Predicting price spikes in the UK power market

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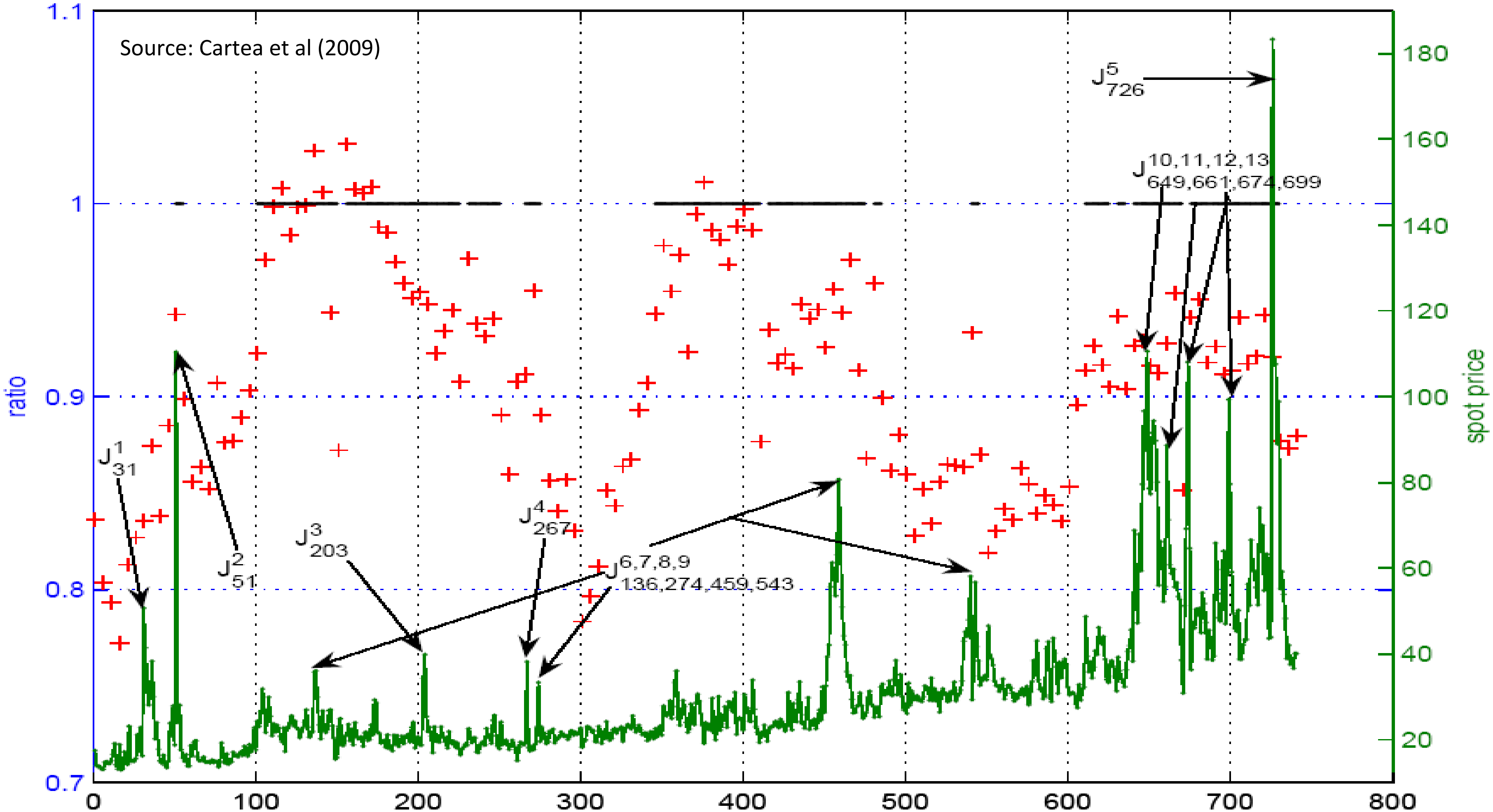
Capacity constraints cont.

- Compute the ratio of **D**emand forecast and predicted generation **C**apacity:

$$Q(t,T) = \frac{D(t,T)}{C(t,T)} = \frac{1}{1 + reserve\ margin}$$

  - Like in Anderson & Davidson (2008, IEEE-TPS) and Cartea, Figueroa & Geman (2009, Appl.Math.Fin.)
  - The ratio may take values > 1
- When the ratio is
  - ‘small’ - it is less likely for spikes to appear
  - ‘large’ - it is likely to observe price spikes

Capacity constraints cont.



Spot data 2.6.2003 – 31.3.2006 (excluding weekends)

Capacity constraints cont.

Bin	#spikes	#weeks	Spike numbers
[0.77893, 0.79185)	0	2	n.a.
[0.79185, 0.80476)	0	2	n.a.
[0.81768, 0.83059)	0	1	n.a
[0.83059, 0.84351)	1	3	31
[0.84351, 0.85642)	0	9	n.a
[0.85642, 0.86934)	0	7	n.a
[0.86934, 0.88225)	0	13	n.a
[0.88225, 0.89517)	0	12	n.a
[0.89517, 0.90808)	0	7	n.a
[0.90808, 0.92100)	3	7	267 , 699, 726
[0.92100, 0.93391)	3	14	543 , 649, 661
[0.93391, 0.94682)	3	15	51, 459, 674
[0.94682, 0.95974)	2	7	203, 274
[0.95974, 0.97265)	0	16	n.a.
[0.97265, 0.98557)	0	7	n.a.
[0.98557, 0.99848)	0	7	n.a.
[0.99848, 1.01140)	0	5	n.a.
[1.01140, 1.02430)	0	6	n.a.
[1.02430, 1.03720)	1	2	136

Source: Cartea et al (2009)

Agenda

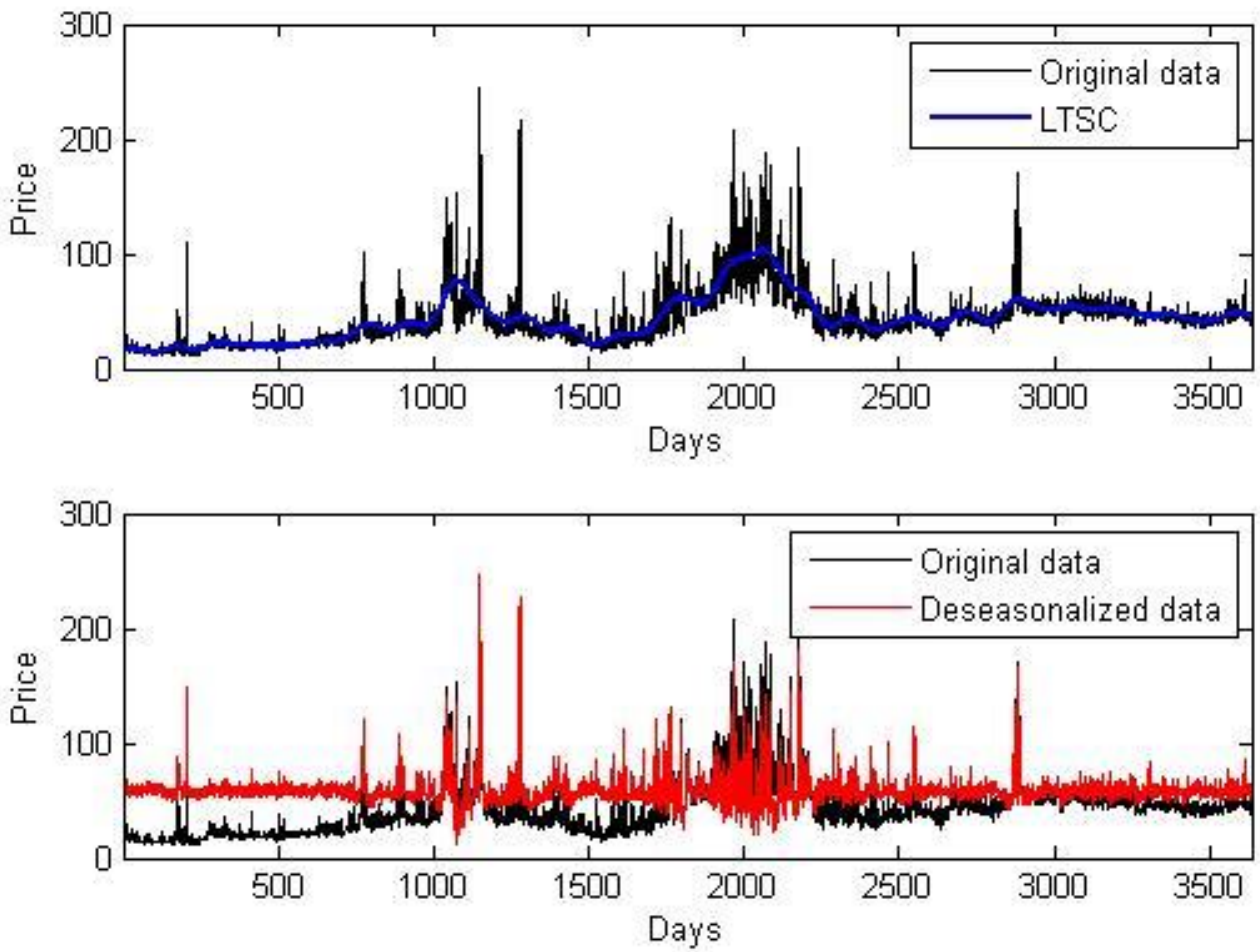
- Motivation
- Elexon data for the UK market 2003-2012
  - Indicated demand, indicated generation
- Identifying spikes
- Spike clustering
- Demand-to-Generation ratio and spikes

UK market data

- Considered period 01.01.2003-31.12.2012
  - Mean daily prices (UK Power Exchange Spot Index)
  - Demand (*National Demand Forecast*) and surplus forecasts from Elexon
    - 2-14 days ahead, 2-52 weeks ahead
- Prices are deseasonalized
  - The long term seasonal component (LTSC) is removed using a wavelet transform, while the short-term (STSC) by computing a weekly mean

UKPX Spot Index 2003-2012

Original and deseasonalized



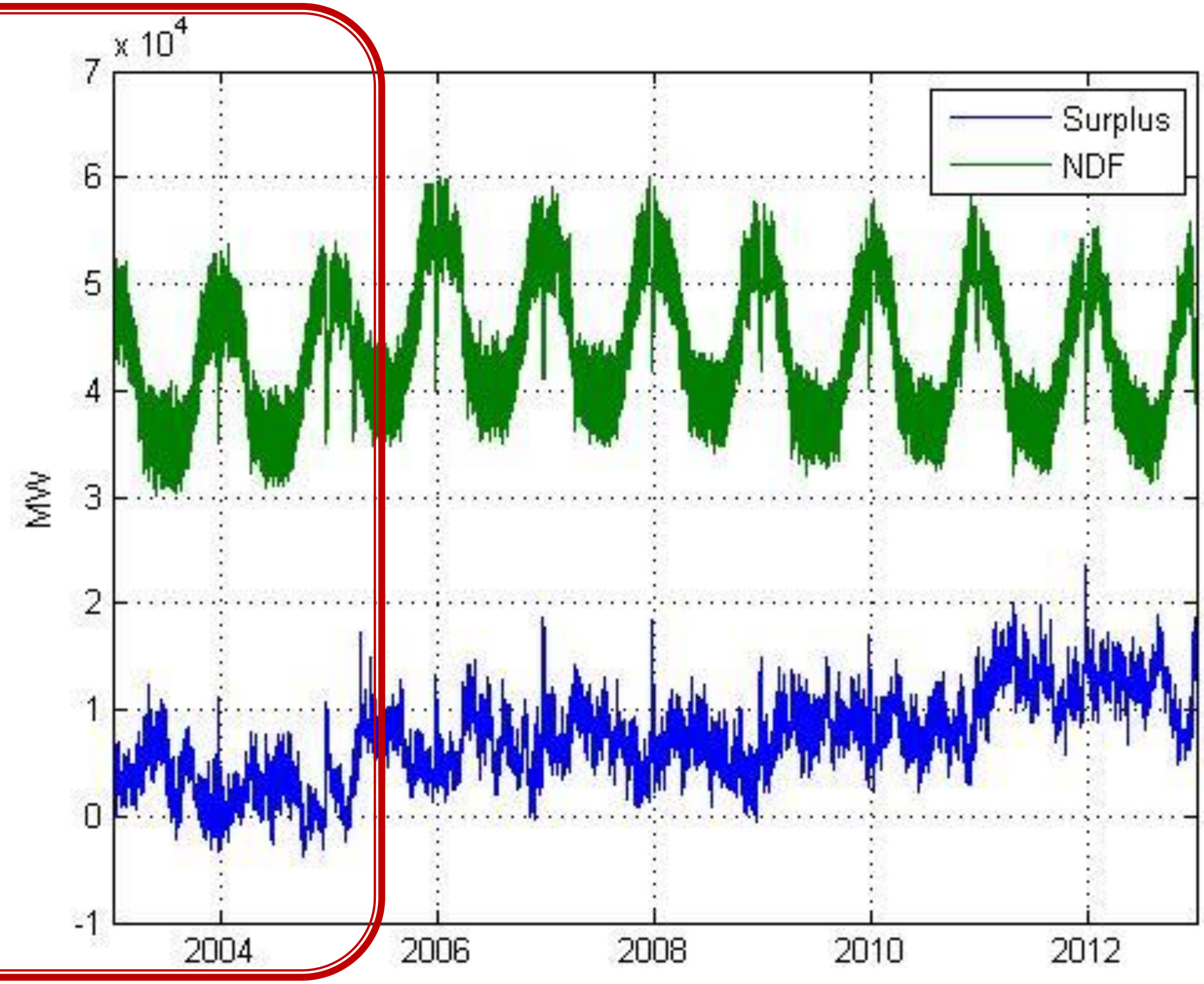
Demand and surplus forecasts

Source: Elexon

- National demand forecasts
  - For 2-14 days ahead are published daily
  - For 2-52 weeks ahead weekly
- Surplus forecasts
  - For 2-14 days ahead are published daily but only on weekdays
  - For 2-52 weeks ahead are published weekly
- To construct reserve margin we use the latest available forecast for that day
  - e.g. 2 days ahead forecast of surplus for Monday is the same as 3 days ahead

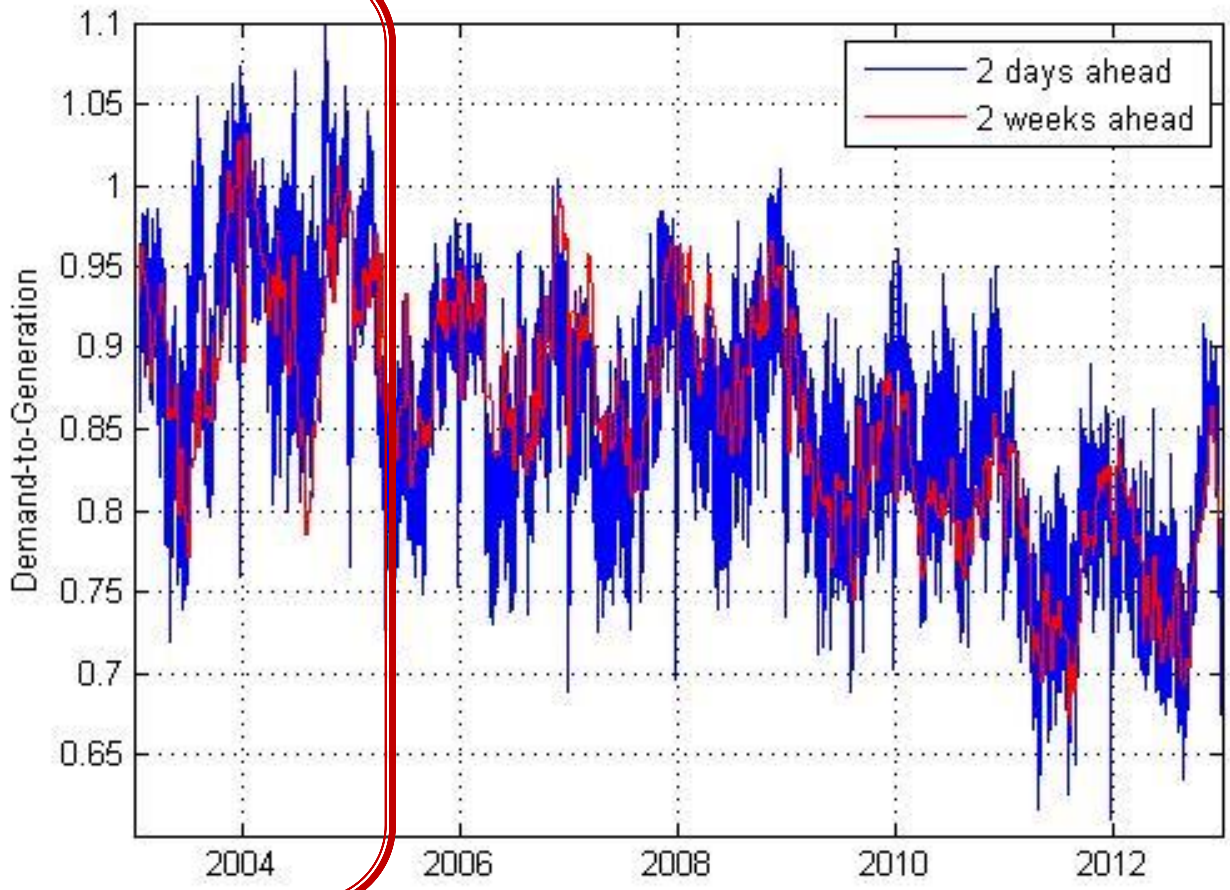
Demand and surplus forecasts

2 days ahead, 2003-2012 (Source: Elexon)



Cartea et al (2009)

Demand-to-Generation ratio



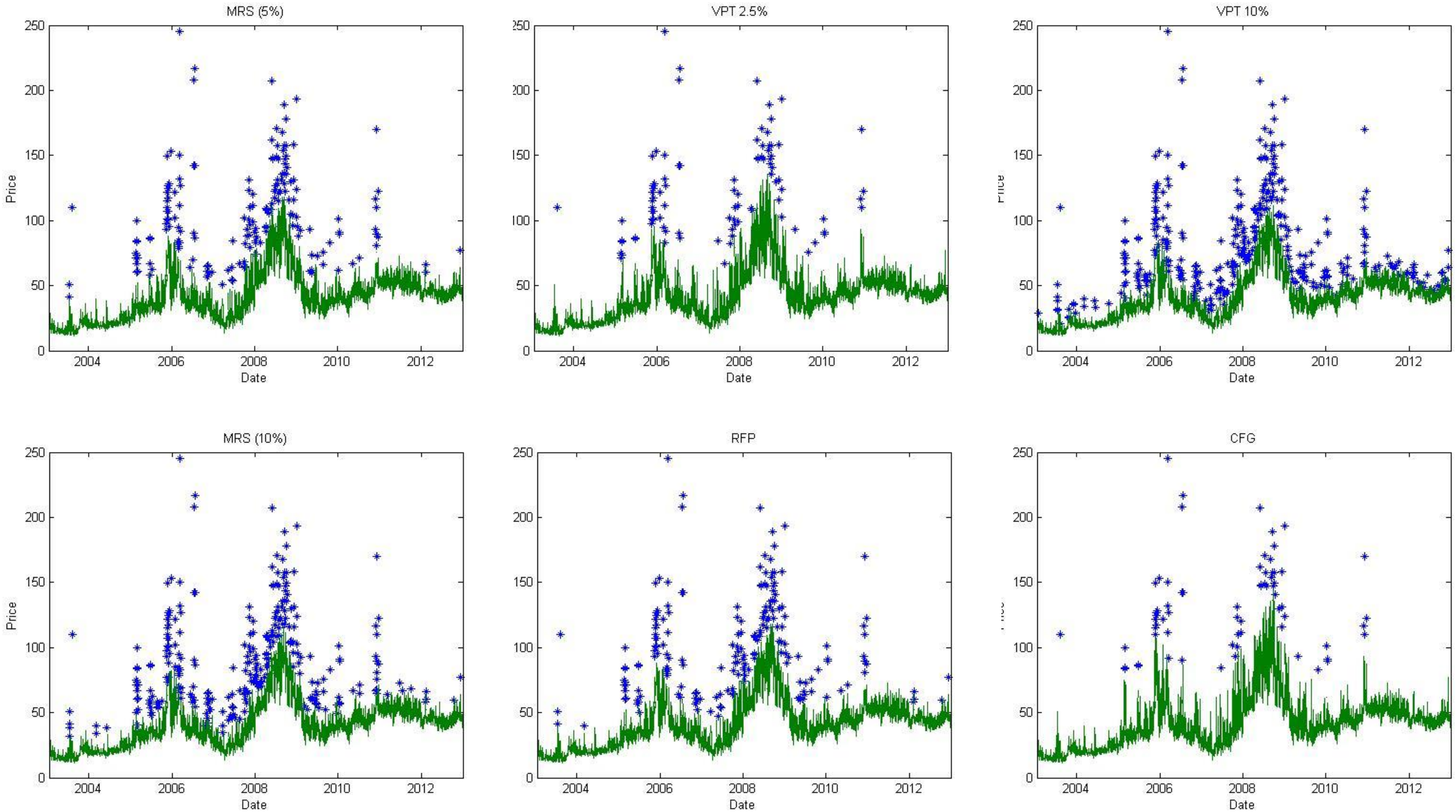
Cartea et al (2009)

Identification of spikes

See: Janczura, Trueck, Weron & Wolff (2013, EE)

- MRS model classification → MRS
- Recursive Filter on Prices → RFP
- Variable price threshold → VPT
- Cartea & Figueroa (2005) – spikes are observations which deviate more than 3 SD from the sample mean → CF

	MRS (5%)	MRS (10%)	MRS (25%)	RFP	VPT (2.5%)	VPT (10%)	CF
Number of spikes	175	283	348	192	91	363	68
Minimum	41.47	31.89	20.94	39.88	67.16	20.94	82.98
Maximum	245.43	245.43	245.43	245.43	245.43	245.43	245.43

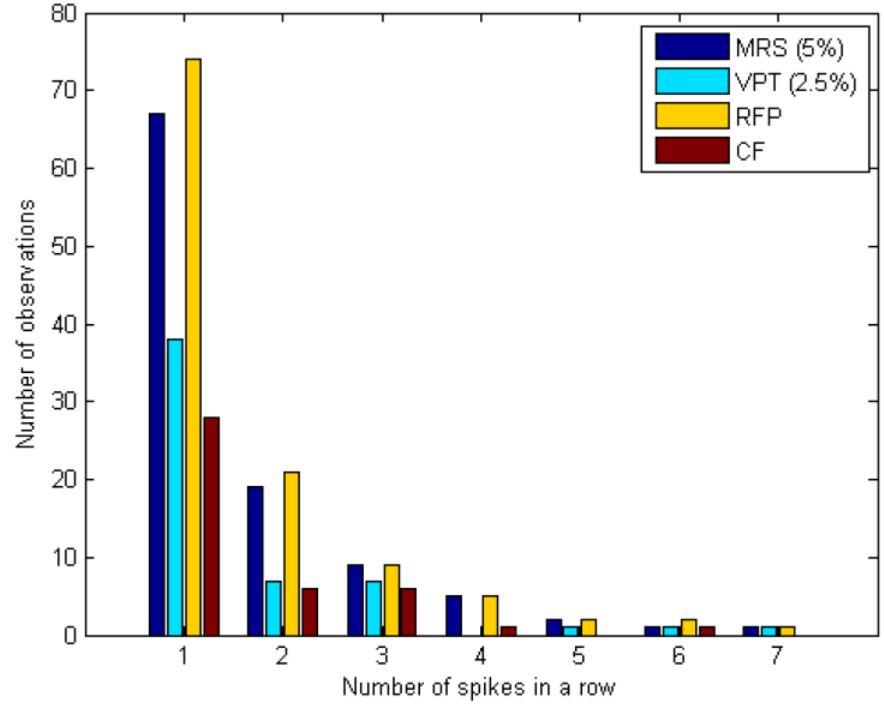

MRS (5%)
VPT 2.5%
VPT 10%
MRS (10%)
RFP
CFG
Price
Date
0
50
100
150
200
250
2004
2006
2008
2010
2012

Spike clustering

- The probability that a spike will occur after another spike

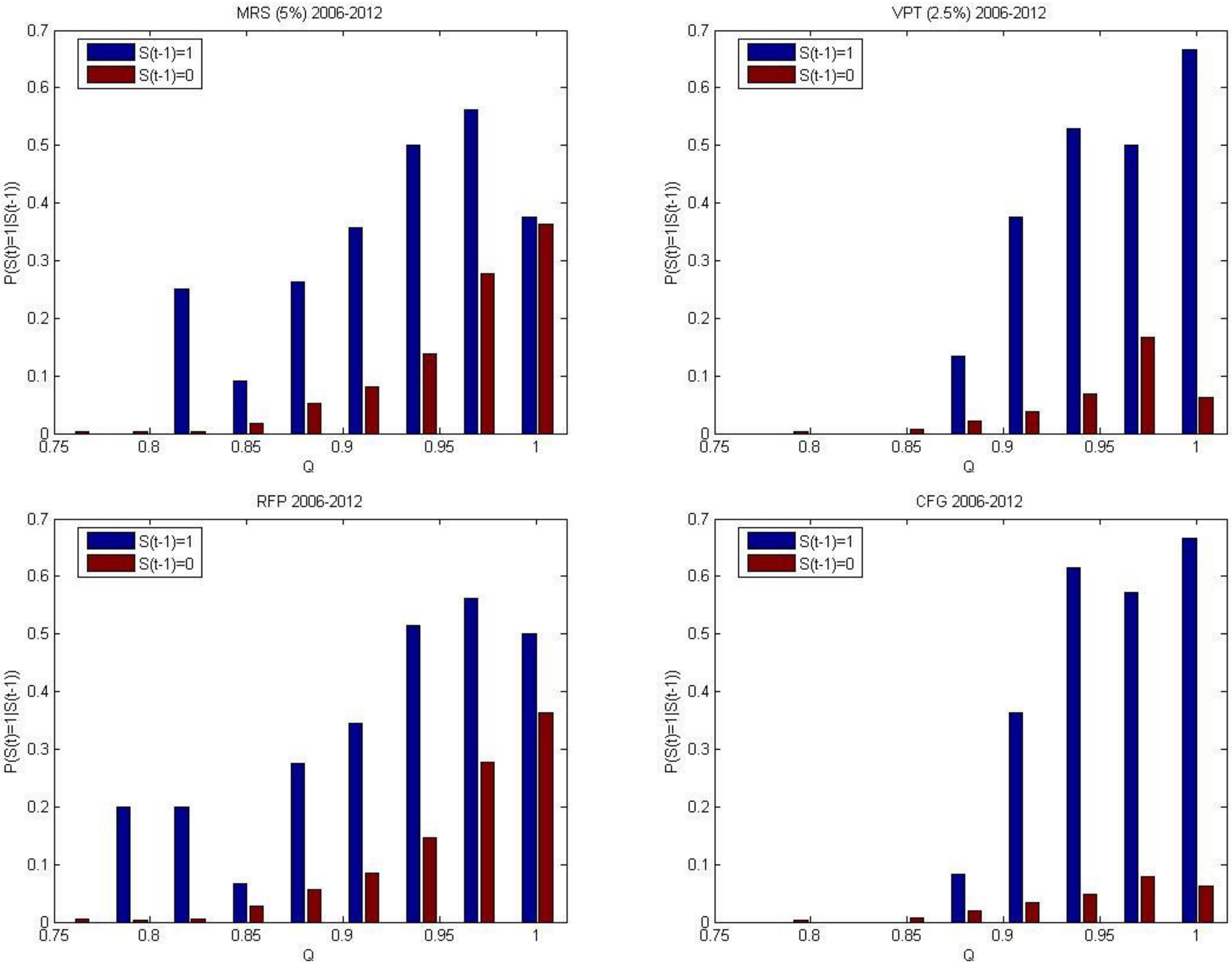
  $P(S_t=1|S_{t-1}=1)$

- is significantly higher than that it will occur not preceded by another spike



	$S_{t-1}=0$			$S_{t-1}=1$		
	$P(S_t=1\|S_{t-1})$	Lower bound	Upper bound	$P(S_t=1\|S_{t-1})$	Lower bound	Upper bound
MRS (5%)	3.8%	3.0%	4.6%	36.2%	28.3%	44.7%
VPT (2.5%)	1.8%	1.3%	2.4%	35.3%	24.1%	47.8%
RFP	4.1%	3.4%	5.0%	35.9%	28.4%	44.1%
CF	1.4%	1.0%	1.9%	35.8%	23.1%	50.2%

Spike clustering $P(S_t=1|S_{t-1})$



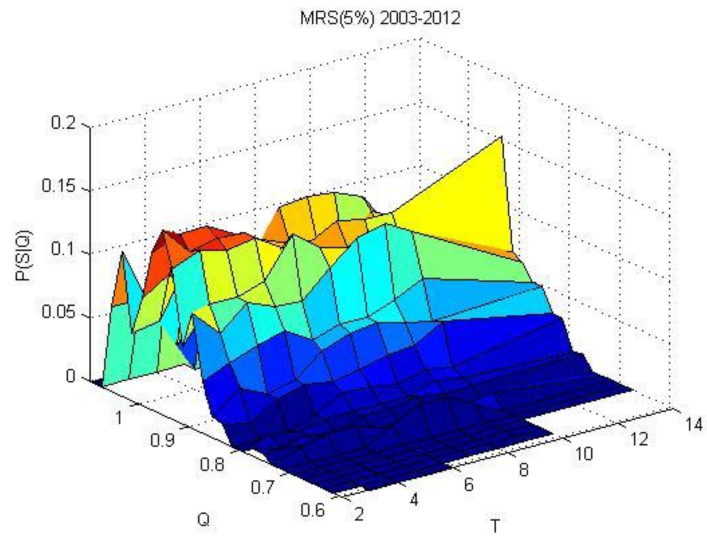
Q-ratio and spikes

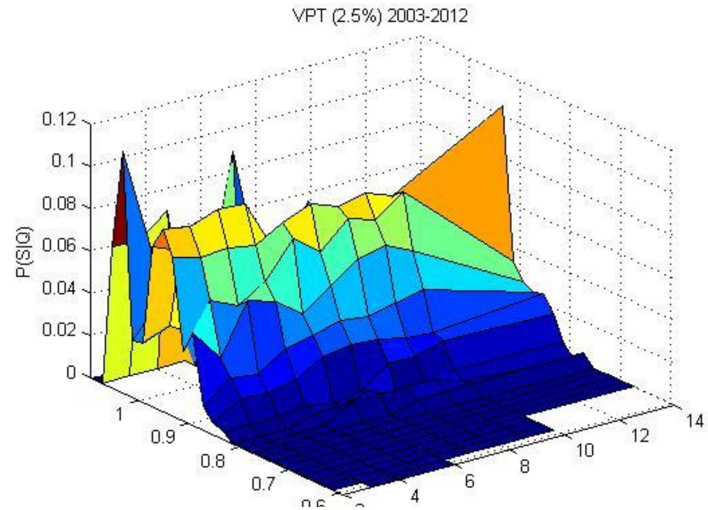
- Calculate empirical conditional probabilities:

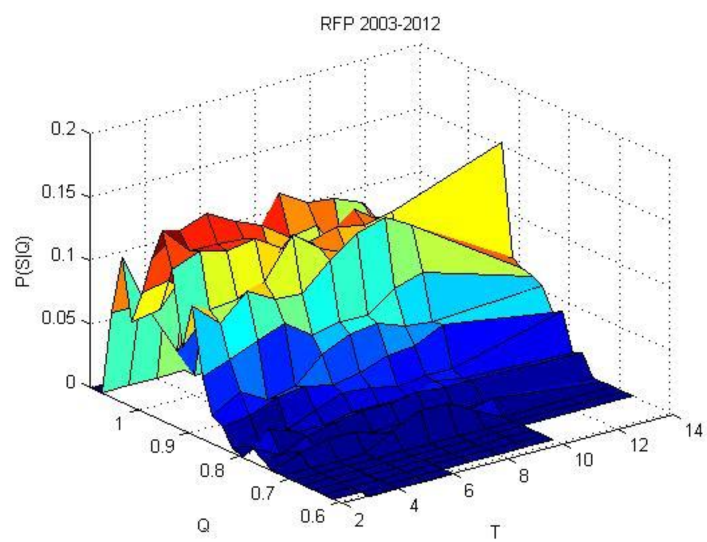
$$P(S_t = 1 | Q \in < x-h, x+h >) = \frac{Number\ of\ spikes\ with\ Q \in < x-h, x+h >}{Total\ number\ of\ observations\ with\ Q \in < x-h, x+h >}$$

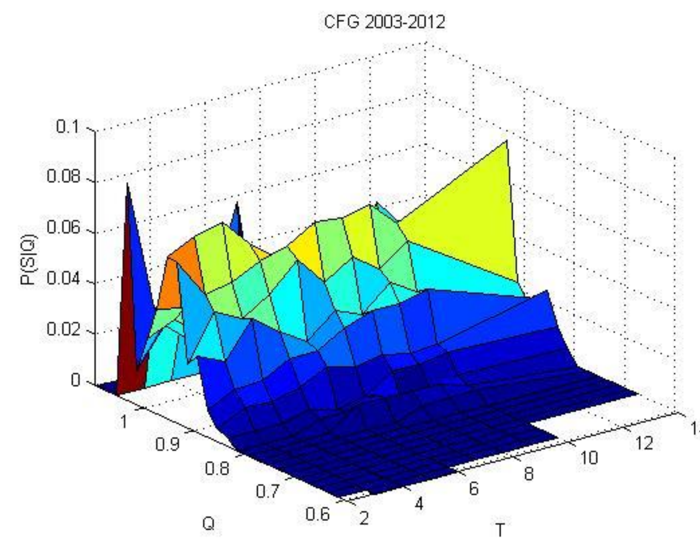
  - i.e. probabilities that a spike will occur given that Q ϵ <x-h,x+h>
  - For different forecasting horizons T=2,…,14 days
- In April 2005 NETA was expanded into the BETTA including also Scotland
  - Before April 2005 very few spikes occurred, most in 1Q 2005

Q-ratio vs. T (2003-2012)

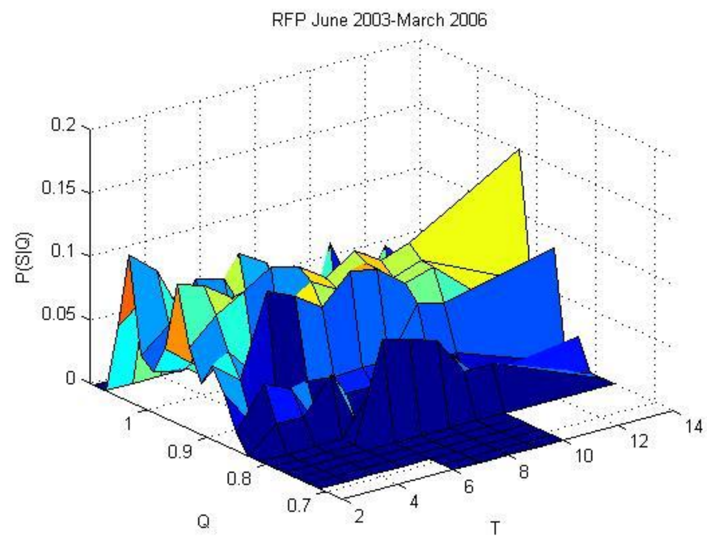


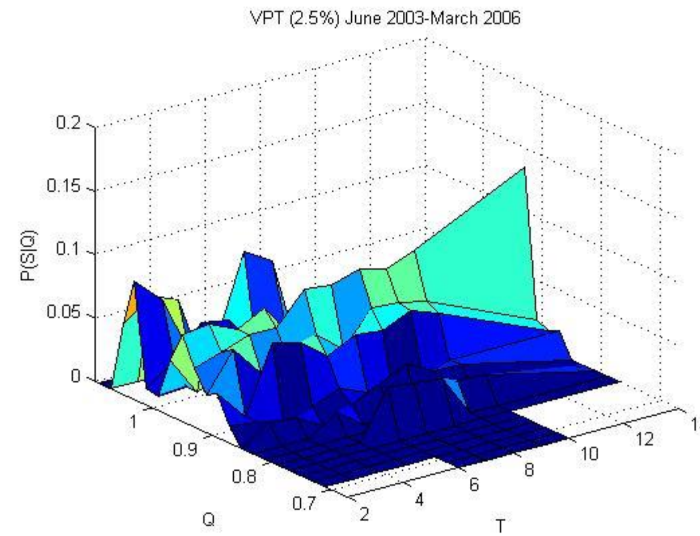


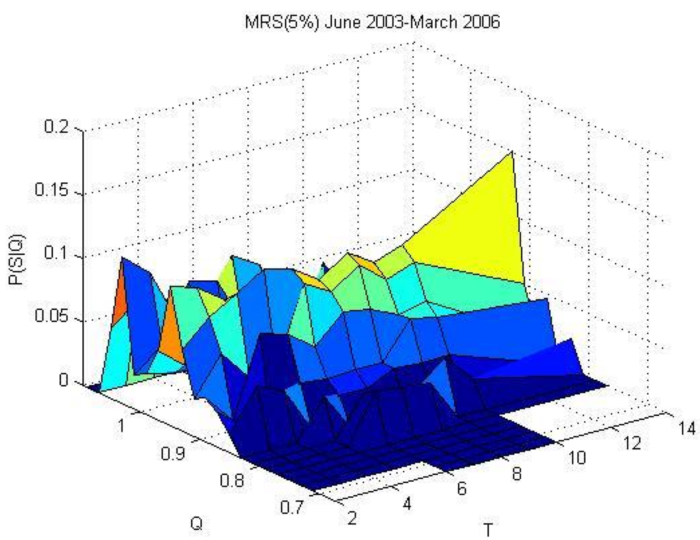


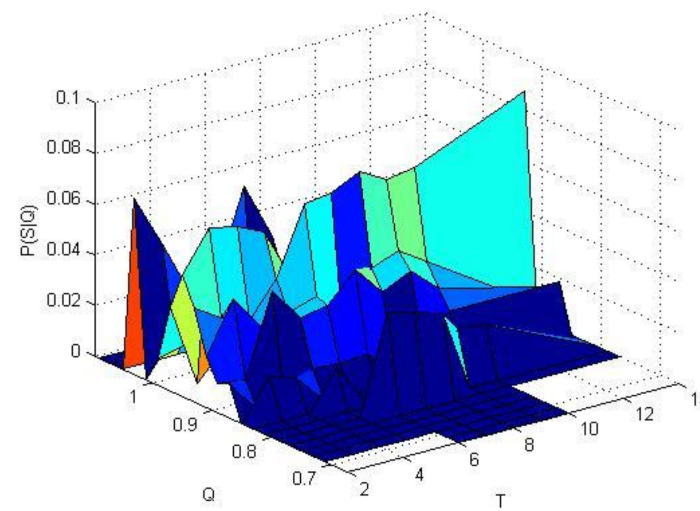


Q-ratio vs. T (6.2003-3.2006)

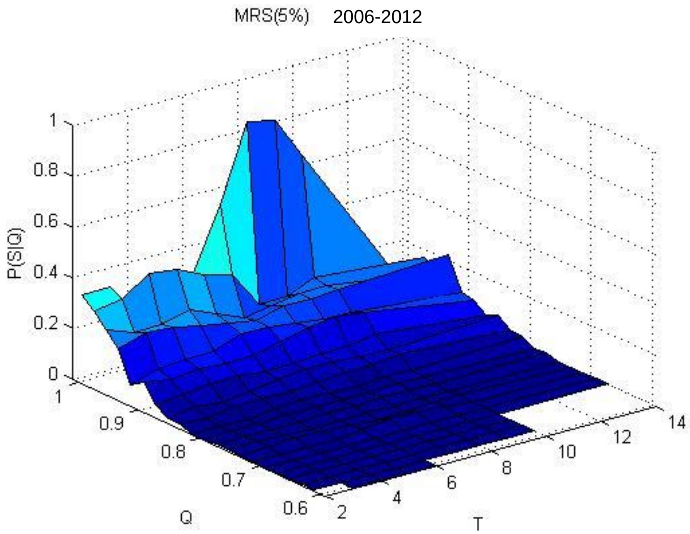


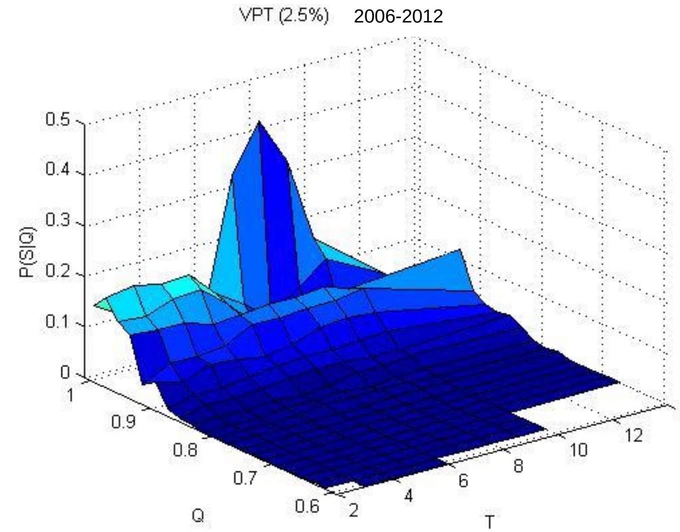


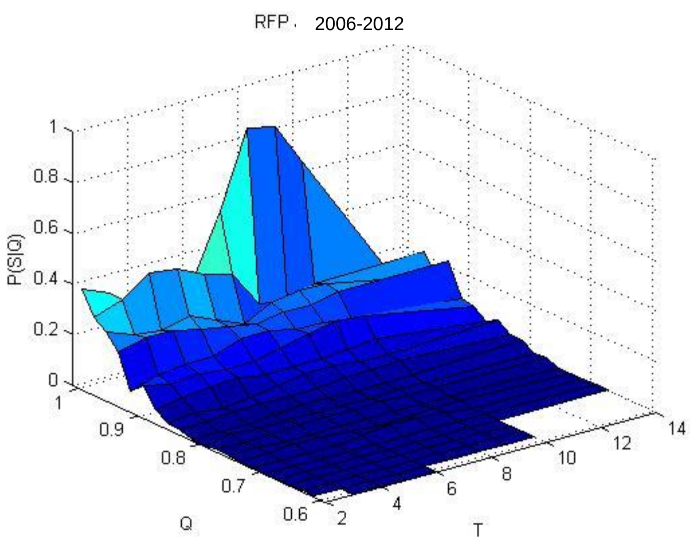


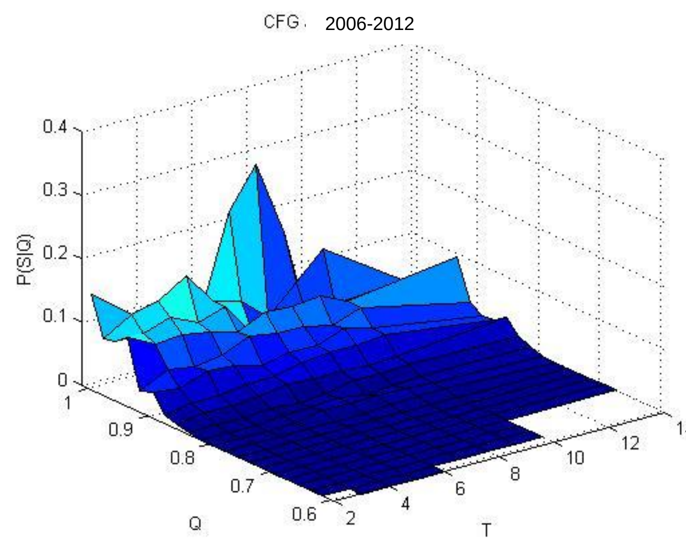


Q-ratio vs. T (2006-2012)



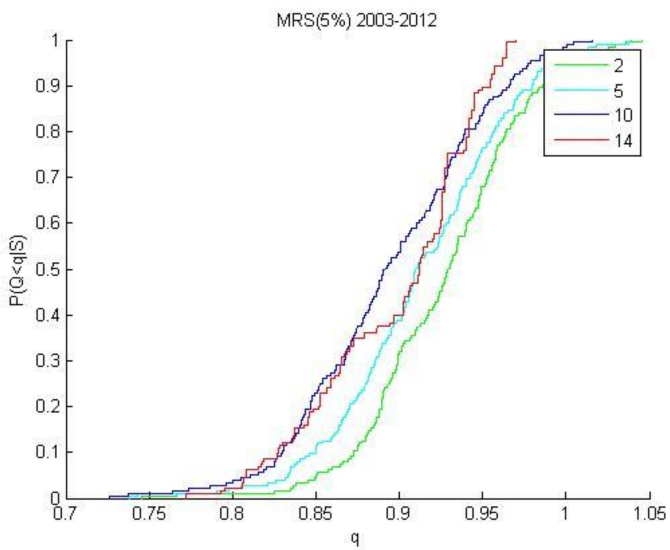


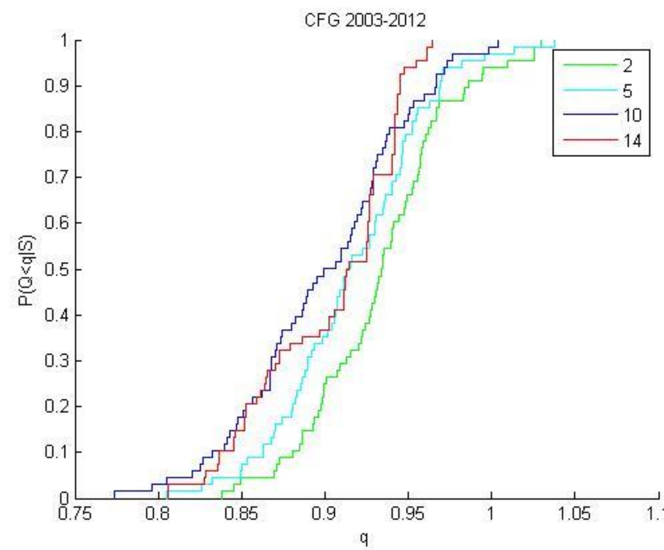




Conditional CDF of Q under spike occurrence

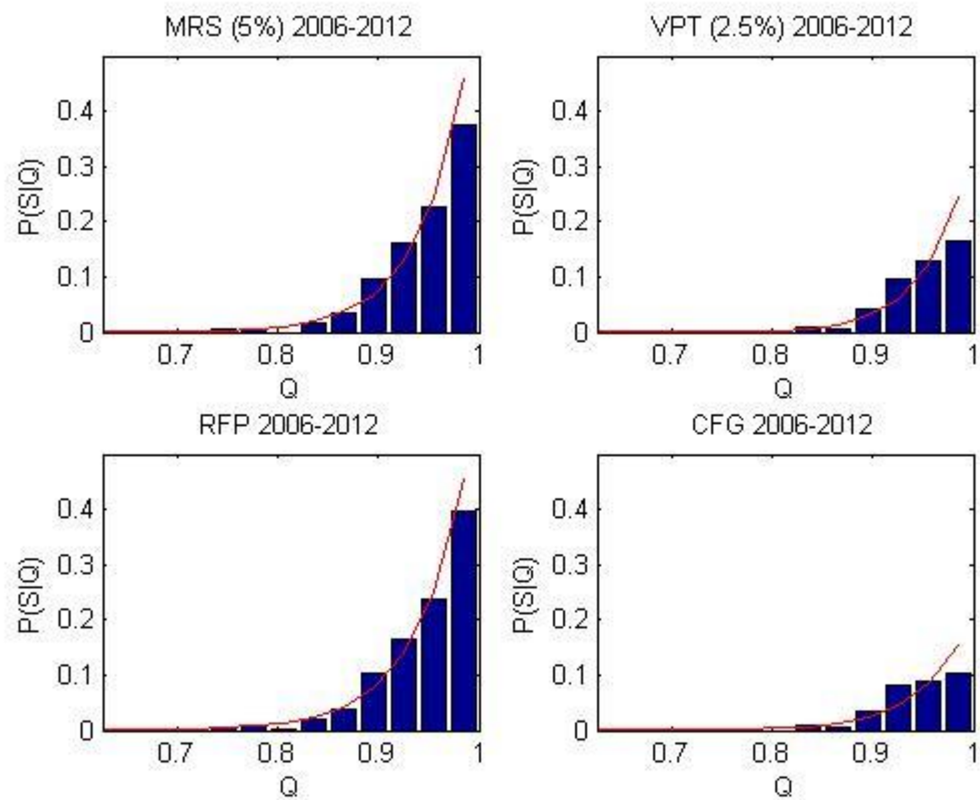
- Except for 2-week forecasts, we can observe stochastic dominance of the short-term over the long-term forecasts → the former are more reliable
- 2-week forecasts are made for a whole week, not for a particular day
  - Should be rather investigated separately





$P(S_t=1|Q_{t-2}, t\in<x-h;x+h>)$, i.e. for 2-days ahead forecasts

- The 'industry standard' of Q=85% (Anderson & Davison, 2008) for the spike occurrence seems to be reasonable
  - However, for MRS(5%) and RFP we observe some spikes under this level of Q



Conclusions

- Spikes cluster
- After a spike the probability of a next spike is different than without it (different transition probabilities)
- Spikes occur only above a certain threshold
  - In agreement with the industry standard of Q=85%
- The probability of spike occurrence depends monotonically on Q

References

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*Post-conference