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Macroeconomic Patterns in System-Wide Liquidity Regimes

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OFR / FRB-Cleveland Conference:
Measurement Challenges in Macroprudential Policy Implementation
Washington, DC: 4 Dec 2014

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Liquidity Measurement

Why we care

- Liquidity is crucial to market functioning – "getting to cash" for contract settlement
- Illiquidity is a common feature of market stress
- Vast research literature

Why it's challenging

- Latent – illiquidity often unobserved until it's too late
- Nonlinear – small fluctuations may not be a good guide for large events
- Emergent – the whole is not the sum of the parts

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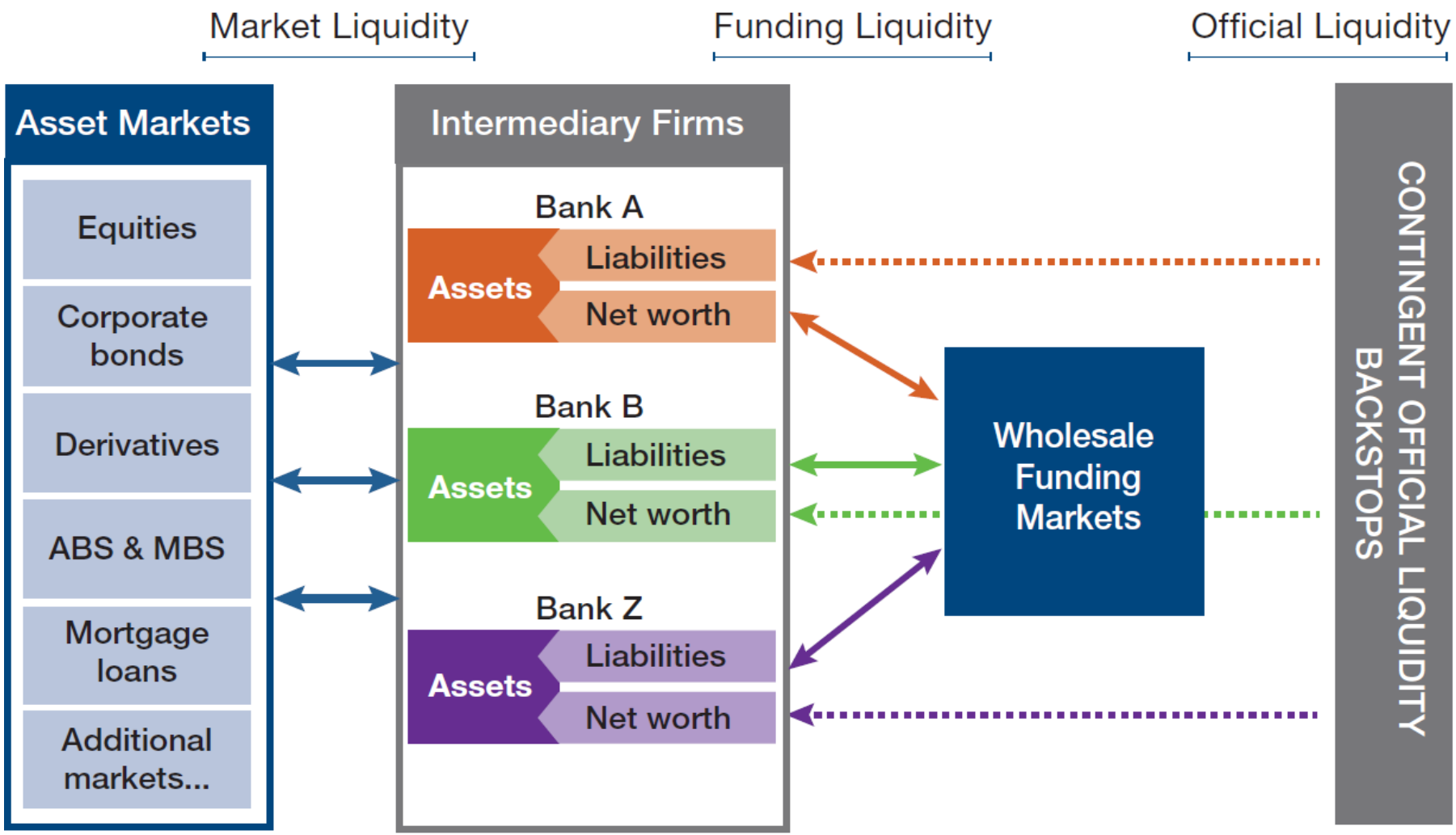
Market and Funding Liquidity



Source: OFR analysis

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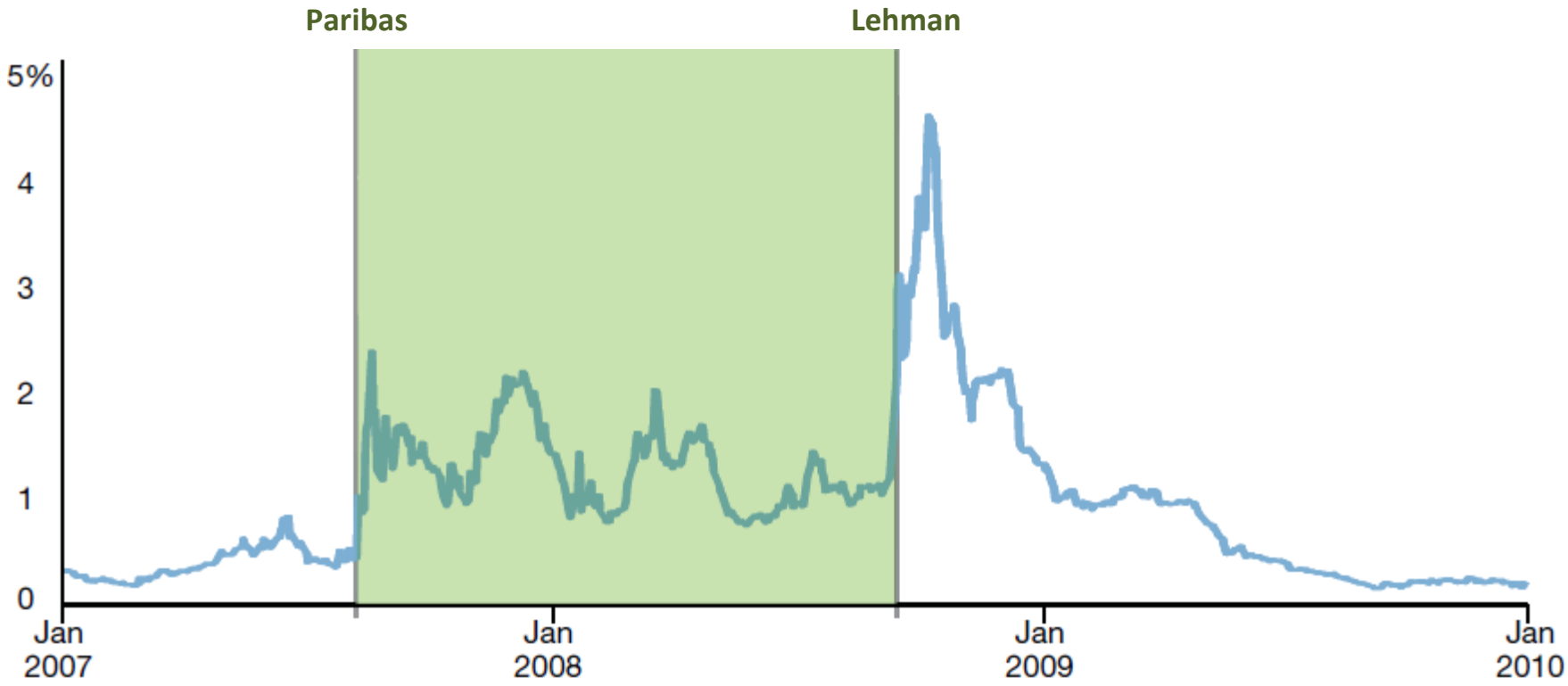
System-wide Liquidity Measurement

TED Spread

2007 – 2009



Source: Bloomberg

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Market Microstructure Invariance

- **Kyle and Obizhaeva (2014)**

  "Market Microstructure Invariants: Theory and Empirical Tests"
- **Daily measure**
- **Works for many markets ("invariant")**
- **The calibrated price-impact trading cost, C(X), in basis points:**

$$C(X) = \frac{\sigma}{0.02}\left[\frac{8.21}{10^4}\left(\frac{W}{(0.02)(40)(10^6)}\right)^{-1/3} + \frac{2.50}{10^4}\left(\frac{W}{(0.02)(40)(10^6)}\right)^{1/3}\frac{X}{(0.01)V}\right]$$

Where:

- σ = **expected volatility**
- **W = "trading activity" = price x volume x volatility**
- **X = order size**

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Interpreting Market Microstructure Invariance

- "Business time" in local markets is paced by "betting" activity – a Poisson process

Trading cost, *C*, as a response function to trading impulse, *X*

3/2 power to normalize to business time

Normalized trading impulse

First-order volatility effect

"Betting" activity

Normalized betting activity

$$C(X) = \frac{\sigma}{0.02}\left[\frac{8.21}{10^4}\left(\frac{W}{(0.02)(40)(10^6)}\right)^{-1/3} + \frac{2.50}{10^4}\left(\frac{W}{(0.02)(40)(10^6)}\right)^{1/3}\frac{X}{(0.01)V}\right]$$

Bid-ask spread component

Market impact component

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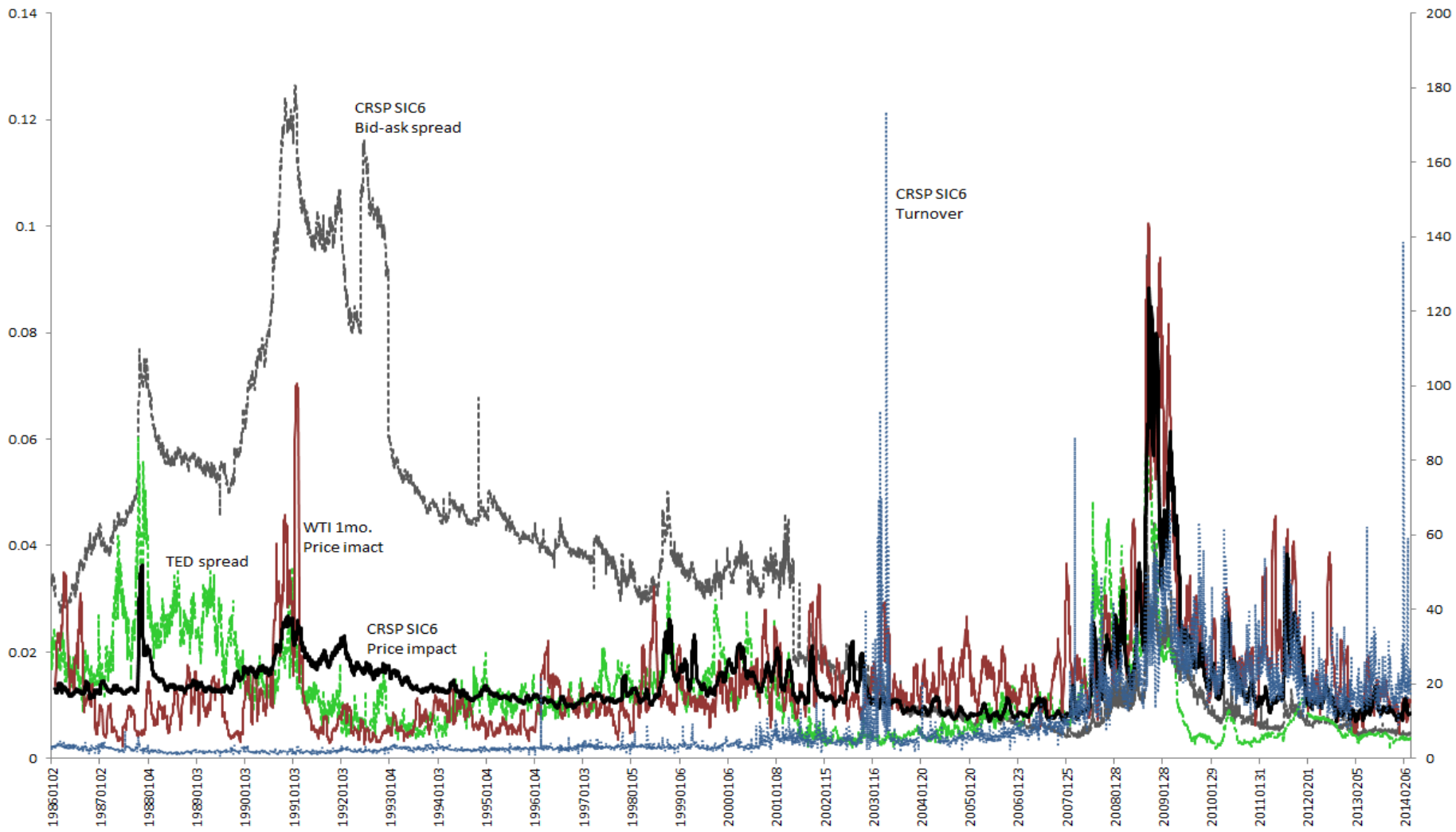
Examples of Market Liquidity Measures



Source: CRSP, Mergent, Bloomberg, WRDS, FINRA, OFR analysis

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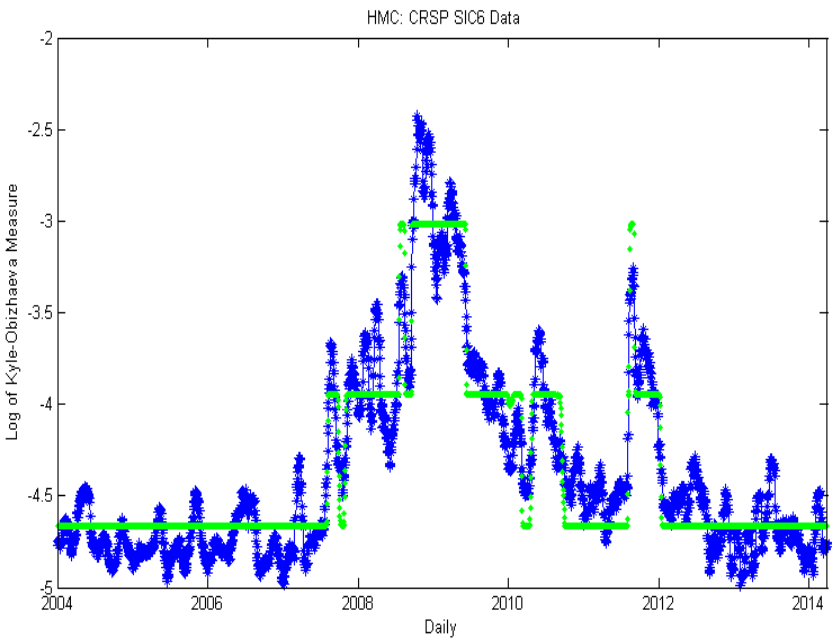
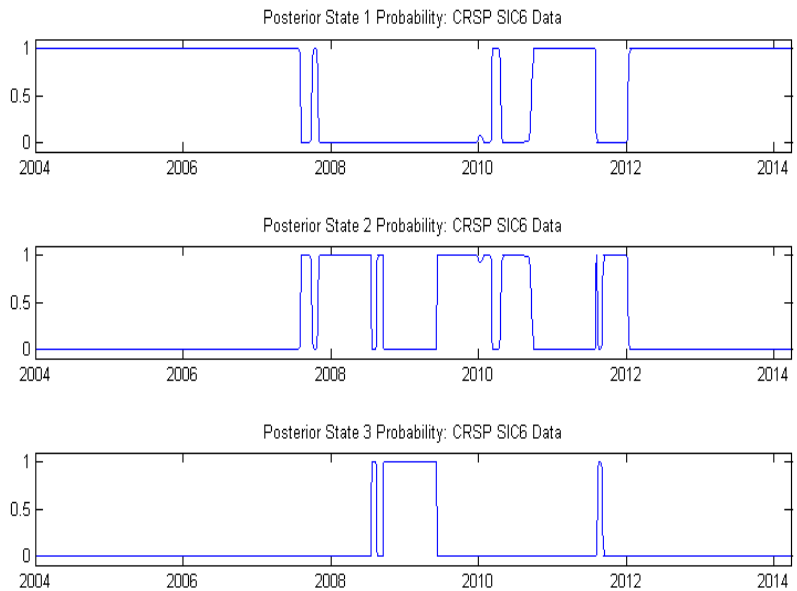
Hidden Markov Chain for observed liquidity

- For each market, estimates a "latent" or unobserved level of liquidity
- Bayesian Hierarchical Model; Inference using Markov Chain Monte Carlo
- Detected three distinct liquidity states (levels of the price impact measures)
- Estimated level of liquidity for each state and probability of being in a state





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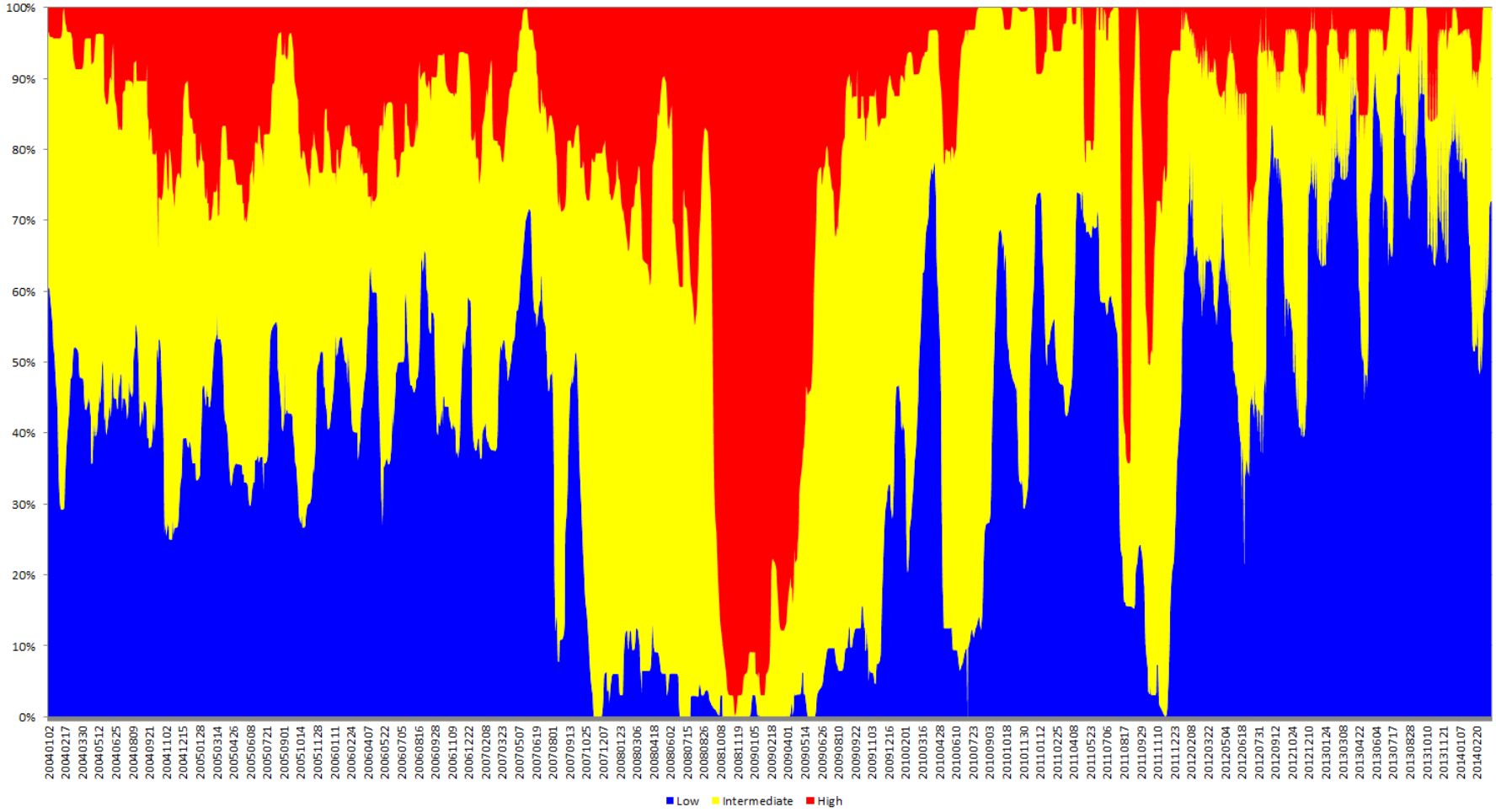
Estimated Liquidity States

Average Estimated State Probabilities

(Hidden Markov Chains, 33 series, Apr. 2004 – Mar. 2014)



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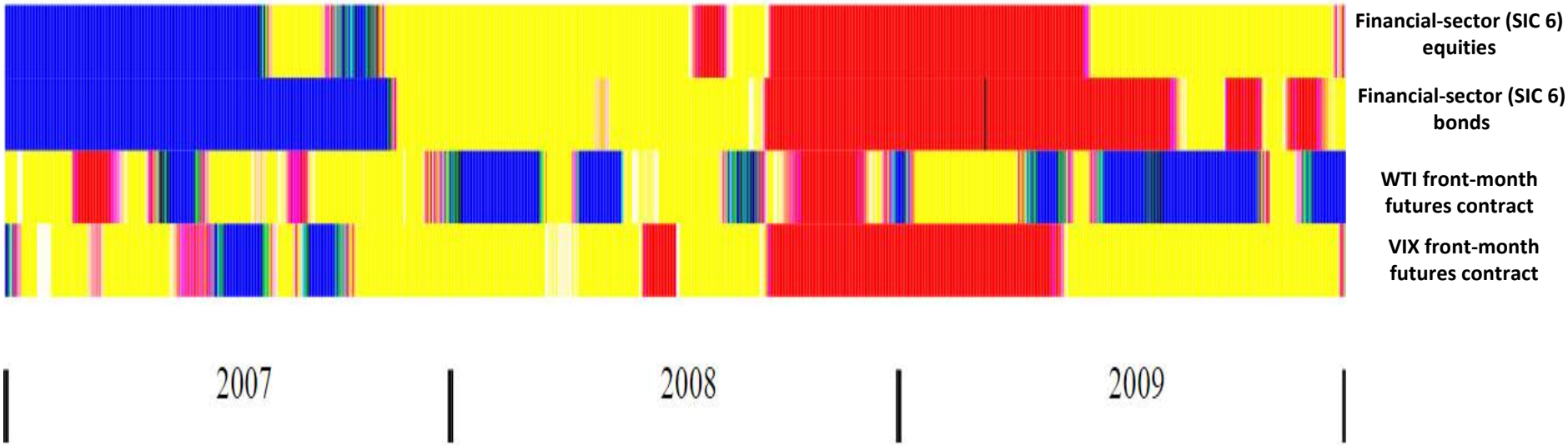
Mixed Price-Impact States

4 Markets, Daily, 2007 – 2009



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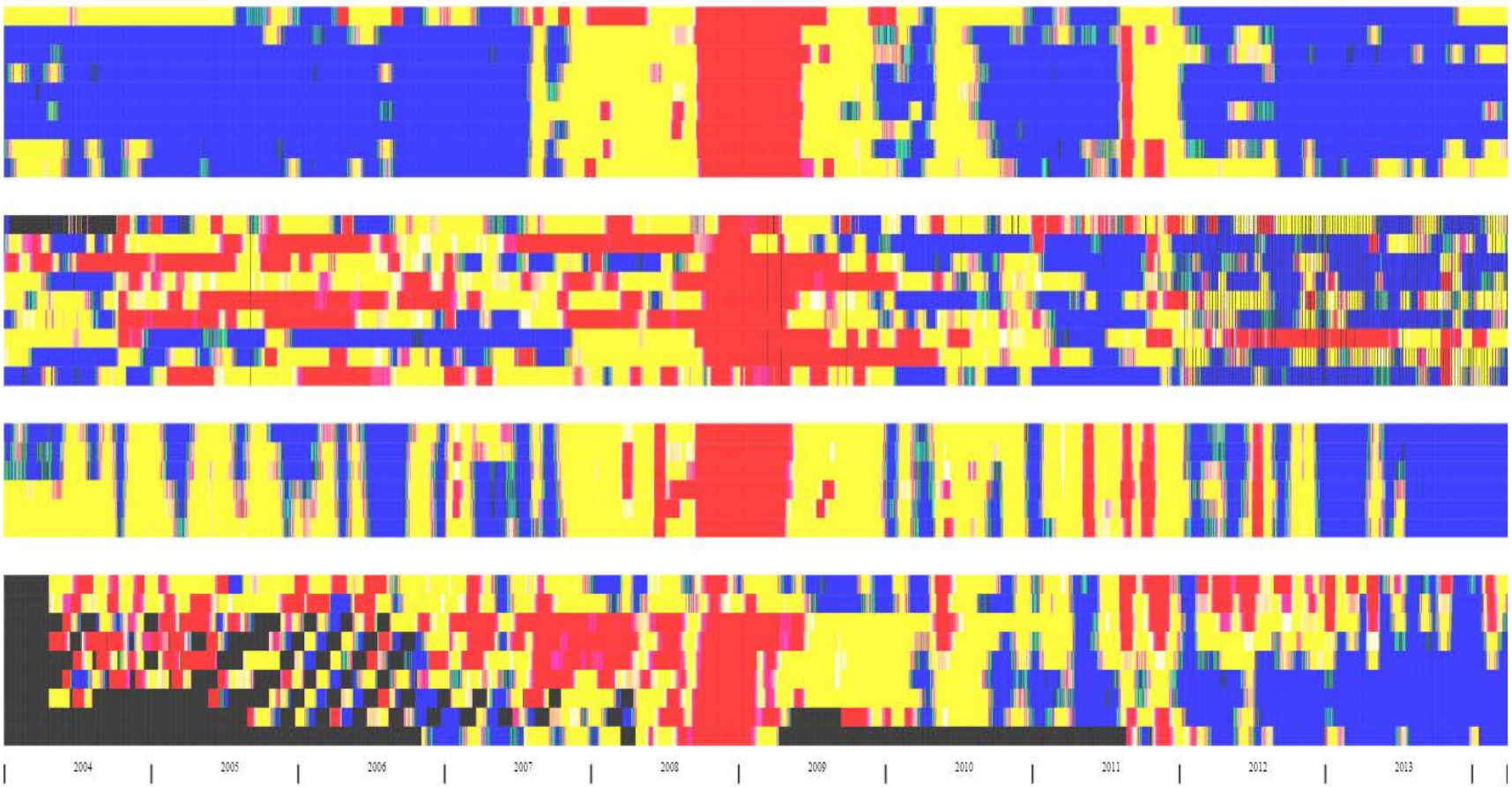
Big Heat Map

Mixed Price-Impact States

4 Markets, Daily, 2004 – 2014



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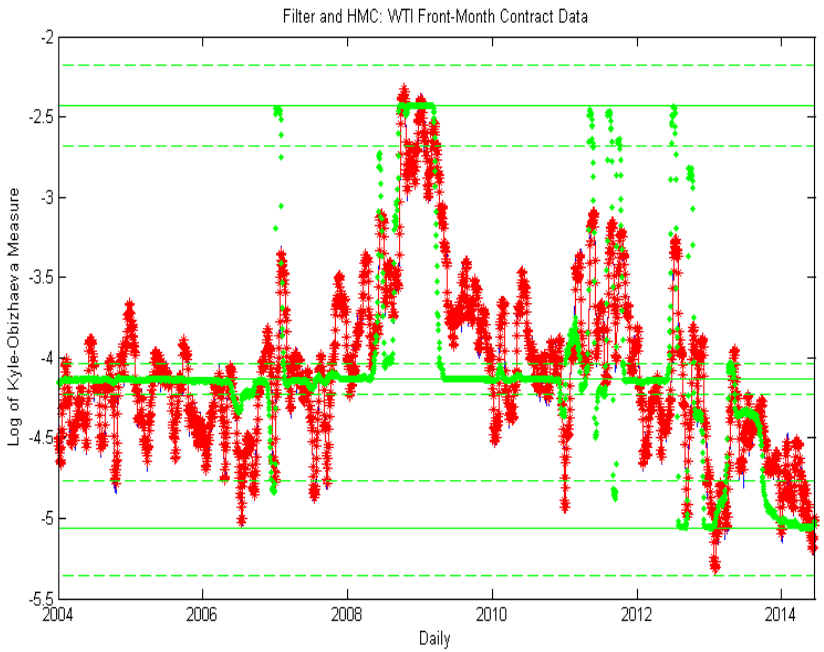
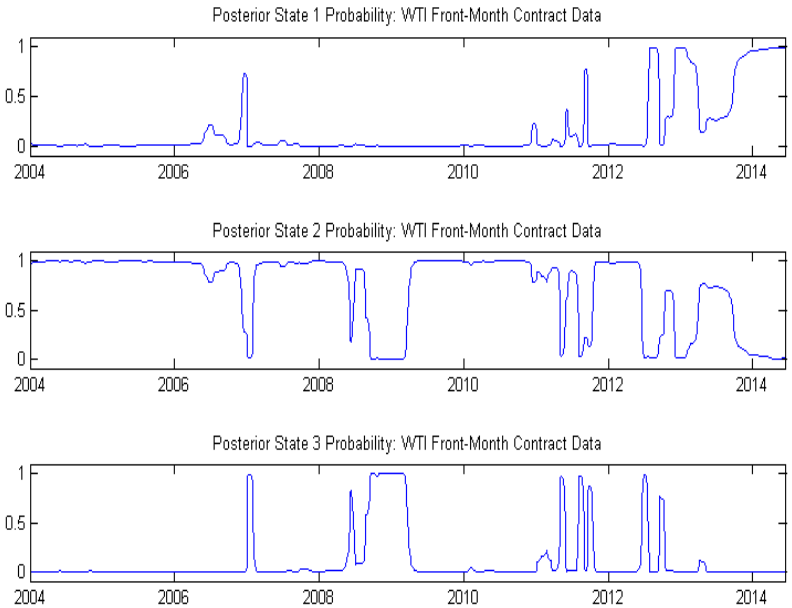
Filter and Hidden Markov Chain

- Filtered liquidity (red) mean reverts around a "latent" level of liquidity (green)
- Improvements over initial HMC model
  - Lessens the impact of outliners
  - More parsimonious model (with respect to the number of latent states)





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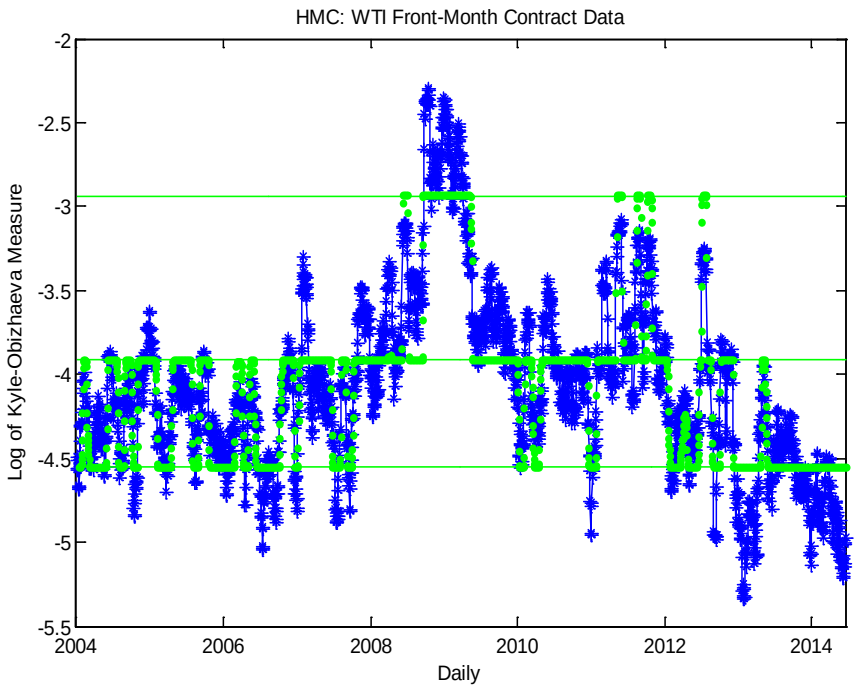
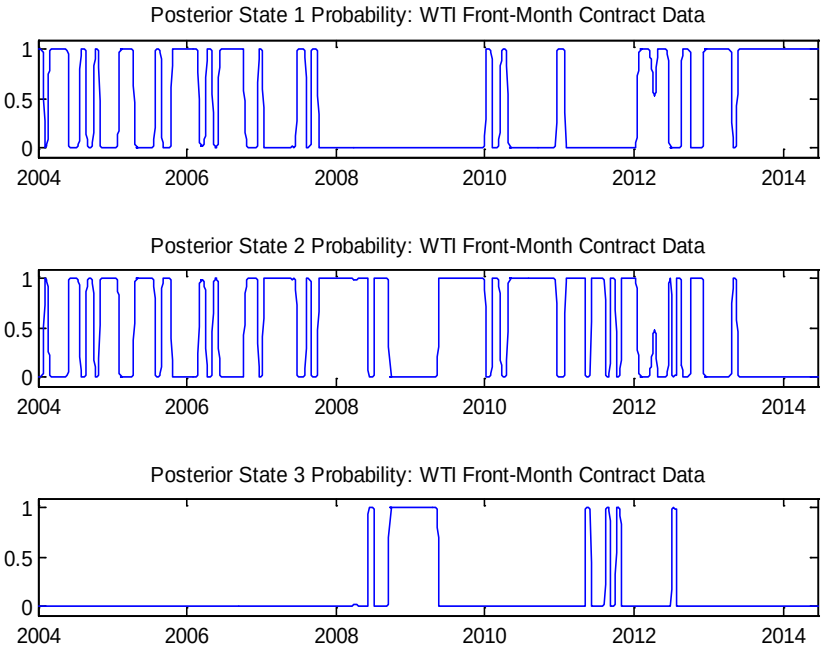
Comparison with Hidden Markov Chain





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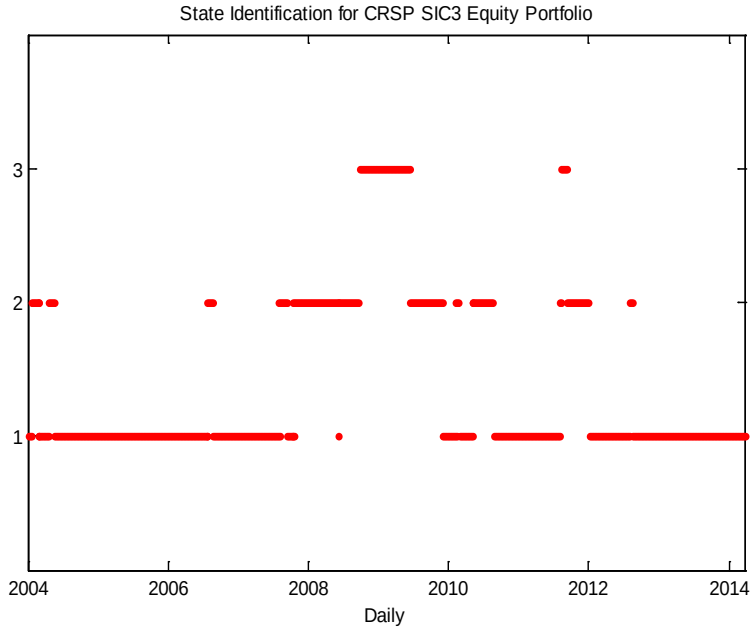
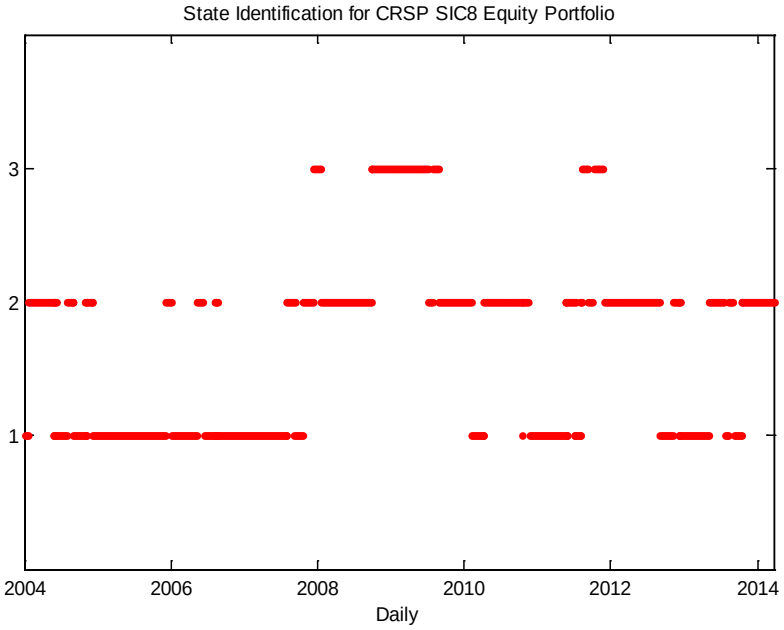
What is driving the hidden Markov models?

- How are macro summaries of the financial markets/economy related to changes in the latent liquidity states?
- Using a Multivariate (multiple markets) filtered Hidden Markov Chain model
  - Have estimates of being in each state for every market at each point in time
  - Treat as a choice problem and use a Multinomial Probit model





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What is driving the hidden Markov models?

- **Considered 11 financial market/macro indicators (such as inflation, the yield curve, dollar index, etc.) to predict each latent state.**

	Posterior Mean		Posterior StDev		t-Stat	
Macro Variable	State 2	State 3	State 2	State 3	State 2	State 3
Intercept	-0.64**	-1.01**	0.02	0.01	-40.27	-102.11
VIX®	0.62**	0.26**	0.03	0.02	23.77	15.67
WTI	0.83**	-0.23**	0.03	0.01	30.65	-16.53
3m Repo Rate	0.68**	-0.41**	0.02	0.01	38.28	-49.12
TED Spread	0.49**	-0.09**	0.03	0.01	18.53	-10.98
Yield Curve (10y–2y)	0.19**	-0.38**	0.02	0.04	9.66	-56.07
S&P 500 P/B Ratio	0.68**	-0.13**	0.03	0.01	23.85	-9.86
Dow Jones Real Estate Index	-1.17**	0.13**	0.02	0.01	-64.48	11.69
Moody's Baa Index	-0.67**	0.47**	0.02	0.01	-43.57	60.83
LIBOR–OIS Spread	-0.64**	0.13**	0.05	0.02	-13.07	7.38
DXY Dollar Index	-0.39**	-0.37**	0.04	0.01	-10.67	-41.05
U.S. 5y Breakeven Inflation	-0.03	0.00	0.02	0.01	-1.43	0.36

** Significant at a 99% confidence level

MCMC Average Hit Rate = 66%, Naive Hit Rate = 33%

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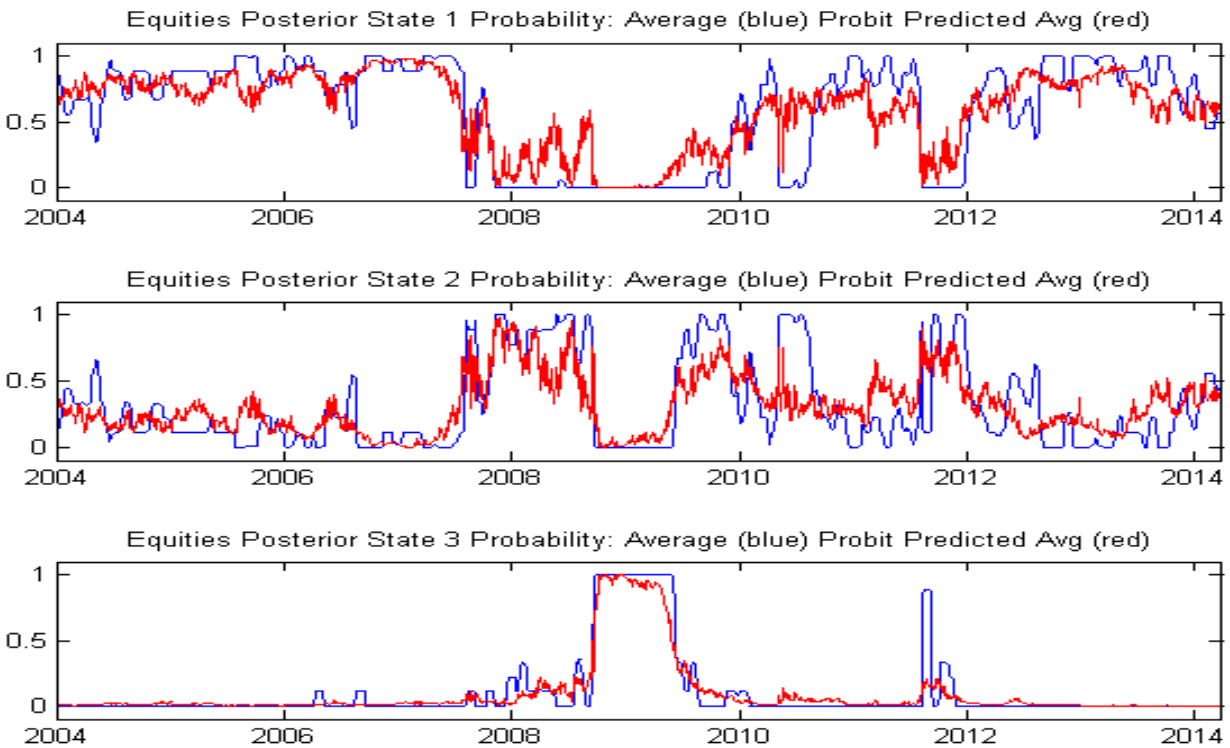
Predicting Macroeconomic Variables

Can we predict macro variables (and then liquidity)?

- Hidden liquidity states
- Macro drivers of hidden states (predict these, predict liquidity)



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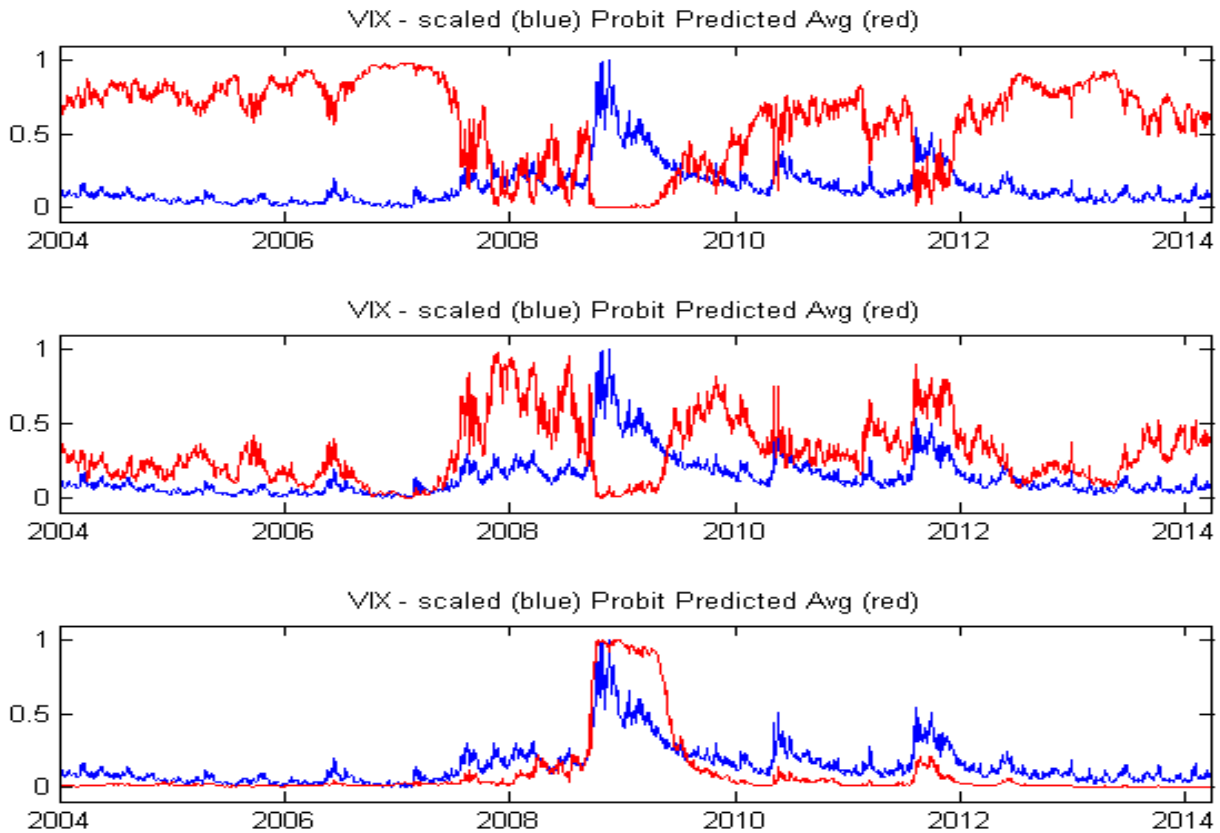
Hierarchical Model

What is driving the hidden Markov models?



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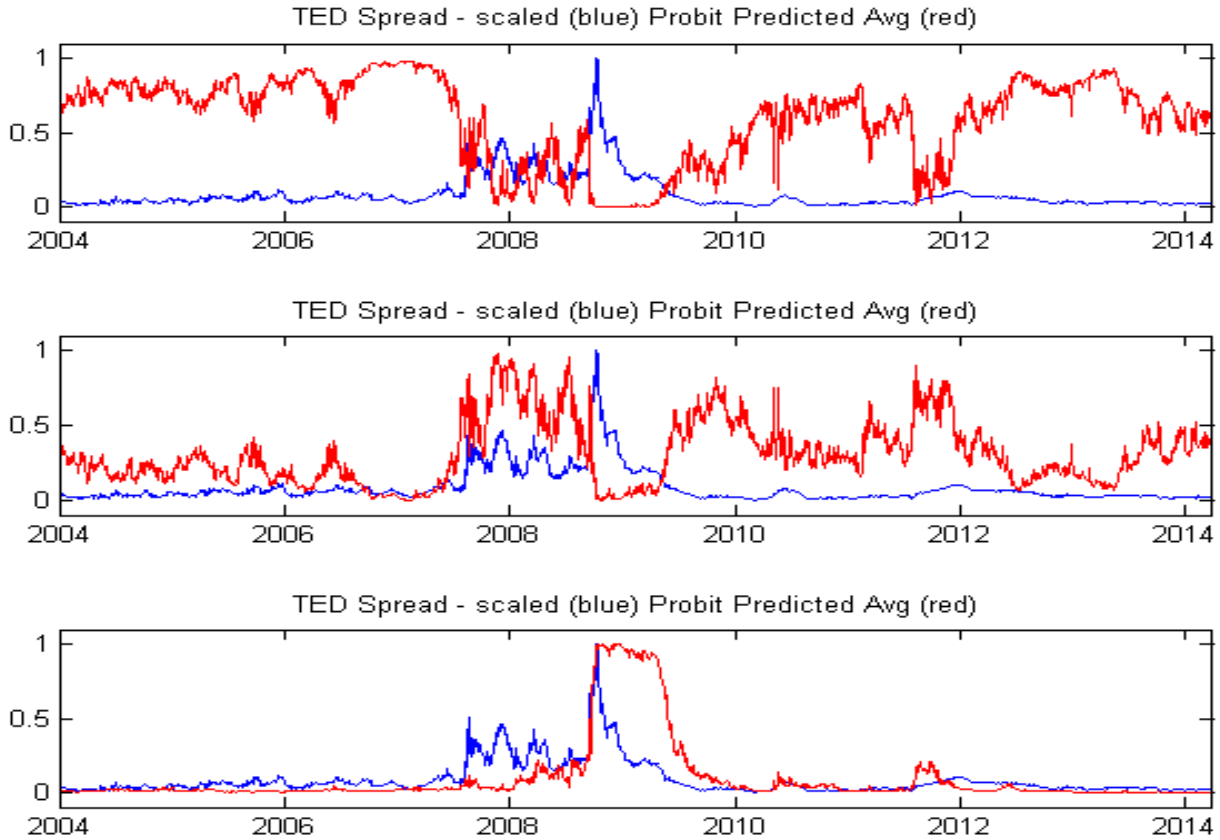

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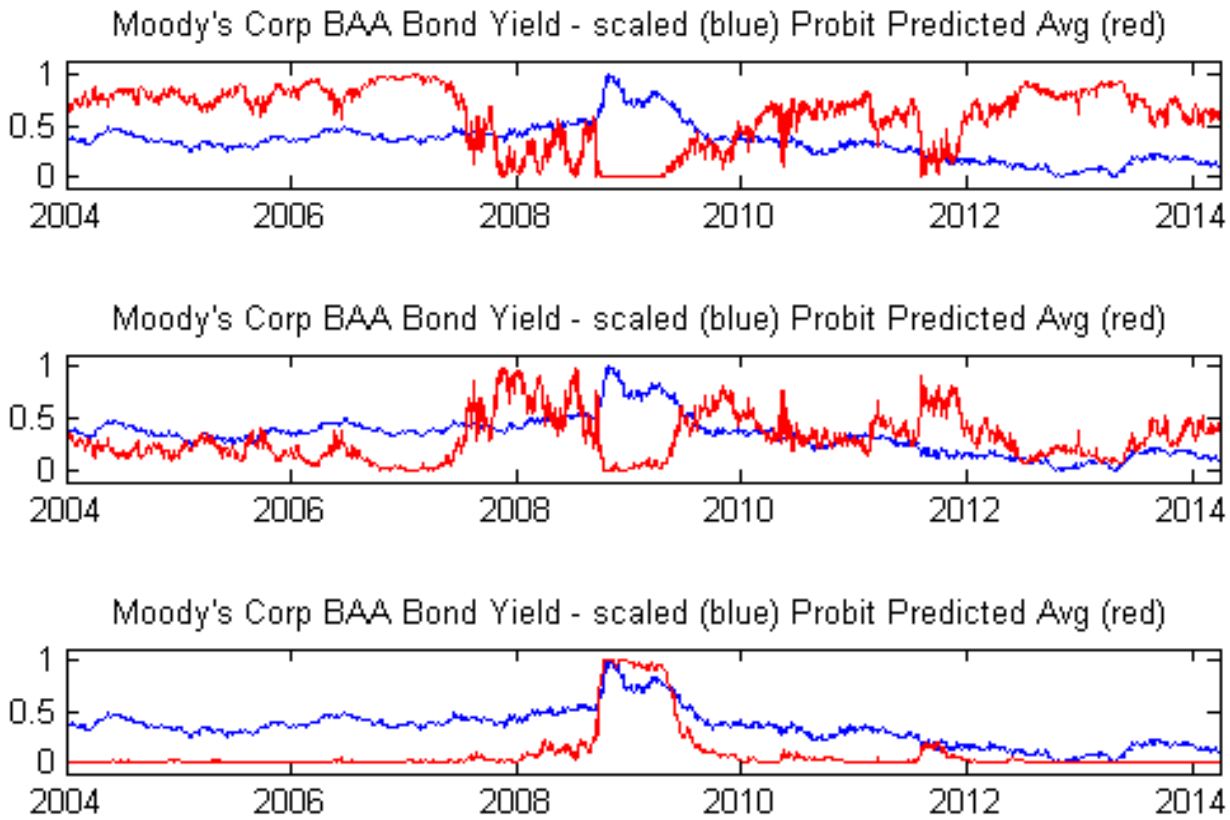

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Next Steps: Under Construction

Tools: Accounting for Missing Data

- Incorporating a feature where we can have missing observations in our input data
- The missing values will be imputed as part of the Markov Chain Monte Carlo analysis
- The program will assume that a 'reasonable guess' of the missing value comes in with the dataset

Tools: Accounting for data outliers

- Some portfolios of liquidity metrics have extreme outliers that can adversely affect the hidden Markov chain estimation
- A data truncation routine is being developed to help improve the accuracy when using volatile data that may imply an extreme state that does not exist

Alternative measures of liquidity

- Our initial analysis was run on Kyle price impact measures; we have also run on turnover and bid-ask; plan to expand to more measures of liquidity

Alternative asset markets

- Our initial analysis looked at the equity markets, corporate bond markets, and VIX and WTI futures markets; we plan to expand to other contracts/securities and eventually add an international aspect

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Gratitude

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Thanks!

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