

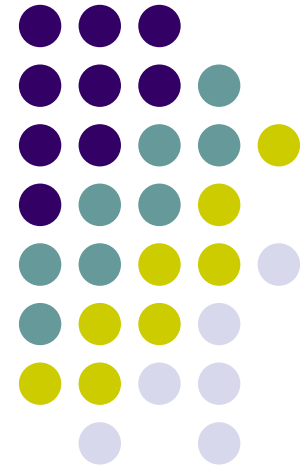
# *EQUITY PORTFOLIO RISK (VOLATILITY) ESTIMATION USING MARKET INFORMATION AND SENTIMENT*

Leela Mitra

Co-authors: Gautam Mitra and  
Dan diBartolomeo



Sponsored by:





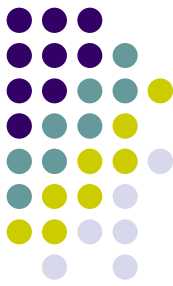
# *Outline*

- Introduction and background
- Problem setting
- Model description
- Updating the model using quantified news
- Study I
- Study II
- Discussion and conclusions



# *Introduction & background*

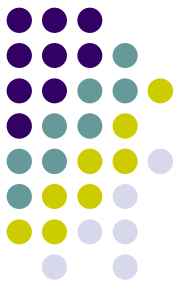
- Relationship between information release (news) and volatility widely reported
  - Ederington & Lee (1993) macro economic announcements and foreign exchange and interest rate futures
  - Stock message board activity is a good predictor of volatility  
Antweiler & Frank (2004); Wysocki (1999); Das & Chen (2007)
  - GARCH model with news inputs  
Kalev et al. (2004); Robertson, Geva & Wolff (2007)



# *Introduction & background*

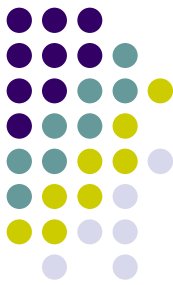
- Factor models
  - Decompose an asset's return into
    - Return derived from exposure to common factors
    - An asset specific component
  - Method also results in consistent variance estimates ... assets influenced by similar factors will have similar variances
  - In contrast to computing sample asset variances the method is efficient and accurate

# *Introduction & background*



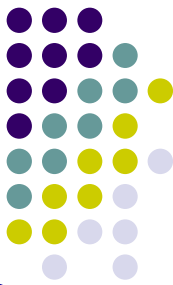
- Factor models
  - Risk estimation problem is reduced...
    - Estimates of *factor* variances and covariances now needed

# *Introduction and background*

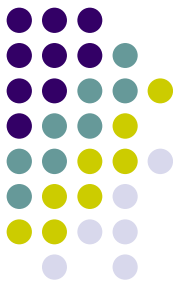


- Active portfolio manager seeks to incorporate investment insight to “beat” the market
- Accurate (good) description of asset price uncertainty is key
- Perceptions of riskiness determined by investors knowledge about company and operating environment ... “information sets” .

# *Introduction & background*



- Tetlock et al. (2007) note there are three main sources of information
  - Analyst forecasts
  - Publicly disclosed accounting variables
  - Linguistic descriptions of operating environments
- If first two are incomplete third may give us relevant information
- Tetlock et al. (2007) introduce “news” to a fundamental factor model



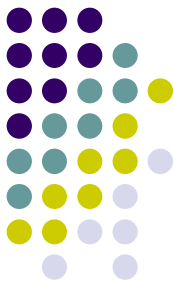
# *Outline*

- Introduction and background
- Problem setting
- Model description
- Updating the model using quantified news
- Study I
- Study II
- Discussion and conclusions



# *Problem setting*

- Three main types of factor models
  - Macroeconomic – use economic variables as factors (Chen, Ross and Roll; Sharpe)
  - Fundamental – use firm specific (cross-sectional) attributes (BARRA and Fama-French)
  - Statistical – factors are unobservable and derived via calibration, often orthogonal.
- Differ on sources of risk (uncertainty); can be shown to be rotations of each other.



# *Problem setting*

- Ability of models to update risk structure as environment changes
  - All models are single period, based on independent, identically distributed distributions
  - Do not directly allow for changing levels of volatility over time



# *Problem setting*

- Need for models to update risk structure as environment changes
  - GARCH/ARCH models account for time varying volatility
    - Not directly linked to market sentiment
    - Can be difficult to incorporate for a large number of assets
      - BARRA use GARCH processes to model factors
    - Can display counter-intuitive behaviour in relation to news (earnings announcements)



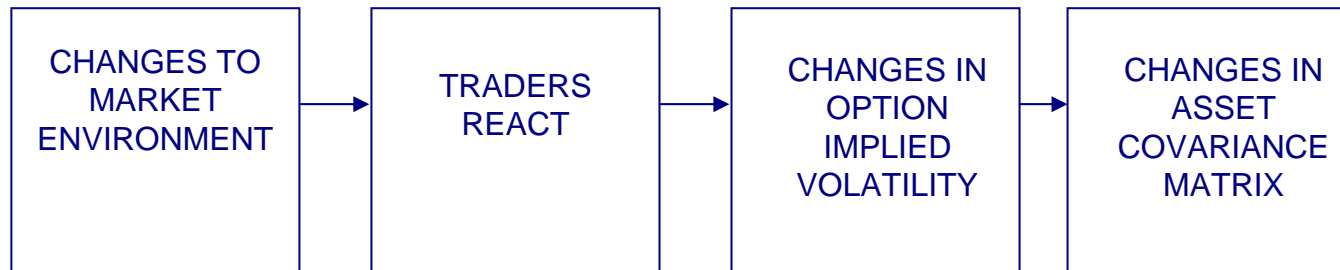
# *Problem setting*

- Need for models to update risk structure as environment changes
  - Levels of risk can change *rapidly* over time as market participants react to new information as market conditions change
  - Models are re-calibrated over time but update slowly to changes

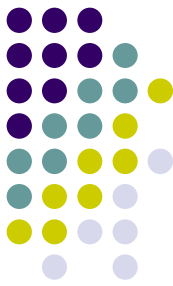


# *Problem setting*

- Need for models to update risk structure as environment changes
- diBartolomeo and Warrick update covariance estimates using option implied volatility

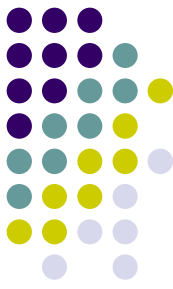


- Traders respond quickly in an intelligent fashion



# *Outline*

- Introduction and background
- Problem setting
- Model description
- Updating the model using quantified news
- Study I
- Study II
- Discussion and conclusions



# *Model description*

- Slightly modified version of diBartolomeo & Warrick(2005)
- In two parts
  - “Basic” statistical factor model
  - Factor variance estimates are updated for changes in option implied volatility



# *Model description*

- We construct a statistical factor model using principal component analysis to find orthogonal factors

$$V_{kt} = \sum_{i=1}^F \beta_{kit}^2 \sigma_{it}^2 + \sigma_{s(k)t}^2$$

- Update the asset variances using option implied volatility data

$$V_{lt}^* = V_{lt} M_{lt}$$

$$M_{lt} = \left[ \prod_{r=0}^{w-1} \frac{I_{l t-r}}{I_{l t-r-1}} \right] \div \left[ \prod_{r=0}^{w-1} \frac{V_{l t-r}}{V_{l t-r-1}} \right]$$



# *Model description*

- For each asset for which we have option implied volatility data

$$V_{lt}^* = \sum \beta_{lit}^2 (\sigma_{it}^*)^2 + \sigma_{s(\ell)t}^2$$

- We wish to identify the *new factor variances*  $(\sigma_{it}^*)^2$  and *asset specific variances* -  $\sigma_{s(\ell)t}^2$

implied by updated asset variances

- Solve this set of simultaneous equations to derive the values, subject to some further conditions



# *Model description*

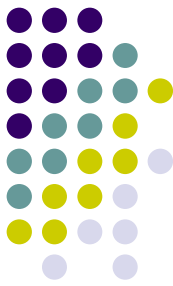
- Further conditions
  - Allow for structure that is expected of principal component factors

$$(\sigma_{it}^*)^2 \geq (\sigma_{i-1t}^*)^2$$

- Assume factor variances do not decline substantially from one period to the next

$$(\sigma_{it}^*)^2 \geq p_1 (\sigma_{it-1}^*)^2$$

- Similarly assume asset specific variances do not decline substantially from one period to the next



# *Outline*

- Introduction and background
- Problem setting
- Model description
- Updating model using quantified news
- Study I
- Study II
- Discussion and conclusions

# *Updating model using quantified news*

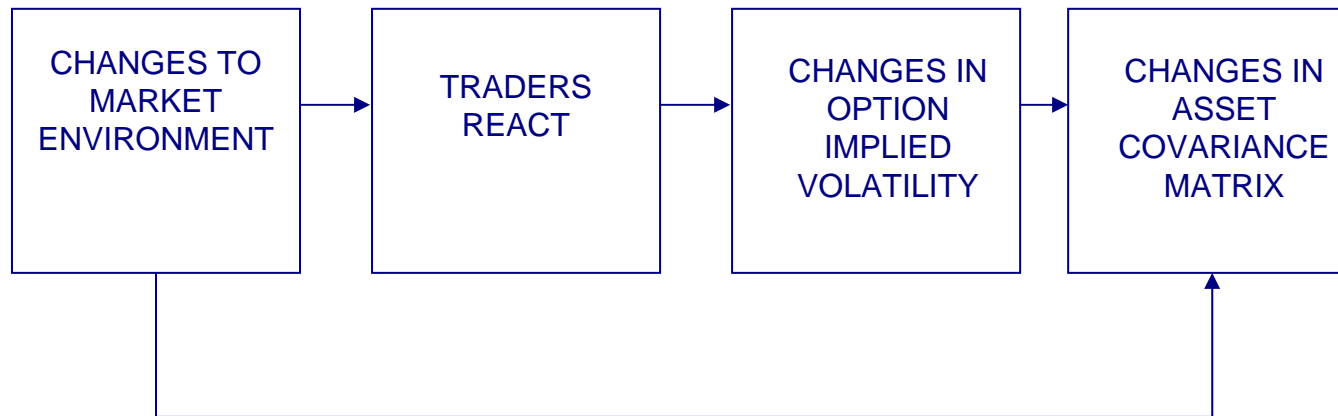


- Strong yet complex relationship between market sentiment and news
- To incorporate news (qualitative data) to models need quantitative data
- RavenPack have developed linguistic analytics which process textual input of news to determine quantitative scores
- Scores for EURO STOXX 50 and Dow Jones 30 companies
  - based on stories relating to the company and the industry it operates in
  - classification of stories as POSITIVE, NEGATIVE or NEUTRAL

# Updating model using quantified news



- We extend diBartolomeo & Warrick's model to incorporate quantified news



# Updating model using quantified news



- The score  $a_{nt}$  measures the market sentiment about company  $n$  at time  $t$ 
  - If the score varies significantly over time this indicates market belief about the company is changing quickly indicating rising volatility of the stock
- $b_{nt}$  the variance of the score over a day

# Updating model using quantified news



- $S_{nt} = \sum_{r=0}^6 b_n t-r$  cumulative sum of variance of

score over the last 7 days

- Company may be in news a lot and have large changes in sentiment
- It may then become “old” news, however, its volatility is likely to still be high
- Cumulating allows us to account for this

# Updating model using quantified news



- We introduce an adjustment factor based on the changes in cumulative sentiment variance

$$M_{nt}^S = \left[ \prod_{r=0}^{w-1} \frac{S_{n \ t-r}}{S_{n \ t-r-1}} \right] \div \left[ \prod_{r=0}^{w-1} \frac{V_{n \ t-r}}{V_{n \ t-r-1}} \right]$$

- We wish to identify the **new factor variances**  $(^N \sigma_i^*)^2$  and **asset specific variances**  $(^N \sigma_{s(l)}^*)^2$  implied by updated asset variances
- Solve this set of simultaneous equations to derive the values, subject to some further conditions

# Updating model using quantified news



- We can use updated factor variances and asset specific variances from option implied data

$$({}^O\sigma_i^*)^2 \quad ({}^O\sigma_{s(l)}^*)^2$$

- We can use updated factor variances and asset specific variances from news sentiment data

$$({}^N\sigma_i^*)^2 \quad ({}^N\sigma_{s(l)}^*)^2$$

# Updating model using quantified news



- We can use **both** sources of information to derive a combined update for factor variances and asset specific variances

$$({}^C \sigma_i^*)^2 = q({}^O \sigma_i^*)^2 + (1 - q)({}^N \sigma_i^*)^2$$

$$({}^C \sigma_{s(l)}^*)^2 = q({}^O \sigma_{s(l)}^*)^2 + (1 - q)({}^N \sigma_{s(l)}^*)^2$$

$$0 \leq q \leq 1$$



# *Outline*

- Introduction and background
- Problem setting
- Model description
- Updating model using quantified news
- Study I
- Study II
- Discussion and conclusions



# *Study I*

- Period 17 January 2008 to 23 January 2008
  - Market sentiment worsened
  - Option implied volatility measures surged
  - Few key events
    - Large interest rate cut
    - George Bush announced stimulus plan
    - Soc Gen hit by Jerome Kerviel rogue trader scandal



# *Study I*

- On 21 January 2008 sharp decline in non-US stock markets
  - Reasonable to assume stock volatility rose on this date
- Consider the variance of portfolio of finance stocks weighted by market capitalisation

# Study I



Table 1: Volatility of portfolio of EURO STOXX 50 finance stocks

Dates	Volatility under “basic” statistical model	Volatility under model updated by option implied volatility (q=1)	Volatility under model updated by option implied volatility and market sentiment (q=0.5)	Volatility under model updated by market sentiment (q=0)
17 1 2008	19.065	19.130	20.853	22.430
18 1 2008	19.032	21.564	21.619	21.625
21 1 2008	19.319	26.575	28.845	30.845
22 1 2008	21.187	26.759	28.911	30.829
23 1 2008	21.453	26.212	27.869	29.370

- Portfolio volatility from option implied model
  - is higher than “basic” model
  - rises significantly on 21 January

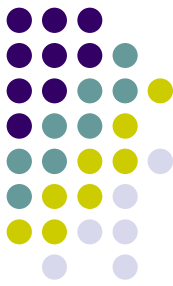


# Study I

Table 1: Volatility of portfolio of EURO STOXX 50 finance stocks

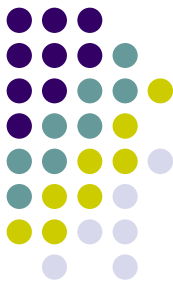
Dates	Volatility under “basic” statistical model	Volatility under model updated by option implied volatility (q=1)	Volatility under model updated by option implied volatility and market sentiment (q=0.5)	Volatility under model updated by market sentiment (q=0)
17 1 2008	19.065	19.130	20.853	22.430
18 1 2008	19.032	21.564	21.619	21.625
21 1 2008	19.319	26.575	28.845	30.845
22 1 2008	21.187	26.759	28.911	30.829
23 1 2008	21.453	26.212	27.869	29.370

- Portfolio volatility from market sentiment (news) model
  - is higher than both of the others
  - Rises earlier than the option implied model... could indicate the model is picking up increased volatility at an earlier date and could act as a “early” indication or warning that volatility is rising



# *Outline*

- Introduction and background
- Problem setting
- Model description
- Updating model using quantified news
- Study I
- Study II
- Discussion and conclusions



## *Study II*

- Over 2008 markets fell
  - Loss of liquidity in credit markets and banking system
  - Many banks suffered bankruptcy or propped up
- September and October 2008 – Volatility for financial firms particularly high
  - Lehman Bankruptcy
  - Lloyds takeover of HBOS
  - Restrictions on short selling of financials



## *Study II*

- 18 September 2008 to 24 September 2008
  - Portfolio of three finance stocks
    - Bank of America, CitiGroup and JP Morgan Chase
    - Equal weight on each stock
  - Portfolio of three non-finance stocks
    - Johnson & Johnson, Kraft Foods and Coca Cola
    - Equal weight on each stock
  - Can the model predict impact in one sector...?

# Study II

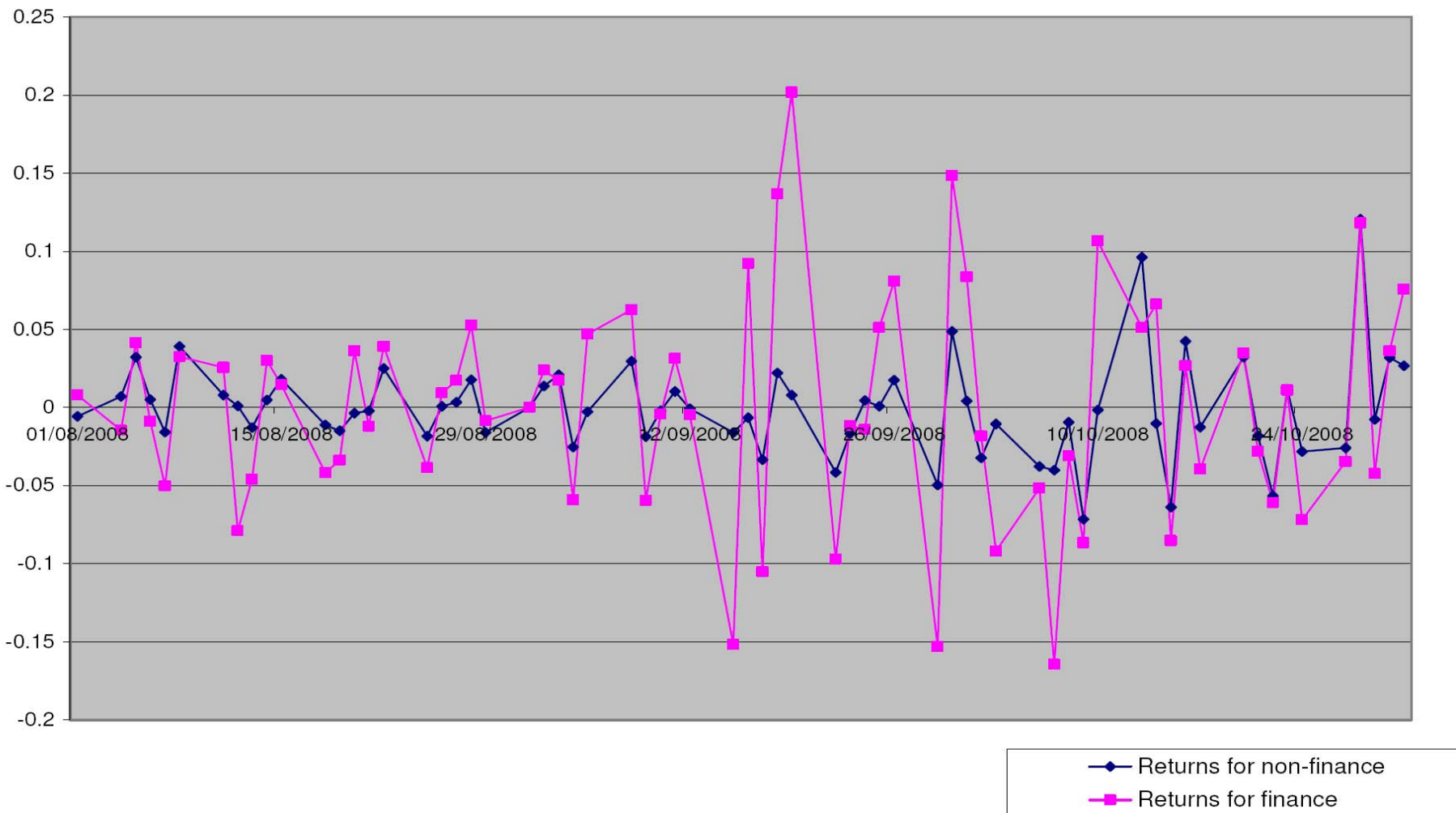


Figure 1: Returns for finance and non-finance portfolio over August to October 2008

# Study II



Table 2: Volatility of portfolio of Dow Jones 30 finance stocks

Dates	Volatility under “basic” statistical model	Volatility under model updated by option implied volatility (q=1)	Volatility under model updated by option implied volatility and market sentiment (q=0.5)	Volatility under model updated by market sentiment (q=0)
18 9 2008	56.031	71.023	70.326	69.622
19 9 2008	57.949	67.770	72.765	77.439
22 9 2008	61.719	66.302	71.014	75.433
23 9 2008	62.270	62.766	67.557	72.030
24 9 2008	62.279	59.531	63.968	68.118

Table 3: Volatility of portfolio of Dow Jones 30 non-finance stocks

Dates	Volatility under “basic” statistical model	Volatility under model updated by option implied volatility (q=1)	Volatility under model updated by option implied volatility and market sentiment (q=0.5)	Volatility under model updated by market sentiment (q=0)
18 9 2008	13.751	15.474	15.274	15.196
19 9 2008	13.912	14.907	15.392	16.214
22 9 2008	13.935	15.109	15.819	15.933
23 9 2008	14.316	15.159	16.593	16.709
24 9 2008	14.360	14.169	16.021	16.443



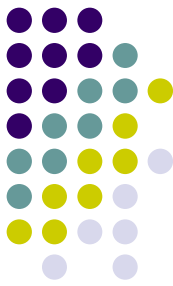
## *Study II*

- Higher volatility estimate for finance portfolio to “basic” model
  - When updated using option implied data
  - When updated using sentiment data
- Finance volatility has risen significantly more than non-finance volatility



## *Study II*

- Differences in volatility estimate
  - When updated using option implied data
  - When updated using sentiment data



## *Study II*

- Complex nature of news and the way it impacts markets
  - Study and scores based on relative volume of negative and positive news items
  - Do not account for how different news items may impact volatility differently
- Though estimates differ there could be value in using a variety of sources of information when updating risk estimates



# *Outline*

- Introduction and background
- Problem setting
- Model description
- Updating model using quantified news
- Study I
- Study II
- Discussion and conclusions



## *Discussion and conclusion*

- Multifactor models are often used as a tool to describe portfolio risk
- Naturally risk is dependent on the market environment and investor sentiment
- Traditional factor models fail to update as conditions change
- We have addressed problem of making short term risk estimates sensitive to changes in the market environment and investor sentiment



# *Discussion and conclusion*

- We have seen that both option implied volatility and quantified news can provide a way to update these models
- Strong yet complex relationship between market sentiment and news
- May be value in using a variety of sources of information when updating risk estimates
- Frequent crises in markets remind us investors should be attentive to short term fluctuations in markets



# References

- **Antweiler & Frank 2004**

Is All That Talk Just Noise? The Information Content of Stock Message Boards

*Journal of Finance* 59(3)

- **diBartolomeo & Warrick 2005**

“Making covariance based portfolio risk models sensitive to the rate at which markets reflect new information ”

Ch12 in *Linear Factor models* Edited. Knight, J. & Satchell, S. Elsevier Finance

- **Das & Chen 2007**

Yahoo! for Amazon: Sentiment Extraction from Small Talk on the Web

*MANAGEMENT SCIENCE* 53: 1375-1388

- **Ederington & Lee, 1993**

How markets process information: News releases and volatility

*Journal of Finance* 48 p. 1161—1191



# References

- **Kalev, Liu, Pham, & Jarnecic 2004**  
Public Information Arrival and Volatility of Intraday Stock Returns  
*Journal of Banking and Finance* 28(6): 1441-1467
- **Robertson, Geva & Wolff 2007**  
News aware volatility forecasting: Is the content of news important?  
*Proceedings of the sixth Australasian conference on Data mining and analytics* 70 : 161--170
- **Tetlock, Saar-Tsechansky, & Macskassy 2007**  
"More Than Words: Quantifying Language to Measure Firms' Fundamentals"  
*Journal of Finance*
- **Wysocki 1999**  
Cheap Talk on the Web: The Determinants of Postings on Stock Message Boards  
*Working Paper No. 98025 University of Michigan*