Columbia Business School

Regime Changes and Financial Markets

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Columbia University and NBER

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Professor Ang is a financial economist whose work centers on understanding the nature of risk and return in asset prices. His work spans municipal and government bond markets, equities, investment management and portfolio allocation, and alternative investments. Professor Ang is a Research Associate of the National Bureau of Research and serves as an associate editor for several leading journals. He currently serves as advisor to Martingale Asset Management and the Norwegian sovereign wealth fund. In March 2013, he was named as one of the top 10 influential academics in the institutional investing world by aiCIO.

The paper can be downloaded from http://www.columbia.edu/~aa610

Outline

- Why regime switching?
- Structure of a regime-switching model
- Applications
- Non-recurring regimes
- Conclusions

Why Regime Switching?

- Natural and intuitive
  - First application in Hamilton (1989) was to boom-bust business cycles
- Different, recurring periods in regulation, policy and other secular changes
  - Fixed income: monetary policy regimes
  - Equities: high/low volatility and bull/bear market periods
  - Foreign exchange: risk on/risk off
- Capture fat tails, time-varying volatility (GARCH effects), higher moments, even jumps
- Non-linearities can be captured tractably by models that are *linear within a regime*

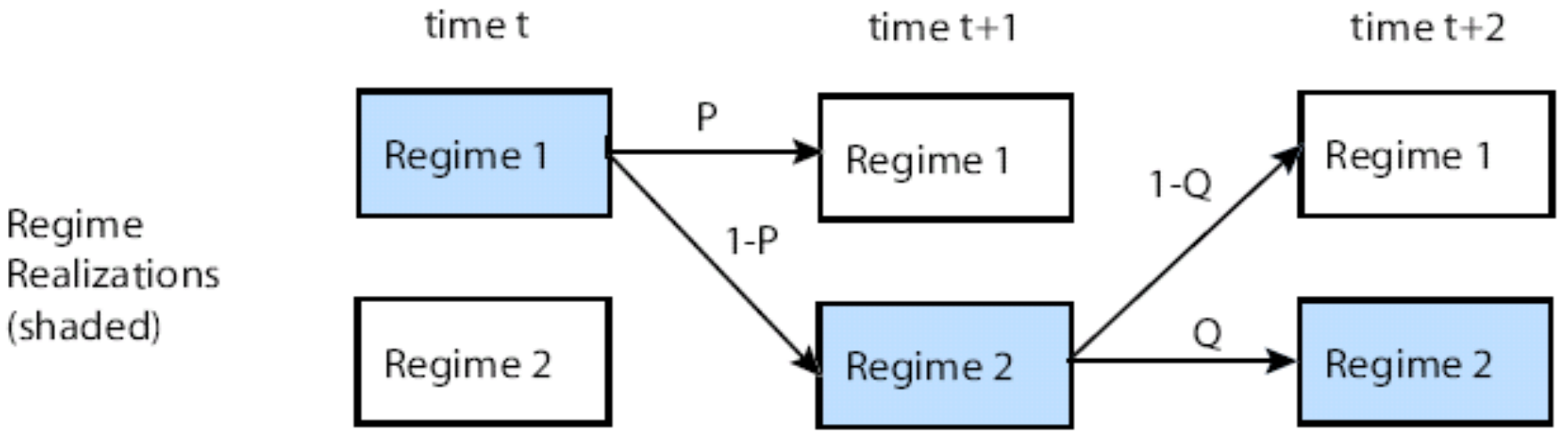
Regime-Switching Models

Ingredients

- Regimes
  - Specify how regimes change over time. Regimes can be persistent and regime probabilities may be predictable.
  - Regimes are identified econometrically, but can be “assigned”
- Different data generating processes within each regime
- Estimation is via a “Bayesian updating” procedure.
  - Intuitively infer the probability of being in a regime given all available information up to the current time.
  - Estimating highly non-linear models can be non-trivial!

Regime-Switching Models

- Regimes
  - Two or more regimes which change over time



  - A transition probability matrix captures the persistence of regimes

Regime-Switching Models

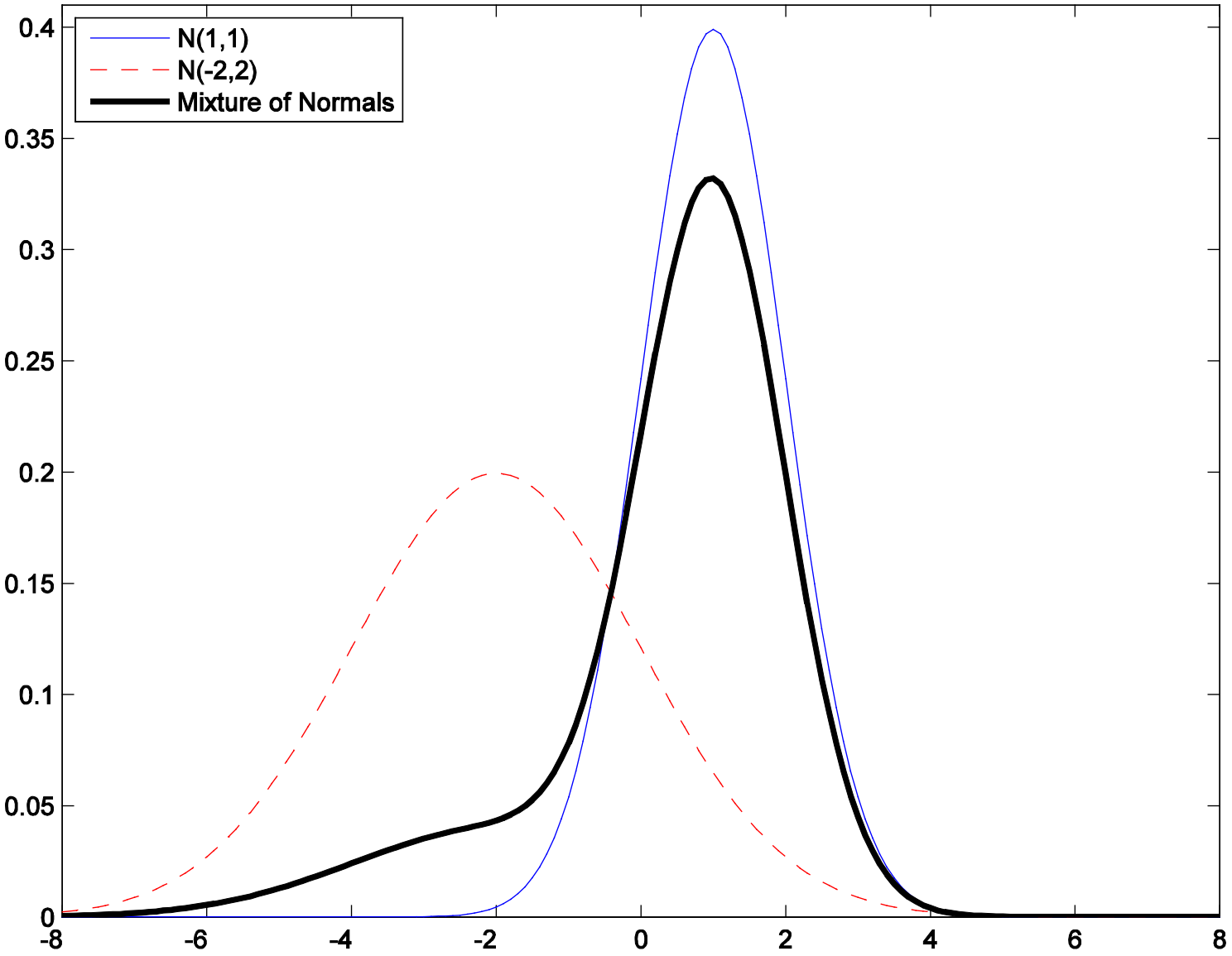
- Specifying bull, bear and negative jump regimes could take the form:

This Regime \ Next Regime	Bull	Bear	Jump
Bull	0.85	0.10	0.05
Bear	0.20	0.75	0.05
Jump	0	1	0

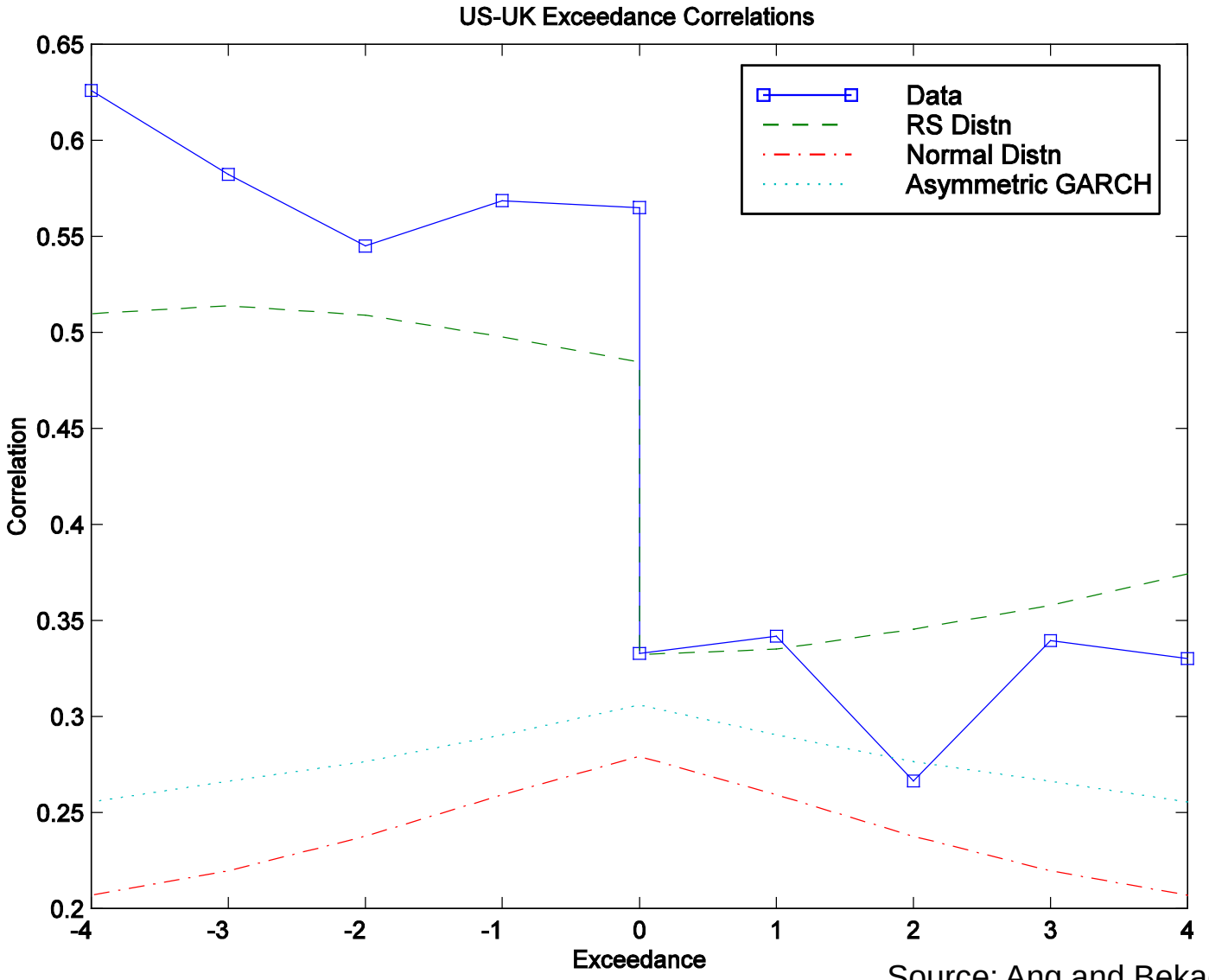
After a down jump, transition always to a bear regime

- Thus, regime-switching models nest “rare events” and “disasters” as special cases

Statistical Properties: Fat Tails



Examples: Asymmetric Correlations



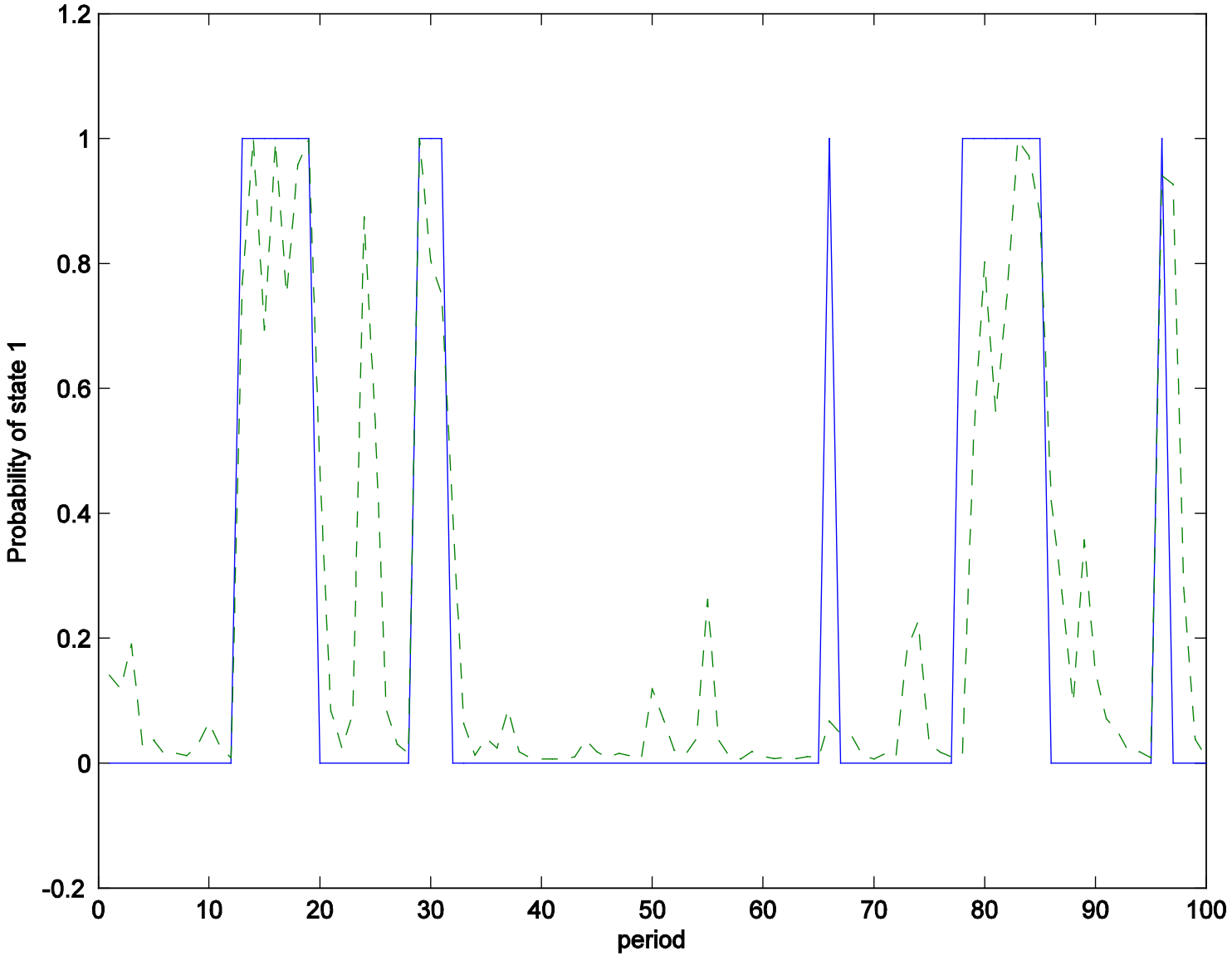
Source: Ang and Bekaert (2002)

Asset Pricing with Regimes

Introducing regimes in fundamentals can produce

- Time-varying expected returns
- Time-varying volatility
- Time-varying skewness and other higher moments
- The risk-return trade-off can be inverted

Learning About Regimes



Equity Returns

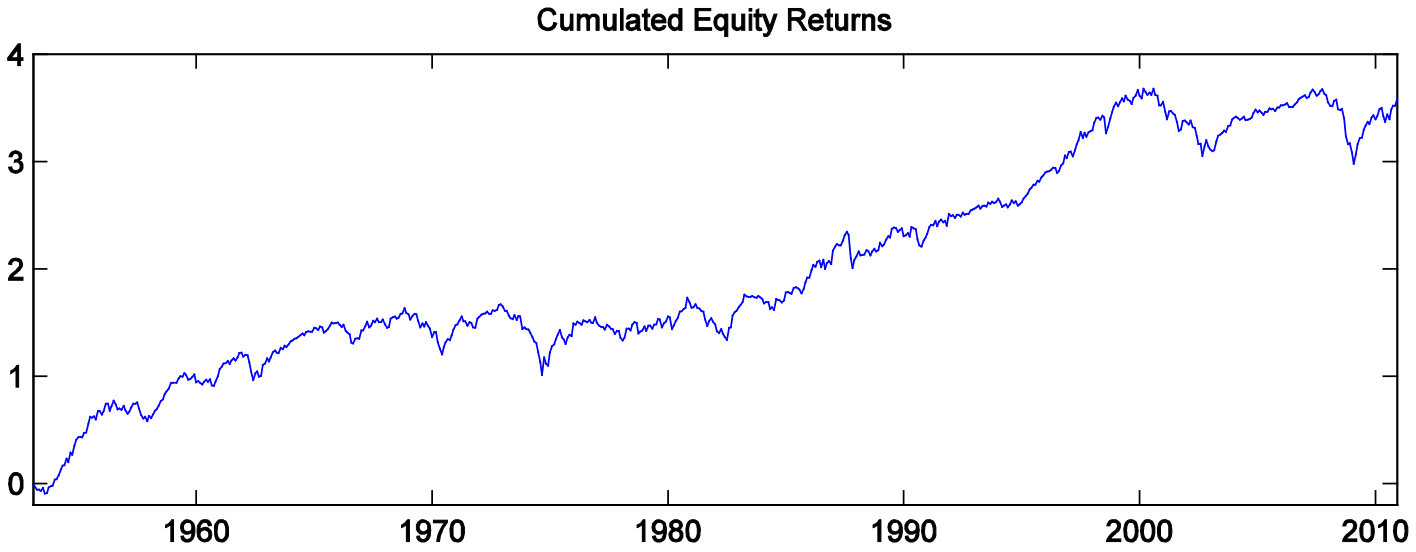
$$r_t = \mu_i + \phi_i r_{t-1} + \sigma_i \varepsilon_{t+1}$$

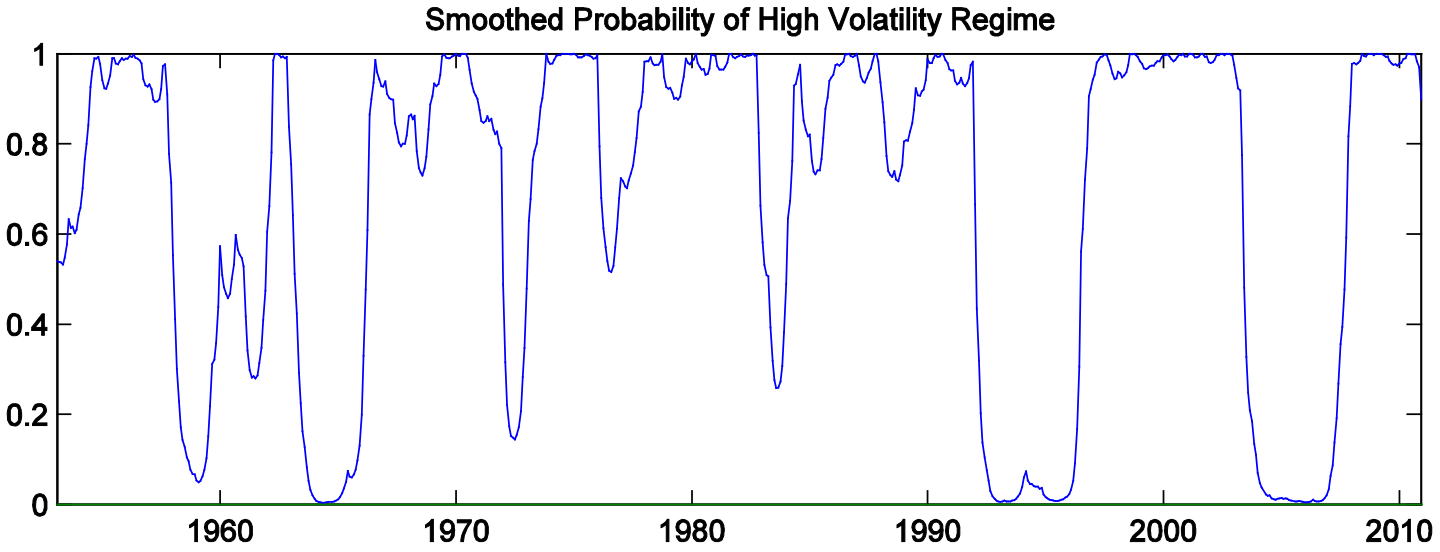
$s_t = i$ has transition matrix $\begin{pmatrix} P & 1-P \\ 1-Q & Q \end{pmatrix}$

Sample: 1953:01 to 2010:12

	Equity returns	
	Estimate	Std. error
μ_0	0.3326	0.2354
μ_1	0.8994	0.2614
ϕ_0	0.0633	0.0460
ϕ_1	−0.0426	0.0928
σ_0	4.8867	0.3448
σ_1	2.4462	0.4637
P	0.9770	0.0196
Q	0.9512	0.0206
	p-value	
Test $\mu_0 = \mu_1$	0.1057	
Test $\phi_0 = \phi_1$	0.0406	
Test $\sigma_0 = \sigma_1$	0.0160	

Equity Returns

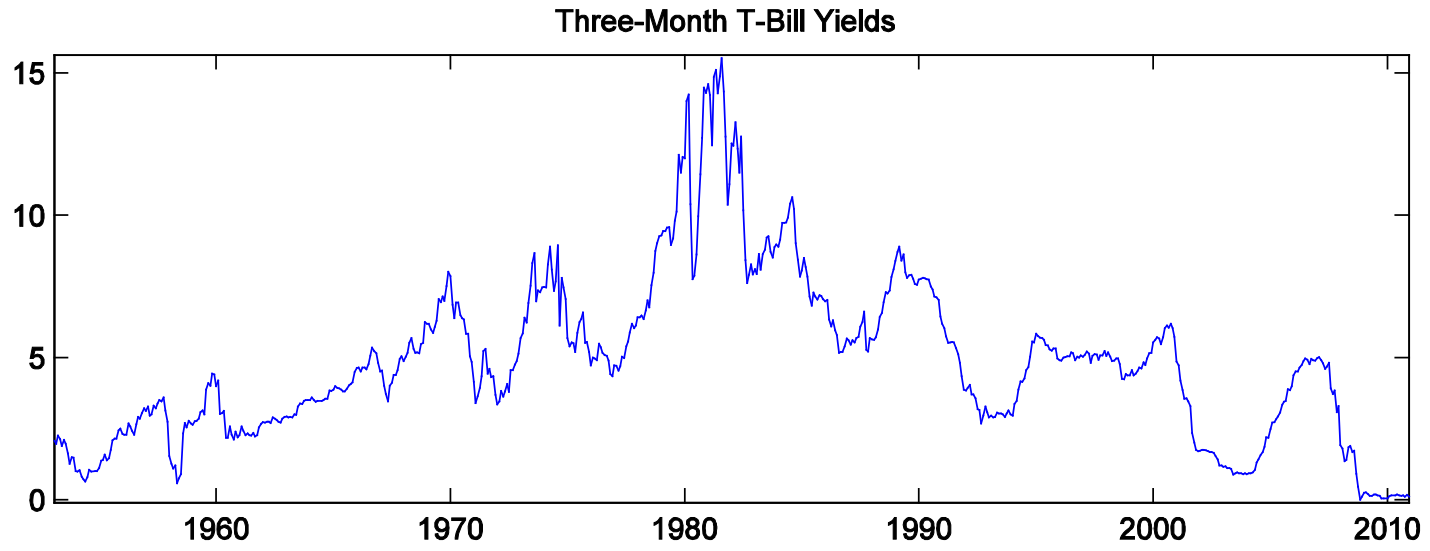


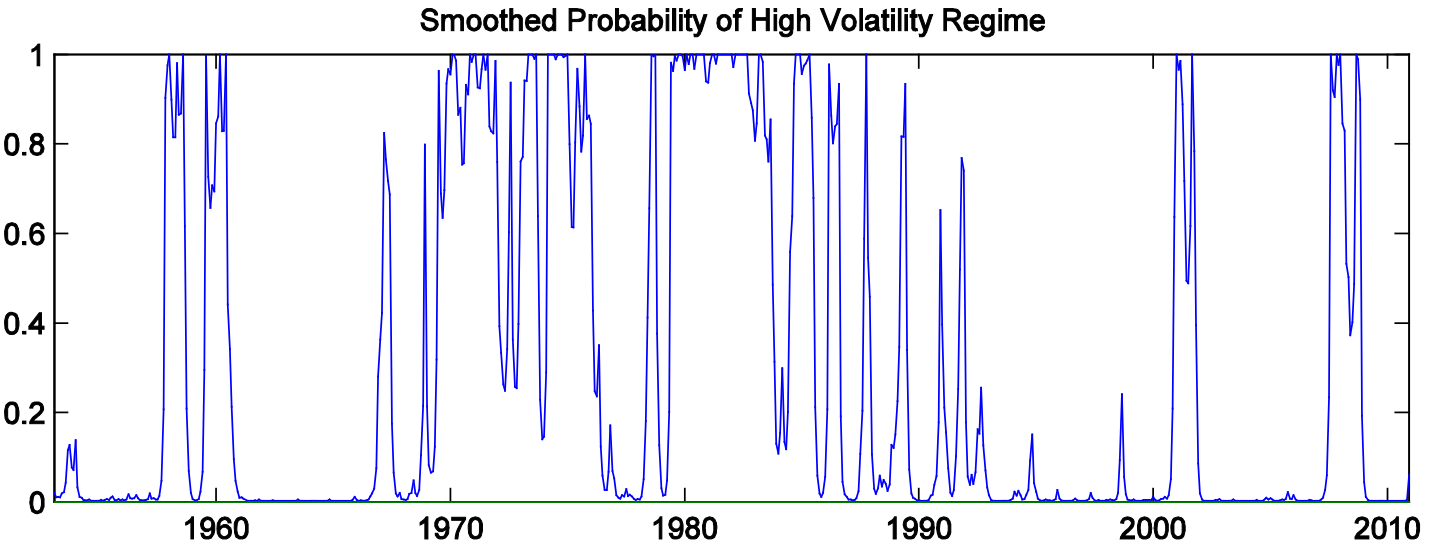


Equity Returns

- Predictability of equity returns changes over time, is subject to breaks and parameter instability. Predictability is weak during business cycle expansions, but strongest during recessions.
- Time-varying second moments are well captured by regime-switching models
- Value-growth, size, and momentum premiums (and other cross-sections of portfolios) also exhibit regime-switching behavior

Interest Rates

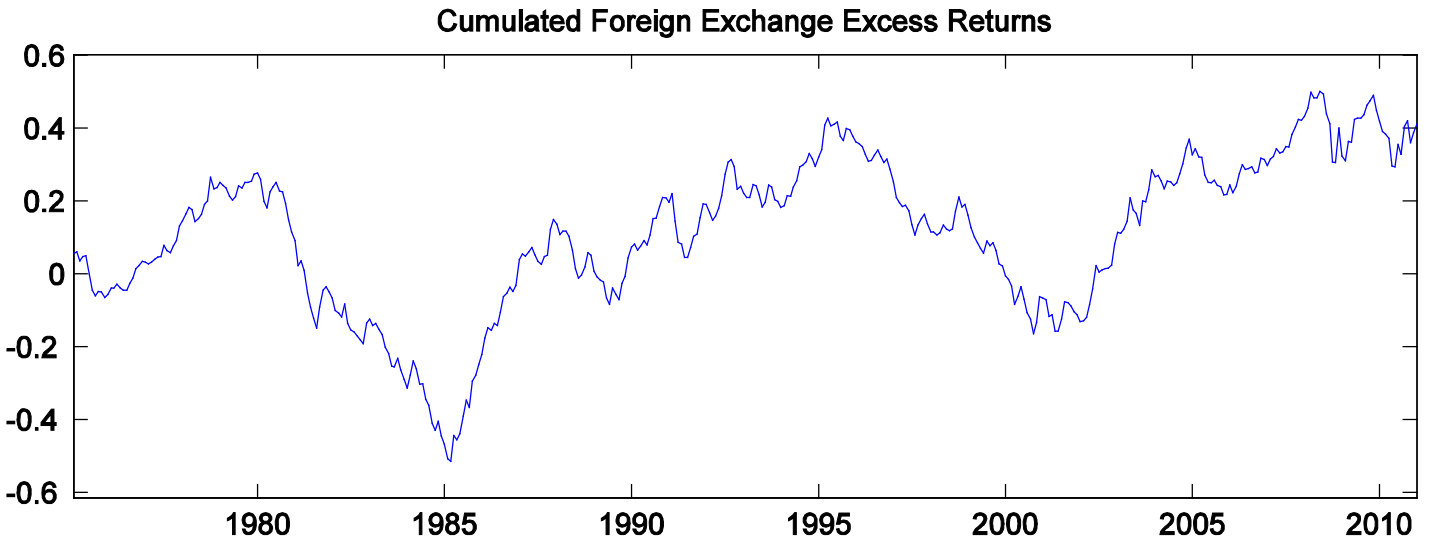


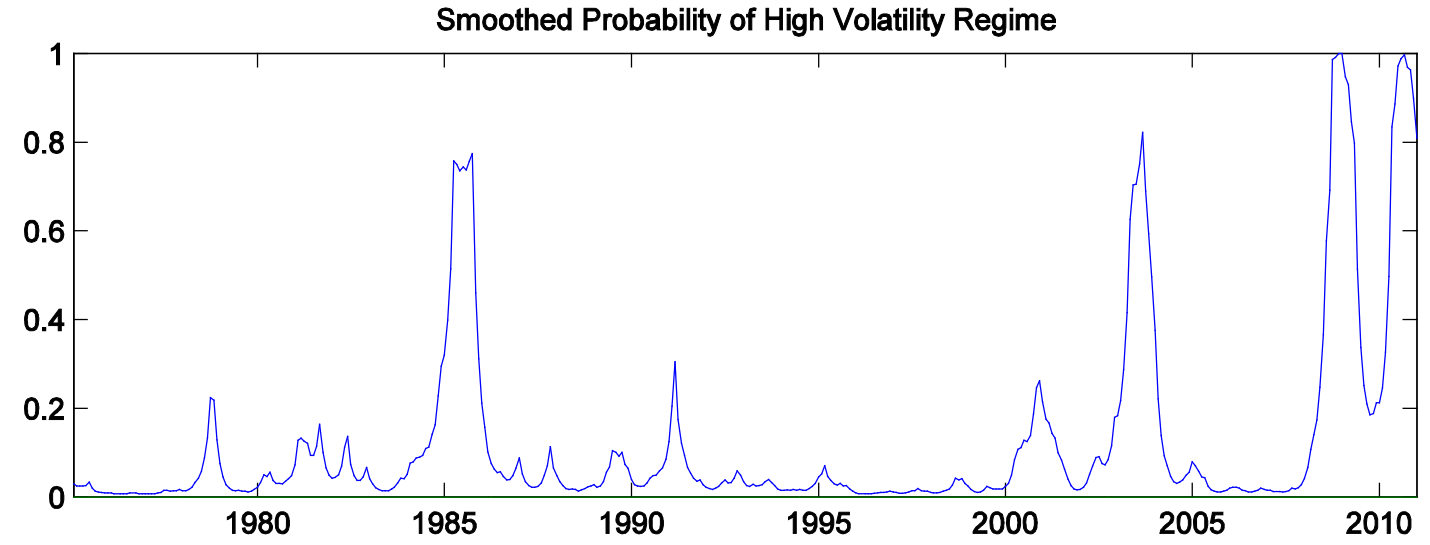


Interest Rates

- Real rates and inflation also exhibit regime changes
- Monetary policy regimes are very important
- *Term structure models* with regime-switching are tractable because they specify yields to be affine (constant + linear) within regimes, but mixing across regimes produces non-linear, dynamic behavior

USD-EUR/DEM Returns

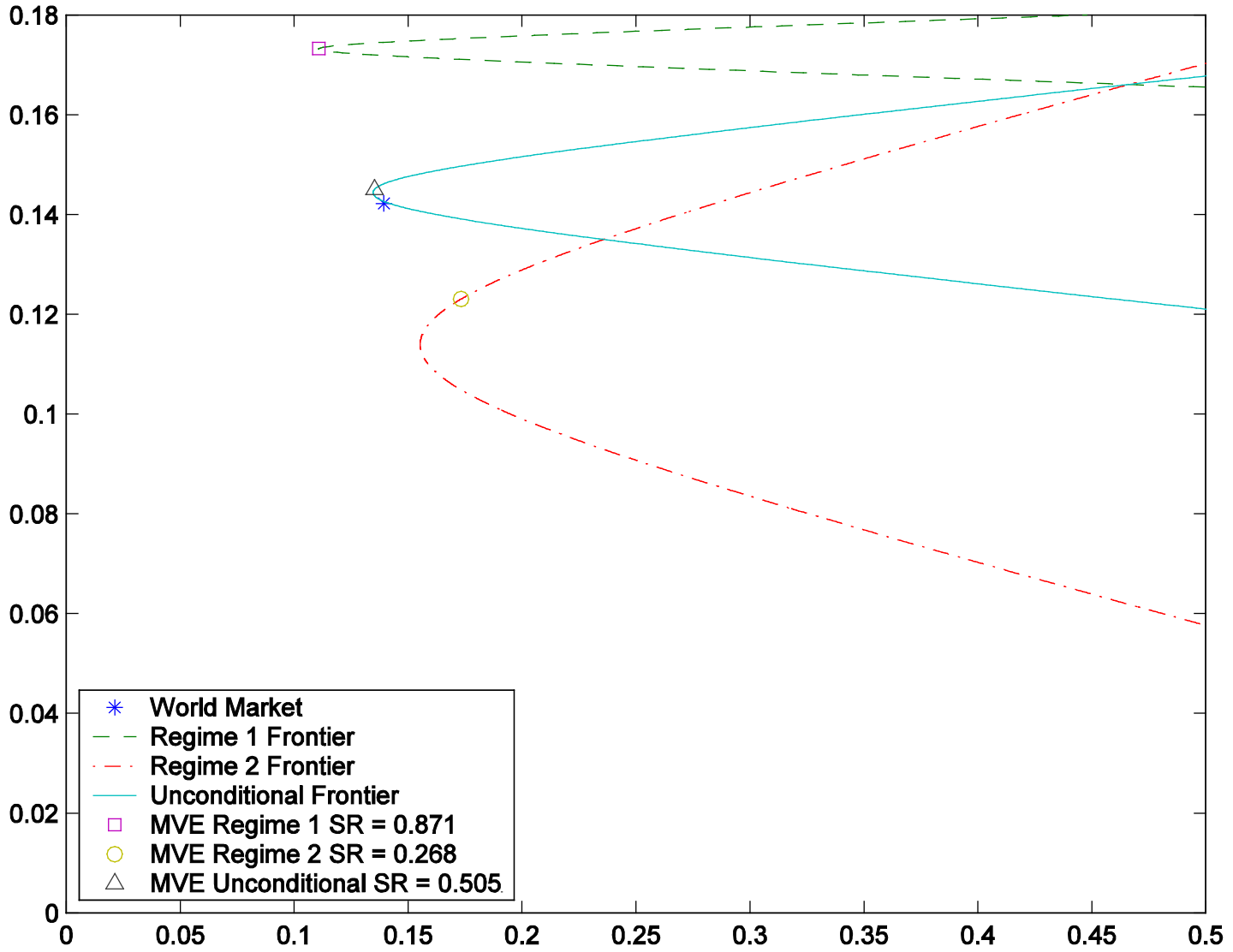




Foreign Exchange Returns

- Regime-switching models capture well risk on/risk off behavior in carry portfolios
- “Going up by the stairs and coming down by the elevator” represent two separate, but recurring, regimes

Asset Allocation



Asset Allocation

- Extensions to “non-linear” preferences that take into account skew and kurtosis preferences. Note that regime-switching models endogenously generate higher moments.
- Updating or learning about regimes have a large effect on optimal allocation decisions

Non-Recurring Regimes

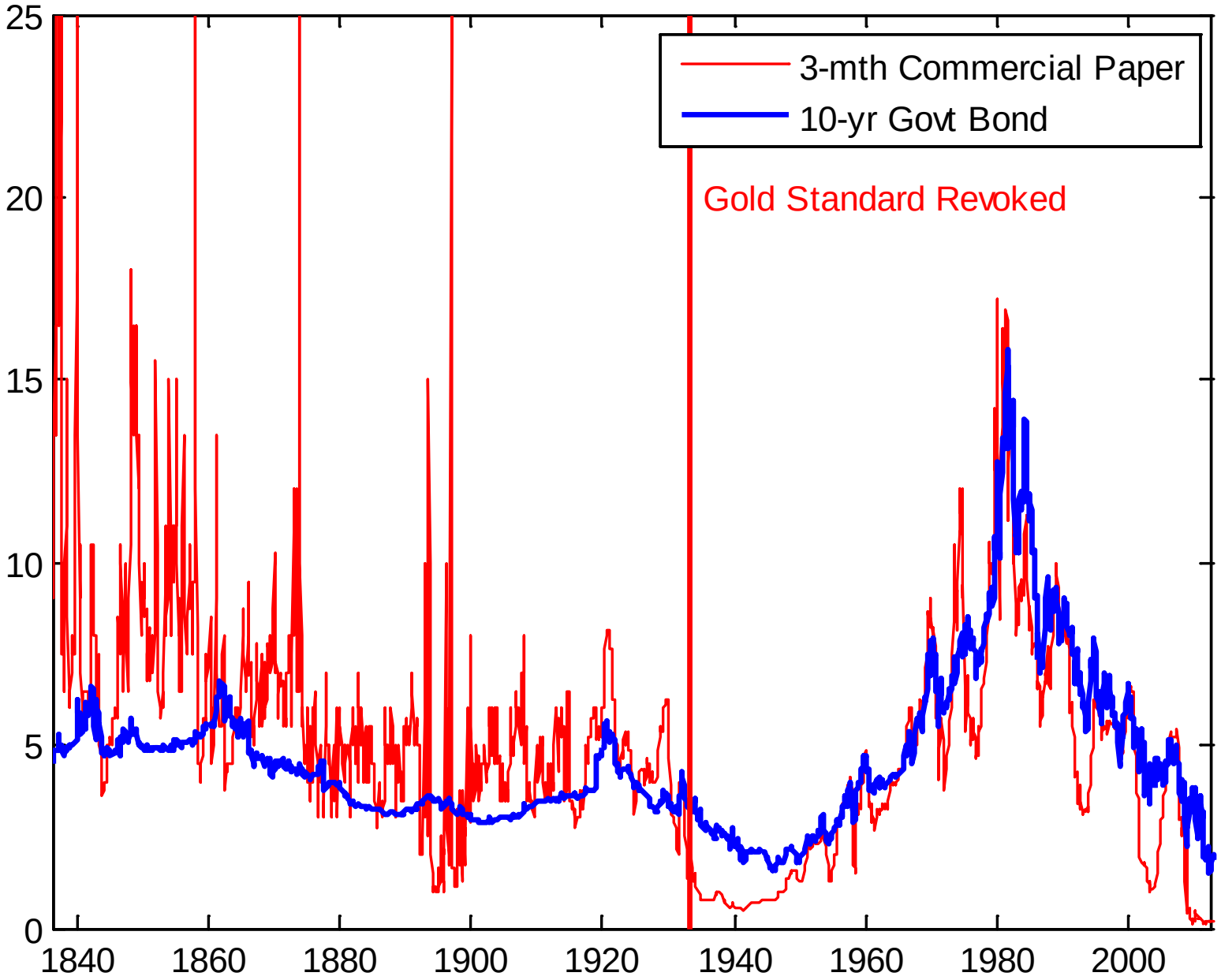
- Regime switching models assume that history will reoccur, usually over low frequencies. What if this time is truly different? Then past regimes give no guidance for future regimes and no past data is useful for the new regime.
- Example:

  Spreads between 3-mth commercial paper and 10-yr government bond yields:

  Full Sample: Dec 1835 to Feb 2013

Pre-Mar 1933	-1.85%
Post-Mar 1933	0.94%

- In the years before 1933, hedge funds would have shorted Treasuries and gone long commercial paper!


25
20
15
10
5
0
1840
1860
1880
1900
1920
1940
1960
1980
2000
3-mth Commercial Paper
10-yr Govt Bond
Gold Standard Revoked

Non-Recurring Regimes

- Executive Order 6073 issued by Roosevelt in 1933 confiscated all privately owned gold in the United States and in compensation owners received paper money. Gold owners received losses of approximately 40%.
- 1934 Gold Reserve Act devalued the USD from $20.67 per troy ounce of gold to $35
- New (perhaps not fully unexpected) approach to banking, monetary policy, and finance. What does past data tell about the new post-1933 regime?

- Before 1987 there was only a small (or no) volatility smile and it was symmetric. Post-1987 it became a volatility smirk.

Non-Recurring Regimes

- Non-recurring regimes can be captured by an expanding set of regimes over time, so that previous regimes are not revisited again
- Transition matrix takes the form:

$$\Pi = \begin{pmatrix} p_{11} & 1-p_{11} & 0 & 0 \\ 0 & p_{22} & 1-p_{22} & \cdots \\ \vdots & \vdots & \vdots & \vdots \\ 0 & \cdots & 0 & p_{kk} \end{pmatrix}$$

- Of course, we can model a combination of recurrent regimes and new regimes

Conclusion

- When history repeats itself, modeling the common components across different regimes is valuable
- Regime switching models capture common behavior across regimes by allowing the data generating process to change regimes periodically, but data are generated from the same regime when that same regime prevails
- Two-regime models identify “bull” regimes (with high means, low volatility, and low correlations) and “bear” regimes (with low means, high volatiltiy, and high correlations)
- Applications of regime switching models include asset pricing, asset allocation, risk modeling, and risk management