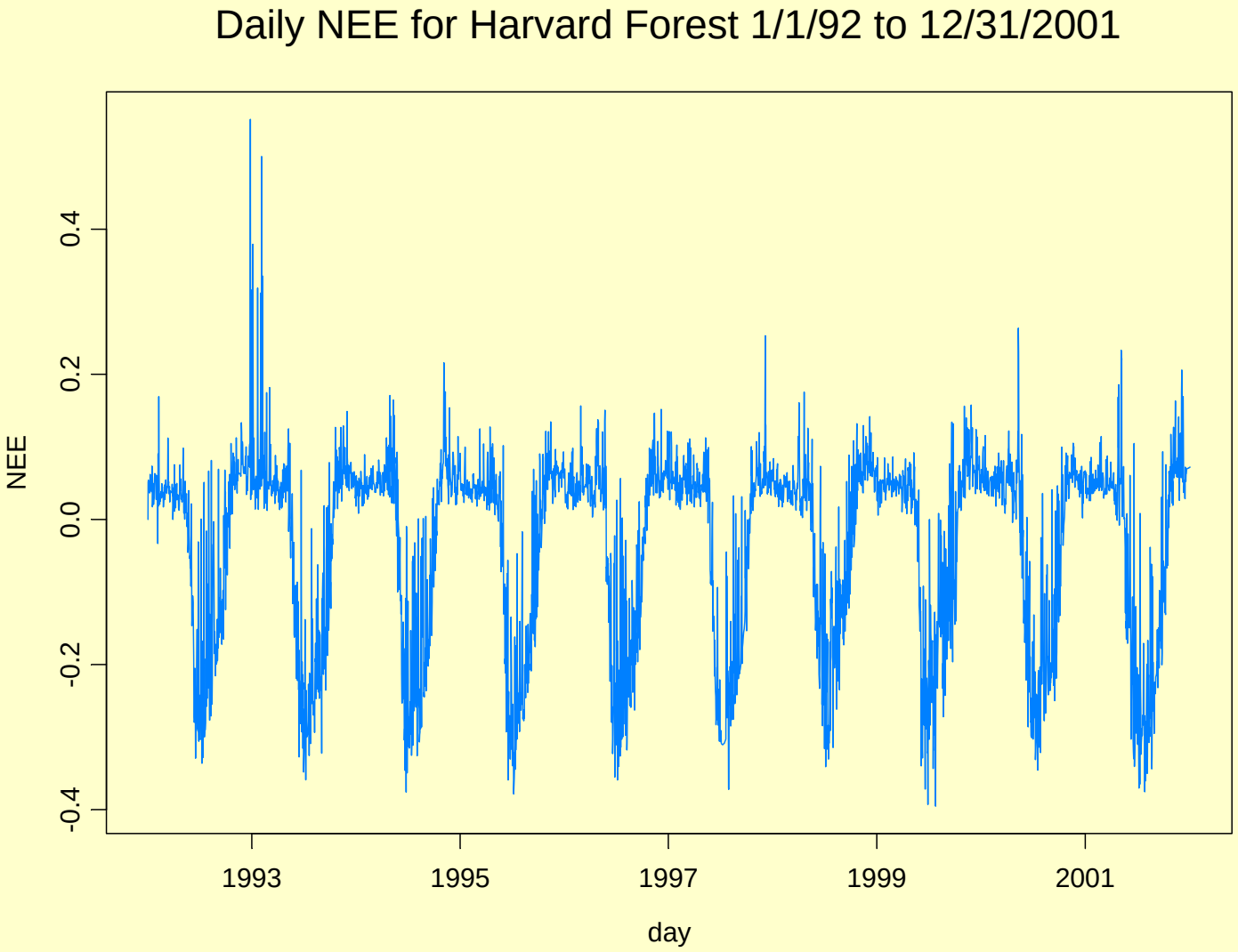
NEE= (Rh + Ra) – GPP (carbon flux)

GPP = Gross Primary Production (photosynthesis)

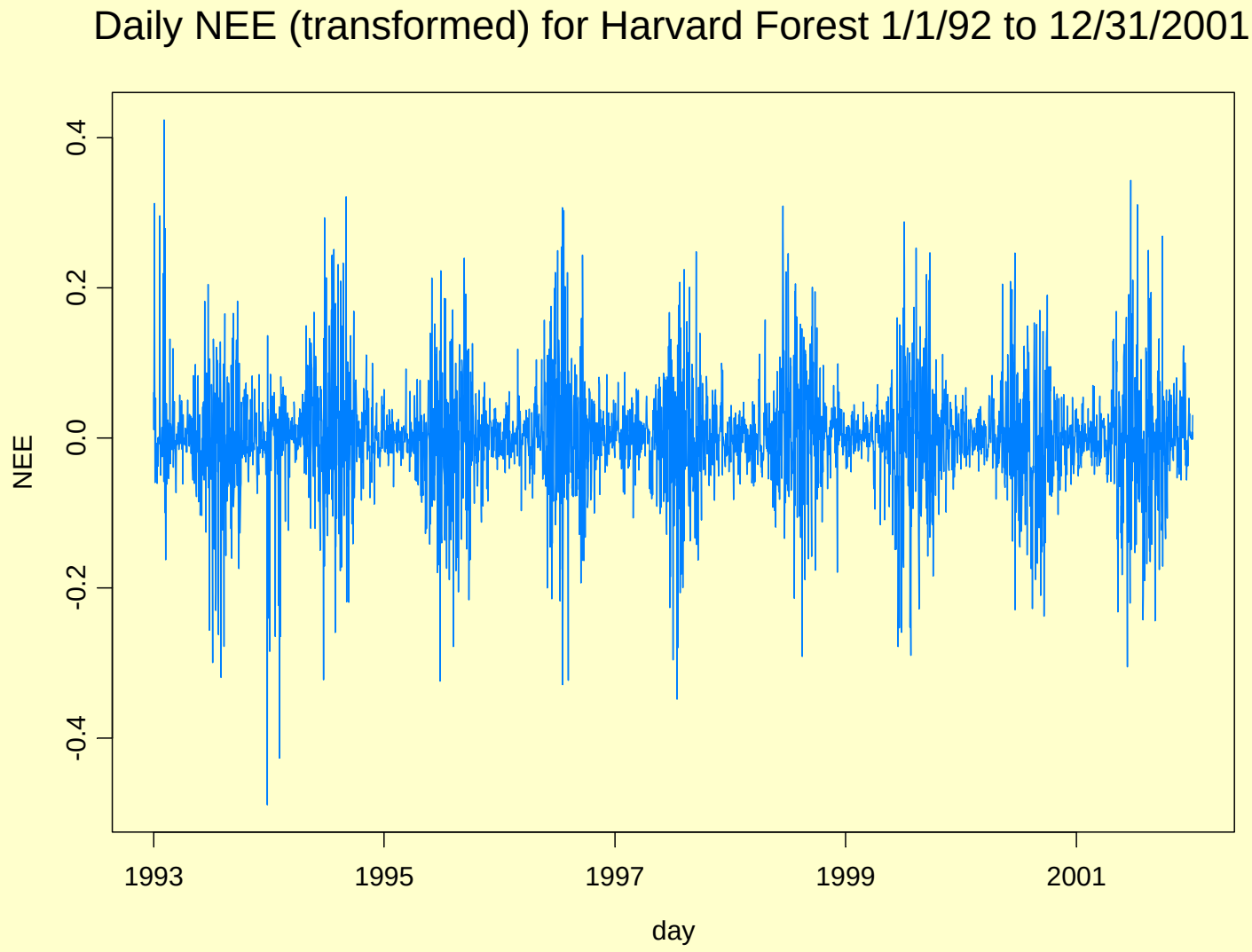
Rh = Heterotrophic (microbial) respiration

Ra = autotrophic (plant) respiration.

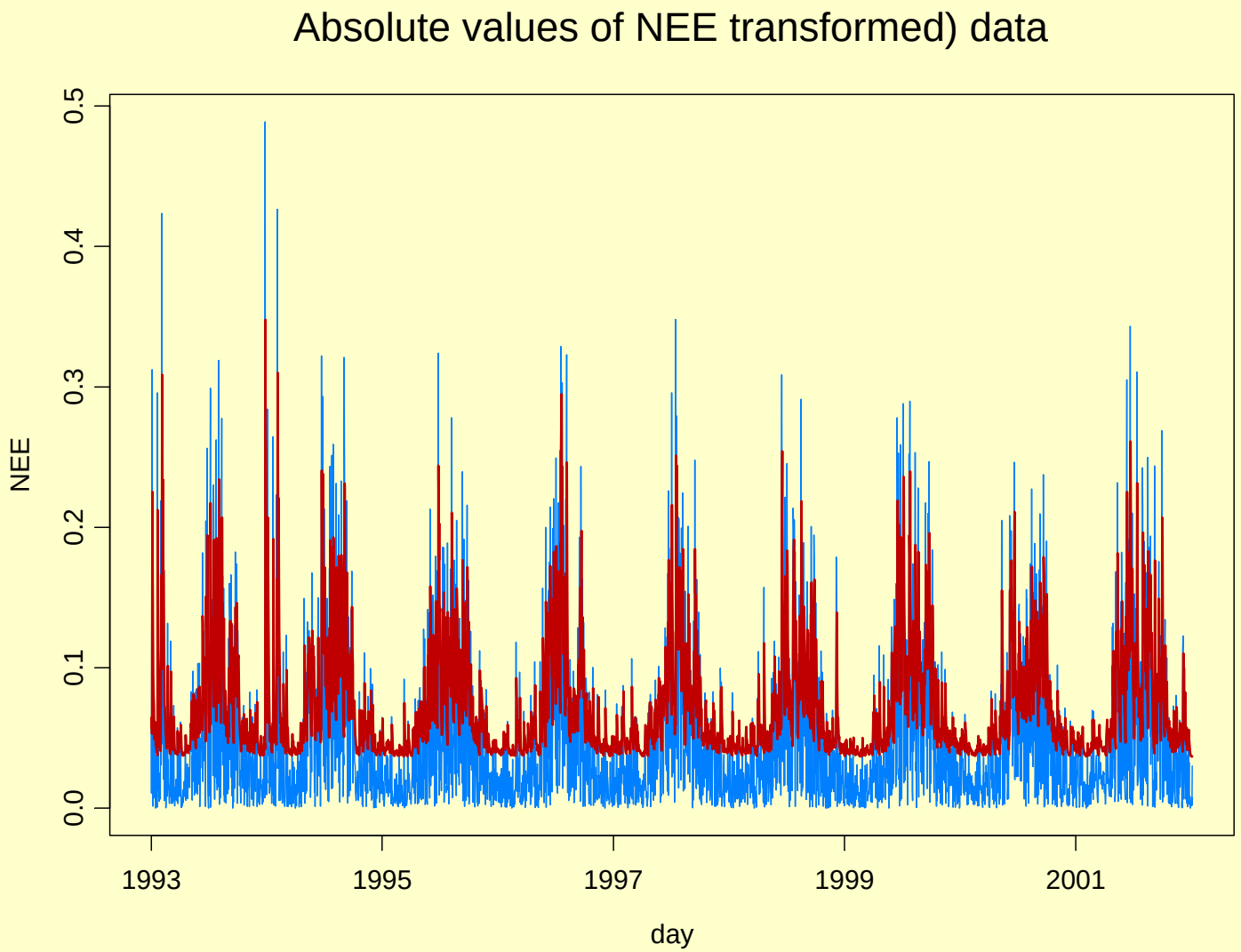
The NEE data from the Harvard Forest consists of hourly measurements. We will aggregate over the day and consider daily data from Jan 1, 1992 to Dec 31, 2001.


Daily NEE for Harvard Forest 1/1/92 to 12/31/2001
NEE
0.4
0.2
0.0
-0.2
-0.4
1993
1995
1997
1999
2001
day

NEE data after transformation-remove seasonality, etc



Estimating SV using GARCH(1,1) model.



Lessons learned.

- look for volatility in data
- there now exist tools and techniques that are helpful for detecting and modeling volatility
- volatility may be present in many ecological and environmental data sets.
  - modeling paths of hurricanes near Hawaii
  - wind speed data
  - pricing weather derivatives