

# Quantitative Research

Ron Bewley

14 September 2006



A presentation of:

## **Market volatility in time and space**

### **Who is driving the bus?**

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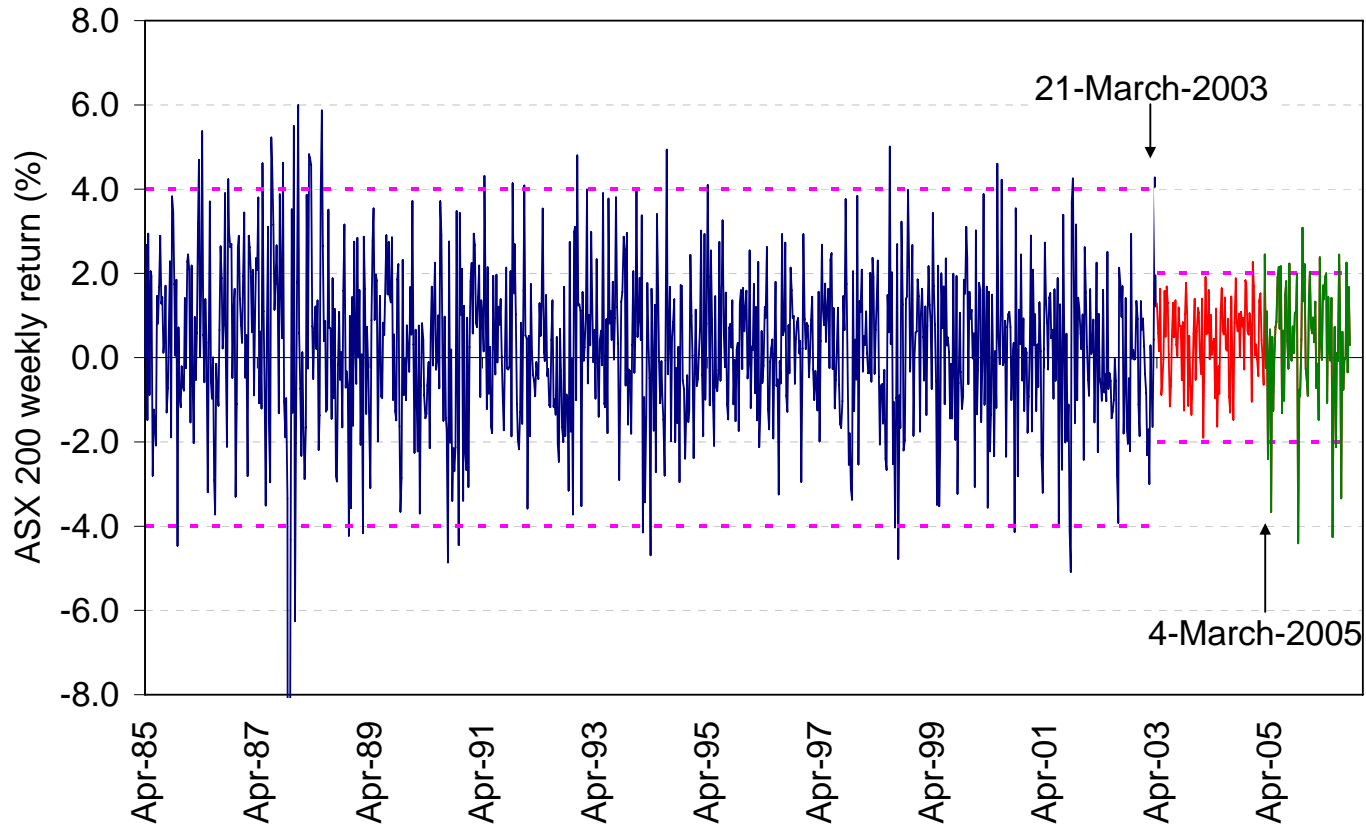
Please see the full disclaimer on the last slide.

# The problems



- Stylised facts:
  - Long-run S&P/ASX 200 volatility fell in March 2003
  - Cross-sectional volatility has been falling
- Questions:
  - Are these two “facts” related?
  - Are recent events consistent with our view?
  - Can we use our models to isolate volatility from market corrections?
  - Can we trade off our models?

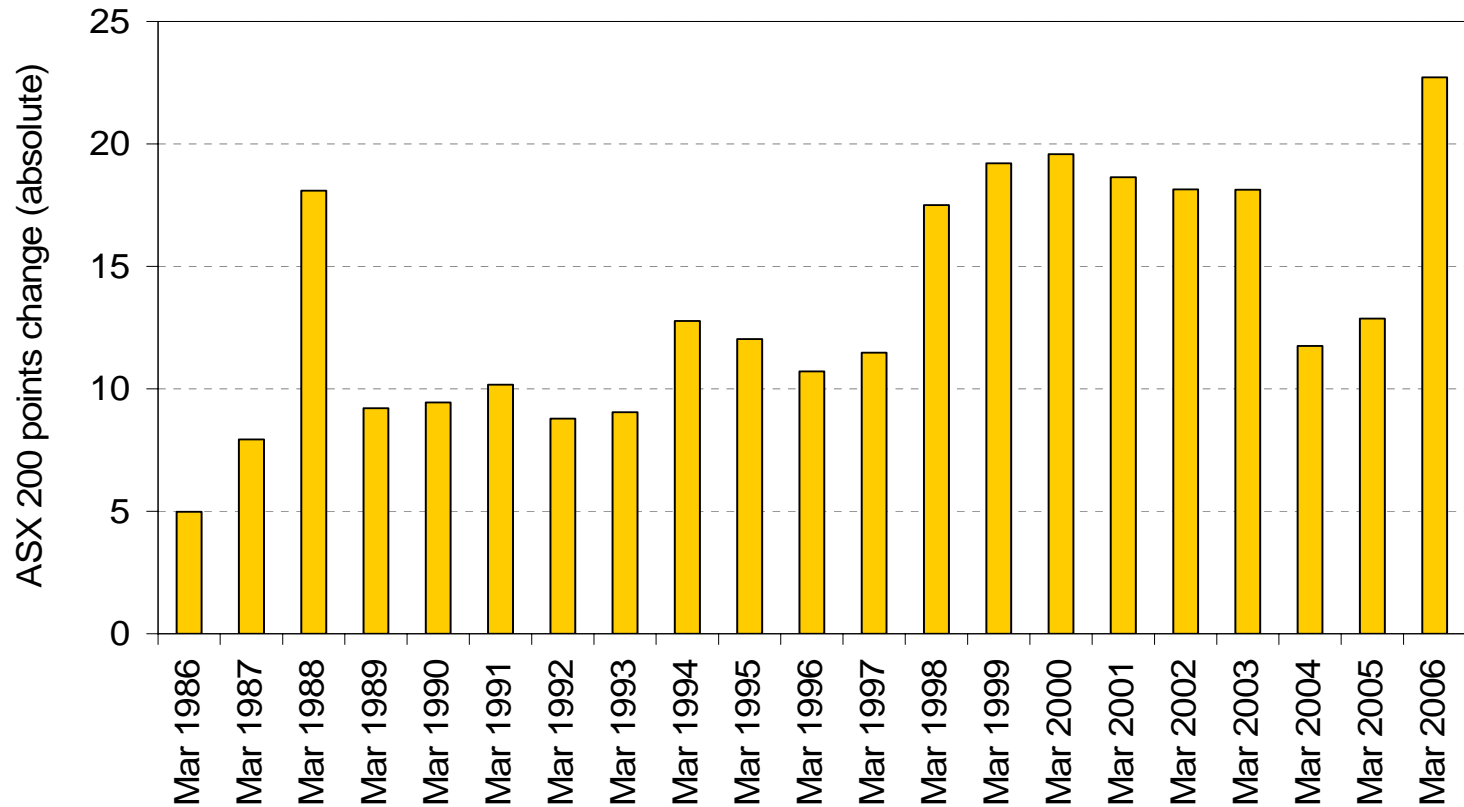
# Volatility halved in March 2003



Source: CommSec Quantitative Research, Data to 8 September 2006



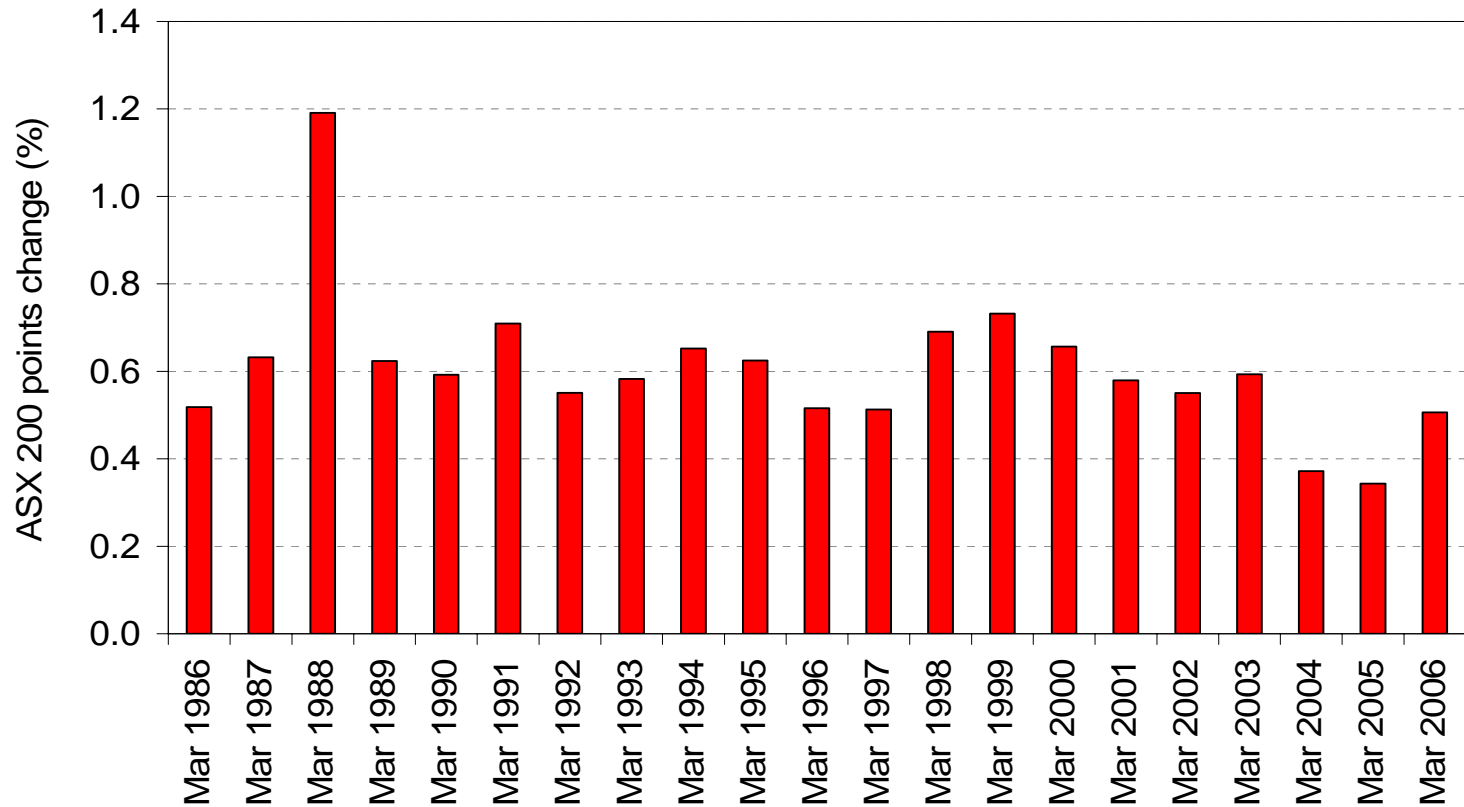
# ASX 200 – yearly average of daily change in index points (absolute)



Source: CommSec Quantitative Research, Data to 31-March-2006



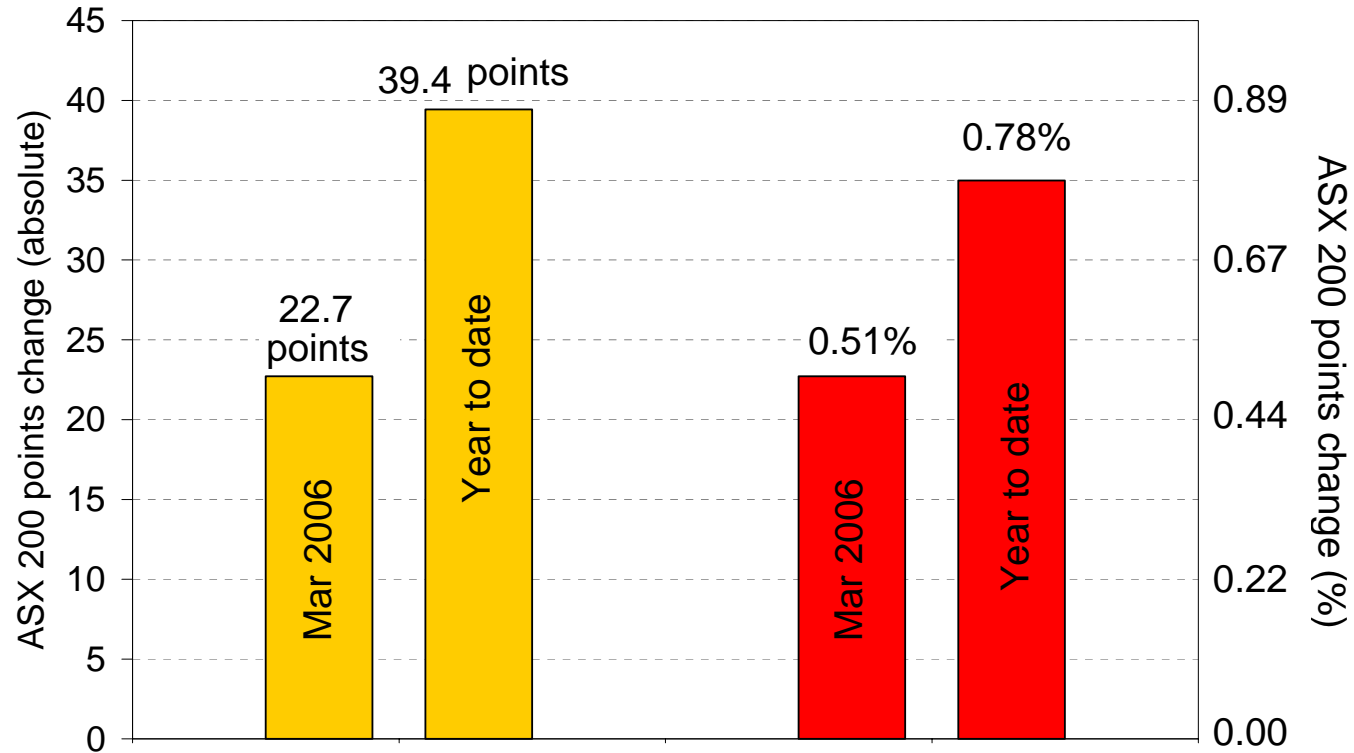
# ASX 200 – yearly average of daily change in index points (percent)



Source: CommSec Quantitative Research, Data to 31-March-2006



# Looking at the year-to-date



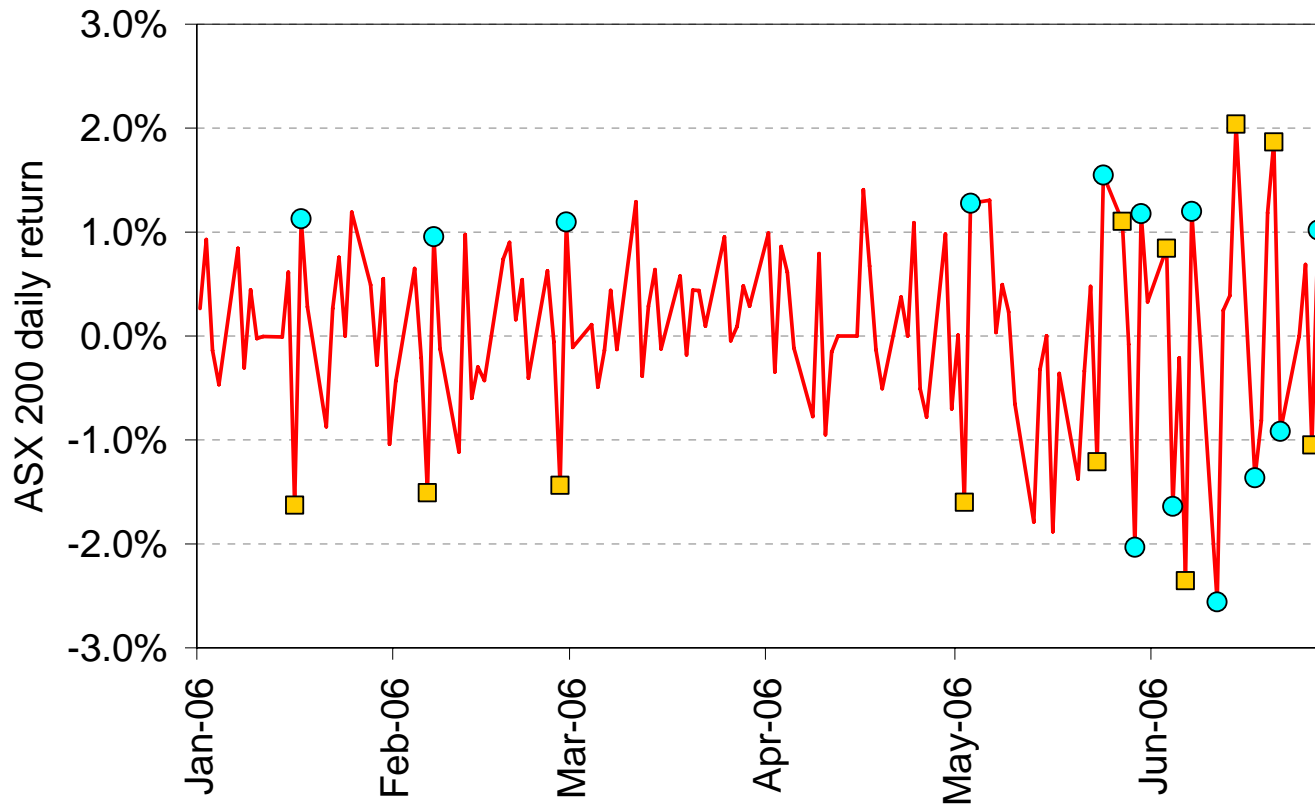
Source: CommSec Quantitative Research, Data to 31-August-2006



# What is a switchback?

- An unusually large increase or decrease followed by a correction over 1 or 2 days.
- For example, down 1.5% one day, up approximately 1.5% in the next day or two.
- Can be daily.
- Can be intra-daily.

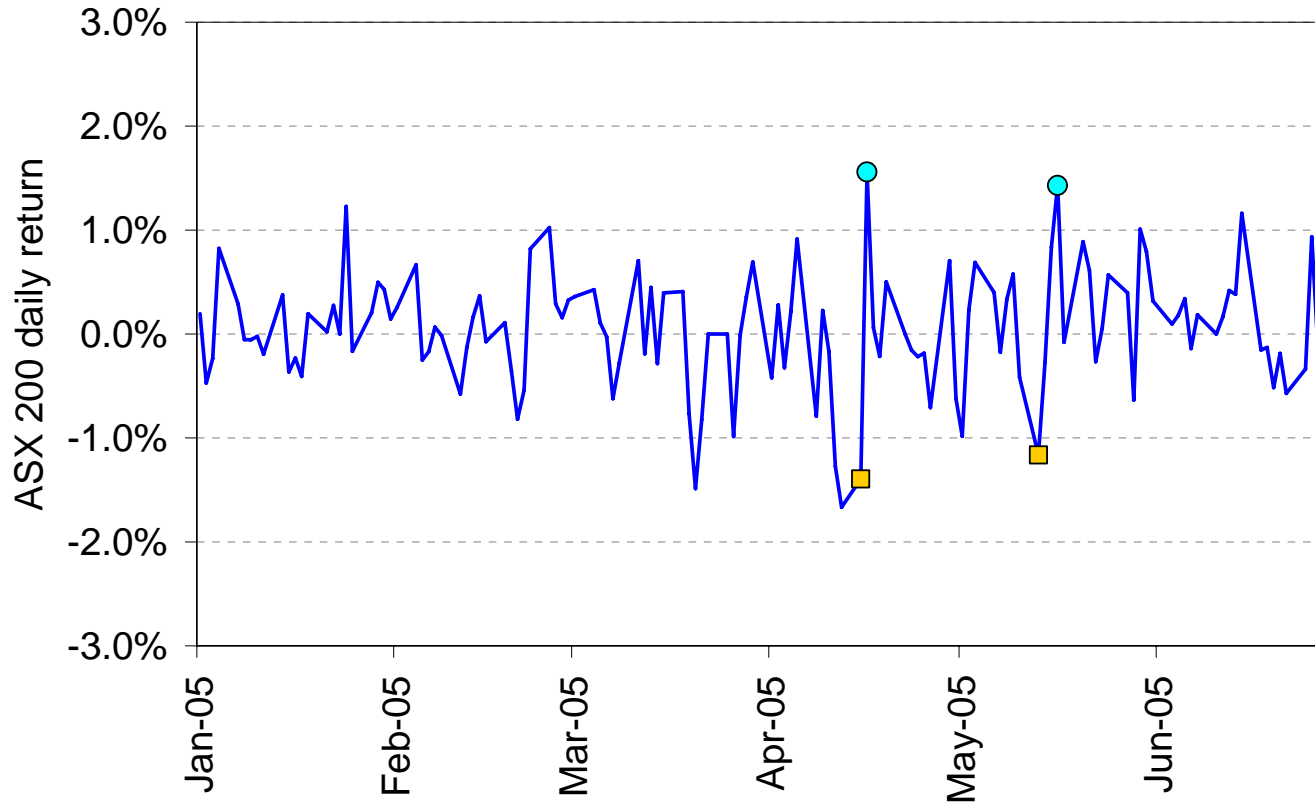
# ASX 200 daily returns: 14 switchbacks in the six months to 30 June 2006



Source: CommSec Quantitative Research, Data to 30-June-2006



# Compared to only 2 for the same period last year!



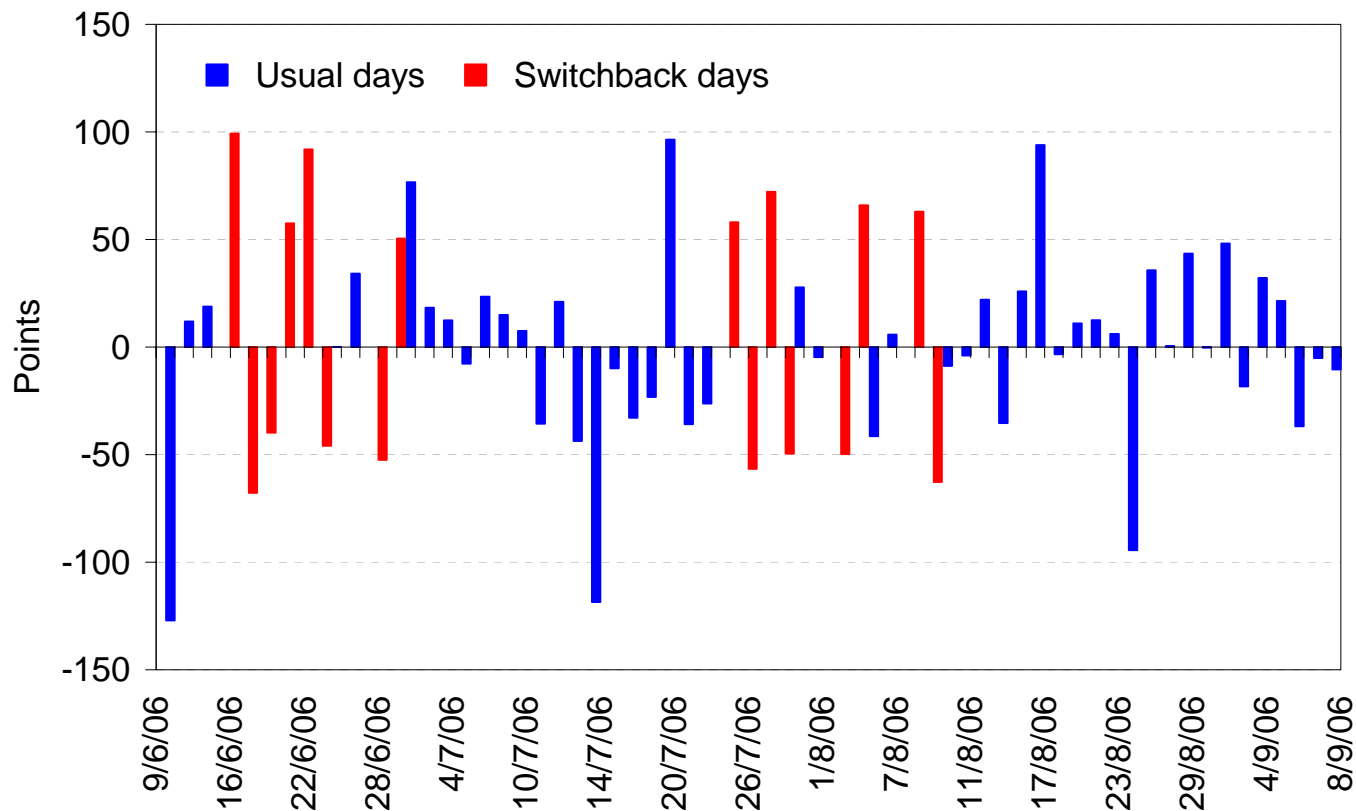
Source: CommSec Quantitative Research, Data to 30-June-2005



# 20 breaches of 50 pts – 6 not switchbacks



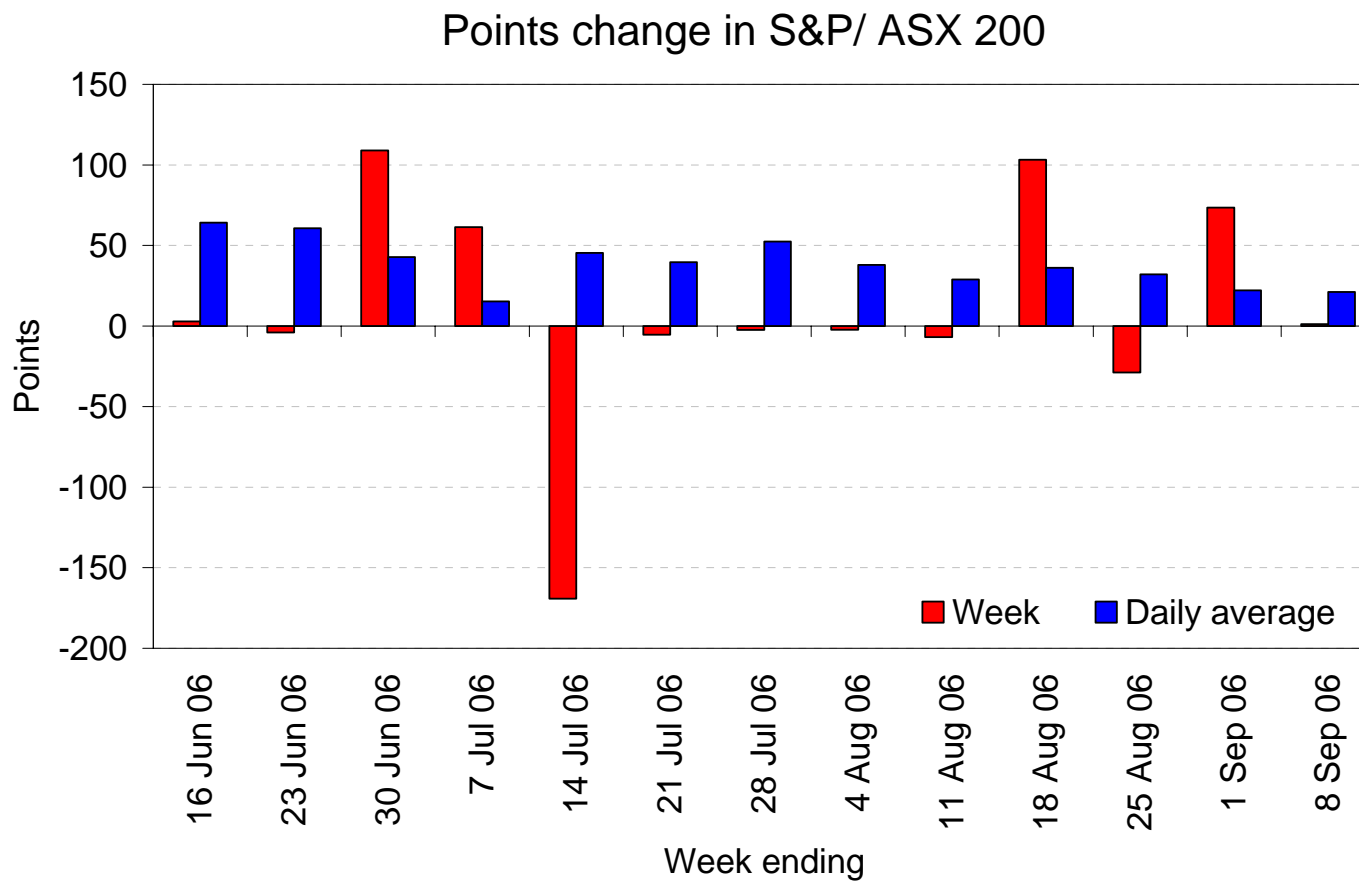
Switchbacks in S&P/ ASX 200



Source: CommSec Quantitative Research, Data to 8 September 2006



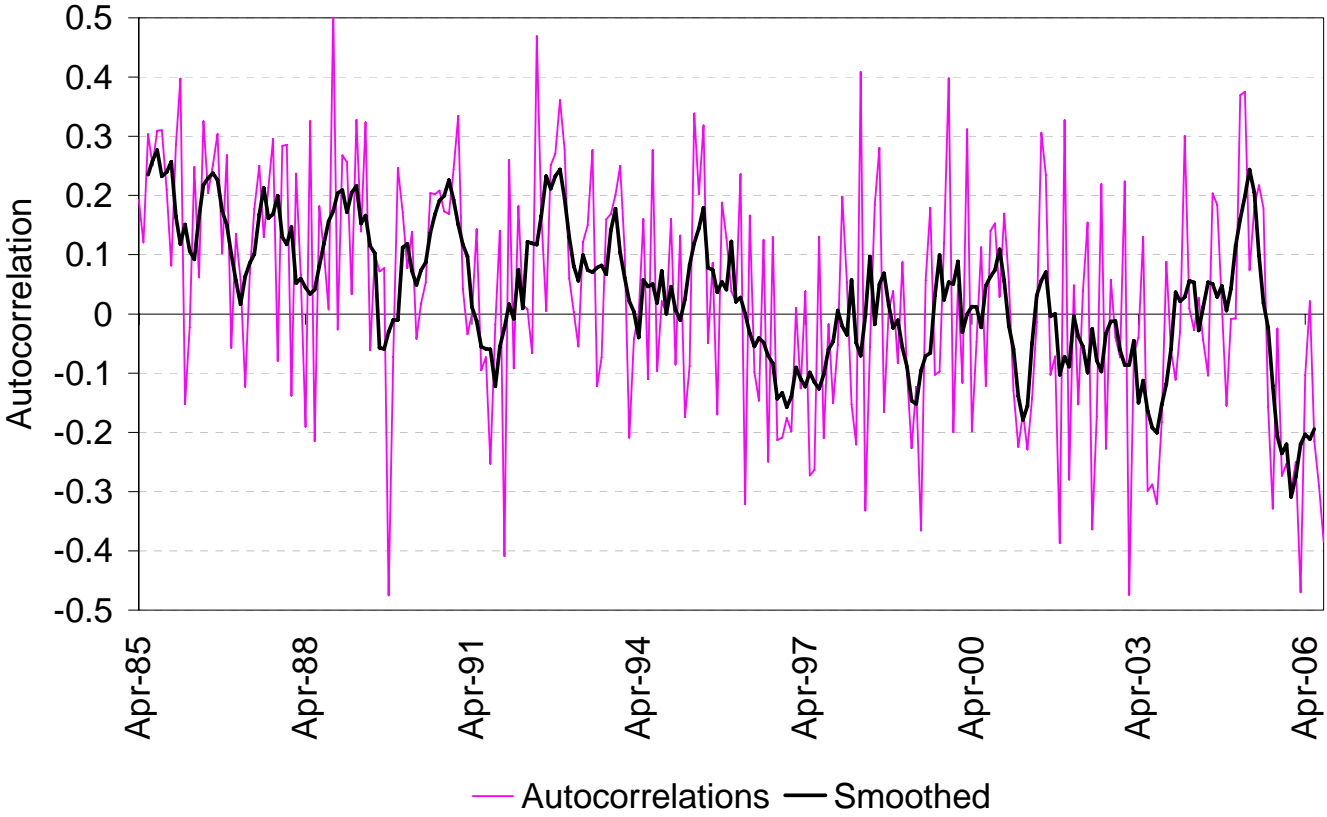
# Who stole the daily volatility?



Source: CommSec Quantitative Research, Data to 8 September 2006



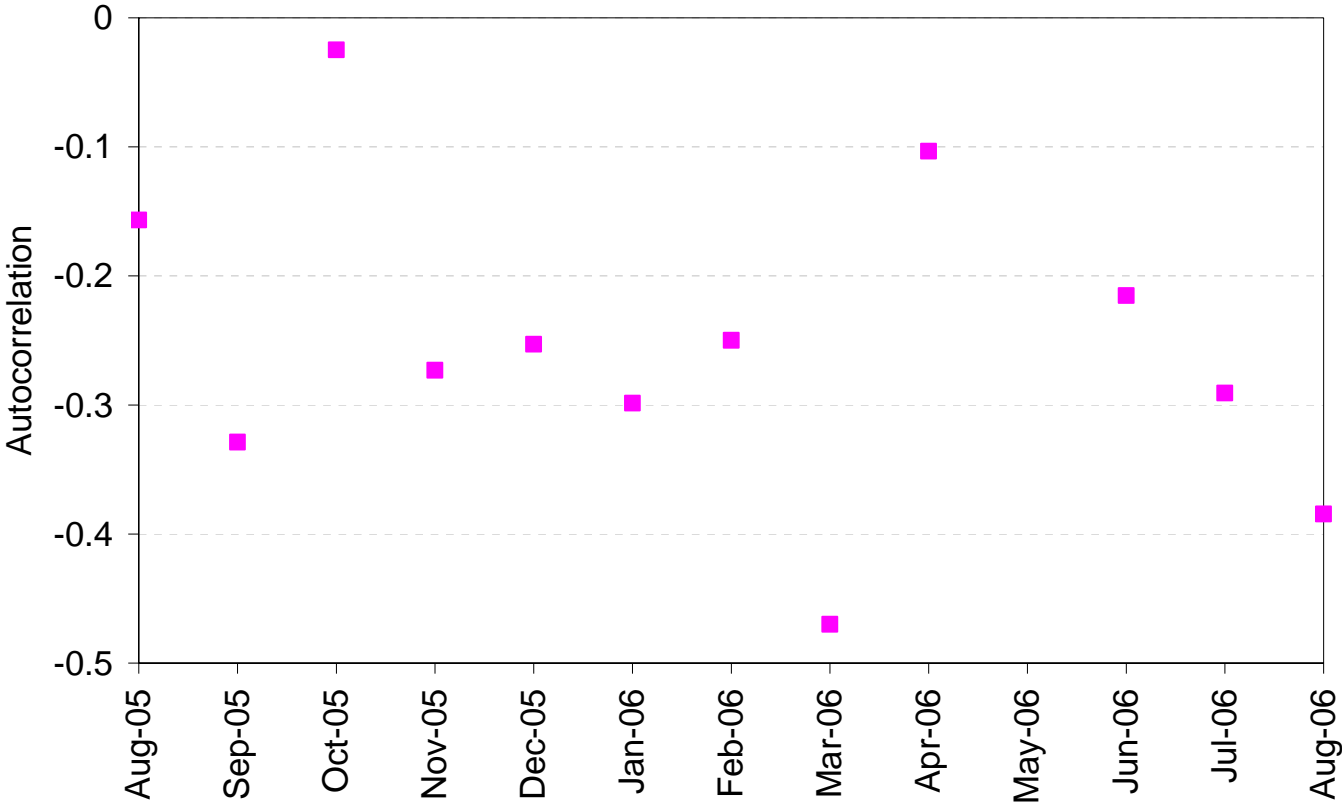
# Realised autocorrelations



Source: CommSec Quantitative Research. Data to 31 August 2006



# Recent autocorrelations



Source: CommSec Quantitative Research. Data to 31 August 2006



# Realised volatilities

- Can treat as data (eg use daily returns for monthly volatilities)
- No parameters to be assumed or estimated
- Can easily allow for breaks in levels
- Need to compensate for skewness
- Need to compensate for autocorrelation

# Autocorrelation example with quarterly returns

$$\begin{aligned}\text{Annual variance} &= E(r_1 + r_2 + r_3 + r_4)^2 && \text{where } r_i = \text{demeaned quarterly log return} \\ &= E(r_1^2) + E(r_2^2) + E(r_3^2) + E(r_4^2) + 2E(r_1r_2) + 2E(r_1r_3) \\ &\quad + 2E(r_1r_4) + 2E(r_2r_3) + 2E(r_2r_4) + 2E(r_3r_4) \\ &= 4\sigma^2 + 6\rho_1\sigma^2 + 4\rho_2\sigma^2 + 2\rho_3\sigma^2 \\ &= \sigma^2(4 + 6\rho_1 + 4\rho_2 + 2\rho_3)\end{aligned}$$

$$\text{Annual volatility} = \sigma\sqrt{4 + 6\rho_1 + 4\rho_2 + 2\rho_3}$$

If no 2<sup>nd</sup> or 3<sup>rd</sup> order autocorrelation:      Annual volatility =  $\sigma\sqrt{4 + 6\rho_1}$

And if no autocorrelation:      Annual volatility =  $\sigma\sqrt{4}$     i.e.  $\sigma\sqrt{T}$

# Dealing with autocorrelation

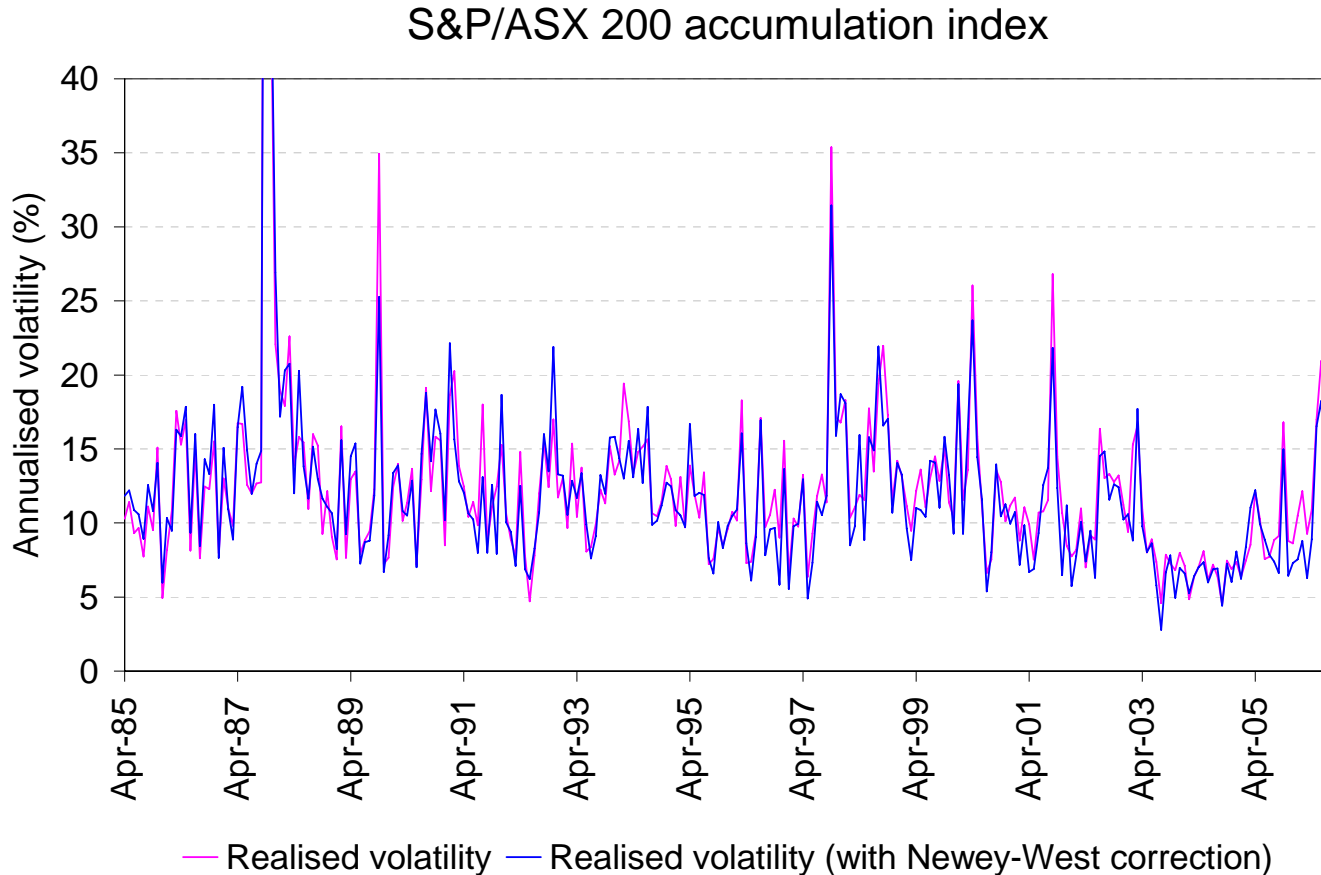


- Implication of autocorrelation:
  - Traditional annualising formula ( $\sigma\sqrt{T}$ ) is biased
  - Volatility understated when autocorrelation is high
  - Volatility overstated when autocorrelation is low
- We account for this autocorrelation by using a Newey - West correction in our realised volatility calculation.

# The Newey - West correction

- Non-parametric  $\Omega = \Sigma_0 + w_1(\Sigma_1 + \Sigma_1') + w_2(\Sigma_2 + \Sigma_2')$
- Allows for general non-specific forms of autocorrelation.
- When there is no autocorrelation the traditional formula is closely approximated.
- When there are switchbacks or positive autocorrelation we remove the bias.

# So how do our Newey - West corrected volatilities compare with the 'regular' realised volatilities



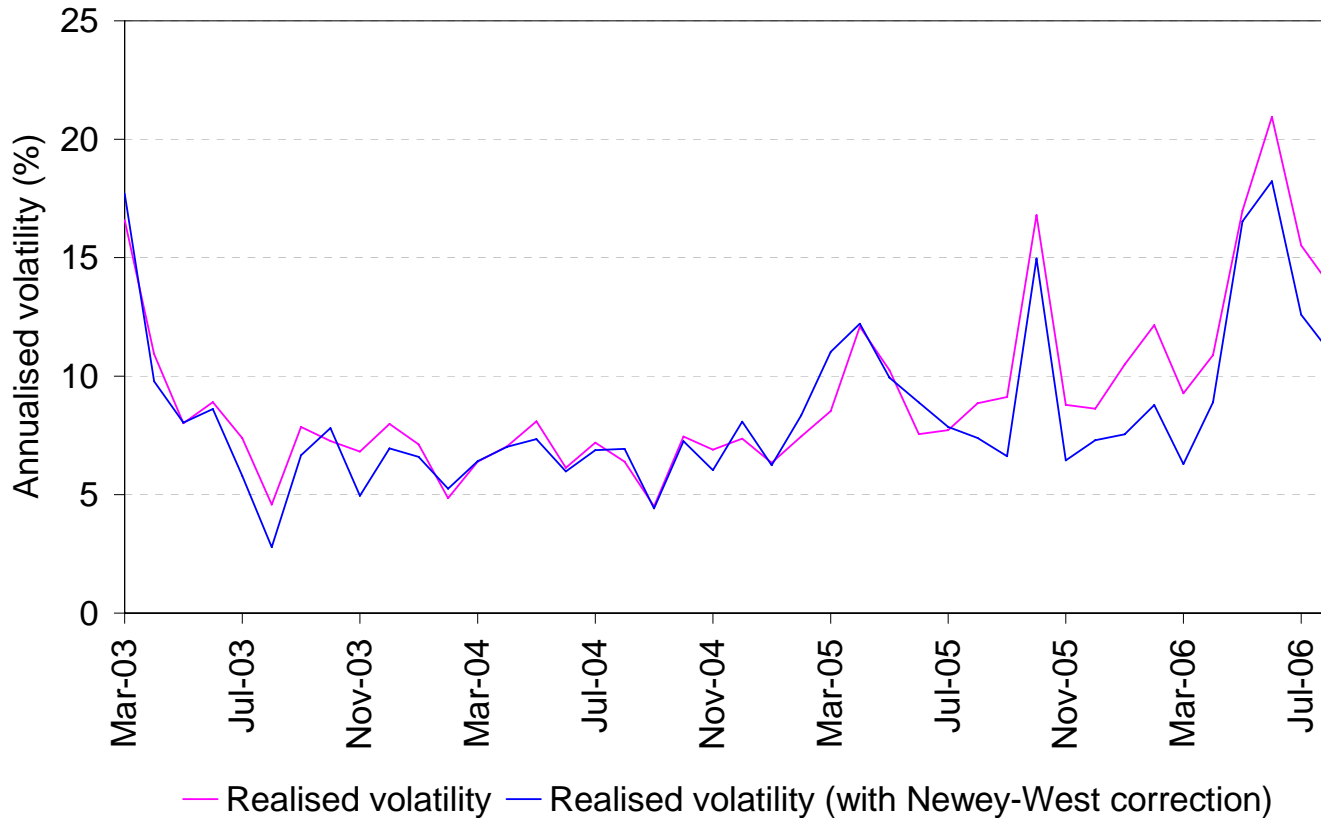
Source: CommSec Quantitative Research. Data to 31 August 2006



# ... and since March 2003



S&P/ASX 200 accumulation index



# Box-Cox transformation

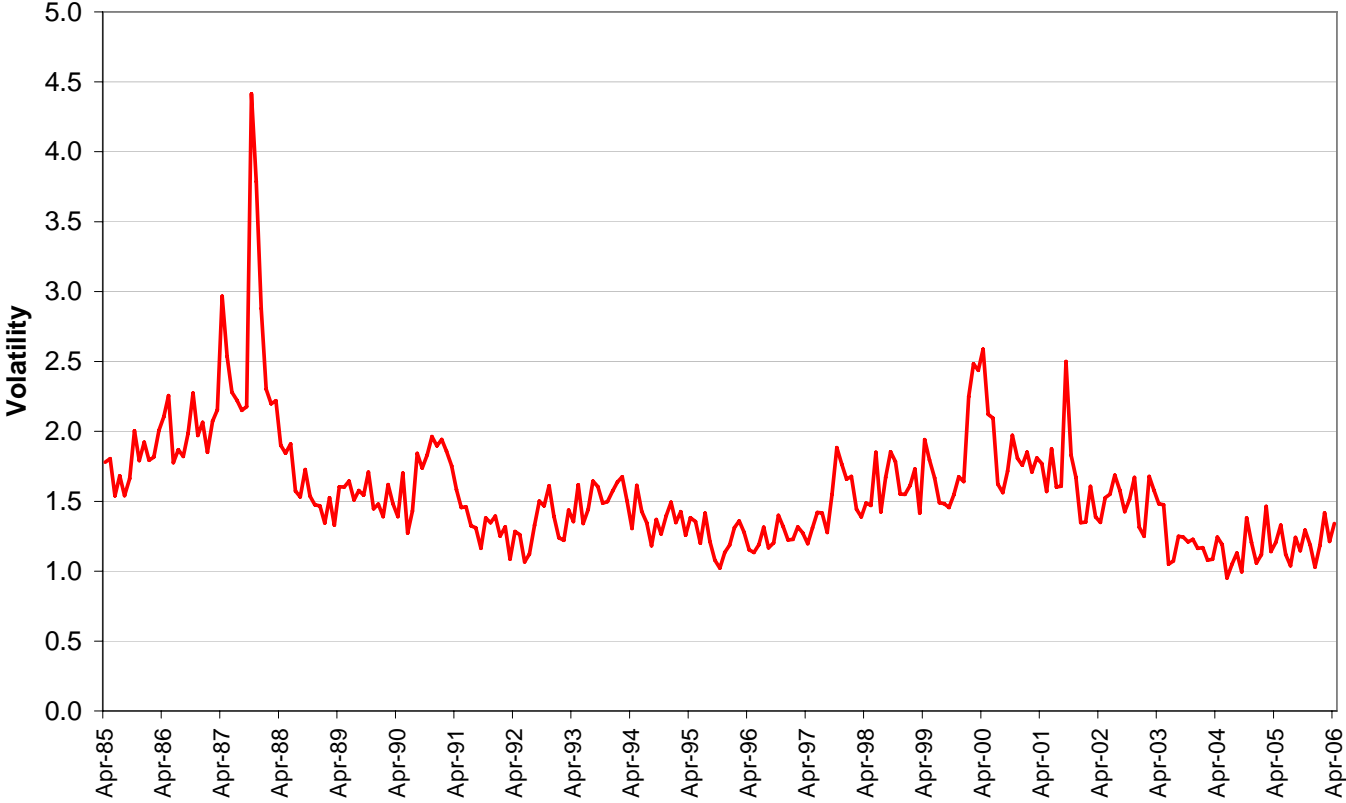
- Compensates for positive skew inherent in volatility data
- Logarithms and the data are special cases
- L'Hôspital's rule

$$x^{(\lambda)} = \frac{x^\lambda - 1}{\lambda} \quad \lambda \neq 0$$

$$x^{(\lambda)} = \ln(x) \quad \lambda = 0$$

- $\lambda$  is the Box-Cox parameter to be estimated and  $x^{(\lambda)}$  is the transformed variable.

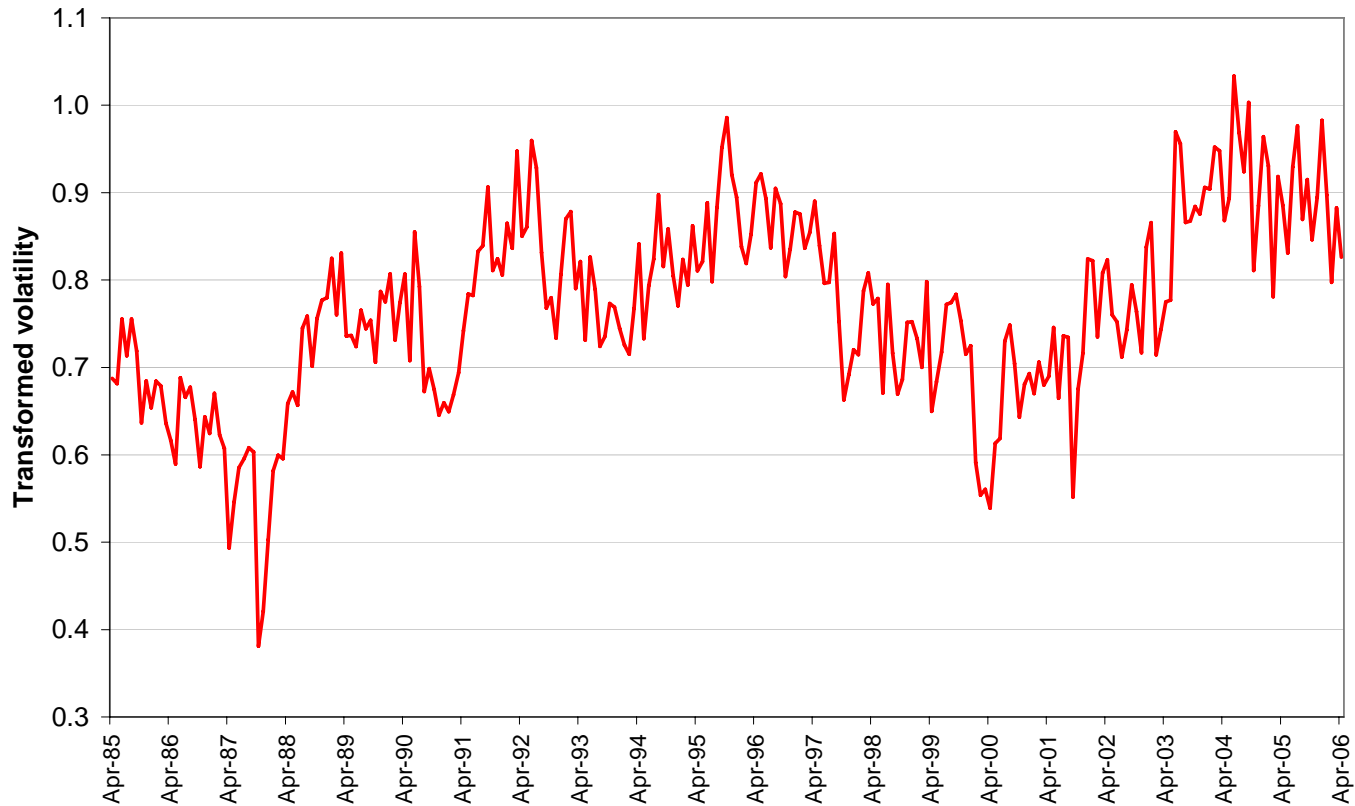
# Cross-sectional volatility



Source: CommSec Quantitative Research



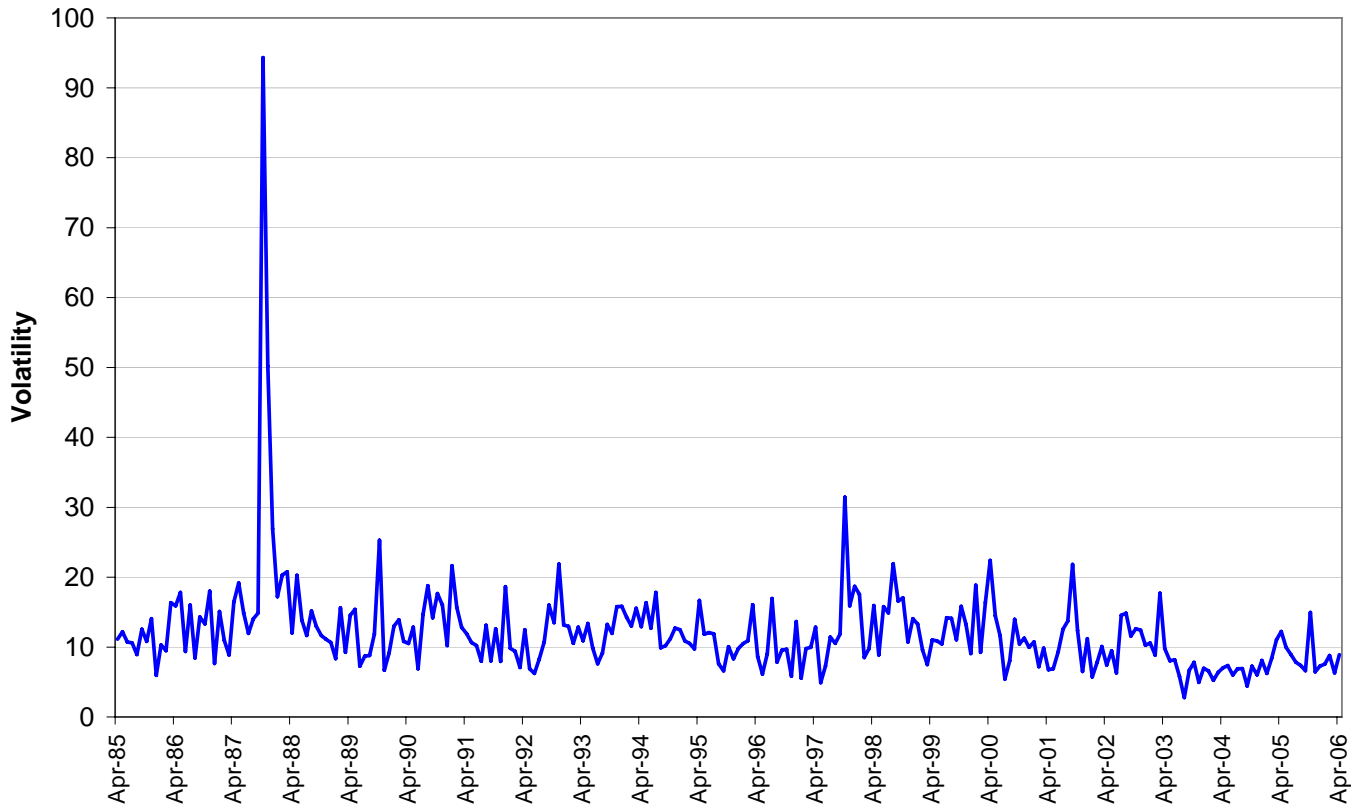
# Transformed cross-sectional volatility



Source: CommSec Quantitative Research



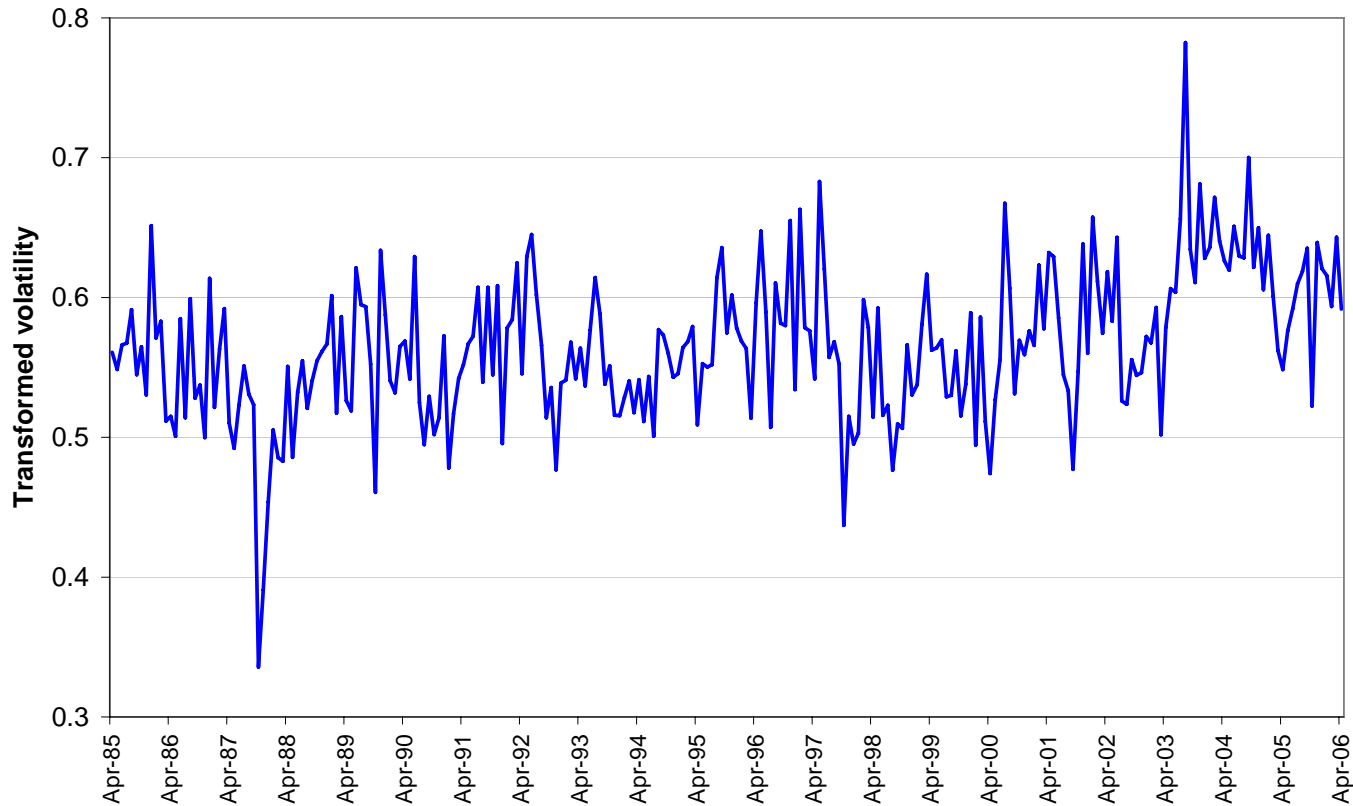
# Time-series volatility



Source: CommSec Quantitative Research



# Transformed time-series volatility



Source: CommSec Quantitative Research

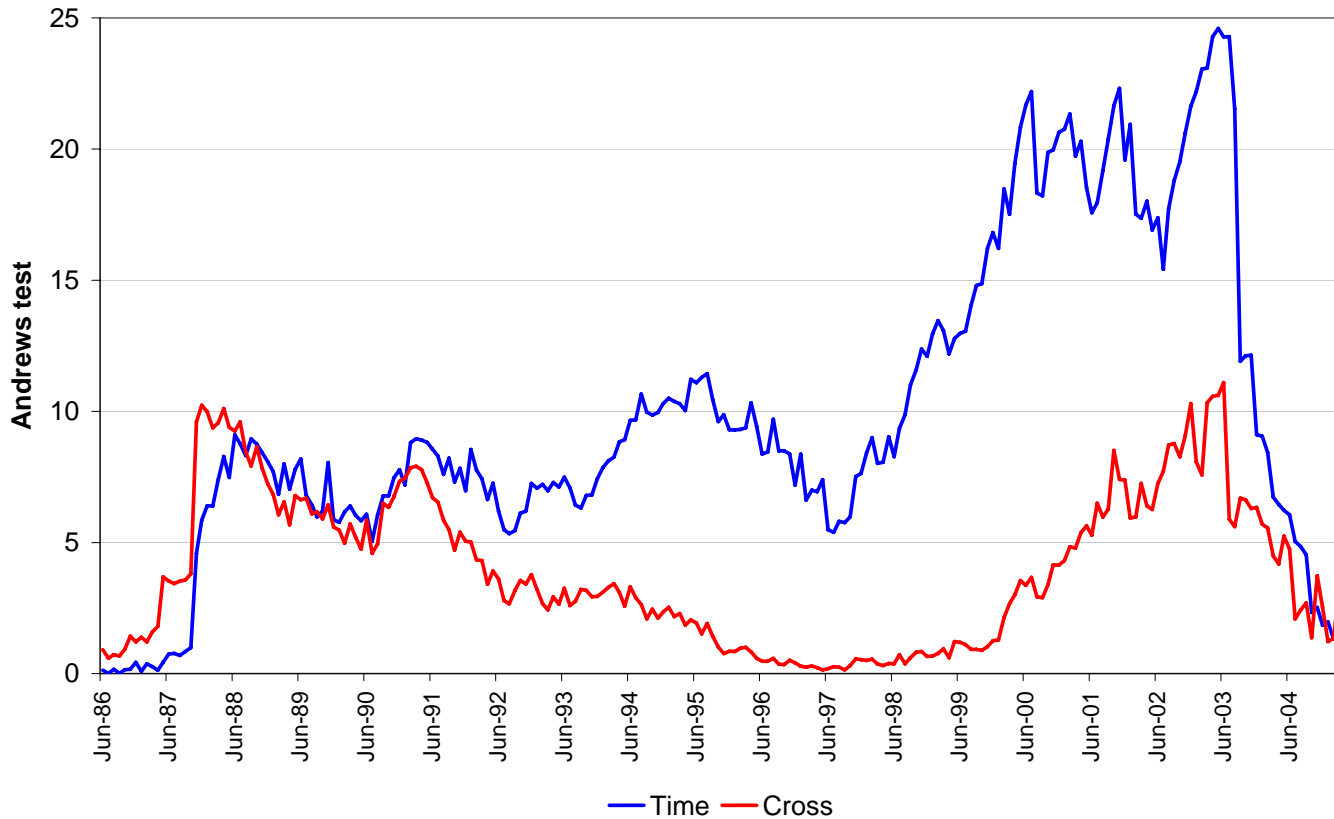


# Andrews' tests for stability

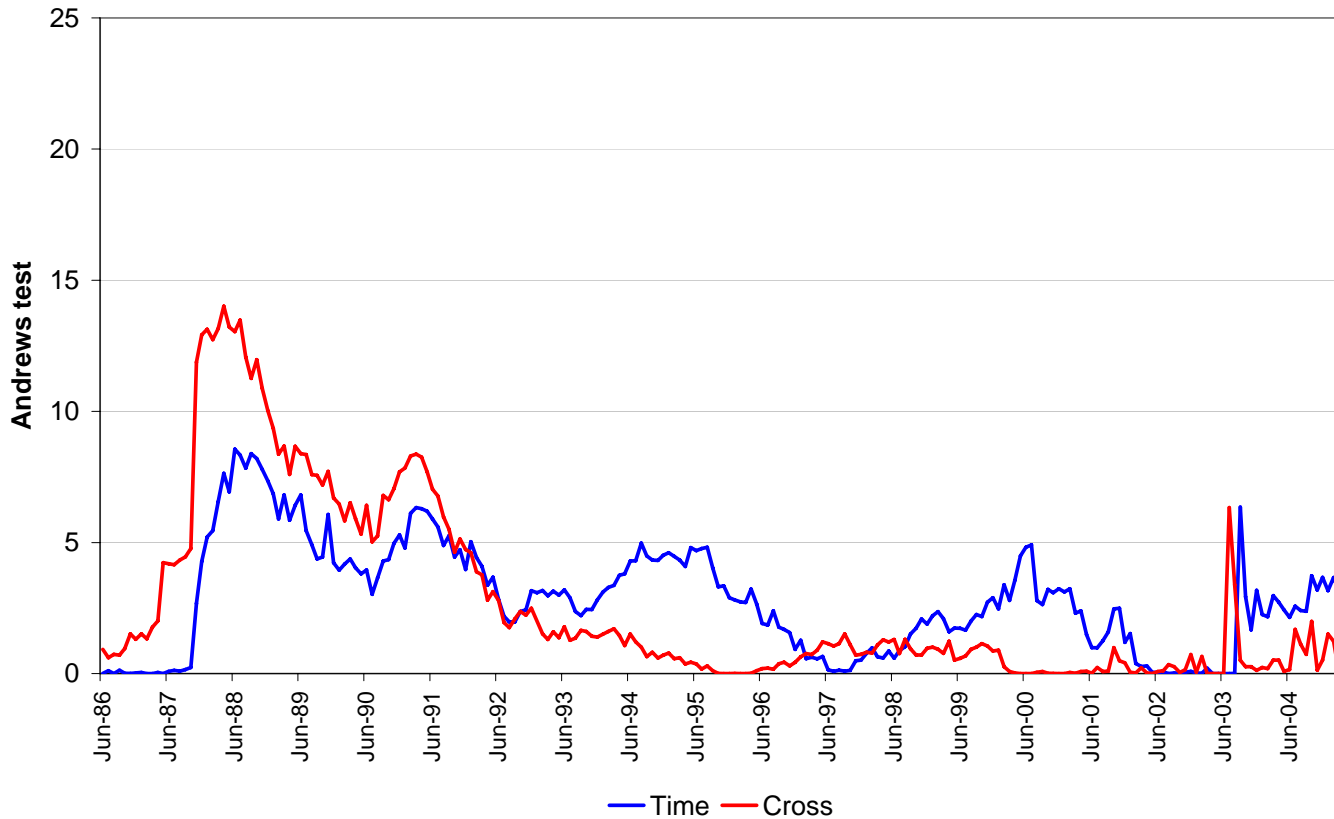
$$y_t^\lambda = \beta_0 + \sum_{i=1}^n \beta_i y_{t-i}^\lambda + \gamma D_t + \varepsilon_t$$

- Trim 5% of data
- C.V. first test = 9.8
- C.V. increases with each subsequent test

# Testing for first break – single equations



# Testing for second break – single equations



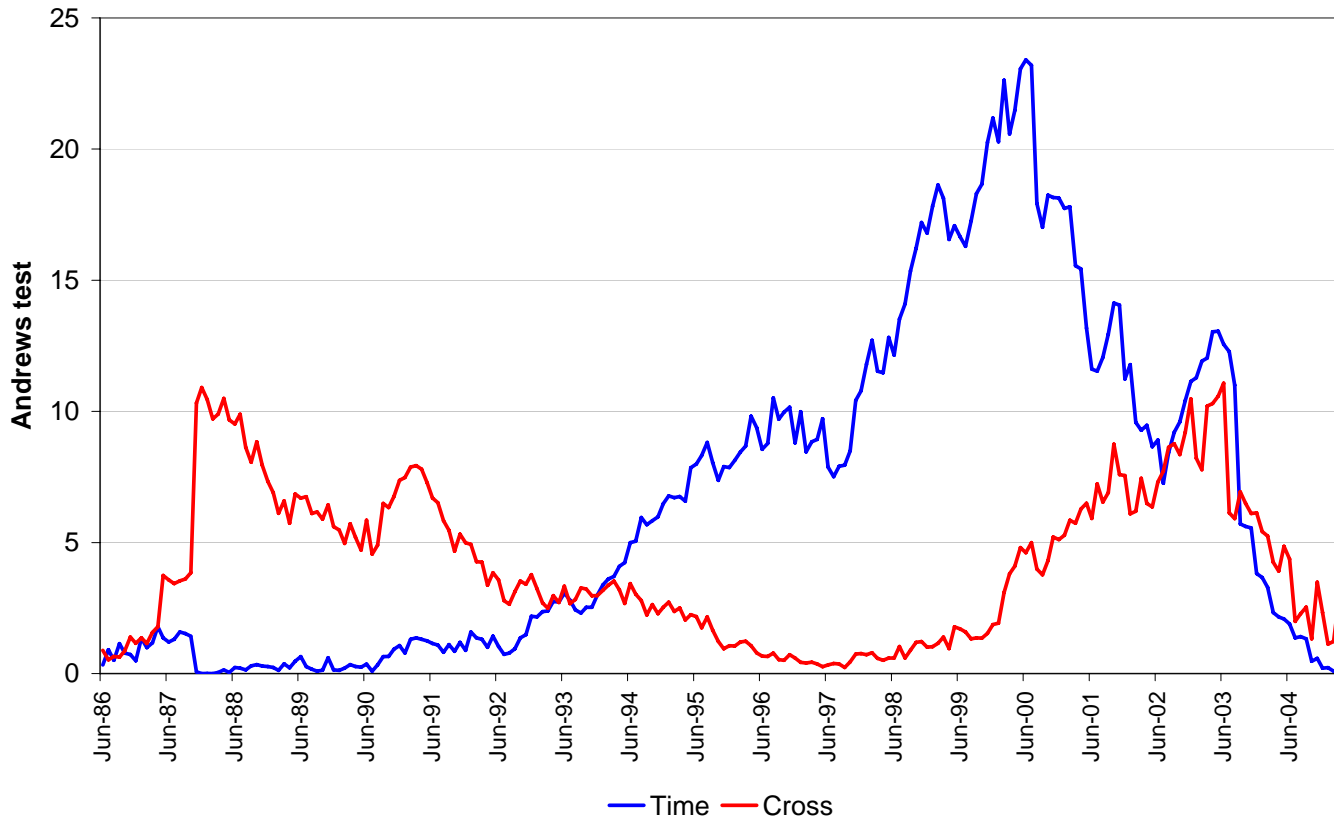
Source: CommSec Quantitative Research



## Andrews' tests - system

$$x_t^{\lambda_1} = \alpha_0 + \sum_{i=1}^n \alpha_i x_{t-i}^{\lambda_1} + \sum_{i=1}^n \delta_i y_{t-i}^{\lambda_2} + \gamma_1 \mathbf{D}_{1t} + e_t$$
$$y_t^{\lambda_2} = \beta_0 + \sum_{i=1}^n \pi_i x_{t-i}^{\lambda_1} + \sum_{i=1}^n \beta_i y_{t-i}^{\lambda_2} + \gamma_2 \mathbf{D}_{2t} + \varepsilon_t$$

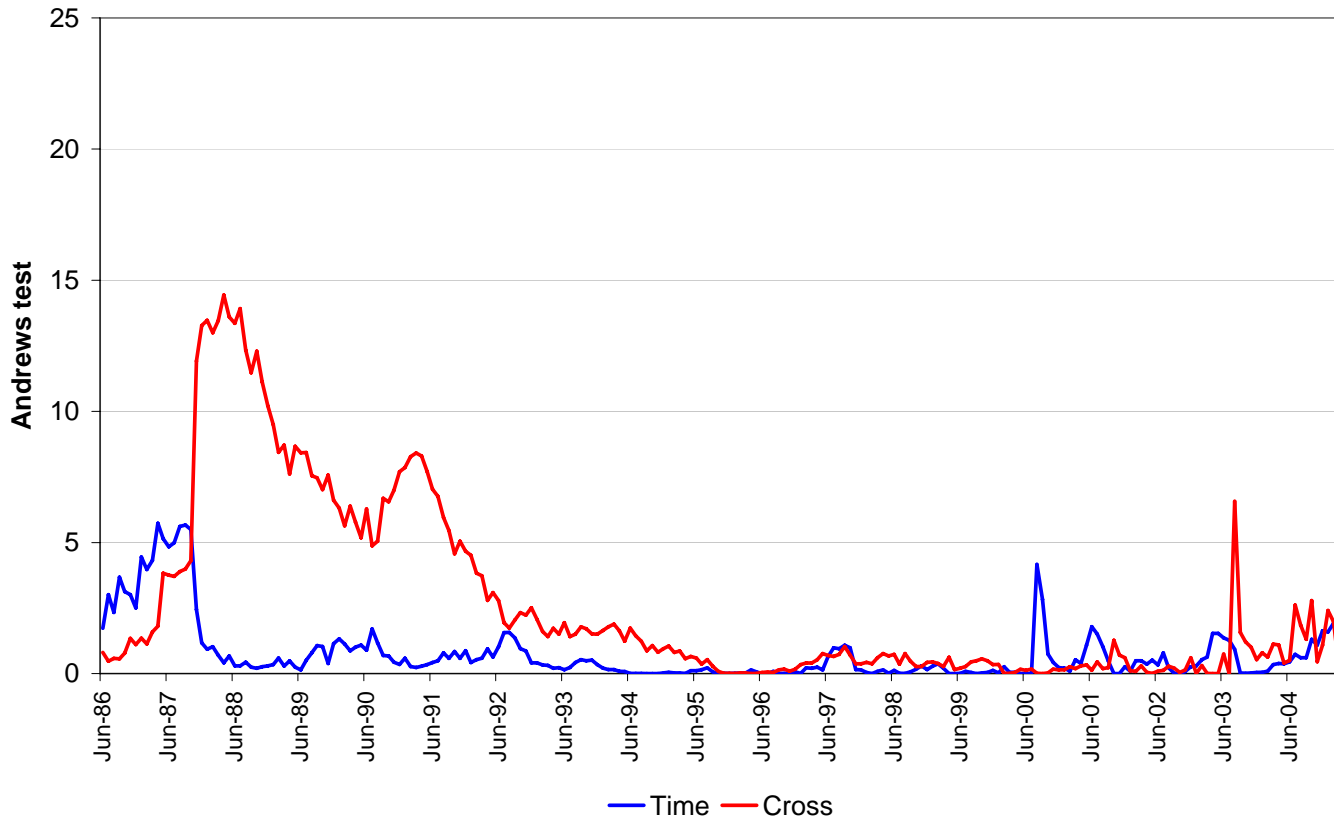
# Testing for first break – system



Source: CommSec Quantitative Research



# Testing for second break – system



Source: CommSec Quantitative Research



# Equation estimates

Equation	Time-series		Cross-section	
	Coef	t-ratio	Coef	t-ratio
Constant	0.4746	3.07	0.3312	5.07
Lambda	-0.1711	2.35	-0.5016	2.96
Time-series (-1)**L1	0.1019	1.27	-0.0626	0.60
Cross-section (-1)**L2	0.1770	2.16	0.6884	12.33
Dummy: June 2000	-0.0300	3.10		
Dummy: June 2003			-0.0336	2.46
Dummy: April 1988			-0.4619	3.00

# Causality

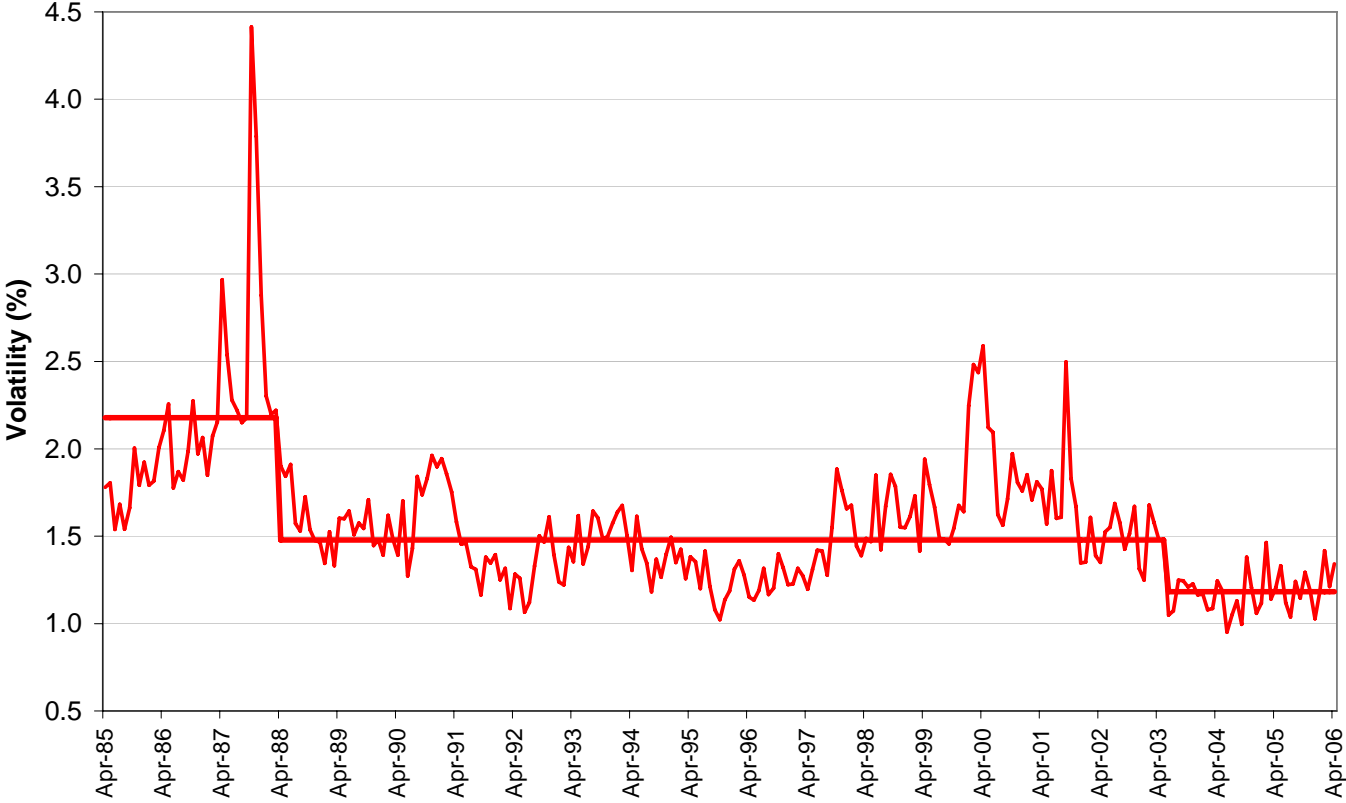
- Time-series volatility does not cause cross-sectional volatility
- Time-series volatility does not cause time-series volatility
- Cross-sectional volatility causes time-series volatility
- Cross-sectional volatility causes cross-sectional volatility
- Co-breaking occurs at June 2003

# Final model



Equation	Time-series		Cross-section	
	Coef	t-ratio	Coef	t-ratio
Constant	0.4950	2.68	0.3069	7.21
Lambda	-0.1850	3.32	-0.5034	3.20
Time-series (-1)**L1				
Cross-section (-1)**L2	0.2130	2.87	0.6660	13.98
Dummy: June 2000	-0.0347	3.69		
Dummy: June 2003			-0.3258	2.51
Dummy: April 1988			-0.0487	3.35

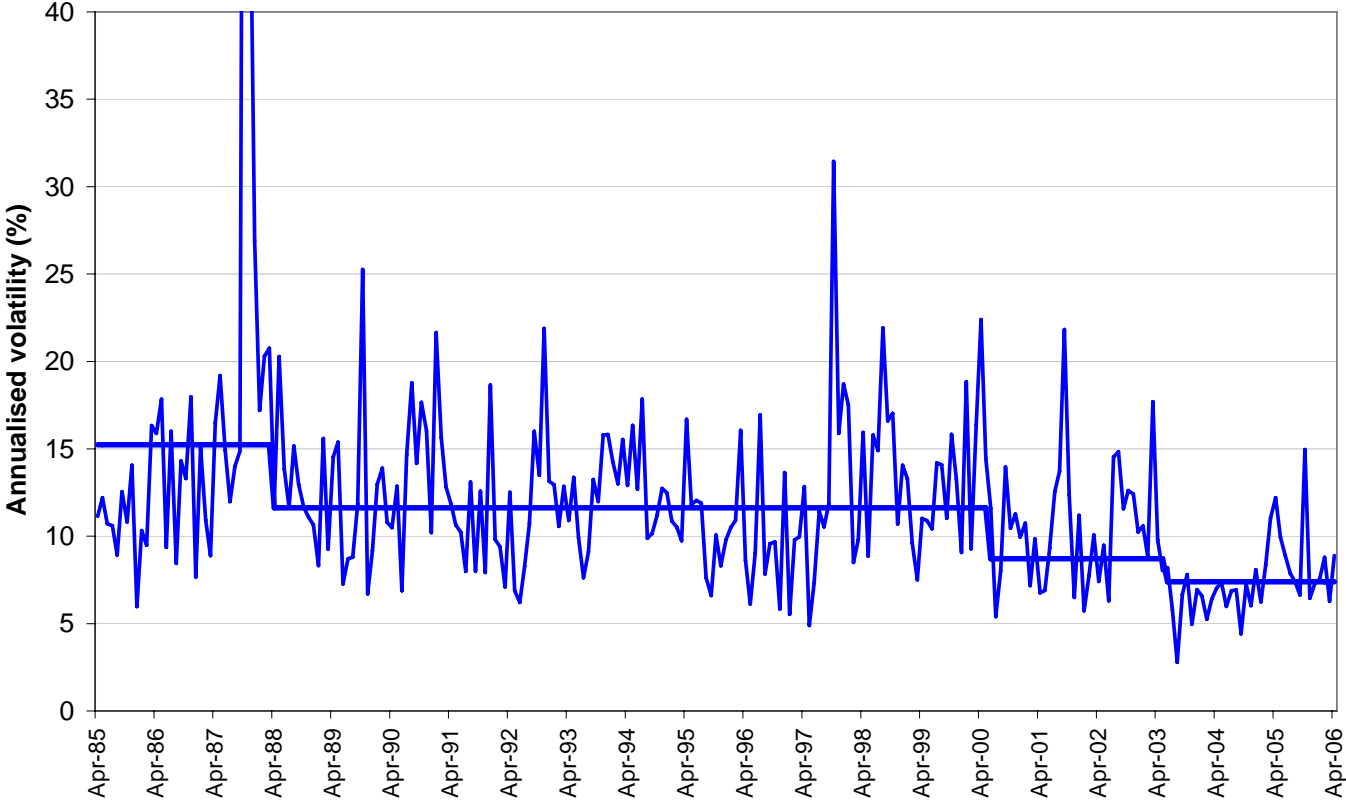
# Equilibrium levels of cross-sectional volatility



Source: CommSec Quantitative Research



# Equilibrium levels of times-series volatility



Source: CommSec Quantitative Research

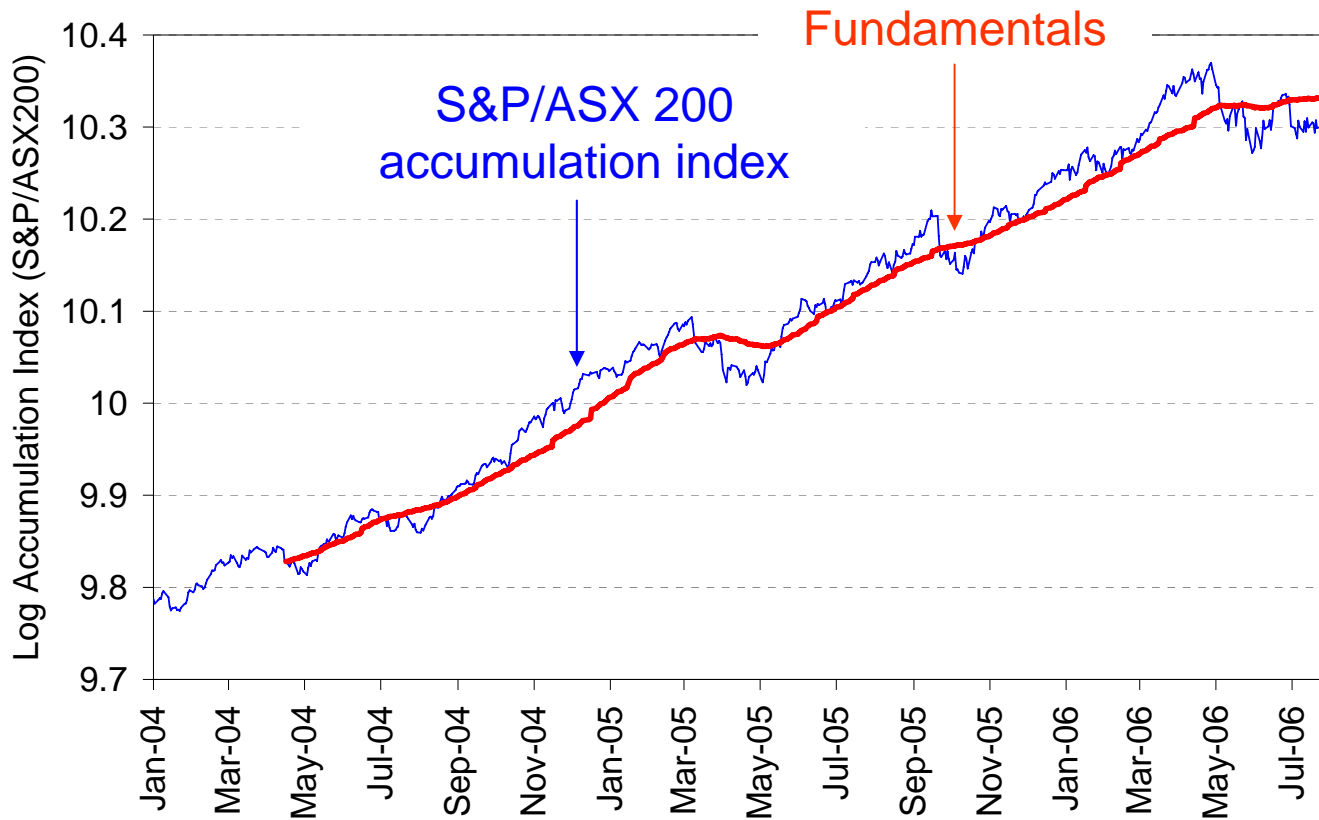


# Conclusions



- Logs inappropriate
- Independence not supported (market inefficiency)
- Unidirectional causality
- Recent time series fall in long-run vol 'explained' by fall in cross-sectional vol
- But what do we do with this information?

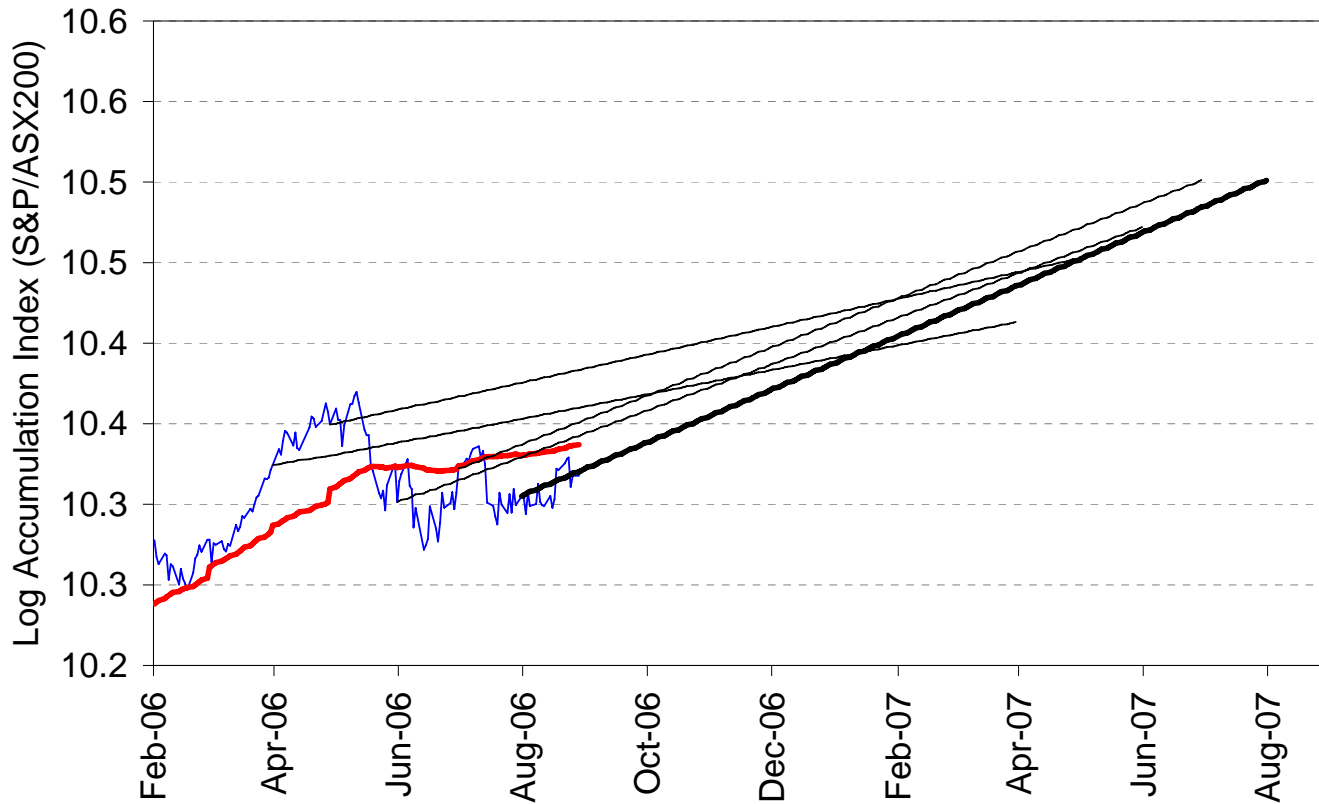
# Industry Quarterly forecasts used to determine market fundamentals



Source: CommSec Quantitative Research, Reuter's Knowledge, Data to 15 August 2006



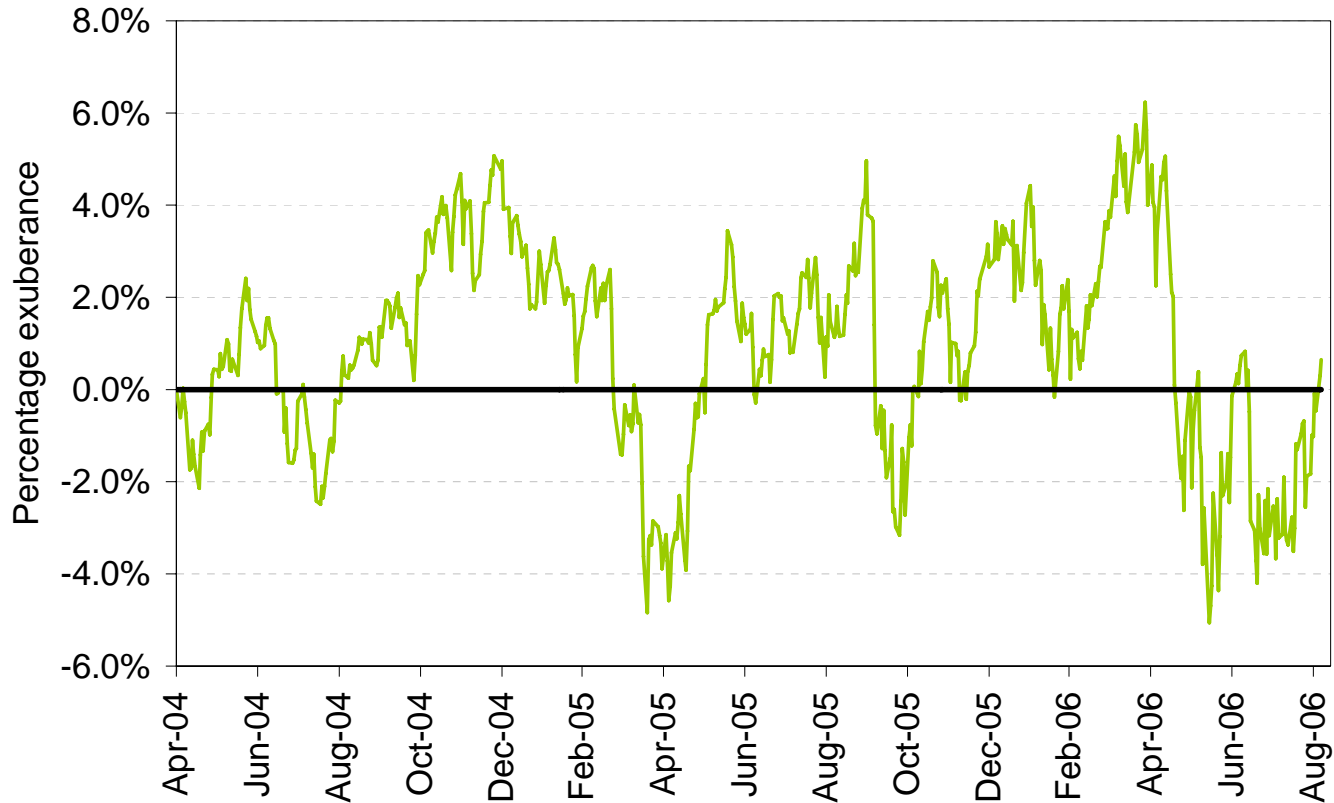
# Looking to the future ...



Source: CommSec Quantitative Research, Reuter's Knowledge, Data to 15 August 2006



# From our fundamentals we now have the “Exuberance Monitor” – ASX 200 index



Source: CommSec Quantitative Research, Reuter's Knowledge, Data to 5 September 2006



# To drag it out!



- If expected volatility is low and expected returns are high – gear up and hard
- Trade off switchbacks – but very risky
- Trade off exuberance
- Monitor volatility and returns

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