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
Executive Chairman
Z/Yen Group
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
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.

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.

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 of 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)

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 description of 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 market.

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

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

Ideal Market:
Rational,
Benign,
Predictable

Real Market:
Irrational,
Hostile,
Speculative

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

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.

<table>
<thead>
<tr>
<th>Entries in a “sentiment analysis” dictionary and &amp; domain specific</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimension</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Activation</td>
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<tr>
<td>Dominance</td>
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<tr>
<td>Evaluation</td>
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<td></td>
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<tr>
<td></td>
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<tr>
<td>Domain specific terms</td>
</tr>
<tr>
<td>Economics &amp; Finance</td>
</tr>
<tr>
<td>Nuclear Power</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Arbitrage Works</th>
<th>If informed trader is optimistic BUT noise trader is pessimistic Then</th>
<th>Buy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arbitrage Fails</td>
<td>If both informed trader AND noise trader are optimistic Then</td>
<td>Herding (Boom)</td>
</tr>
<tr>
<td></td>
<td>If both informed trader AND noise trader are pessimistic Then</td>
<td>Herding (Bust)</td>
</tr>
</tbody>
</table>
Affect, Emotion, and Market Movement

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

The ‘world’ according to Richard Thaler

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)
The Markets according to K Ahmad

- Behavioural Finance = Simulated emotional intelligence + Time series analysis = Modelling Noise $\rightarrow$ 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 the market moved - FTSE 2000-2021
μ=0.031*10^{-4}, σ=0.52*10^{-2}
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

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 cryptocurrency movements now

How markets move?
Economic Policy Uncertainty Index & FTSE

Economic Policy Uncertainty 1/1/01-22/3/21
How markets move?
Economic Policy Uncertainty Index & FTSE

FTSE Return & Economic Policy Uncertainty 1/1/01-22/3/21

FTSE Return
Economic Policy Uncertainty Index

Trinity College Dublin, The University of Dublin
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
  o 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.

  o 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?

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Tag</th>
<th>Example</th>
<th>Tag</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activation</td>
<td>Active</td>
<td>“abolish”</td>
<td>Passive</td>
<td>“accept”</td>
</tr>
<tr>
<td>Dominance</td>
<td>Strong</td>
<td>“admirer”</td>
<td>Weak</td>
<td>“afraid”</td>
</tr>
</tbody>
</table>

**PSYCHO-LINGUISTIC, SOCIAL & POLITICAL DIMENSIONS**

<table>
<thead>
<tr>
<th>Evaluation (often called ‘sentiment’)</th>
<th>Dimension</th>
<th>Tag</th>
<th>Example</th>
<th>Tag</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive valence</td>
<td>Positive</td>
<td>“comedy”</td>
<td>Negative</td>
<td>“conflict”</td>
<td></td>
</tr>
<tr>
<td>Negative valence</td>
<td>Negative</td>
<td>“crude”</td>
<td>“debt”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transaction Gain</td>
<td>“afford”</td>
<td></td>
<td>Loss</td>
<td>“cut”</td>
<td></td>
</tr>
<tr>
<td>Transaction Loss</td>
<td>Vice</td>
<td>“contempt”</td>
<td>Fall</td>
<td>“collapse”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hostile</td>
<td>“combat”</td>
<td>Pain</td>
<td>“cramp”</td>
<td></td>
</tr>
</tbody>
</table>

**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

<table>
<thead>
<tr>
<th>Text type</th>
<th>Source</th>
<th>Content analysis</th>
<th>Econometric Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online messages</td>
<td>Message Boards</td>
<td>BoW</td>
<td>Naïve Bayes, Support Vector Machine, Classifier ensemble</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>Corporate</td>
<td>EDGAR, Compustat</td>
<td>BoW (+Triplets for Henry 2006)</td>
<td>Panel Regression, Naïve Bayes, OLS &amp; Fama-Macbeth regression, Multivariate regression,</td>
</tr>
<tr>
<td>releases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Media</td>
<td>Twitter, Twitter (+Google)</td>
<td>BoW, OpinionFinder</td>
<td>Self-organizing fuzzy neural network, Naïve Bayes</td>
</tr>
<tr>
<td>General news</td>
<td>Bloomberg News</td>
<td>Latent Dirichlet Allocation</td>
<td>Linear Regression</td>
</tr>
</tbody>
</table>
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 $\text{sentiment}_t$.

- 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

\[
\begin{align*}
\cdot \ r_t &= \alpha_0 + \alpha_1 r_{t-1} + \alpha_2 r_{t-2} + error_t
\end{align*}
\]

Where \( \alpha \) is a constant of proportionality and \( \alpha_0 \) is a measure of average value of return; if the calculation of \( \alpha \) 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;

\[
\begin{align*}
\cdot \ r_t &= \alpha_0 + \alpha_1 r_{t-1} + \alpha_2 r_{t-2} + \beta sentiment_t + new\_error_t
\end{align*}
\]

if \( \beta \) 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)
Volatility in the Marketplace: Emotional Categories
Facial Expressions, Text and Numbers
Volatility in the Marketplace

Facial Expressions, Text and Numbers
## Some of my publications

**Firms, Markets, Futures, Scandals and Sentiment**

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Numbers</th>
<th>Inferences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm level impact of sentiment (Ahmad et al 2016)</td>
<td>News reports 2000-2010; 5.5 million texts for 20 large US firms</td>
<td>Generally, media assists with processing of complex information leading to a return to a weakly efficient market</td>
</tr>
<tr>
<td>Cross-sectional study of three indices (DJIA, OMXC-20, SHCOMP) and WTI over 1984-2015 (Zhao, Kelly, Ahmad 2017)</td>
<td>News reports WSI,FT, Xinhua, and Danish news 75,000 news reports, op-ed columns, editorial</td>
<td>Negative sentiment follows market declines in almost all markets; Negative sentiment impacts volume, and volume impacts returns</td>
</tr>
<tr>
<td>Financial Scandals and negative and vice words (Enron (1997-2002)) (Cook &amp; Ahmad, 2015)</td>
<td>US News reports, newswire, press releases, industry and trade publications 25,000 news report</td>
<td>Vice words impact the returns half as much as negative sentiment words.</td>
</tr>
</tbody>
</table>

**References**


Thank You
Questions And Answers
Forthcoming Events

- 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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