DID THE MARKET MOVE FOR YOU? ARTIFICIAL INTELLIGENCE & FINANCIAL AND COMMODITY TRADING

Professor Khurshid Ahmad, Professor of Computer Science, Trinity College Dublin

Webinar

Friday, 26 March 2021, 15:00 GMT

A Word From Today's Chairman

Professor Michael Mainelli

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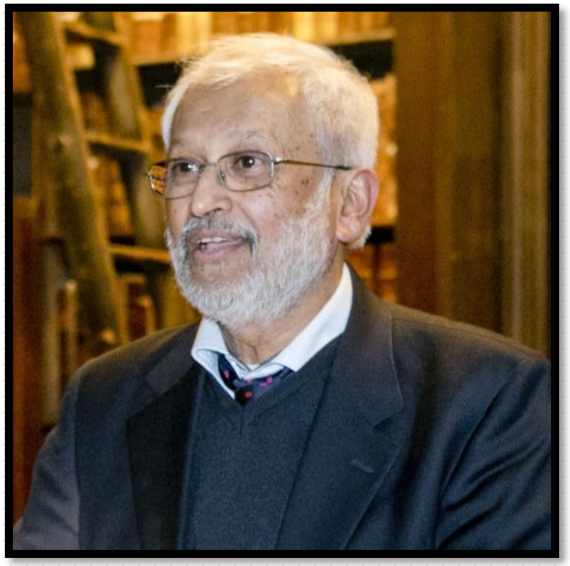
Today's Agenda

- 15:00 – 15:05 Chairman's Introduction
- 15:05 – 15:25 Keynote Address - Professor Khurshid Ahmad
- 15:25 – 15:45 Questions & Answers

Today's Speaker



Professor Khurshid Ahmad

Professor of Computer Science

Trinity College Dublin

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Did The Market Move For You?

Artificial Intelligence & Financial and Commodity Trading

Khurshid Ahmad
Professor of Computer Science,
School of Computer Science & Statistics

March 2021 @ FS Club, London

Affect, Emotion, and Market Movement

Market inputs: Prices, Sentiment – in text, in speech, in facial expressions

Take home keywords:

- Behavioural Finance = Simulated emotional intelligence +Time series analysis = Modelling Noise

The effects of noise on the world, and on our views of the world, are profound. Noise [is rooted in][...] a small number of small events [and] is often a causal factor much more powerful than a small number of large events can be'.

Noise causes to be somewhat inefficient, but often prevents us from taking advantages of the inefficiencies.

Fischer Black
President of the American Finance Association

Black, Fischer. (1986). Noise. *Journal of Finance*. Vol 41 (No.3). 529-541

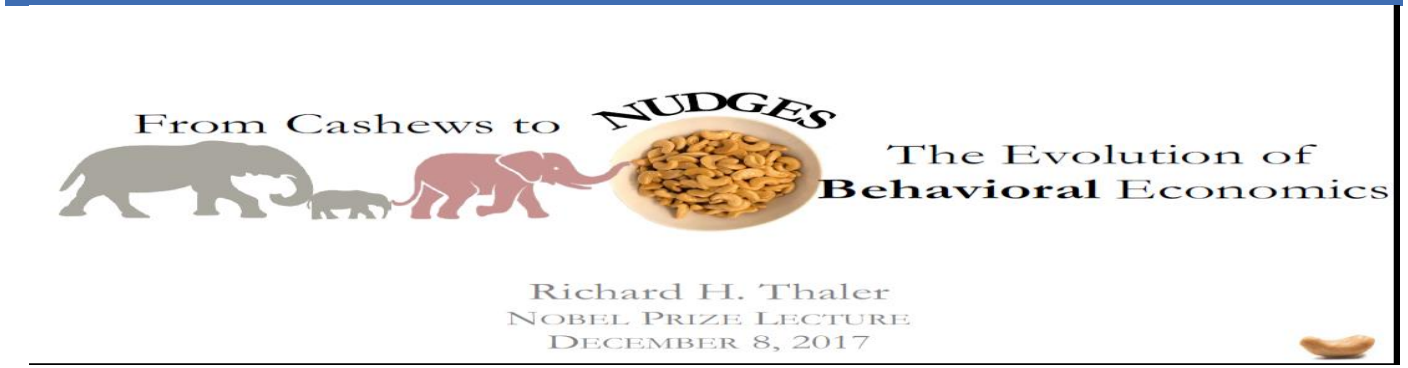
Affect, Emotion, and Market Movement

Market inputs: Prices, Sentiment – in text, in speech, in facial expressions

Take home keywords:

- Behavioural Finance = Simulated emotional intelligence +Time series analysis = Modelling Noise due to mental accounting?

Thaler: Mental accounting violates the economic notion of fungibility. Money in one mental account is not a perfect substitute for money in another account. Because of violations of fungibility, mental accounting matters.



From Cashews to Nudges: The Evolution of Behavioral Economics- A Nobel Lecture (2017).

Affect, Emotion, and Market Movement

Market inputs: Prices, Sentiment – in text, in speech, in facial expressions

Mental Accounting

- Behavioural Finance = Simulated emotional intelligence +Time series analysis = Modelling Noise due to mental accounting? Fungibility, nudging, framing

Suppose you bought a case if good 1982 Bordeaux in the futures market for $20 a bottle. The wine now sells at auction for about $75 a bottle. You decided to drink a bottle of this wine *over* dinner. Which of the following best captures your feeling of the cost to you of drinking this bottle?

1. No loss or gain ($0)
2. I lost $20
3. I lost $20 plus interest
4. I lost $75
5. I gained $55 ($75-$20)

From Cashews to Nudges: The Evolution of Behavioral Economics- A Nobel Lecture (2017).

Affect, Emotion, and Market Movement

Market inputs: Prices, Sentiment – in text, in speech, in facial expressions

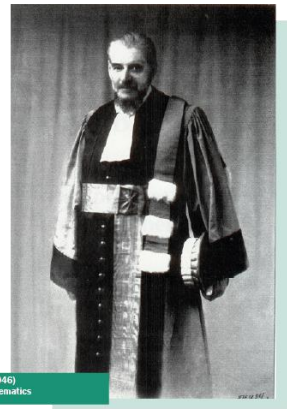
Take home keywords:

- Behavioural Finance – Radiation of Probabilities - *Louis Bachelier (1900).*

- **Bachelier's thesis, *Thèorie de la Spèculation*, contains a detailed descriptionof products available at that time in the French stock market, such as forward contracts and options in France.**

- **Bacheliers uses 'Brownian' motion, Planck's quantum theory, Gaussian distributions, to tell us about the *radiation of probability* in the markets**

- **His work preceded that of Albert Einstein; commended by Poincare.**



Jean-Michel Courtault et al (2014)LOUIS BACHELIER ON THE CENTENARY OF *THÉORIE DE LA SPÉCULATION. Mathematical Finance*, Vol.10, No.3 (July 2000), 341–353

Affect, Emotion, and Market Movement

Market inputs: Prices, Sentiment – in text, in speech, in facial expressions

Take home keywords:

• Artificial Intelligence: The capacity of computers or other machines to **exhibit or simulate** intelligent behaviour; AI deals largely with cognitive behaviour related problem solving, language understanding, machine vision.

•AI deals with NOISE.

• Simulated emotional intelligence: The capacity of computers to be able to **extract** *affect* from text, speech, facial expressions; affect is a broad term for sentiment, emotion, and is characteristic of euphoric/manic behaviour.

• EAI deals with category noise.

•Time series analysis which helps to **understand** evolution of behaviour, say of a market, over time, but does not necessarily predict the behaviour.

•TSA deals with the NOISE of measurement

Affect, Emotion, and Market Movement

Market inputs: Prices, Sentiment – in text, in speech, in facial expressions

Take home keywords:

- Behavioural Finance = Simulated emotional intelligence +Time series analysis
- **Prices change in the markets are, or should be, due to changes in supply and demand. Rapid decreases or increases in prices, outside that of random changes, are seen as a sign of price volatility.**

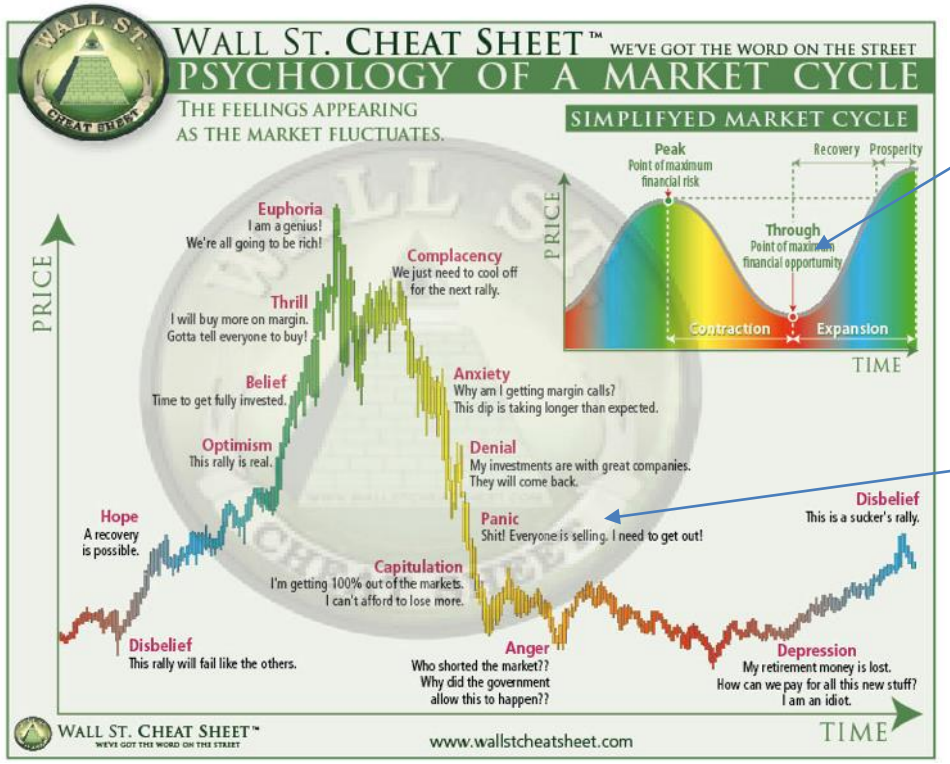
- **It is a dictum in economics and finance that *price volatility* is caused by external quantifiable factors, say IPO's, → behavioural finance experts say that it is the human sentiment.**

Affect, Emotion, and Market Movement

Market inputs: Prices, Sentiment – in text, in speech, in facial expressions

Take home keywords:

- Behavioural Finance = Simulated emotional intelligence +Time series analysis



Source: https://mcallisterreport.wordpress.com/2010/09/19/investor-sentiment-cycle/

Ideal Market: Rational, Benign, Predictable

Real Market: Irrational, Hostile, Speculative

How *negative sentiment* moves the markets?

Artificial Intelligence and Statistical Time series analysis lead the way

- Negative sentiment in news, in 8-K filings, and in professional blogs impacts on the returns (on investment) in trading at all levels of economic description
  - Firms (c. 4 basis points)
  - Market Indices (4-8 basis points)
  - Oil Futures (7-10 basis points)
  - Sovereign debt yields (<4 basis points)

- We have built an information extraction system that is based on natural language processing, a branch of AI, and statistical time series analysis. (Software available on request; publications at the end of the talk.

Affect, Emotion, and Market Movement

Market inputs: Prices, Sentiment – in text, in speech, in facial expressions

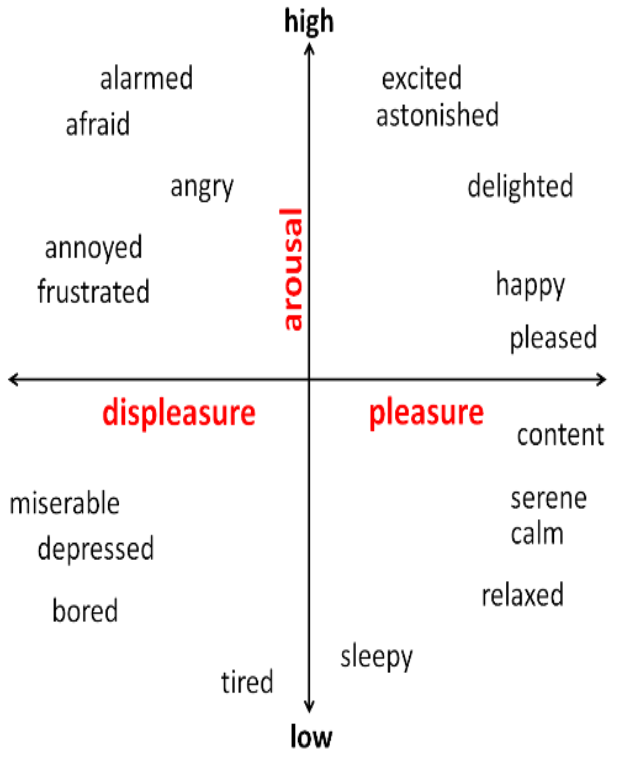
Behavioural Finance = Simulated emotional intelligence +Time series analysis = Modelling Noise with a bag of affect words

Our choice of words sometimes reflects how we feel emotionally (*bull/bear*).

We have words for evaluation → good/bad, up/down

We have for denoting activation→ active/passive, energetic/lazy

We have words to describe dominance→ strong/weak, aggressive/submissive

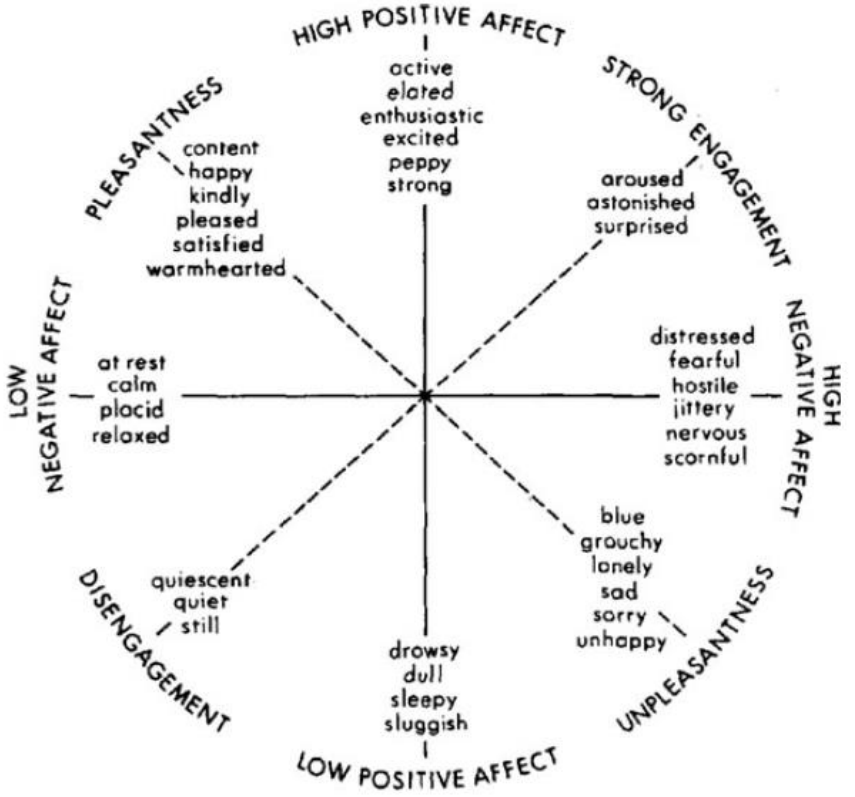


Affect, Emotion, and Market Movement

Market inputs: Prices, Sentiment – in text, in speech, in facial expressions

Behavioural Finance = How 'choice' of affect words changes markets? Dimensions of emotions

Watson, D., & Tellegen, A. (1985). Toward a consensual structure of mood. Psychological Bulletin, 98(2), 219–235



Two factor structure of affect (Watson and Tellegen 1985, p. 22)

Affect, Emotion, and Market Movement

Market inputs: Prices, Sentiment – in text, in speech, in facial expressions

Politics, psychology, finance = How 'choice' of affect words changes markets? Linguistic analysis of specialist texts and sentiment dictionaries.

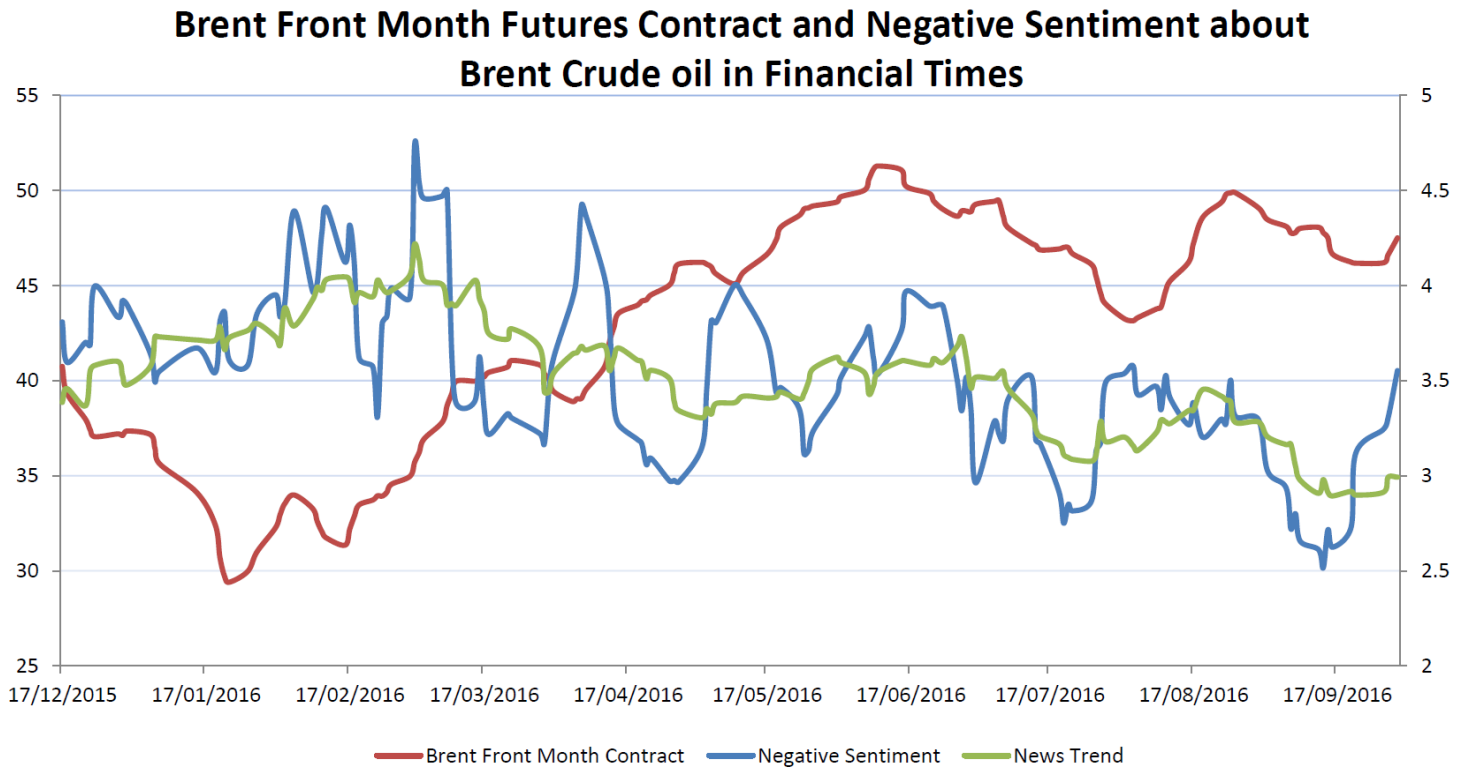
Devitt, A., & Ahmad, K. (2013). Is there a language of sentiment? An analysis of lexical resources for sentiment analysis. *Language resources and evaluation*, 47(2), 475-511

Entries in a "sentiment analysis" dictionary and & domain specific

PSYCHO-LINGUISTIC, SOCIAL & POLITICAL DIMENSIONS				
Dimension	***Tag***	***Example***	***Tag***	***Example***
Activation	Active	''abolish''	Passive	''accept''
Dominance	Strong	''admirer''	Weak	''afraid''
Evaluation	Positive valence		Negative valence	
	Positive	''comedy''	Negative	"conflict"
		"share"		"crude"
		"sweet"		"debt"
	Transaction Gain	"afford"	Transaction Loss	''cut''
			Vice	''contempt''
			Fall	''collapse''
			Hostile	"combat"
			Pain	"cramp"
DOMAIN SPECIFIC TERMS				
Economics & Finance	"share"; "debt ratio"	Oil & Gas	"Light sweet crude"; "Heavy sour crude"	
Nuclear Power	"radio-active decay", "poison"	Automobile	"anti-lock breaks"; "net zero"	

Sentiment and Oil Prices 12/15-11/16

Crude Oil Benchmark and News Sentiment



Affect, Emotion, and Market Movement

Market inputs: Prices, Sentiment – in text, in speech, in facial expressions

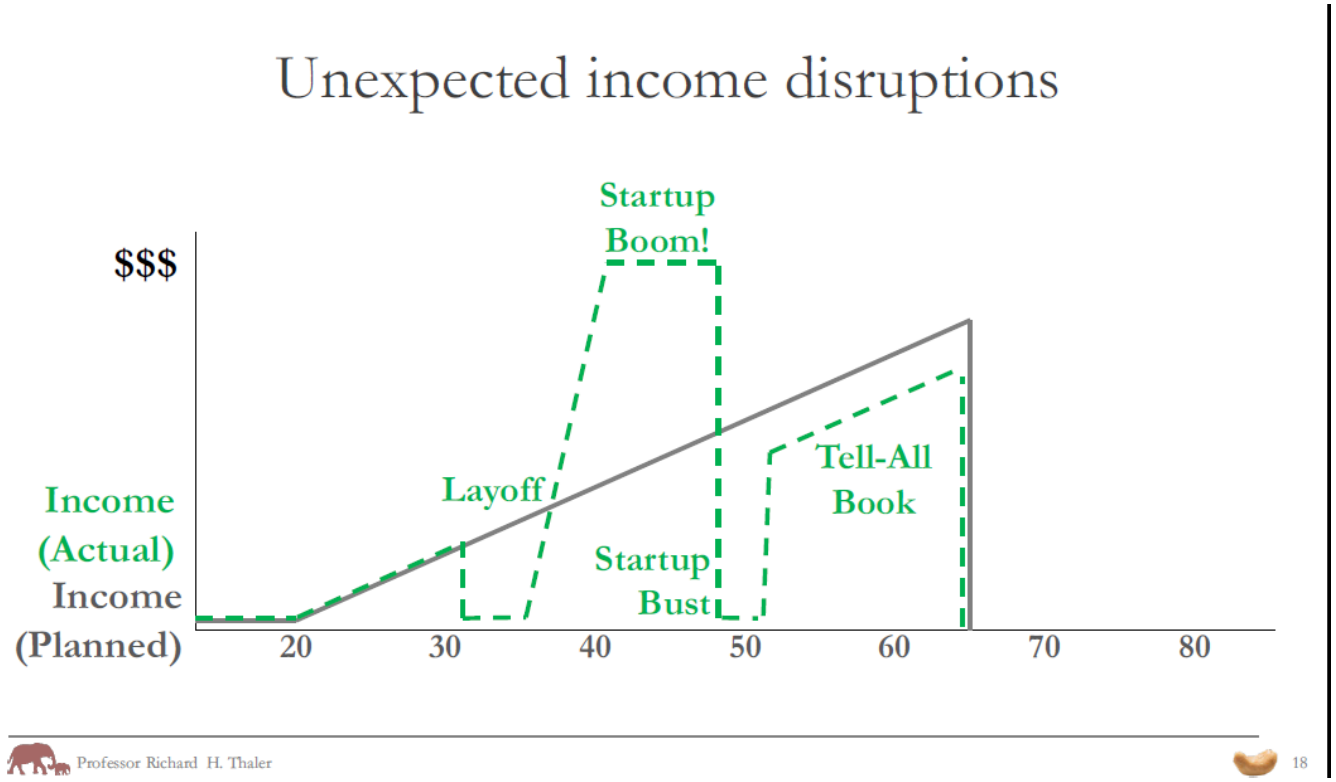
Behavioural Finance = Simulated emotional intelligence +Time series analysis = Modelling Noise → Incorporating emotion

ARBITRAGE WORKS	If informed trader is optimistic BUT noise trader is pessimistic Then	Buy
	If informed trader is pessimistic BUT noise trader is optimistic Then	Sell
ARBITRAGE FAILS	If both informed trader AND noise trader are optimistic Then	Herding (Boom)
	If both informed trader AND noise trader are pessimistic Then	Herding (Bust)

Affect, Emotion, and Market Movement

Market inputs: Prices, Sentiment – in text, in speech, in facial expressions

The ‘world’ according to Richard Thaler



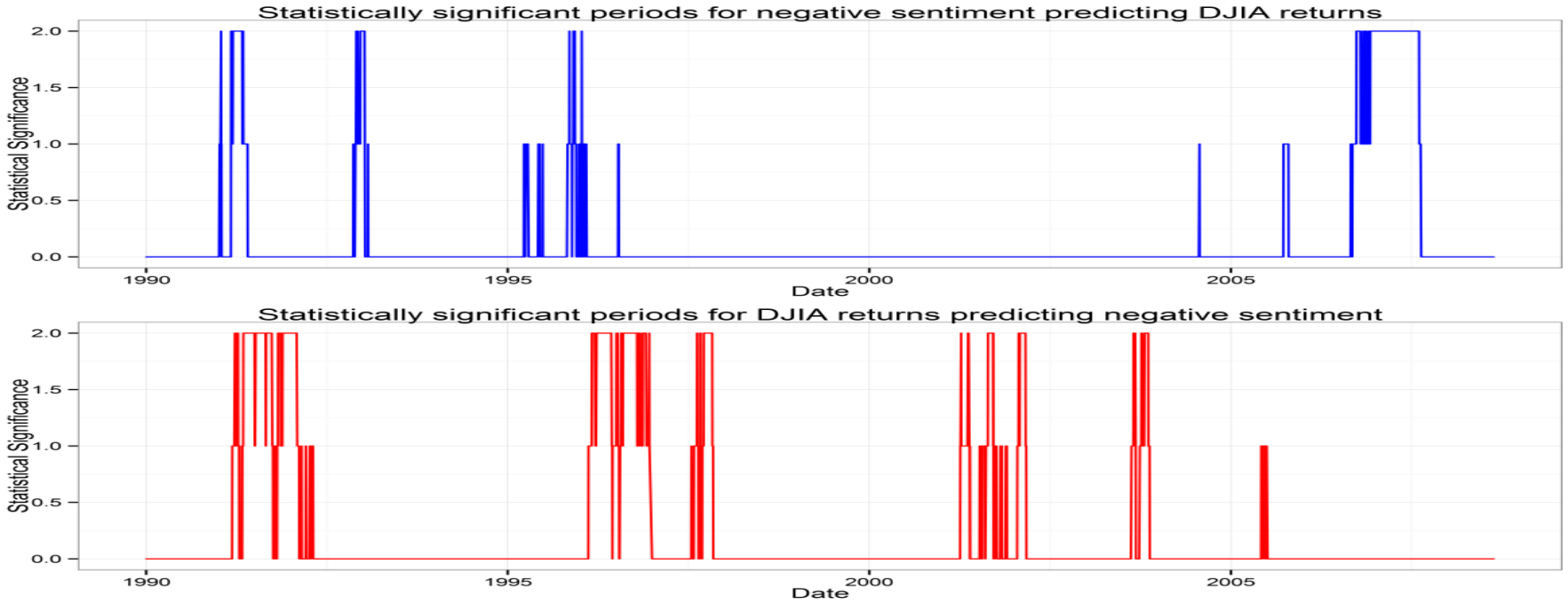
Cut and Pasted from: Richard Thaler (2018). https://www.nobelprize.org/uploads/2018/06/thaler-lecture-slides.pdf

Affect, Emotion, and Market Movement

Market inputs: Prices, Sentiment – in text, in speech, in facial expressions

The Markets according to K Ahmad

- Behavioural Finance = Simulated emotional intelligence +Time series analysis = Modelling Noise → Incorporating emotion; sometimes emotions lead markets and at other markets lead emotions (financial markets)

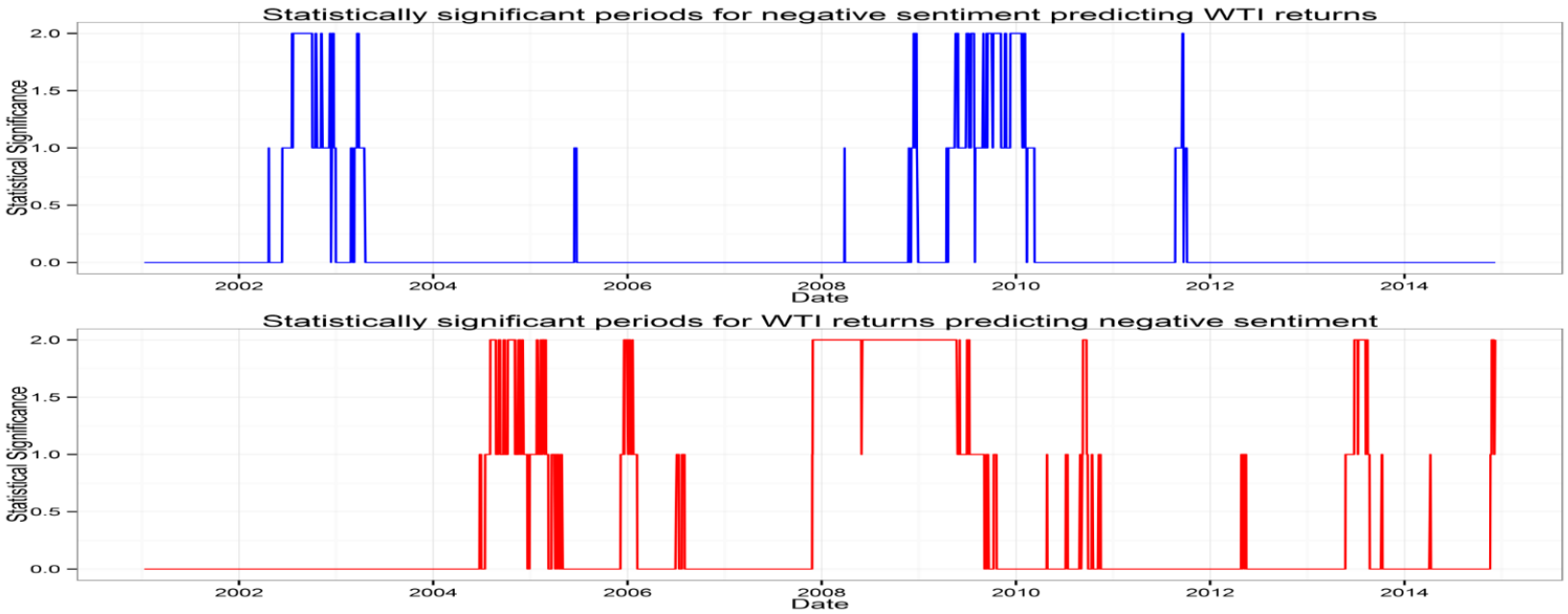


How markets work – in 140 characters

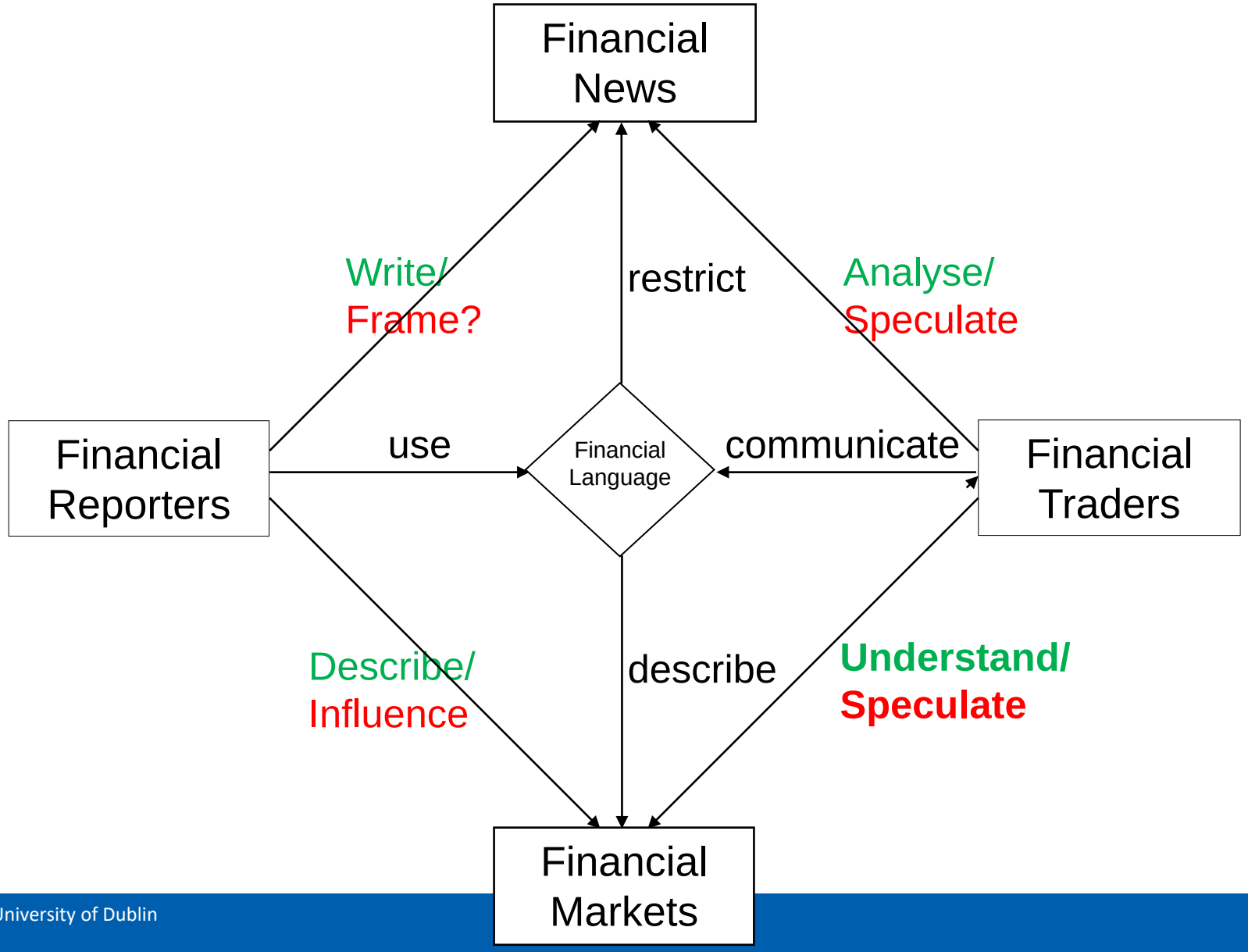
Big data challenges and promises

The Markets according to K Ahmad

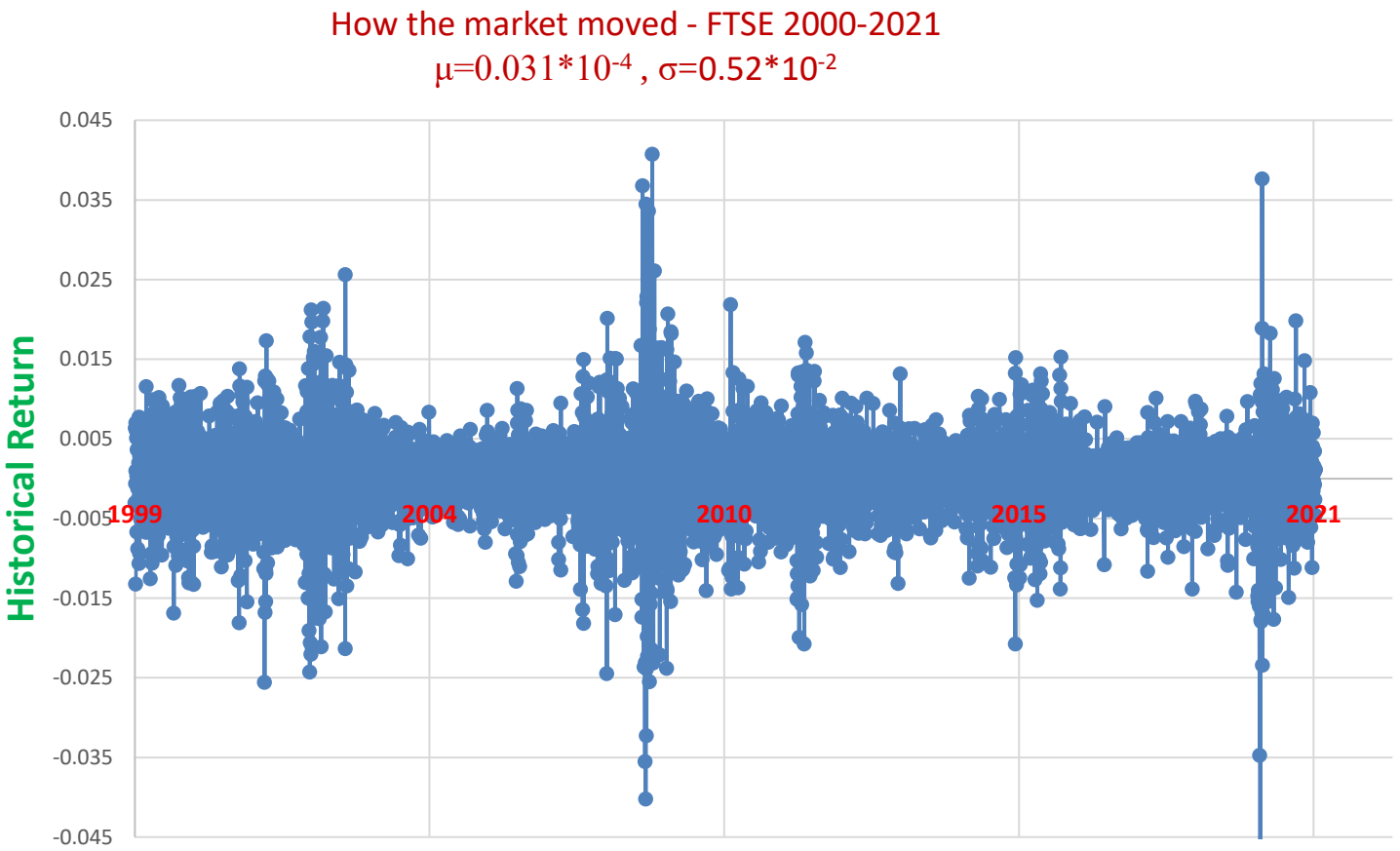
- Behavioural Finance = Simulated emotional intelligence +Time series analysis = Modelling Noise → Incorporating emotion; sometimes emotions determine market returns and at other markets determine emotions (commodity markets)



How markets move?
A behavioural finance view



How markets move?
A quantitative finance view



How markets move?
A quantitative finance view:

Market sentiment can be measured from *exogenous variables: (Baker & Wurgler 2007)*

- *Sentiment Index* is dependent positively on *Share Turnover, Number of IPOs (and return on IPOs), Equity Shares in New Issues;*
- *Sentiment Index* is decreased by *increased Closed-End Fund Discount & Dividend Premium.*
- *Standard methodology for estimating betas must take market sentiment into account;*
- *Sentiment noise is information bearing noise*

Baker, M., & Wurgler, J. (2007). Investor sentiment in the stock market. *Journal of economic perspectives*, *21*(2), 129-152

How markets move?
Economic Policy Uncertainty Index

Uncertainty Calculated from the number of news articles that contain

ECONOMIC UNCERTAINTY TERMS	uncertain or uncertainty, economic or economy
POLICY UNCERTAINTY TERMS	'policy', 'tax', 'spending', 'regulation', 'Bank of England', 'budget', and 'deficit'.
DATA	The FT, The Times and Sunday Times, The Telegraph, The Daily Mail, The Daily Express, The Guardian, The Mirror, The Northern Echo, The Evening Standard, and The Sun.

Baker, S. R., Bloom, N., & Davis, S. J. (2016). Measuring economic policy uncertainty. *The quarterly journal of economics*, *131*(4), 1593-1636.

How markets move?

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

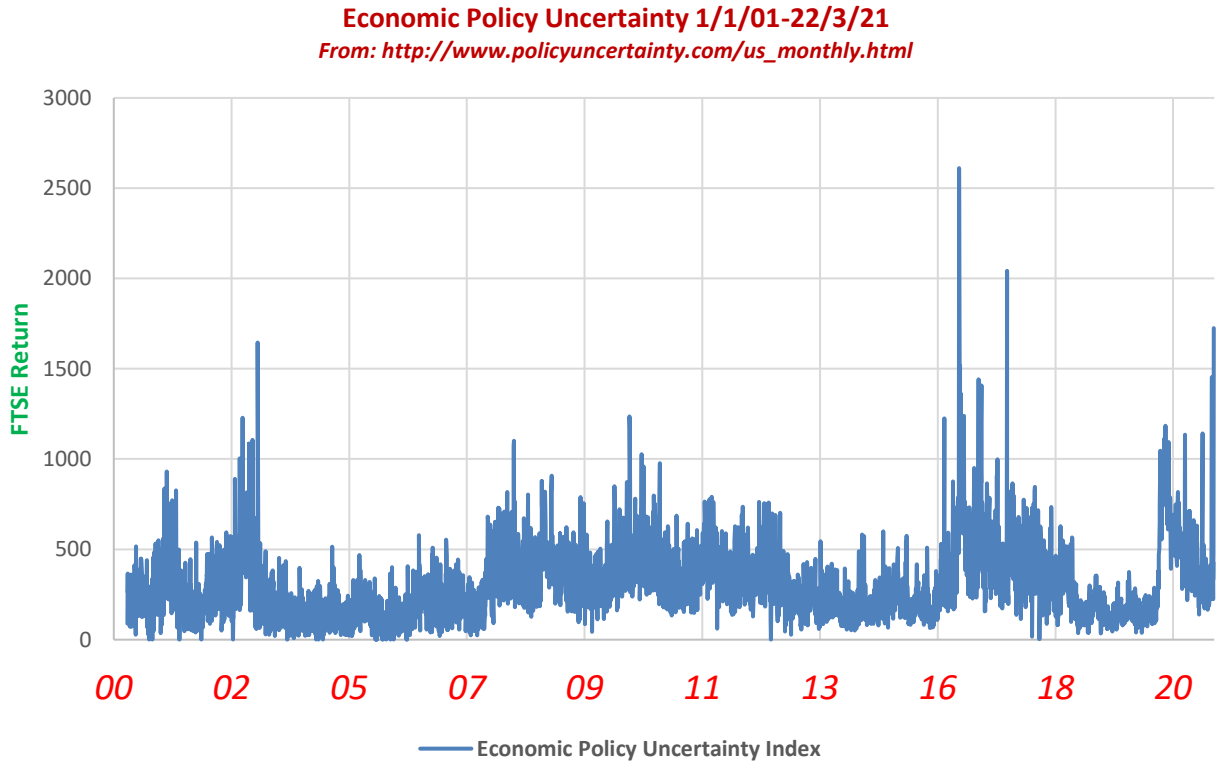
- The traffic on a message board used by a closed community can be used as a measure for market sentiment;
- A selected stream of words (Wi) in a text can be attributed to a message of type T (say positive or negative)

$$P(T|W_i) = \frac{P(T|W_{i-1})P(W_i|T)}{P(T|W_{i-1})P(W_i|T) + (1 - P(T|W_{i-1}))P(W_i|\bar{T})}.$$

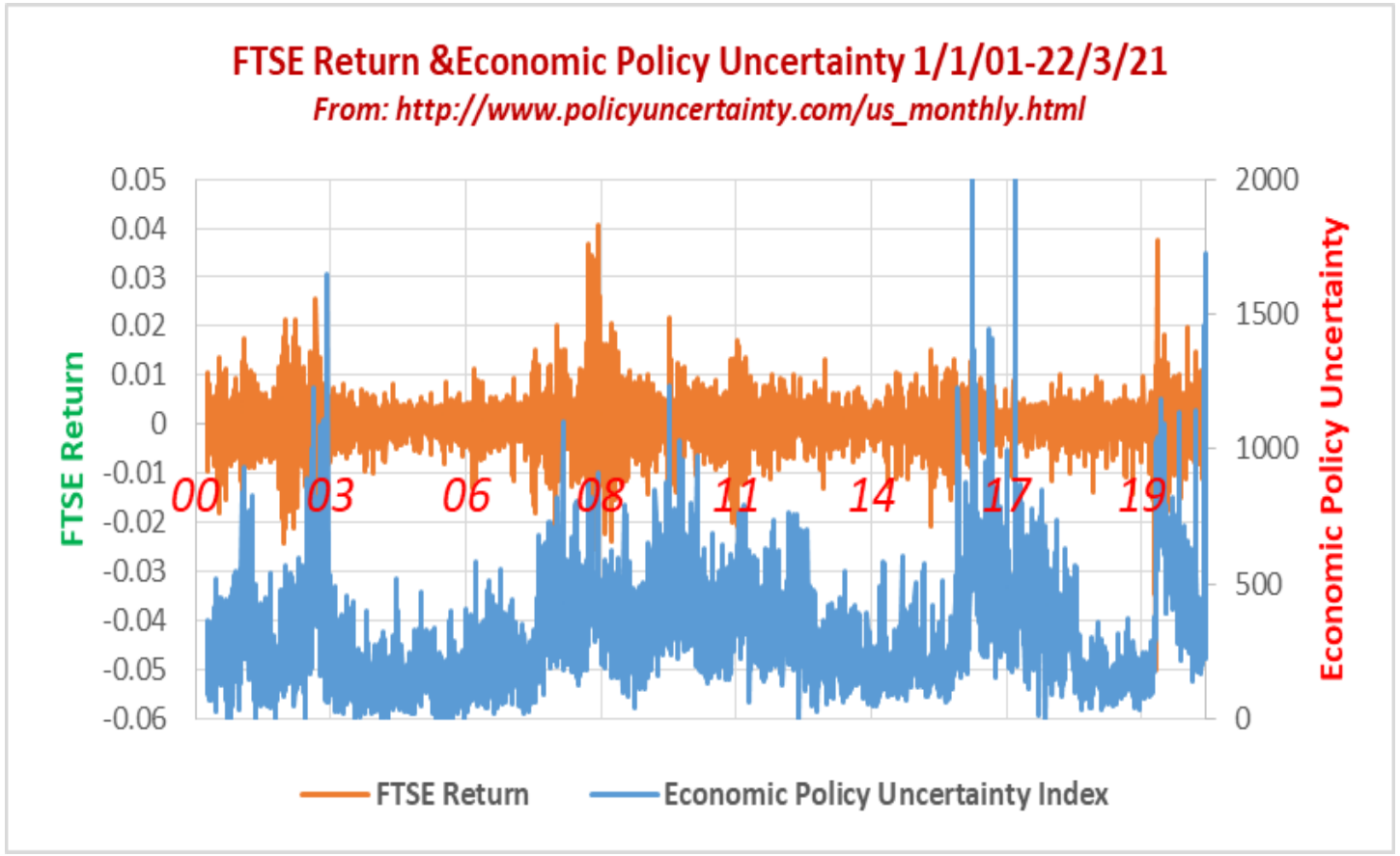
- The relation between the message type and the market returns can be 'learnt' (using Bayesian Statistics) and be used to 'predict' the market.
- Positive shocks lead to negative returns;
- Message postings relate to volatility – say in cyptocurrency movements now

Antweiler, W., & Frank, M. Z. (2004). Is all that talk just noise? The information content of internet stock message boards. *The Journal of finance*, *59*(3), 1259-1294.

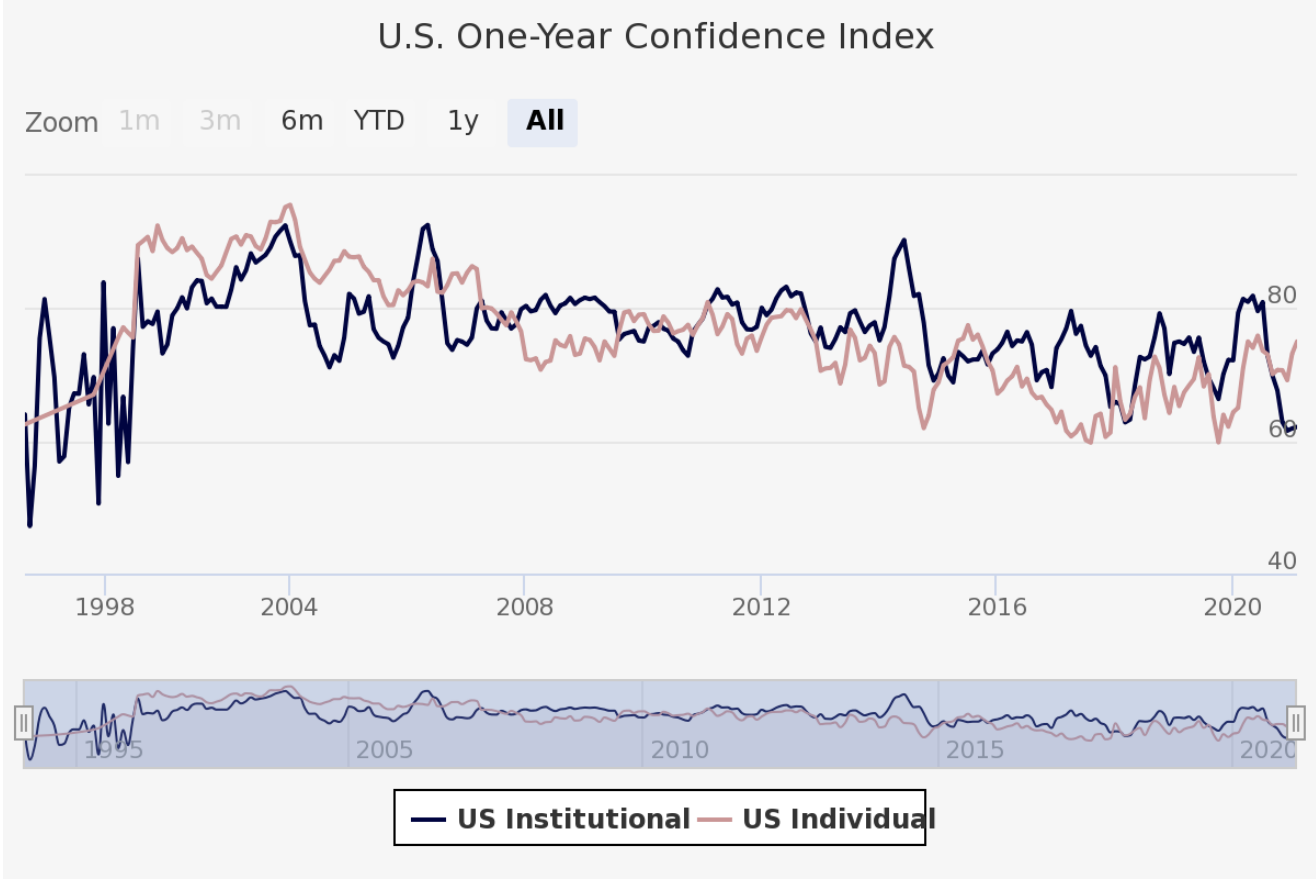
How markets move?
Economic Policy Uncertainty Index & FTSE

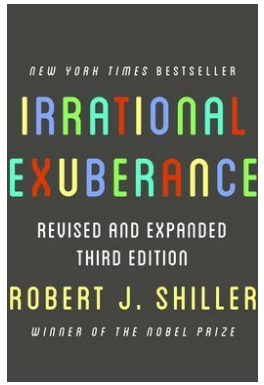


How markets move?
Economic Policy Uncertainty Index & FTSE



How markets move?
Robert Shiller's Yale Confidence Surveys





Question: How much of a change in percentage terms do you expect in the following (use + before your number to indicate an expected increase, or - to indicate an expected decrease, leave blanks where you do not know): [Fill in one number for each]

Sentiment Analysis?
How does it work

- Sentiment analysis covers a range of tasks related to the automatic identification of aspects of affective content in unimodal input, such as text, or multimodal input, such as video (moving images + speech+ head movement + hand gestures).

- The tasks range from word- to document-level analysis, coarse-grained identification of subjectivity to fine-grained attribution of specific opinions, single to multiple domain input across a variety of languages.

Sentiment Analysis?
How does it work

- Many current approaches use
  - Machine learning (ML) techniques to build affective text classifiers from data, tagged (supervised ML) or untagged (unsupervised ML) using a variety of algorithms :Naive Bayes, Support Vector Machines, Bayesian Belief Networks.

  - Lexicon-based approach: based on large collections of words classified according to affect, and specialist domain knowledge
    - General Inquirer (Stone et al. 1966); Loughran and Macdonald updated version
    - Dictionary of affect in language (Whissell 1989);
    - WordNet affect (Strappavara and Valitutti 2004);
    - • SentiWordNet (Esuli and Sebastiani 2006).

- **A key factor in determining the success of approach is the quality and volume of the training data**

Sentiment Analysis?
How does it work

Entries in a "sentiment analysis" dictionary and & domain specific

PSYCHO-LINGUISTIC, SOCIAL & POLITICAL DIMENSIONS				
Dimension	***Tag***	***Example***	***Tag***	***Example***
Activation	Active	"abolish"	Passive	"accept"
Dominance	Strong	"admirer"	Weak	"afraid"
Evaluation (often called 'sentiment')	Positive valence		Negative valence	
	Positive	"comedy"	Negative	"conflict"
		"share"		"crude"
		"sweet"		"debt"
	Transaction Gain	"afford"	Transaction Loss	"cut"
			Vice	"contempt"
			Fall	"collapse"
			Hostile	"combat"
			Pain	"cramp"
DOMAIN SPECIFIC TERMS				
Economics & Finance	"share"; "debt ratio"	Oil & Gas	"Light sweet crude"; "Heavy sour crude"	

Texts published at a specific date/time are used to extract negative words (as given in the dictionary) → number of negative words is a measure of sentiment suitably scaled for the length of each text.

Sentiment Analysis

Sentiment Analysis: Different modalities and texts, varied sources, range of analytic techniques

Text type	Source	Content analysis	Econometric Model
Online messages	Message Boards	Bag of Words	Naïve Bayes, Support Vector Machine
			Classifier ensemble
Corporate releases	EDGAR, Compustat	BoW (+Triplets for Henry 2006)	Panel Regression
			Naïve Bayes,
			OLS & Fama-Macbeth regression
			Multivarite regression,
Financial News	Wall Street Journal, NY Times, Dow Jones News Service, News Wires	BoW	VAR & OLS regression
			Panel & Fama-Macbeth regression
			Support Vector Regression
			OLS Regression
Social Media	Twitter,	BoW, OpinionFinder	Self-organizing fuzzy neural network,
	Twitter (+Google)		Naïve Bayes
General news	Bloomberg News	Latent Dirichlet Allocation	Linear Regression

Sentiment Analysis?
How does it work

- **Texts published at a specific date/time are used to extract negative words (as given in the dictionary) → number of negative words is a measure of sentiment suitably scaled for the length of each text. We call it $sentiment_t$**

- **Market quotations are taken for a firm or index, or future, over a period of time and we get a series of quotes on a given date and time.**

- **Market return is computed by taking the difference of the current value of the quote and its immediate previous value; historical market returns are calculated by taking logarithm of the two values. The expected average value of return in a well run market (efficient) is ZERO: every uptick is followed by a downtick.**

Sentiment Analysis?
How does it work

- **Return values are 'regressed' that is we try to establish a statistically significant relationship between the current return value and its past values. This statistically significant correlation may lead us to understand how prices (and returns) move : So the return at future date *t* will be**

$$r_t = \alpha_0 + \alpha_1 r_{t-1} + \alpha_2 r_{t-2} + error_t$$

Where α is a constant of proportionality and α_0 is a measure of average value of return; if the calculation of α values show shows statistical significance then the return value of that preceding day is important

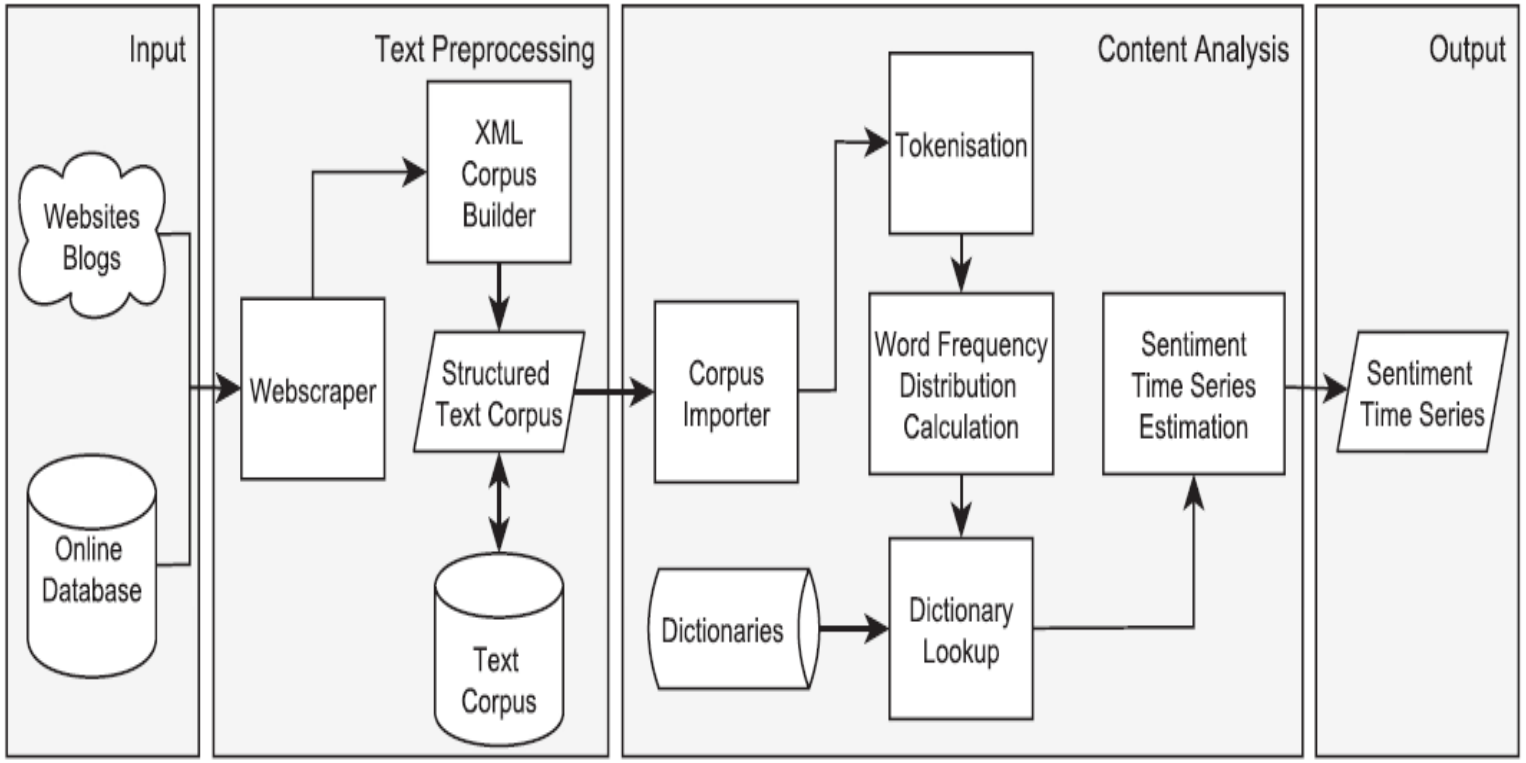
- **We use *vector auto-regression* to incorporate our sentiment series into the *return* series;.**

$$r_t = \alpha_0 + \alpha_1 r_{t-1} + \alpha_2 r_{t-2} + \beta sentiment_t + new\_error_t$$

if β is statistically significant then sentiment is important

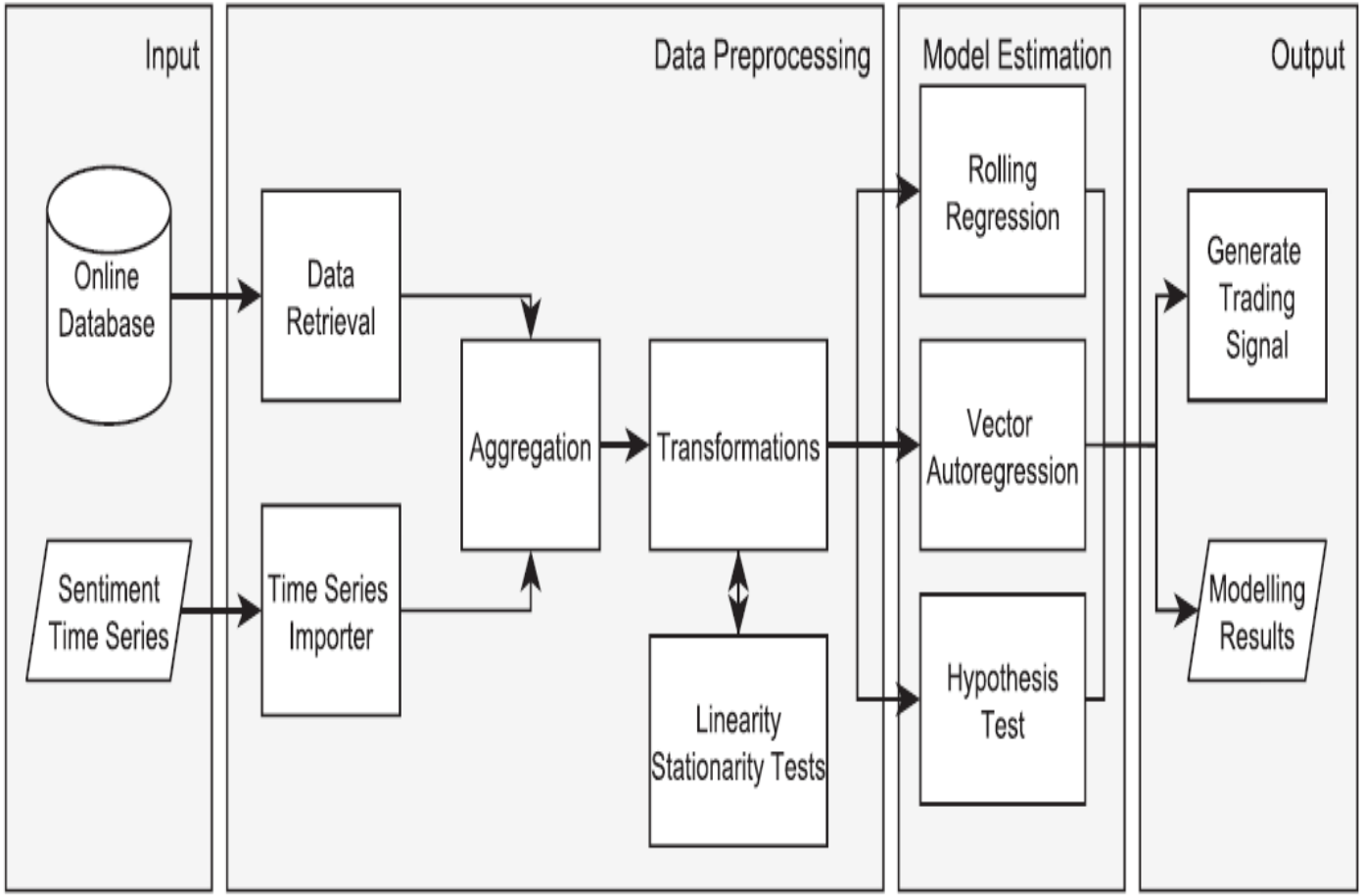
Text analytics used in sentiment analysis

A recent movement of prices



Statistical Regression for fusing market returns with sentiment

A recent movement of prices



How the markets have moved for me?

Methods, Data, Inferences

Data: Extracted Sentiment & (log) Returns or change in prices

Methods:

(I) Vector Auto regression fuses sentiment and returns;

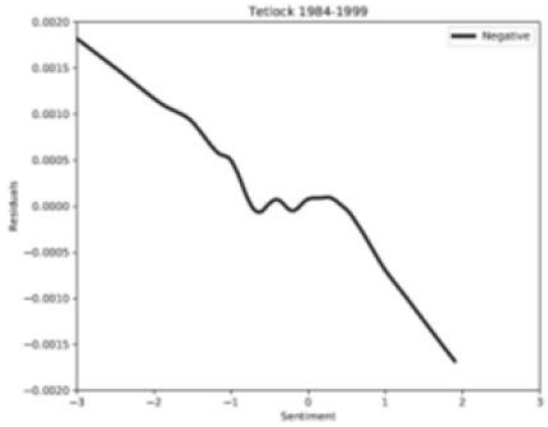
(II) Locally weighted scatterplot smoothing (also known as LOWESS) to explore the relationship between residuals and sentiment values.

(III) Inference:

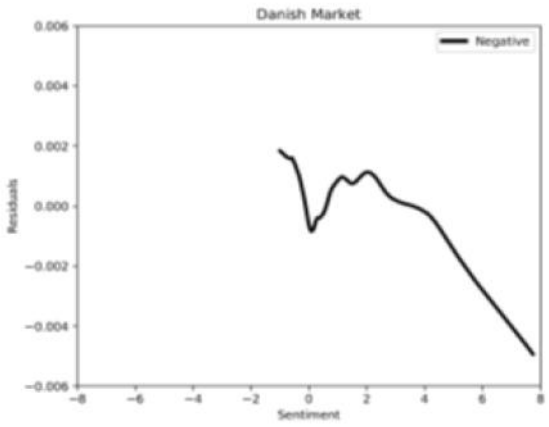
- For prolonged periods no impact of sentiment; For short periods sentiment has impact which reverses in time;
- Efficient method of ascertaining price information

Movement and indices/futures & Sentiment

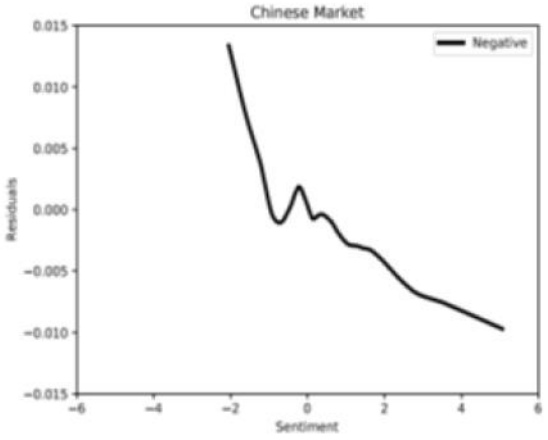
Residuals correlate with sentiment when markets go down.(Zhao, Kelly, Ahmad



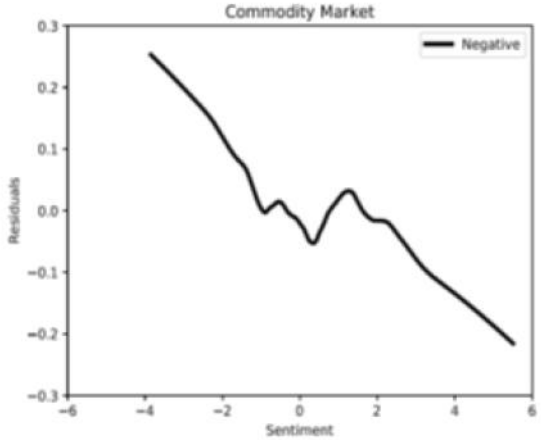
DJIA 1984-1999



OMXC 2002-2015



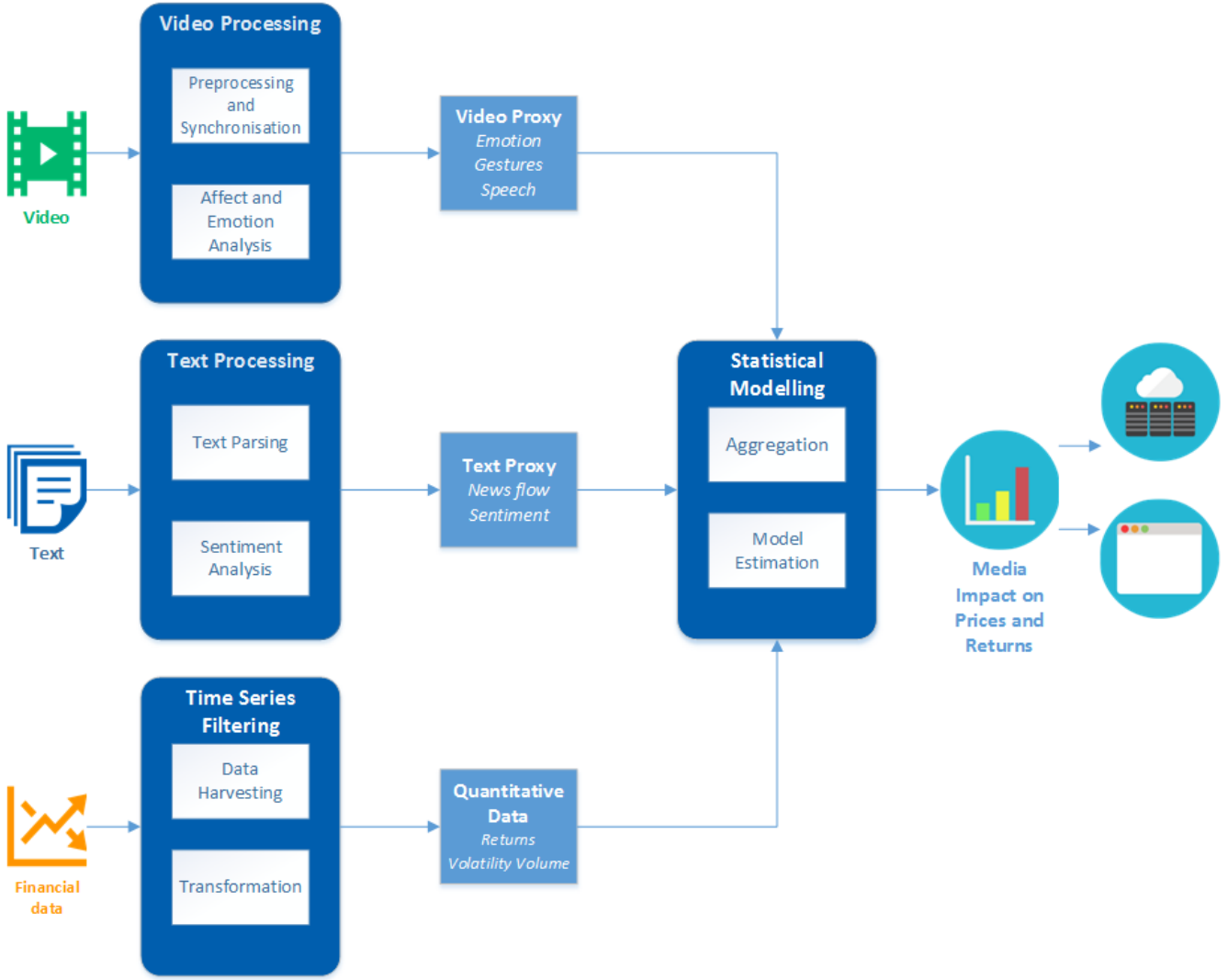
SHCOMP 2000-2015



WTI 2000-2014

Volatility in the Marketplace: Emotional Categories

Facial Expressions, Text and Numbers



Volatility in the Marketplace

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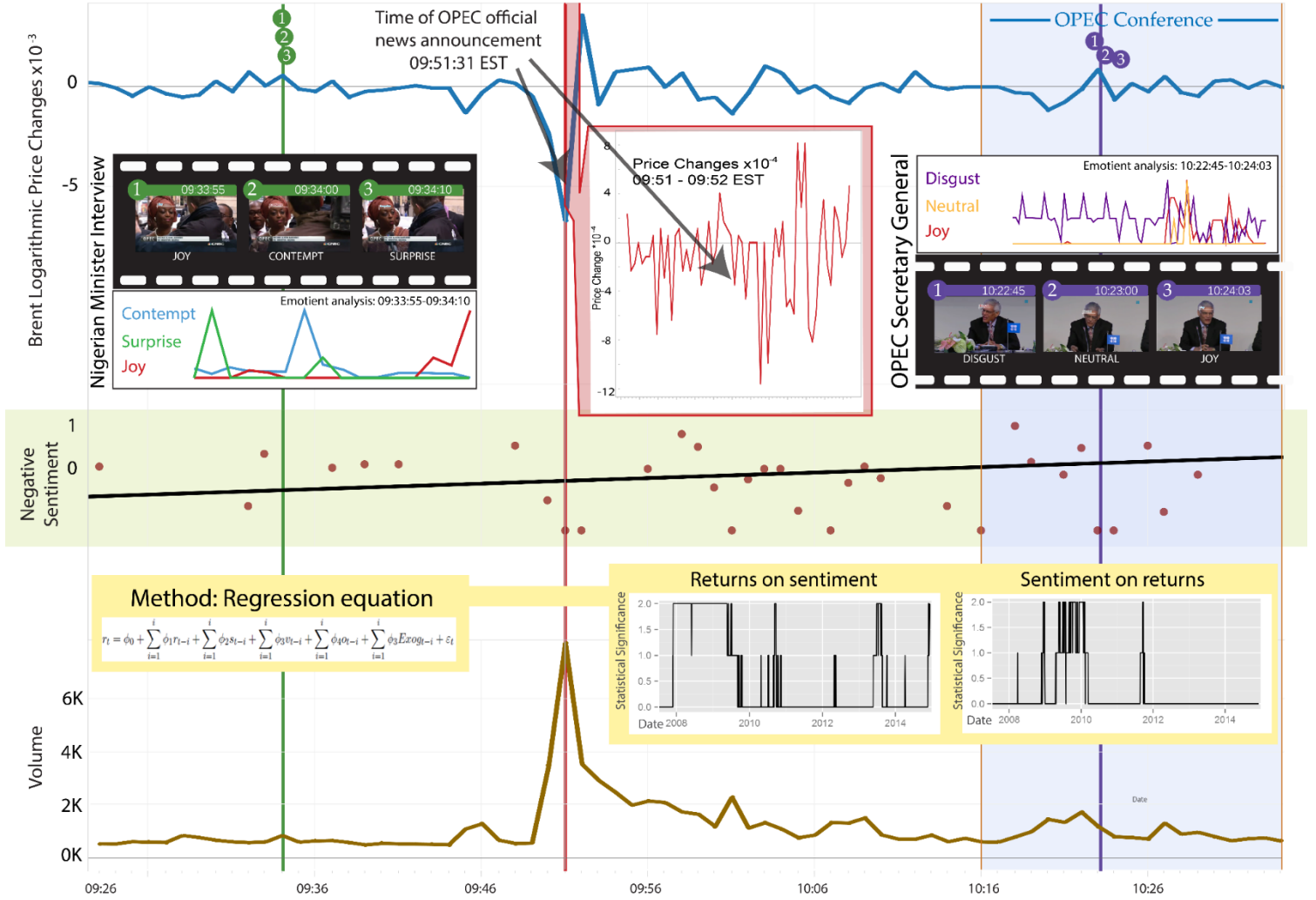

Some of my publications

Firms, Markets, Futures, Scandals and Sentiment

Objectives	Numbers	Inferences
Firm level impact of sentiment (Ahmad et al 2016)	News reports 2000-2010; 5.5 million texts for 20 large US firms	Generally, media assists with processing of complex information leading to a return to a weakly efficient market
Cross-sectional study of financial and commodity markets (DJIA/WTI; 2000-2015) (Kelly & Ahmad 2018)	News reports and Op-eds from FT & Wall Street Journal (Total 43000); *Oildrum Blog* (83000) (2000-2015)	Incorporating news sentiment into a trading strategy increases annual returns over a simple buy and hold strategy for both markets.
Cross-sectional study of three inidices (DJIA, OMXC-20, SHCOMP) and WTI over 1984-2015 (Zhao, Kelly, Ahmad 2017)	News reports WSJ,FT, Xinhua, and Danish news 75,000 news reports, op-ed columns, editorial	Negative sentiment follows market declines in almost all markets; Negative sentiment impacts volume, and volume impacts returns
Financial Scandals and negative and vice words (Enron (1997-2002)) (Cook & Ahmad, 2015)	US News reports, newswire, press releases, industry and trade publications 25,000 news report	Vice words impact the returns half as much as negative sentiment words.

References

Kelly, S., & Ahmad, K. (2018). Estimating the impact of domain-specific news sentiment on financial assets. *Knowledge-Based Systems*, 150, 116-126.

Ahmad, K., Han, J., Hutson, E., Kearney, C., & Liu, S. (2016). Media-expressed negative tone and firm-level stock returns. *Journal of Corporate Finance*, 37, 152-172

Zhao, Z., Kelly, S., & Ahmad, K. (2017, October). Finding Sentiment in Noise: Non-linear Relationships Between Sentiment and Financial Markets. In *International Conference on Intelligent Data Engineering and Automated Learning* (pp. 580-591). Springer, Cham.

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- Mon, 29 Mar (10:00-10:45) The Time Is Now – The Financial Impact Of The Energy Transition
- Tue, 30 Mar (16:00-16:45) Humanity Detection In Digital Advertising, Utilising Smart Ledgers
- Wed, 31 Mar (12:00-12:45) Why The Roots Of True Conservatism Are Essential To Saving The Planet
- Thu, 01 Apr (10:00-10:45) Gold – The Only True Measure Of Performance

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