On the behaviour of financial markets: People, systems and concepts

Khurshid Ahmad,
Chair of Computer Science
Trinity College, Dublin, IRELAND
11-13th November 2013

Behavioural Finance: A definition

There is an understanding in economics, and in finance, that stakeholders in a market, “on average, [...] the stakeholders] make unbiased decisions and maximise their self-interests” and that those who make “suboptimal decisions would be punished through poor outcomes”. The rewarding and punishing episodes make the stakeholders “would either learn to make better decisions or leave the marketplace”. The erroneous behaviour of the stakeholders, it is further assumed, is idiosyncratic of each stakeholder and there is little or no correlation between the errors of and that of the other – irrespective of spatial distances and time spans.

Behavioural finance argues that some financial phenomena can plausibly be understood using models in which some agents are not fully rational. The field has two building blocks: limits to arbitrage, which argues that it can be difficult for rational traders to undo the dislocations caused by less rational traders; and psychology, which catalogues the kinds of deviations from full rationality we might expect to see.

The actors in a financial market are:
- **Traders and speculators**, who have particular and complex relations to what they understand to be the market;
- **Inventors of market models and formulas**, that prove to be contested and fallible interpretations of economic reality rather than unproblematic representations;
- **Designers of technology and risk assessment models**, which have normative choices and criteria at their hearts;
- **Journalists who do not just write impassive financial news**, but play important roles in marketing financial products and creating space for speculation in everyday life;
- **Regulators and policy makers**, create regulatory frameworks, develop financial and economic policies; technocrats, business people and government officials.
Behaviour and Financial Markets: Kenneth Arrow 1972

From the time of Adam Smith’s Wealth of Nations in 1776, one recurrent theme of economic analysis has been the remarkable degree of coherence among the vast numbers of individual and seemingly separate decisions about the buying and selling of commodities. In everyday, normal experience, there is something of a balance between the amounts of goods and services that some individuals want to supply and the amounts that other, different individuals want to sell. Would-be buyers ordinarily count correctly on being able to carry out their intentions, and would-be sellers do not ordinarily find themselves producing great amounts of goods that they cannot sell.

Behaviour and Financial Markets: Louis Bachelier 1870-1946

Bachelier’s Equation: Calculating the price of the Napoleonic era perpetual bonds issued by the French government. First attempt to include interest rates into the calculation of securities and a discussion of risk through the notion of random changes in the prices introduced by Louis Bachelier (1870-1946). Bachelier borrowed concepts from heat conduction (Fourier), statistical mechanics (Gauss), and the experimental reports about Brownian motion.
Human behavior in business firms constitutes a highly interesting body of empirical phenomena that calls out for explanation as do all bodies of phenomena.

The classical theories of economic decision making and of the business firm make very specific testable predictions about the concrete behavior of decision-making agents. Behavioral theories make quite different predictions. Since these predictions can be tested directly by observation, either theory (or both) may be falsified as readily when such predictions fail as when predictions about aggregate phenomena are in error. (pp 346-347)

The special sphere of finance within economics is the study of economic resources, both spatially and across time, in uncertain environment.

.. uncertain environment. To capture the influence of time and uncertainty requires sophisticated mathematical and computational tools.


Behaviour and Financial Markets: Vernon Smith 2002

Historically, a recurrent theme in economics is that the values to which people respond are not confined to those one would expect based on the narrowly defined canons of rationality.

intuitive judgments occupy a position – perhaps corresponding to evolutionary history – between the automatic operations of perception and the deliberate operations of reasoning.

psychology of intuitive beliefs and choices → heuristics of judgment, risky choice, and framing effects.


Many of the things we think about, actions we take, the way we react to stimuli, generate a feeling or subjective experience, for example, an emotion, or a mood.

The generic term used in the 20th century psychology and philosophy literature to denote such an emotion or mood is an old, Middle English (14th century), word affect.
Preamble

Defining Rationality

1. The quality or condition of possessing reason; the ability to exercise reason.
2. The fact or condition of being based on, or in accordance with, reason or rationalism.
3. As a count noun: a rational or reasonable view, practice
4. The tendency to regard everything from a purely rational point of view.

Defining Rationality

<table>
<thead>
<tr>
<th>Domain</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature</td>
<td>The tendency to regard everything from a purely rational point of view.</td>
</tr>
<tr>
<td>Mathematics</td>
<td>The property of a number or quantity of being rational: A set of numbers is called a domain of rationality when the sums, differences, products, and quotients of any numbers in the set always yield as results numbers belonging to the set.</td>
</tr>
<tr>
<td>Philosophy</td>
<td>The quality or condition of possessing reason; the ability to exercise reason.</td>
</tr>
<tr>
<td>Psychology</td>
<td>The fact or condition of being based on, or in accordance with, reason or rationalism</td>
</tr>
</tbody>
</table>

Defining Rationality: The genesis of the term rationalism

<table>
<thead>
<tr>
<th>Year</th>
<th>Domain</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1732</td>
<td>Theology</td>
<td>The practice of treating reason as the ultimate authority in religion; (also) the practice of explaining supernatural or miraculous events on a rational basis</td>
</tr>
<tr>
<td>1782</td>
<td>Moral Philosophy</td>
<td>The doctrine or belief that reason should be the only guiding principle in life, obviating the need for reliance on, or adherence to, any form of religious belief.</td>
</tr>
<tr>
<td>1797</td>
<td>Philosophical</td>
<td>The doctrine or theory that emphasizes the role of reason in knowledge, or claims that reason rather than sense experience is the foundation of certainty in knowledge</td>
</tr>
<tr>
<td></td>
<td>Analysis</td>
<td></td>
</tr>
<tr>
<td>1915</td>
<td>Economics</td>
<td>The principle or practice of using reasoning and calculation as a basis for analysis, planning, etc., esp. in social and economic organization.</td>
</tr>
<tr>
<td>1918</td>
<td>Architecture</td>
<td>A theory or style based on the application of rationalist principles to architecture, characterized by a rejection of ornament and an emphasis on geometrical simplicity and functionalism</td>
</tr>
</tbody>
</table>

Behaviour and Financial Markets

So what am I going to talk to you for the next 2.5 days?

1. Introduction & Terminology
2. Fluctuations in the Financial Markets
3. Prospect Theory
4. Herd Behaviour
5. Volatility and Sentiment
Behaviour and Financial Markets: What happens in a market?

- S&P 500 Prices (p) and Traded Volume (Vol) 1950-2013: log scales; 75% correlation between p and Vol. Self correlation prices: 99%; volume 97.87%. Exponential trendlines added to both.

Behaviour and Financial Markets: What happens in a market?

- S&P 500 compounded rates for price \( r_{p,t} = \log(p_t/p_{t-1}) \) and traded volume \( r_{vol,t} = \log(Vol_t/Vol_{t-1}) \) 1950 to 2013. Correlation between price returns and compounded rate of traded volume: 5.4%; self correlation of price returns: 5.4% and volume: -98.2%.
Behaviour and Financial Markets:
What happens in a market?

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Std. Dev</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prices</td>
<td>433</td>
<td>491</td>
<td>1.03</td>
<td>-0.52</td>
</tr>
<tr>
<td>Volume</td>
<td>7.04E+08</td>
<td>1.39E+09</td>
<td>2.56</td>
<td>6.70</td>
</tr>
</tbody>
</table>

**Compounded Rates**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Price Return</td>
<td>0.013%</td>
<td>0.42%</td>
<td>-1.03</td>
<td>27.66</td>
</tr>
<tr>
<td>Volume Return</td>
<td>0.022%</td>
<td>8.4%</td>
<td>-0.05</td>
<td>17.13</td>
</tr>
</tbody>
</table>

Behaviour and Financial Markets:
What happens in a market?

![Distribution of S&P 500 returns between 1990-2013](image)
Behaviour and Financial Markets:
What happens in a market?

Number \( N_j \) of days in which compounded return for S&P 500 [1950-2013] showed successive increase or decrease. \( N_{max} = 16509, N_j = 7548 \)

Behaviour and Financial Markets:
What happens in a market?
Galbraith (1958/1998:38) suggested that over the last 400 years successive downturns, or ‘deep trouble’, in the financial markets, have been described by terms that help to ‘soften the connotation of deep trouble’; 17th century financial mania was replaced by the softer financial/market bubble (18th century), which, in turn, was replaced by market panics (19th century). The 20th century begat market crash and, and then we have had the borrowing from the physics of wave-like behaviour terms including economic depression and economic recession.

The 21st century downturn (c. 2008) was so severe that the softer terms like credit squeeze/freeze gave way to credit crunch. It does not mean that the older, ‘harsher’ terms disappear – ‘banking panic’, a technical term used in the 1960’s, has resurfaced in the research literature.

‘Stock prices rose (fell) when firms reported earnings that were higher (lower) than expected by a simple time series model. …. [A]ccounting earnings, however, are considerably delayed reports of financial and include accruals, which can be viewed as a noisy measure of the cash flows that provide the foundation of most valuation models in finance’ (Baker and Nofsinger 2010:29).

The market response to the earnings announcement is usually sharp and lasts for months.

The efficient market hypothesis has had difficulty in dealing with this (above suspicion) anomaly.
Experimental economists have reported mixed results on rationality: people are often better (e.g. in two-person anonymous interactions), in agreement with (e.g. in flow supply and demand markets), or worse (e.g. in asset trading), in achieving gains for themselves and others than is predicted by rational analysis.

Patterns in these contradictions and confirmations provide important clues to the implicit rules or norms that people may follow, and can motivate new theoretical hypotheses for examination in both the field and the laboratory.

The “prize in economic sciences in memory of Alfred Nobel”, as it is officially known, sometimes struggles to command the same respect as its counterparts.

This year’s winners appeared to reinforce doubts about the prize’s standing. One, Eugene Fama of Chicago, is known for his ardent belief in the efficiency of markets: he declined to renew his subscription to this newspaper after tiring of its incessant warning about bubbles, the very existence of which he denies. Robert Shiller from Yale, in contrast, is known for his prescient warnings of bubbles, in technology stocks in the 1990s and in housing in the 2000s.

Lars Hansen developed what has since become a very influential statistical technique known as “generalised method of moments estimation”.

Information Asymmetry in Financial Trading

Information invariably comprises an element of surprise.

Information flows when there is an asymmetry – the writer knows more than the reader/listener.

The providers of information can present information that blends facts and opinion.

It is important to understand the attitude of the writer and how the attitude is expressed.

Information Asymmetry: Noise Traders and Informed

Assume that there are two kinds of traders only in a market: informed traders and noise traders. The noise trader fails to ascertain the true value of an asset and relies on guesswork, heuristics, imitation of the informed trader, or prayer. The noise trader misprices and the informed trader should see this as an opportunity to create a margin through arbitrage. This arbitrage is not always possible and worse still the informed tries to follow the noise trader.

<table>
<thead>
<tr>
<th>Traders</th>
<th>Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pessimistic</td>
</tr>
<tr>
<td>Informed</td>
<td>Herding</td>
</tr>
<tr>
<td>Optimistic</td>
<td>Buy</td>
</tr>
</tbody>
</table>
Impact of News on Prices and Traded Volume

- News Effects
  - I: News Announcements Matter, and Quickly;
  - II: Announcement Timing Matters
  - III: Volatility Adjusts to News Gradually
  - IV: Pure Announcement Effects are Present in Volatility
  - V: Announcement Effects are Asymmetric – Responses Vary with the Sign of the News;
  - VI: The effect on traded volume persists longer than on prices.


Affect, Emotion and Mood

<table>
<thead>
<tr>
<th>AFFECT CATEGORY</th>
<th>SCALE/VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Putting a qualitative value on entities</td>
<td>Positive/Negative</td>
</tr>
<tr>
<td>Showing how the depth or shallowness of affect</td>
<td>Strong/Weak</td>
</tr>
<tr>
<td>Indicating the persistence of affect</td>
<td>Active/Passive</td>
</tr>
<tr>
<td>Implying a moral judgement</td>
<td>Virtue/Vice</td>
</tr>
</tbody>
</table>
Sentiment Analysis

Sentiment analysis: a systematic, computer-based analysis of written text and speech excerpts, for determining the attitude of the author or speaker respectively in relation to a specific topic.


Sentiment Analysis

Sentiment analysis systems were used first by political scientists to understand the orientation of political parties – through an analysis of party manifestos.

Scholars in economics and finance have used opinion columns in financial newspapers to estimate the impact of opinions and opinion makers on prices and traded volumes of equities.

**Sentiment Analysis**

**Existing terminology/ontology resources**
**Ontological commitments of a new term – dark liquidity pools**

**dark liquidity pools**

Secretive actions conducted by large brokerages to make transactions outside of the markets so that the trades will not adversely affect the price of large sections of stock. Institutional investors commonly use dark liquidity pools as a method of concealing their investors or investments. Because the prices of these transactions are concealed, investors are typically able to receive a lower price.
### Action

The *price movement* and *volume* of a *stock* or overall *market*.

### brokerage

Used interchangeably with broker when referring to a *firm* rather than an *individual*. *Also called* brokerage house or brokerage firm.

### transactions

(a) An *agreement* between a *buyer* and a *seller* to *exchange* an *asset* for *payment*.

(b) In *accounting*, any *event* or *condition* recorded in the *book of accounts*.

### market

A *public* place where *buyers* and *sellers* make *transactions*, directly or *via intermediaries*. Also sometimes *means* the *stock market*.

### trades

(a) A *transaction* of a *security* or *commodity*.

(b) *The exchange* of *products* and/or *services* without the use of *money*. *Also called* barter.

### price

*Cost*, usually expressed in *monetary terms*.

---

### Regulatory Change & The Text Deluge

A selection of key sources of compliance and regulatory documents, most have a digital "pressroom" and RSS feed:

- **FINRA**: The Financial Industry Regulatory Authority is a self-regulatory organization for all securities firms doing business in the USA.
- **FDIC**: The Federal Deposit Insurance Corporation was created to maintain stability and public confidence in the US financial system.
- **CFPB**: The Consumer Financial Protection Bureau administers and enforces consumer financial protection laws based on US foreign policy and national security goals.
- **OFAC**: The Office of Foreign Assets Control enforces economic and trade sanctions based on US foreign policy and national security goals.
- **CFTC**: The Commodity Futures Trading Commission enforces US futures laws, oversees commodity futures markets, and enforces related federal securities laws.
- **Federal Reserve System**: The Federal Reserve System comprises a banking regulation division in addition to its other activities.
- **Patent being applied for the CiCui**
### Defining Rationality

<table>
<thead>
<tr>
<th>Method</th>
<th>Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systematic study of archives detailed observations</td>
<td>Mathematical/Statistical Models</td>
</tr>
<tr>
<td>Elicitation Experiments</td>
<td>Psychological/Anthropological Experimentation</td>
</tr>
<tr>
<td>Introspection or broad-based observation</td>
<td>Logical Philosophical</td>
</tr>
</tbody>
</table>

### Defining Rationality

<table>
<thead>
<tr>
<th>Method</th>
<th>Instances</th>
<th>Data Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systematic study of archives detailed observations</td>
<td>Econometrics esp. asset dynamics</td>
<td>Large data sets of quantitative variables</td>
</tr>
<tr>
<td>Elicitation Experiments</td>
<td>Bounded Rationality &amp; Prospect Theory</td>
<td>Case studies of exemplar behaviour</td>
</tr>
<tr>
<td>Introspection or broad-based observation</td>
<td>Wealth (re-) distribution; poverty alleviation</td>
<td>Limited historical data; narratives</td>
</tr>
<tr>
<td></td>
<td>Expected Utility Models; Choquet/Sugeno</td>
<td>Paradoxes in uncertainty management</td>
</tr>
<tr>
<td></td>
<td>Expected Utility;</td>
<td></td>
</tr>
</tbody>
</table>
### Risk: Behaviour and Rationality

Risk assessment is an integral part of modern finance theory and practice. Conventional or standard finance (with its β’s risk-free assets) discounts impact of human behaviour whilst behavioural finance gives much prominence to human fallibility. (Baker and Nofsinger 2010).

<table>
<thead>
<tr>
<th>Standard Finance</th>
<th>Behavioural Finance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classical Decision Making</td>
<td>Decision Making Heuristics</td>
</tr>
<tr>
<td>Modern Portfolio Theory</td>
<td>Prospect Theory</td>
</tr>
<tr>
<td>Capital Asset Pricing Model</td>
<td>Framing and Weighting of Chance Events</td>
</tr>
<tr>
<td>Normative Decision Making (operations research)</td>
<td></td>
</tr>
<tr>
<td>Omniscient Rationality</td>
<td>Bounded Rationality</td>
</tr>
</tbody>
</table>

### Behaviour and Financial Markets

Long-Term Capital Management L.P. (LTCM) was a hedge fund management firm that utilized absolute-return trading strategies, including fixed-income arbitrage, statistical arbitrage, and pairs trading, combined with high leverage.

Founded in 1994 and had annualised returns of over 40% until 1997. The firm, got entangled in the transformation of Russia from a controlled economy to a market-based economy, and was bailed-out after making losses of $4.6Billion in 1998 by other institutions under the guidance of the US Federal Reserve.


Behavior and Financial Markets: LCTM a precursor

Long-Term Capital Management L.P. (LTCM) was a hedge fund management firm that utilized absolute-return trading strategies, including fixed-income arbitrage, statistical arbitrage, and pairs trading, combined with high leverage.

Founded in 1994 and had annualised returns of over 40% until 1997. The firm, got entangled in the transformation of Russia from a controlled economy to a market-based economy, and was bailed-out after making losses of $4.6 Billion in 1998 by other institutions under the guidance of the US Federal Reserve.


The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 1997 was awarded jointly to Robert C. Merton (Right) and Myron S. Scholes (Left) "for a new method to determine the value of derivatives"

http://nobelprize.org/nobel_prizes/economics/laureates/1997/

Behaviour and Financial Markets: LCTM a precursor

APPLICATIONS OF OPTION-PRICING THEORY: TWENTY-FIVE YEARS LATER

Nobel Lecture, December 9, 1997

by

Robert C. Merton

Graduate School of Business Administration, Harvard University, Boston, MA 02163, USA and Long-Term Capital Management, L.P., Greenwich, CT 06830, USA

New financial product and market designs, improved computer and telecommunications technology and advances in the theory of finance during the past quarter-century have led to dramatic and rapid changes in the structure of global financial markets and institutions. The scientific breakthroughs in financial modeling in this period both shaped and were shaped by the extraordinary flow of financial innovation which coincided with those changes. Thus, the publication of the option-pricing model in 1973 surely helped the development and growth of the listed options and over-the-counter (OTC) derivatives markets. But, the extraordinary growth and success of those markets just as surely stimulated further development and research focus on the derivative-security pricing models. To see this in perspective, consider some

It is difficult to define financial derivatives in a dynamic environment. The purest among us might argue that any security is a derivative if its price dynamics depend on the dynamics of some other underlying asset or assets and time. This broad definition allows not only for what currently exists but also what new derivative instruments will be developed in the future with enhanced understanding and changing production costs. The popular press, however, tends to limit the definition to include financial options, futures and forward contracts either traded on an exchange or issued in the OTC industry. In the future they may come to be called financial products.

LTCM’s basic strategy was ‘convergence’ and ‘relative-value’ arbitrage: the exploitation of price differences that either must be temporary or have a high probability of being temporary. Typical were its many trades involving ‘swaps’: by the time of LTCM’s crisis, its swap book consisted of some 10,000 swaps with a total notional value of $1.25 trillion.” (MacKenzie 2003:354).


The value of $1,000 invested in LTCM, the Dow Jones Industrial Average and invested monthly in U.S. Treasuries at constant maturity.
Hedge funds report their performance on a monthly basis. In August 1998, LTCM reported that ‘it lost 44 per cent of its capital. However, though massive, and far greater than had seemed plausible on the basis of LTCM’s risk model, this loss was not in itself catastrophic. LTCM still had ‘working capital’ of around $4 billion [...] of which only $2.1 billion was being used for financing positions [...].’ LTCM was, it seemed, a long way from being bankrupt. (Mackenzie 2003: 365)

Realising that the long term (sic) potential of LTCM was good, John Merriwether decided to seek more funds from the hedge-fund investors. He sent a fax that comprised, amongst other items, the following: ‘In August, many of them diverged at a speed and to an extent that had not been seen before. LTCM thus believes that it is prudent and opportunistic to increase the level of the Fund’s capital to take full advantage of this unusually attractive environment.’
Meriwether’s fax, intended to be private to LTCM’s investors, became public almost instantly. Robert Merton, a fellow director, remarked: ‘Five minutes after we sent our first letter . . . to our handful of shareholders, it was on the Internet’.

This was the first known casualty of the Internet! The *agencement*, the collective for stakeholders and machines, was visibly in operation – messages reaching untold millions, all imitating each other.

The outflows of capital resulting from unfavourable marks were particularly damaging in LTCM’s index option positions, where they cost the fund around $1 billion, nearly half of the September losses that pushed it to the brink of bankruptcy (ibid:366).

Donald MacKenzie, University of Edinburgh, has analysed the LTCM’s 1998 crisis using both qualitative, interview-based data and quantitative examination of price movements.

He suggests that ‘the roots of the crisis lay in an unstable pattern of imitation that had developed in the markets within which LTCM operated. As the resulting ‘superportfolio’ began to unravel, arbitrageurs other than LTCM fled the market, even as arbitrage opportunities became more attractive, causing huge price movements against LTCM.'
**Behaviour and Financial Markets:**

LCTM a precursor

Donald MacKenzie, University of Edinburgh has analysed the LTCM’s 1998 crisis using both qualitative, interview-based data and quantitative examination of price movements.

According to MacKenzie, the collapse may have been caused because:
1. Arbitrage is typically conducted by people often personally known to each other;
2. the possibility and consequences of imitation;
3. the limits on the capacity of arbitrage to close price discrepancies.


**Behaviour and Financial Markets**

Many contemporary scholars, and not only popular writers, have [...] argued that the standard socio-economic science model [...] requires, justifies and promotes selfish behavior

**Behaviour and Financial Markets**

The study of the behaviour of stakeholders in financial markets attempts to understand why stakeholders do not behave in a ‘rational’ manner. The term stakeholders is a broad one comprising amongst others, investors, traders, speculators, reporters, technologists, theorists, and regulators.

---

**Behaviour and Financial Markets**

Given that technology plays a major role in financial trading, we have to include machines in the ‘assemblage’ or *agencement* that is the collective stakeholders and machines.

Stakeholders may fail to update their beliefs correctly, sometimes machines in the *agencement* may fail them, stakeholders may act in a contrarian manner. Stakeholders sometimes appear risk averse in gainful situations and at others risk seeking in turbulent times.
Information processing in financial trading shows phenomenon like super-additivity and subadditivity that has its correlates in neural processing systems.

The interaction in decision making in economics and finance shows that decision makers (DM) may be using non-additive probability measures (Zhang 2002), and appears to involve issues like co-monotonicity of different acts the DMs perform (Chateauneuf, Grabisch and Rico 2008);

There are indications that mental accounting is used that may be related to subitization –visual enumeration- which has its neural correlates and evolutionary traits

---

The key role played by human interaction in financial markets, contrarian and herd behaviour shown by (large) sections of the trading community, and the ever present information asymmetry, between traders, brokers and (regulatory) institutions, has led to an emphasis on the role of affect in financial trading.

---


### The End of Rationality??

Affect is a superordinate term for feelings, sentiments and emotion. Affect is used for an act that will lead to change or will impress other persons (mind) and make them act. Affect includes evaluation of feeling/emotion/emotional response (negative/positive), strength or weakness of such feelings, and the role played by stakeholders who exhibit or cause emotional response – actively/passively. There is another human moral/ethical dimensions associated with affect which are acts of virtuousness or viciousness.

### The End of Rationality??

Financial trading systems usually facilitate a fundamental analysis (assets, profits/losses etc), and/or technical analysis (share price movements). There is a third type systems that are emerging and are called sentiment analysis systems.

Sentiment Analysis systems typically evaluate feelings/emotions from published formal (e.g. newspapers, regulatory newsletters) and informal (blogs, inter/intra organisational e-mails)sources of news and views.
Sentiment Analysis systems are amongst the more expensive retail information services offered by financial information services providers like Reuters and Dow Jones.
So what am I going to talk to you for the next 2.5 days?

1. I will look at the episodic behaviour of the markets and try and understand why economic cycles show unexpected spikes.

2. I will introduce you to three major thinkers in Decision Sciences, with special reference to economics and finance, especially, Herbert Simon, Daniel Kahneman, Amos Tversky, and Vernon Smith;

3. I will introduce you to the notion that whenever people interact they use a mixture of public and private data that is processed into personal information.

What you see/hear/touch is what you get? Perception of sound/orthography & cognition of language!

- Language can be viewed as 'a communicative process based on knowledge. Generally when humans use language, the producer and comprehender are processing information, making use of their knowledge of the language and of the topics of conversation. Language is a process of communication between intelligent active processors, in which both the producer and the comprehender(s) perform complex cognitive tasks.

Behaviour and Financial Markets

What you see/hear/touch is what you get? Perception of sound/orthography & cognition of language!

Producer

- Current Goals
- Knowledge Base
  - Knowledge of the language
  - Knowledge of the situation
  - Knowledge of the world

Comprehender

- Understood Meaning
- Knowledge Base
  - Knowledge of the language
  - Knowledge of the situation
  - Knowledge of the world

Medium

- Speech
- Writing


---

Behaviour and Financial Markets

What you see/hear/touch is what you get? Perception of sound/orthography & cognition of language!

<table>
<thead>
<tr>
<th>Stored Knowledge</th>
<th>Processes</th>
<th>Assigned Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phonological Rules</td>
<td><strong>Phonological</strong></td>
<td>Sounds</td>
</tr>
<tr>
<td>Morphological Rules</td>
<td><strong>Morphological</strong></td>
<td>Phonemes</td>
</tr>
<tr>
<td>Dictionary (items)</td>
<td><strong>Lexical</strong></td>
<td>Words</td>
</tr>
<tr>
<td>Grammar Rules</td>
<td><strong>Syntactic (Parsing)</strong></td>
<td>Syntactic Structures</td>
</tr>
<tr>
<td>Dictionary Definitions</td>
<td><strong>Semantic</strong></td>
<td>Representation Structures</td>
</tr>
<tr>
<td>Semantic Rules</td>
<td><strong>Reasoning</strong></td>
<td></td>
</tr>
<tr>
<td>Deductive Rules</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inferential Rules</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There are two COMPATIBLE ‘conceptions’ of music (Bigand 1993:233): one stressing the complexity of musical stimuli (PERCEPTUAL) and the other stressing its symbolic dimension (COGNITIVE).

According to the information processing [...] approach to psychology, the link between the perceptual qualities of the sound source, its abstract representation in memory, its identity, and the various meanings or associations it has with other objects in the listener’s environment are hypothesized to result from a multi-stage process.
The notion of recognition suggests that whatever an agent hears at a given time, it should correspond in some way to something that has already been heard in the past, as when a voice on the telephone, […] or a piece of music on the radio, are recognised.

The limits of the so-called rational approach to problem solving, monitoring and prediction have been demonstrated recently in a number of areas of human endeavour. The evidence of this limitation is particularly vivid in two diverse areas – image retrieval using purely visual features and financial decision making using efficient market hypothesis.


An area where there is evidence of *bounded rationality* is the manner in which news, rumours and blogs about financial markets appear to change the (numerical) value of attributes associated with the assets bought and sold in the market, e.g. prices and volumes of shares or currency traded. The rationalist approach is to discount the news altogether and focus on prices/volumes (the efficient market hypothesis.)
The End of Rationality??

But the news in general, and the linguistic, ontological and metaphorical description of the assets in particular, especially the sentiment about the market, has a profound effect on the market and is deemed responsible for the major booms and busts.

The End of Rationality??

Human beings have the propensity to choose radically different solutions to the same problem if the problem is expressed or framed differently. The facial gestures of the stakeholders in the market plays a key role in ‘framing’ news and blogs.

Expert traders and regulators make judicious choices in aggregating linguistic, numerical and gestural information.
Behaviour and Financial Markets

Behavioural models include questions about the role of theories in financial trading. Theories sometimes become the basis of practice (e.g. efficient market hypothesis) and indeed entire new trading systems emerge based on a theory (hedge funds).

Theories are developed with a (number of) assumptions by the theorists. Theories are revised regularly and some assumptions are found wanting.

Theories are refined incrementally and in some instances there is a paradigm shift of revolutionary proportions.

A multi-sensory world

Multisensory Processing
Multisensory Processing is an emergent property of the brain that distorts the neural representation of reality to generate adaptive behaviors.
Multisensory Processing is an emergent property of the brain that distorts the neural representation of reality to generate adaptive behaviors.

**Convergence Pattern:**
*Excitatory - Excitatory*

- Responds to "A" or "B" 
- Integrates "A" and "B"

**Convergence Pattern:**
*Excitatory - Inhibitory*

- Responds to "A" only 
- Modulates "A" by "B"
Multisensory Processing is an emergent property of the brain that distorts the neural representation of reality to generate adaptive behaviors.

**Cross-modal Facilitation**

**Cross-modal Inhibition-Dependent**

**Convergence Pattern: Excitatory-Subthreshold**

Responds to "A" only
Facilitates "A" by "B"

**Modality "A"**

**Modality "B"**

Multisensory Enhancement
Cross-modal Facilitation
Cross-modal Facilitation Inhibition-Dependent
Cross-modal Suppression
Multisensory Processing is an emergent property of the brain that distorts the neural representation of reality to generate adaptive behaviors.
Behaviour and Financial Markets – The Euphoria

The New York Times
Wednesday, March 22, 2000

FINDS PROPAGANDA IN PROSPERITY TALK, Economist of Industrial Conference Board Warns Advertisers on Inflation. FORESEES PROBLEMS AHEAD. Depression in Basic Industries Is Real, He Says, Despite Gain From Investments. Points to Boom Psychology, Fluctuation Less Acute.

There seems to be no basis in production, wages or consumers' purchasing power to account for the year increase in bond credits and other financial activities of the present time, according to Virgil Jordan, chief economist of the National Industrial Conference Board.

EUROPEAN CURRENCY CALLED STABLE NOW. In General, 1928 Closed Period of Violent Fluctuations, Says Commerce Department. EFFECT TIGHTENED TRADE But Financing is on Firmer Basis—Marked Trend Seen Toward Combinations in Industry. Trend Toward Industrial Mergers. French Trade Deficit Noted.

WASHINGTON, Jan. 4 — Progress by Europe toward currency stabilization was emphasized today by the Department of Commerce in a review of European industrial and commercial conditions in 1928, presented by E. H. Huntington, chief.

FOREIGN EXCHANGE; Sterling Rallies; London Turned It Higher Over Night on Buying Orders—Continentalists Dall. CLOSING RATES. FOREIGN BOND AVERAGES. BUDAPEST STOCK EXCHANGE. VIENNA STOCK EXCHANGE.


STOCK TRADING SETS RECORD FOR AUGUST; 95,704,890 Shares Sold on the Stock Exchange, Against 67,704,890 Year Ago. BOND TOTAL $258,455,000 Shows Decline of $55,804,690 From Previous Month and Gain of $77,116,500 Over 1928. Bond Dealings for Month.

FINANCIAL MARKETS; Many Sharp Advances in Stocks. Saron Declines—Call Money Holds at 5%.

Trading on the New York Stock Exchange last month was the heaviest of any August on record, and the third largest month this year. Sales totaled $95,704,890, compared with $92,454,690 in July, and $67,704,890 the same month a year ago. (END OF TEXT FOOTNOTES)
Behaviour and Financial Markets – The Melancholy

A multi-sensory world

Our brain, and perhaps that of a collective of people, generates its own projections of a given ‘reality’: accentuating, (censuring, ignoring) what we (do not) want to see/hear/know
Behaviour and Financial Markets – The Prophecy

STOCK PRICES BREAK ON DARK PROPHECY; Drop in Hectic Last Hour as Babson’s Prediction of a Big Slump Is Printed. Follows 19-DAY ADVANCE ‘Stale’ Market and Fear of Rise in Brokers’ Loans Also Are Factors in Sudden Decline. Caught Off Balance. STOCK PRICES BREAK ON DARK PROPHECY Change Comes Suddenly.

Out of a clear sky a storm of selling broke on the Stock Exchange yesterday afternoon and in one hour wiped out millions of dollars in the open market value of securities of all sorts. [END OF FIRST PARAGRAPH]

Behaviour and Financial Markets – The Confusion

FINANCIAL MARKETS; Recovery in Stocks, After Thursday’s Break--Call Money Goes to 6%.

Following the somewhat violent decline of the day before, the stock market reversed its movement yesterday, recovering much though as a rule by no means all of Thursday’s losses. Transactions were again larger than the recent average.
TREASURY FINANCING TO RELIEVE CREDIT; Extra Funds Are Expected to Be Available at End of Week Through Over-Draft.

September 8, 1929, Sunday
Section: Second News Section, Page N7, 795 words

TENDENCY DOWNWARD ON THE BERLIN BOERSE; General Depression Offset in Part by Brief Rally as Market Closes.

Special Cable to THE NEW YORK TIMES
September 8, 1929, Sunday
Section: Second News Section, Page N13, 542 words

FINANCIAL MARKETS; Stocks Move Irregularly With Both Advances and Declines --Sterling Unchanged.

September 8, 1929, Sunday
Section: Second News Section, Page N9, 713 words

The general repurchasing movement which on Friday's stock market followed the previous day's break was not repeated yesterday. A good deal of promiscuous bidding-up of prices occurred again, but it was not as...
Behaviour and Financial Markets – The Confusion

FINANCIAL MARKETS; Last Week's Reaction in Stocks and the Talk of a Future "Crash."
September 8, 1929, Monday
Swattion: Business & Finance, Page 30, 717 words

The action of last week's stock market, first in wavering undecidedly, then in three weeks' rapid rise, then breaking suddenly and violently, and following this by irregular recovery, repeated the experience of many previous occasions.

Behaviour and Financial Markets – The Melancholy

BANKS' DEALS DRAW NATION'S ATTENTION; Merger of National City With Corn Exchange Chief of New Developments. OTHER MOVES IMPORTANT Subsidiaries for Bank of the Manhattan Company and the Chatham Phenix. GREAT SYSTEMS FORECAST Bankers Consider Legalization of Establishment of Nation-Wide Chains of Branches.
September 22, 1929, Sunday
Swattion: National & Financial, Page 37, 1122 words

ANXIETY IN LONDON OVER HATRY INCIDENT; Collapse in Shares Hits Public, Sensational Developments Upset the Market.
September 23, 1929, Monday
Swattion: Business & Finance, Page 44, 200 words
A multi-sensory world

Multisensory Processing is an emergent property of the brain that distorts the neural representation of reality to generate adaptive behaviors.

Behaviour and Financial Markets – The Farce

SEEK TO WIND UP 4 HATRY COMPANIES; Creditors, Following Investigation Into British Crash, FileCompulsory Petitions.INVESTORS ARE NERVOUSLondon Prices Sag--Exchange Delays Hatry Settlement--Broker Defaulted at Liverpool.

Special Cable to THE NEW YORK TIMES.
September 24, 1932, Tuesday
Page 9, 402 Words

LONDON, Sept. 23.--Reverberations continued through the British financial world today as a result of the crash of the Photomaton Farseet Corporation and other companies controlled by Clarence C. Hatry. Hatry and three associates are now held without bail at Brixton prison charged with fraud involving more than $1,000,000, and trading in securities of his companies has been suspended. [END OF FIRST PARAGRAPH]
### Behaviour and Financial Markets – The Tragedy

Theoretical behavioural models are somewhat ad hoc and designed to explain specific stylised facts.

Empirical work is plagued by data-mining (that is, if researchers set out to find deviations from rational pricing by running numerous regressions, ultimately they will be successful).

Behavioural finance presents no unified theory unlike expected utility maximisation using rational beliefs.

### Behaviour and Financial Markets – The Rationalist Riposte

<table>
<thead>
<tr>
<th>Traditional Finance Theory Criticism</th>
<th>Behavioural Finance Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theoretical behavioural models are somewhat ad hoc and designed to explain specific stylised facts</td>
<td>Behavioural models are based on how people actually behave based on extensive experimental evidence, and explain evidence better than traditional ones</td>
</tr>
<tr>
<td>Empirical work is plagued by data-mining (that is, if researchers set out to find deviations from rational pricing by running numerous regressions, ultimately they will be successful).</td>
<td>Much empirical work has confirmed the evidence out-of-sample, both in terms of time-periods as well as cross-sectionally across different countries</td>
</tr>
<tr>
<td>Behavioural finance presents no unified theory unlike expected utility maximisation using rational beliefs.</td>
<td>Traditional risk-based theories do not appear to be strongly supported by the data.</td>
</tr>
</tbody>
</table>

The history of any discipline shows major changes in the discipline over a period of time. The underpinning theories in a discipline appear to change as well. In physics, we have moved from an indivisible atom (c. 1900) to a divisible atom (c. 1920) comprising elementary particles (protons and neutrons, c. 1935). The elementary particles, it turns out, are in themselves comprise quarks (c. 1970's) ……

There are two major theories of this change: First, new theories appear through a process of **iterative refinement** – a gradual process. Second, theories appear when suddenly anomalies in existing theories are discovered and are discarded.
### Behaviour and Financial Markets

Theories are refined incrementally and in some instances there is a paradigm shift of revolutionary proportions.

<table>
<thead>
<tr>
<th>Term/Concept</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception</td>
<td>In perceiving one sees</td>
<td>beams coming from an object (Aristotle)</td>
</tr>
<tr>
<td>Motion</td>
<td>Objects move because of</td>
<td>an in-built tendency to move (Aristotle)</td>
</tr>
<tr>
<td>Solar Cycle</td>
<td>Sunrise is caused by</td>
<td>a rising Sun (Brahe)</td>
</tr>
<tr>
<td>Combustion</td>
<td>Burning an object (say O) in air means</td>
<td>The mass of O decreases by losing phlogiston to air (Priestley)</td>
</tr>
</tbody>
</table>

---

### Behaviour and Financial Markets

Theories are refined incrementally and in some instances there is a paradigm shift of revolutionary proportions.

<table>
<thead>
<tr>
<th>Term/Concept</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photosynthesis</td>
<td>Glucose <em>produced by plants during photosynthesis</em></td>
<td>Hydrogen combines with Carbon dioxide to form carbohydrates ((CH$_2$O)$_n$) (Van Hel)</td>
</tr>
<tr>
<td>Ventilation</td>
<td>Expiration (during breathing) is facilitated by</td>
<td>contraction of chest as a consequence of higher pressure (Harvey)</td>
</tr>
<tr>
<td>Heartbeat</td>
<td>expansion of chest as a consequence of heating (Calle)</td>
<td>Sea water circulation is caused by</td>
</tr>
<tr>
<td>Species</td>
<td>The distinction between species is</td>
<td>a compression during systole of the heart (Harvey)</td>
</tr>
<tr>
<td></td>
<td>an absolute phenomenon that has been determined in the past (Lamarck)</td>
<td>a contemporaneous phenomenon with borders between the species (Darwin)</td>
</tr>
</tbody>
</table>
Iterative Refinement

Karl Popper tried to build a purely deductive approach to science [and econometrics]. For Popper ‘all scientific discussions start with a problem (P₁), to which we offer some sort of tentative solution – a tentative theory (TT); this theory is then criticized, in an attempt at error elimination (EE); and as in the case of dialectic, this process renews itself: the theory and its critical revision to new problems (P₂)’ (Redman 1994:69).

\[ P₁ \rightarrow TT \rightarrow EE \rightarrow P₂ \]

It is possible, suggested Karl Popper, that science could start anywhere.

Popper has influenced the development of econometrics.


Paradigm Shifts:
What is paradigm shift anyway?

A research paradigm (Kuhn 1970) was defined originally by Kuhn to 'suggest that some accepted example of actual scientific practice - examples which include law, theory, application and instrumentation together - provide models from which spring particular coherent traditions of scientific research' (1970: 10).

Normal Science: science that is considered standard or normative; science that works within the prevailing paradigms of its time and uses generally accepted methods (OED);

“Normal science’ means research firmly based upon one or more past scientific achievements [...] that some particular scientific community acknowledges for a time as supplying the foundation for its further practice.” (Kuhn 1970:10)

Kuhn's attempt to revolutionise the philosophy of science by predicating a structure of scientific revolutions follows a research tradition that was operationalised by, amongst others, Ludwik Fleck. Fleck, a neo-Kantian scientist, attempted to argue that the genesis and development of a scientific fact (Fleck 1935/1979) involved 'thought styles' and 'thought collectives' that show sociological conditioning as vital to the consolidation of scientific facts.
Paradigm Shifts:
What is paradigm shift anyway?

Fleck was aware of the developments in the atomic theory of matter (c. 1900-30) and commented that 'the concepts of the elements and of the atom can thus be constructed from historical factors as well from those of the thought collective. Such concepts are derived from the collective imagination.' (1979:83).

Paradigm Shifts:
What is paradigm shift anyway?

Kuhn's position has shifted over the last quarter century and this has led him to argue that conceptual and linguistic change during scientific revolutions are amongst the key changes. During the last 10 years Kuhn has brought terms like *lexicon* and *lexical structure* into what has otherwise been an historical and sociological analysis of how science works and develops. Every scientific theory, according to Kuhn (1991), has its idiosyncratic structured taxonomic lexicon organised within a particular network whose links comprise structural relationships such as

## Paradigm Shifts:
### What is paradigm shift anyway?

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Possible interpretations of the proposition:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Metaphysical</strong></td>
<td>A paradigm is</td>
</tr>
<tr>
<td></td>
<td>a successful metaphysical speculation (Kuhn 1970:2)</td>
</tr>
<tr>
<td></td>
<td>a set of beliefs <em>(ibid:4)</em></td>
</tr>
<tr>
<td></td>
<td>a myth <em>(ibid:17)</em></td>
</tr>
<tr>
<td></td>
<td>a standard <em>(ibid:102)</em></td>
</tr>
<tr>
<td></td>
<td>a map <em>(ibid:108)</em></td>
</tr>
<tr>
<td></td>
<td>a new way of seeing things <em>(ibid:117-121)</em></td>
</tr>
<tr>
<td></td>
<td>an organising principle governing perception <em>(ibid:120)</em></td>
</tr>
<tr>
<td></td>
<td>something which determines a large area of reality <em>(ibid:128)</em></td>
</tr>
</tbody>
</table>

**Kuhn's 20 senses of the term paradigm. (Masterman, 1970)***

---

**Paradigm Shifts:**
### What is paradigm shift anyway?

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Possible interpretations of the proposition:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constructural or Artefactual</strong></td>
<td>A paradigm is</td>
</tr>
<tr>
<td></td>
<td>(like) a textbook <em>(ibid:10)</em></td>
</tr>
<tr>
<td></td>
<td>(like) an analogy <em>(ibid:14)</em></td>
</tr>
<tr>
<td></td>
<td>a universally recognised scientific achievement <em>(ibid:21)</em></td>
</tr>
<tr>
<td></td>
<td>a grammatical paradigm <em>(ibid:23)</em></td>
</tr>
<tr>
<td></td>
<td>a conceptual and instrumental tools <em>(ibid:37, 76)</em></td>
</tr>
<tr>
<td></td>
<td>a device or type of instrumentation <em>(ibid:59, 60)</em></td>
</tr>
<tr>
<td></td>
<td>(like) a gestalt figure <em>(ibid:63)</em></td>
</tr>
<tr>
<td></td>
<td>an anomalous pack <em>(ibid:85)</em></td>
</tr>
</tbody>
</table>

**Kuhn's 20 senses of the term paradigm. (Masterman, 1970)***

---

Paradigm Shifts:
What is paradigm shift anyway? Players and others

<table>
<thead>
<tr>
<th>People</th>
<th>Knowledge</th>
<th>Exemplars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset-backed security traders</td>
<td>Mathematically Sophisticated?</td>
<td>Yes</td>
</tr>
<tr>
<td>Collateralised Debt</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Obligation Vendors</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Regulators</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Clever Clog Academics</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>