Physics, the distant cousin of Economics

Pratik Bhanuse
(M.Sc. Materials Physics)

OUTLINE OF MY TALK

- History of Econophysics?
- Patterns
- Financial Modelling
- Role of probability
- Optimisation

HISTORY OF ECONOPHYSICS

WHAT IS ECONOPHYSICS?

WHAT IS ECONOPHYSICS?

ECONOMICS **PHYSICS**

WHAT IS ECONOPHYSICS?

Formal Definition

The interdisciplinary conglomeration where a physicist studies the problems in economics and finance with the help of physics.

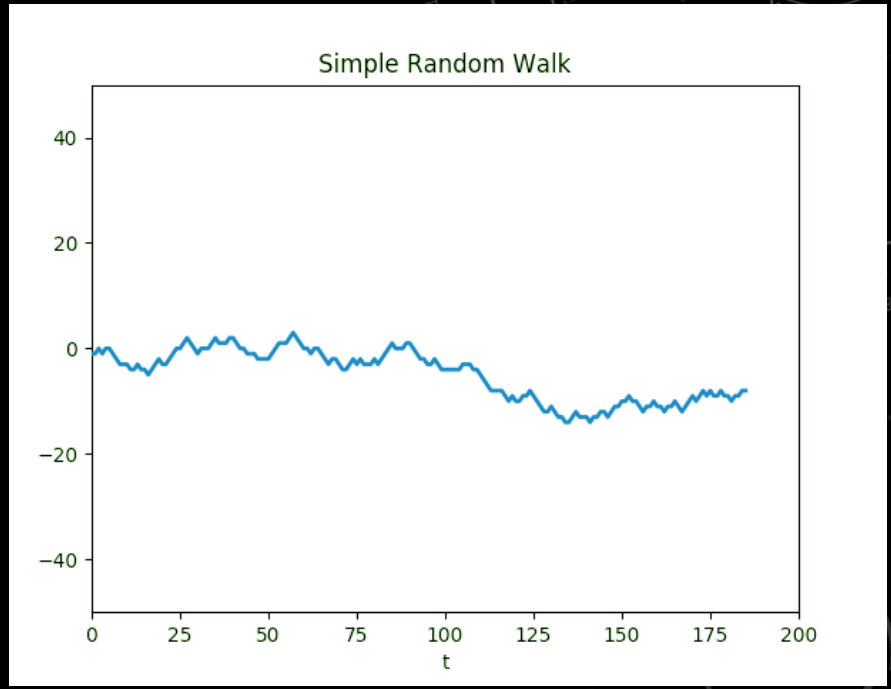
WHAT IS ECONOPHYSICS?

This term was first introduced by Eugene Stanley in a discussion with Bikas Chakrabarti at the conference *Dynamics of Complex Systems* in Kolkata, India in 1995.

References:
Yakovenko, V. M. (2016). Monetary economics from econophysics perspective. *The European Physical Journal Special Topics*, *225*(17-18), 3313-3335.

ROLE OF BROWNIAN MOTION

- Random Walk
- Let’s look how the random walk looks like.
- Application in financial instruments(options).



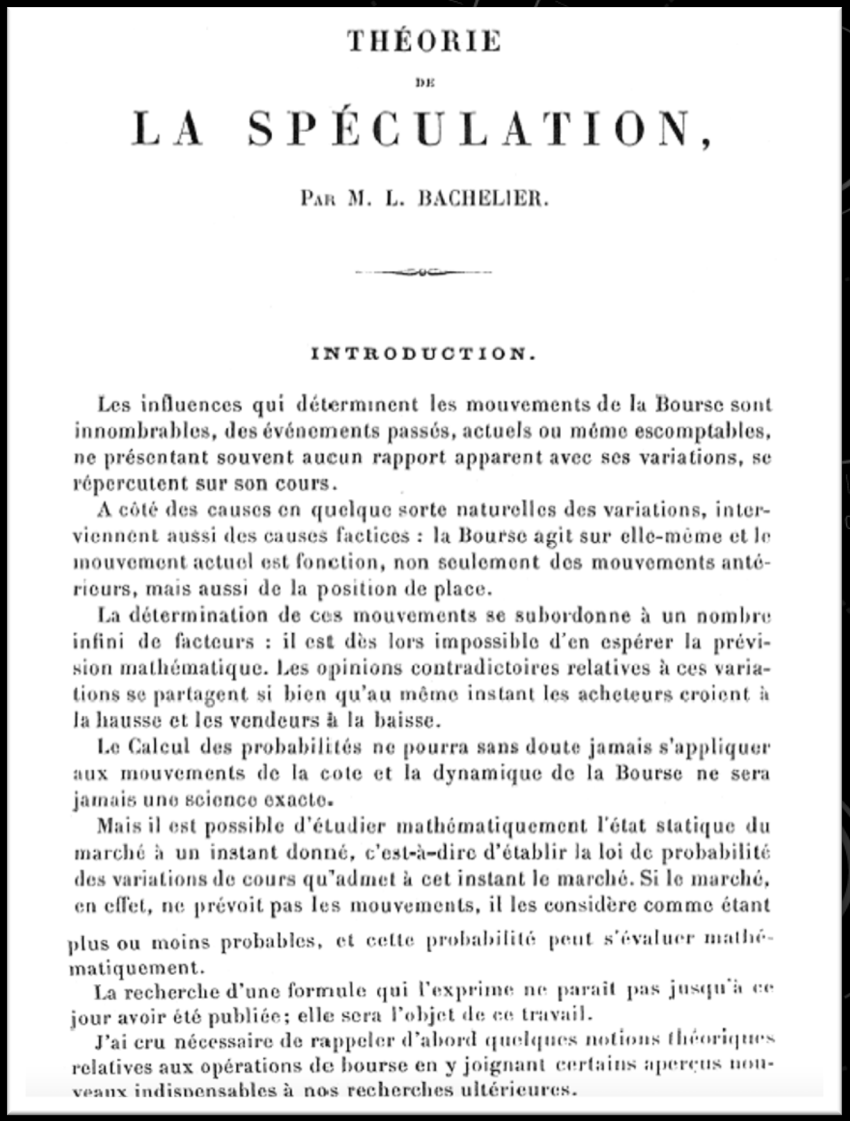
WHO IS LOUIS BACHELIER?

- Born on March 11th , 1870
- French mathematician
- Henri Poincaré

References:
https://en.wikipedia.org/wiki/Louis_Bachelier

WHAT WAS LOUIS BACHELIER'S PHD THESIS?

- Defended on March 29, 1900 at the University of Paris,
- Théorie de la speculation



THÉORIE
DE
LA SPÉCULATION,

PAR M. L. BACHELIER.

INTRODUCTION.

Les influences qui déterminent les mouvements de la Bourse sont innombrables, des événements passés, actuels ou même escomptables, ne présentant souvent aucun rapport apparent avec ses variations, se répercutent sur son cours.

A côté des causes en quelque sorte naturelles des variations, interviennent aussi des causes factices : la Bourse agit sur elle-même et le mouvement actuel est fonction, non seulement des mouvements antérieurs, mais aussi de la position de place.

La détermination de ces mouvements se subordonne à un nombre infini de facteurs : il est dès lors impossible d'en espérer la prévision mathématique. Les opinions contradictoires relatives à ces variations se partagent si bien qu'au même instant les acheteurs croient à la hausse et les vendeurs à la baisse.

Le Calcul des probabilités ne pourra sans doute jamais s'appliquer aux mouvements de la cote et la dynamique de la Bourse ne sera jamais une science exacte.

Mais il est possible d'étudier mathématiquement l'état statique du marché à un instant donné, c'est-à-dire d'établir la loi de probabilité des variations de cours qu'admet à cet instant le marché. Si le marché, en effet, ne prévoit pas les mouvements, il les considère comme étant plus ou moins probables, et cette probabilité peut s'évaluer mathématiquement.

La recherche d'une formule qui l'exprime ne paraît pas jusqu'à ce jour avoir été publiée; elle sera l'objet de ce travail.

J'ai cru nécessaire de rappeler d'abord quelques notions théoriques relatives aux opérations de bourse en y joignant certains aperçus nouveaux indispensables à nos recherches ultérieures.

References:
Bachelier, L. (2011). Louis Bachelier's theory of speculation: the origins of modern finance. Princeton University Press.

PATTERNS

PATTERNS

What’s a Zipf Plot?

Zipf plot in financial history.

POWER LAW

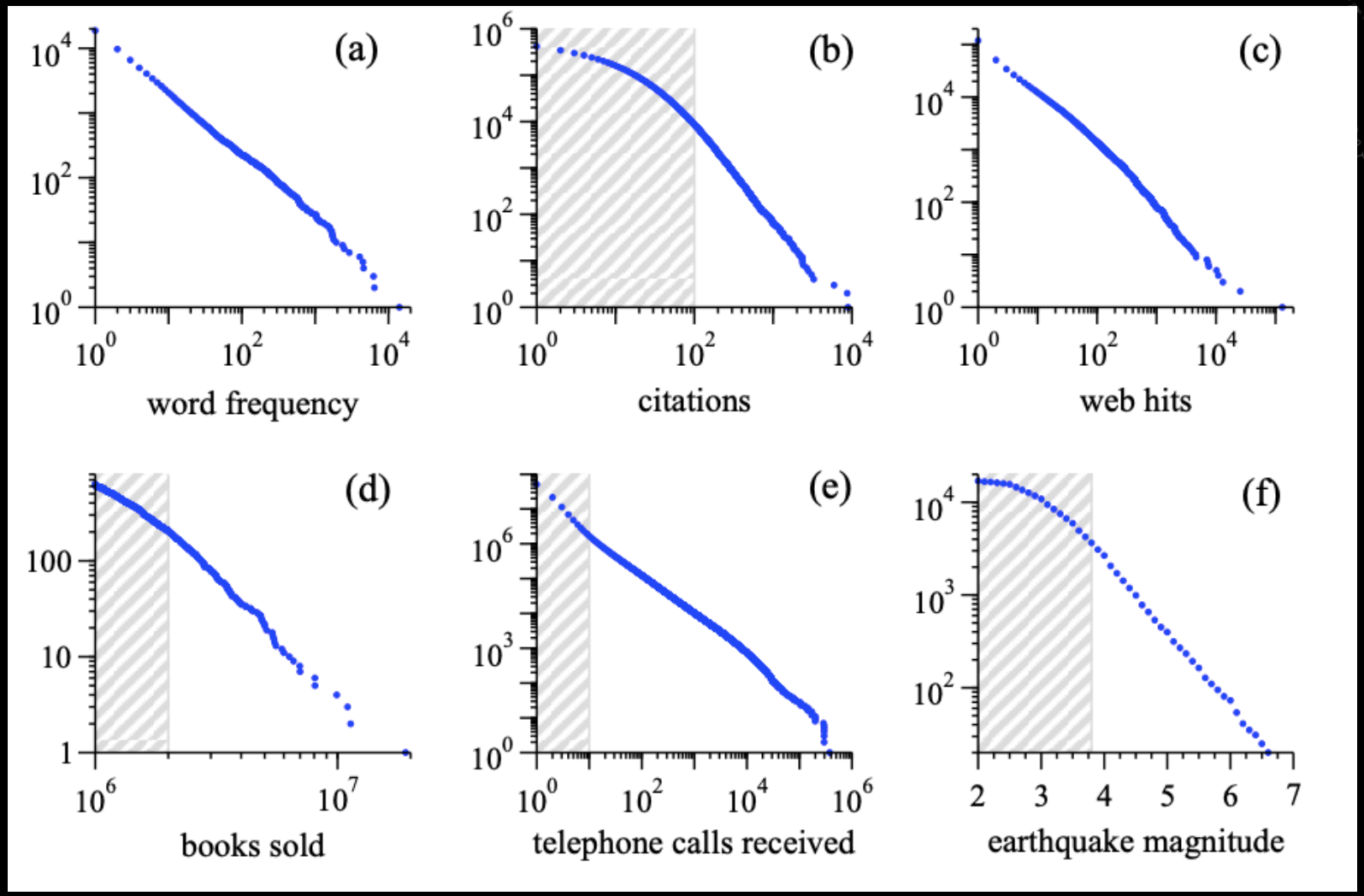
- When the probability of measuring a particular value of some quantity varies inversely as a power of that value, the quantity is said to follow a power law, also known variously as Zipf's law or the Pareto distribution.

$$p(x) = Cx^{\alpha}$$

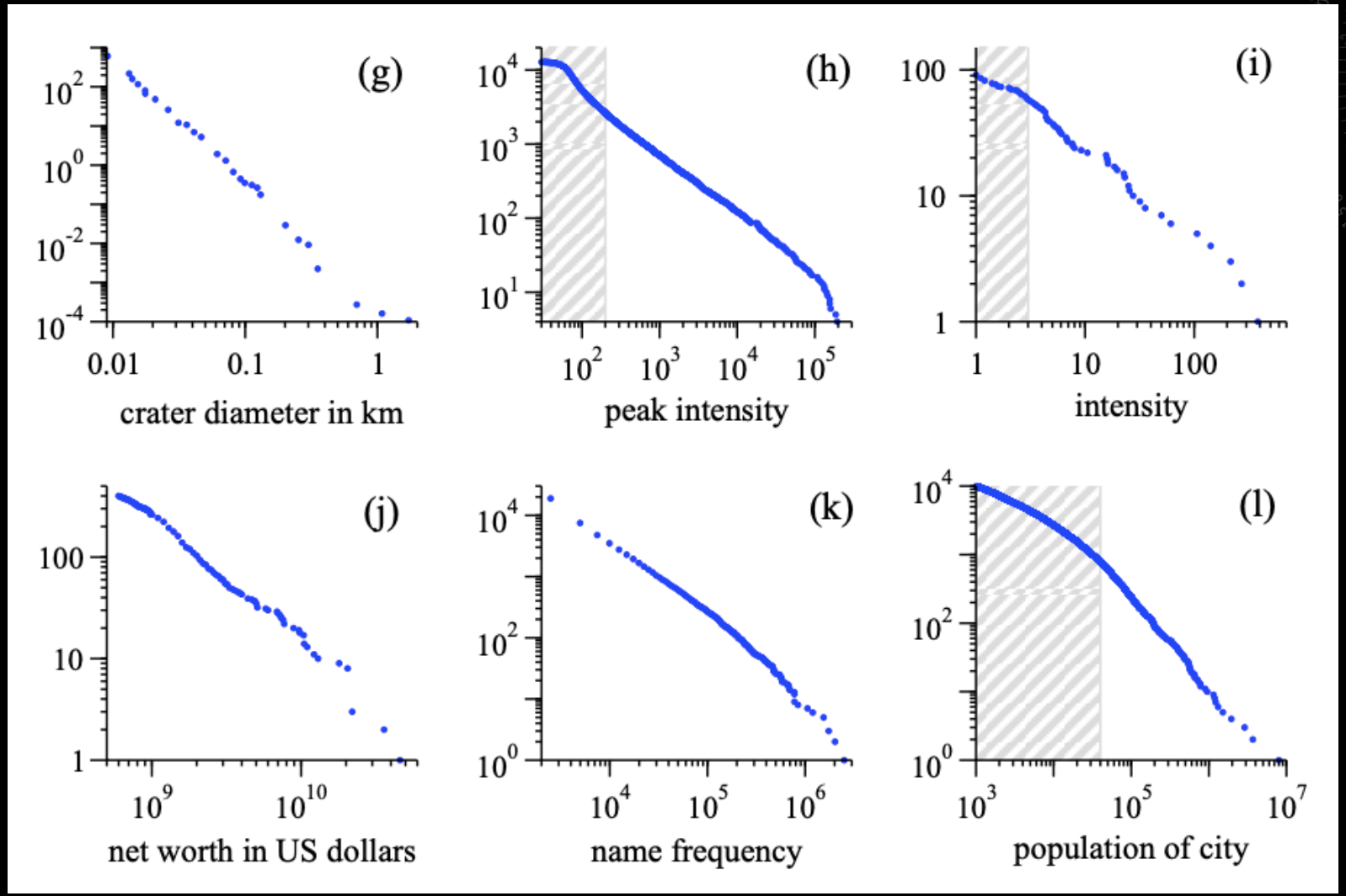
References:
Newman, Mark EJ. "Power laws, Pareto distributions and Zipf's law." Contemporary physics 46.5 (2005): 323-351.

POWER LAW PATTERNS IN NATURE

- Physics
- Biology
- Meteorology
- Astronomy
- Mathematics
- Economics



References:
Newman, Mark EJ. "Power laws, Pareto distributions and Zipf's law." Contemporary physics 46.5 (2005): 323-351.



References:
Newman, Mark EJ. "Power laws, Pareto distributions and Zipf's law." Contemporary physics 46.5 (2005): 323-351.

2008 FINANCIAL CRASH

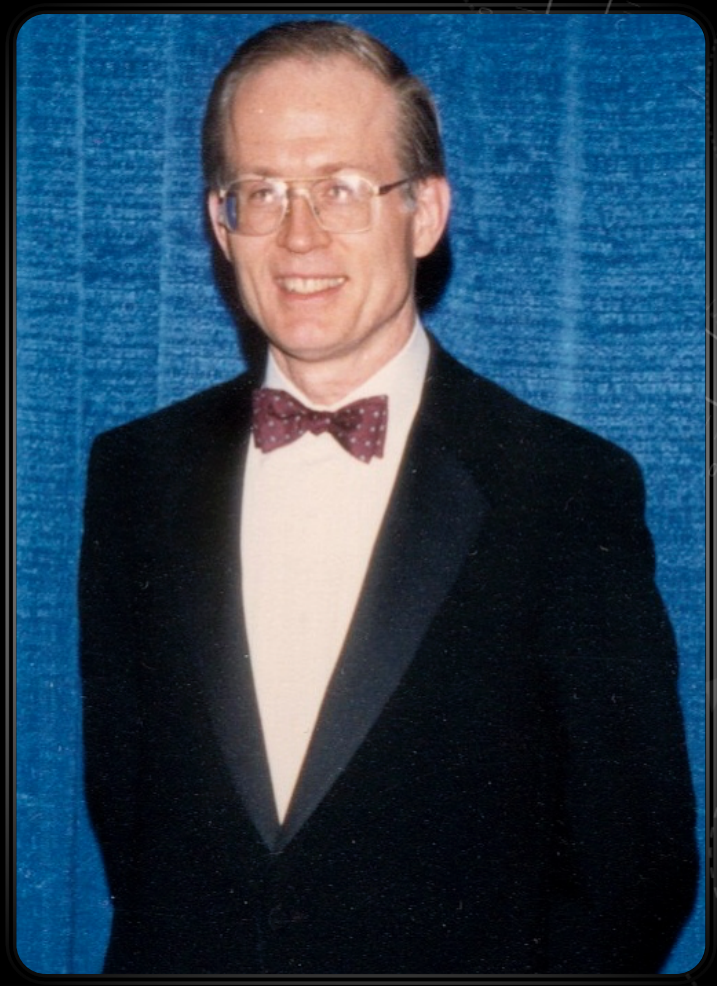
References:
YahooFinance https://ca.finance.yahoo.com/

FINANCIAL MODELLING

BLACK–SCHOLES MODEL

FISHER BLACK

- American mathematician
- Ph.D. Applied mathematics, Harvard
- Missed the Nobel Prize.



References:
https://en.wikipedia.org/wiki/Fischer_Black

MYRON SCHOLES

- Canadian-American economist
- Ph.D. from MIT
- Nobel Prize in Economics (1997)

References:
https://en.wikipedia.org/wiki/Myron_Scholes

WHAT IS THIS BLACK-SCHOLES MODEL

- Derived from Diffusion Equations
- Used for Options Pricing

WHAT IS THIS BLACK-SCHOLES MODEL

$$\frac{\partial C}{\partial t} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 C}{\partial t^2} + rC\frac{\partial C}{\partial t} - rC = 0$$

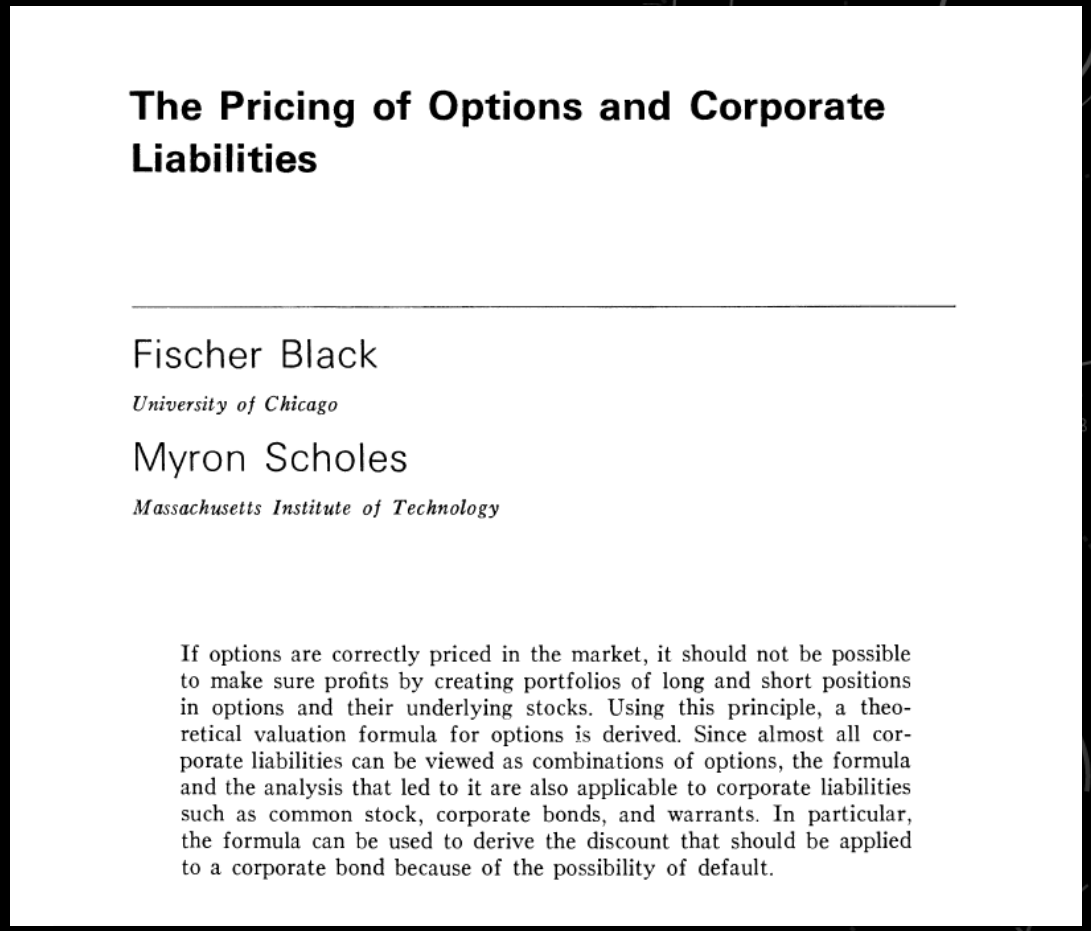
C = price of option

S = Stock price

t = time

r = risk free interest rate

σ = volatility of the stock



The Pricing of Options and Corporate Liabilities

Fischer Black

University of Chicago

Myron Scholes

Massachusetts Institute of Technology

If options are correctly priced in the market, it should not be possible to make sure profits by creating portfolios of long and short positions in options and their underlying stocks. Using this principle, a theoretical valuation formula for options is derived. Since almost all corporate liabilities can be viewed as combinations of options, the formula and the analysis that led to it are also applicable to corporate liabilities such as common stock, corporate bonds, and warrants. In particular, the formula can be used to derive the discount that should be applied to a corporate bond because of the possibility of default.

References:
Black, F., & Scholes, M. (1973). The pricing of options and corporate liabilities. Journal of political economy, 81(3), 637-654.

WHAT IS THIS BLACK-SCHOLES MODEL

$$\frac{\partial C}{\partial t} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 C}{\partial t^2} + rC\frac{\partial C}{\partial t} - rC = 0$$

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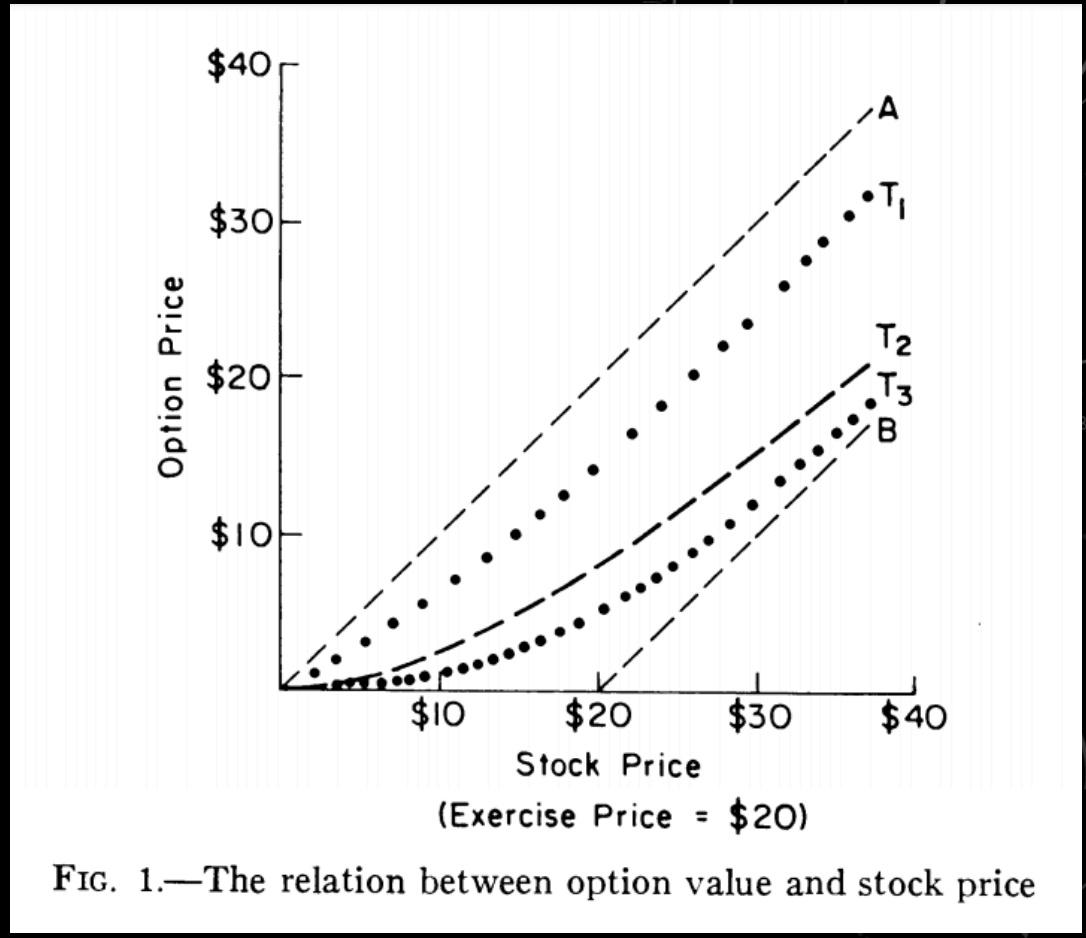


FIG. 1.—The relation between option value and stock price

References:
Black, F., & Scholes, M. (1973). The pricing of options and corporate liabilities. *Journal of political economy*, *81*(3), 637-654.

ROLE OF PROBABLITY

MONTE HALL PROBLEM

References:
https://en.wikipedia.org/wiki/Monty_Hall_problem

MONTE HALL PROBLEM

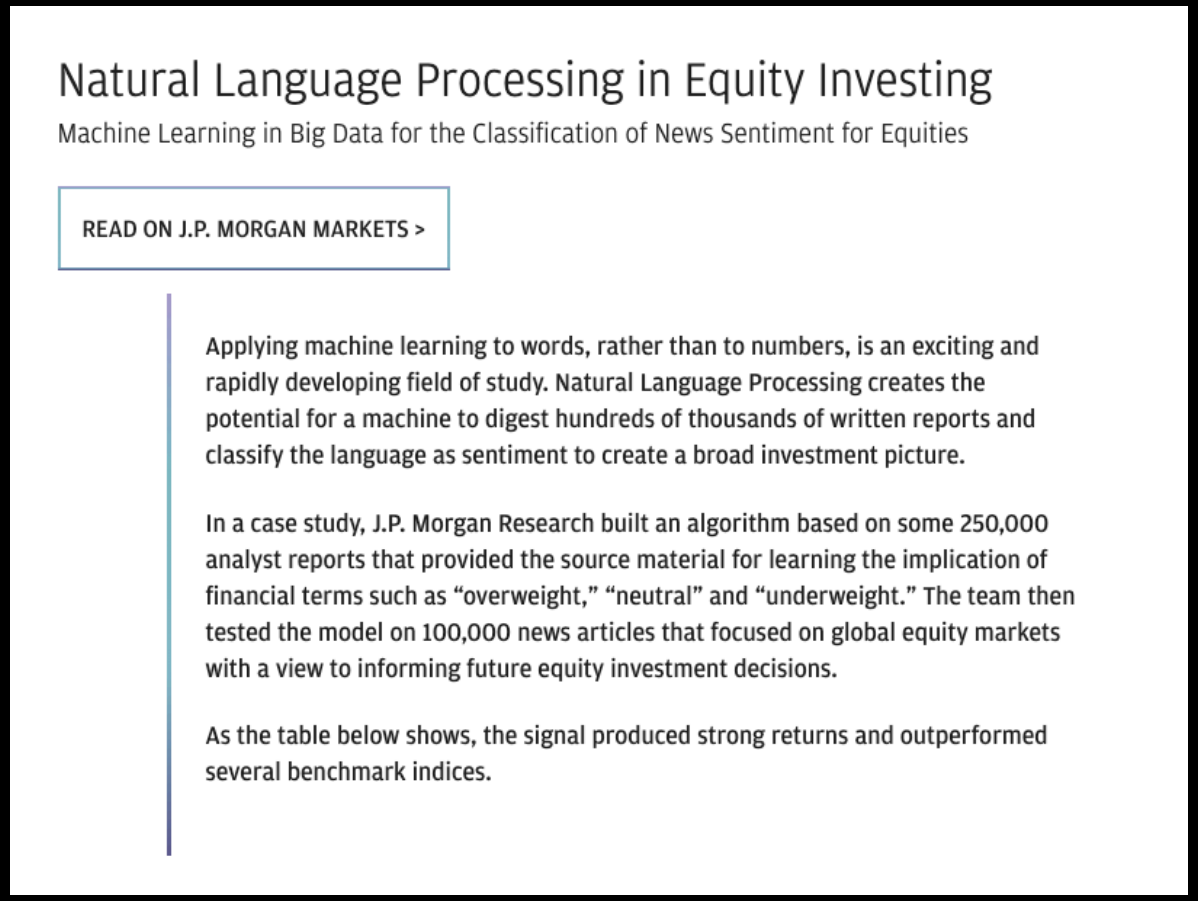
- The alteration in the probability happens mainly due to one most important reason, i.e., INFORMATION
- But, what role does INFORMATION plays in the world of finance and economics.

OPTIMISATION

OPTIMSATION

- Optimisation can be done using a concept called machine learning.
- Machine learning is implementation of artificial intelligence to solve a particular problem.

MACHINE LEARNING



Natural Language Processing in Equity Investing

Machine Learning in Big Data for the Classification of News Sentiment for Equities

READ ON J.P. MORGAN MARKETS >

Applying machine learning to words, rather than to numbers, is an exciting and rapidly developing field of study. Natural Language Processing creates the potential for a machine to digest hundreds of thousands of written reports and classify the language as sentiment to create a broad investment picture.

In a case study, J.P. Morgan Research built an algorithm based on some 250,000 analyst reports that provided the source material for learning the implication of financial terms such as “overweight,” “neutral” and “underweight.” The team then tested the model on 100,000 news articles that focused on global equity markets with a view to informing future equity investment decisions.

As the table below shows, the signal produced strong returns and outperformed several benchmark indices.

References: https://www.jpmorgan.com/global/research/machine-learning

MACHINE LEARNING FOR FINANCIAL MODELING

ETASR - Engineering, Technology & Applied Science Research *Vol. 2, No. 5, 2012, 269-272* 269

Modeling and Trading the EUR/USD Exchange Rate Using Machine Learning Techniques

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Abstract— The present paper aims in investigating the performance of state-of-the-art machine learning techniques in trading with the EUR/USD exchange rate at the ECB fixing. For this purpose, five supervised learning classification techniques (K-Nearest Neighbors algorithm, Naïve Bayesian Classifier, Artificial Neural Networks, Support Vector Machines and Random Forests) were applied in the problem of the one day ahead movement prediction of the EUR/USD exchange rate with

Some approaches examining the performance of machine learning techniques in trading with the EURO-USD exchange rate have already been developed. In [1], Dunis and Williams demonstrated the ability of Multi Layer Perceptron (MLP) Artificial Neural Networks in modeling and trading with the EUR/USD exchange rate. Their empirical results showed that the MLP outperformed all other benchmark models used. Next, in [2], Ullrich et al. used SVMs to trade with a variety of

References:
Theofilatos, K., Likothanassis, S., & Karathanasopoulos, A. (2012). Modeling and trading the EUR/USD exchange rate using machine learning techniques. Engineering, Technology & Applied Science Research, 2(5), 269-272.

ALGORITHMIC TRADING

"algorithmic trading refers to the use of computer programs to automate one or more stages of the trading process: pretrade analysis (data analysis), trading signal generation (buy and sell recommendations), and trade execution."

Algorithmic Trading

Giuseppe Nuti, Mahnoosh Mirghaemi, Philip Treleaven, and Chaiyakorn Yingsaeree
UK Centre in Financial Computing, London

Traders increasingly use automated systems for one or more stages of the trading process, yet the secrecy and complexity of the algorithms prompt providing an overview of how these systems work.

Advances in telecommunications and computer technologies during the past decade have created increasingly global, dynamic, and complex financial markets, which in turn have stimulated trading by computer programs and the rise of systems for *algorithmic trading*—also known as AT, algo, or black-box—to automate one or more stages of the trading process.

These systems seek to capture fleeting anomalies in market prices, profit from statistical patterns within or across financial markets, optimally execute orders, disguise a trader's intentions, or detect and exploit rivals' strategies.[1] Ultimately, profits drive any algorithmic trading system—whether in the form of cost savings, client

However, algorithmic trading is also of major concern to regulators, as the 6 May 2010 Flash Crash clearly illustrated.[3] In this instance, the Dow Jones Industrial Average plunged about 600 points in 5 minutes, causing a loss of $600 billion in the market value of US corporate stocks. This event revealed the lack of knowledge about high-frequency algorithmic trading and exposed its potential vulnerability. Protecting against such events requires an in-depth understanding of the trading process.

MARKET MICROSTRUCTURE

To understand algorithmic trading, it is useful to consider the different types of trading, explore how a trade is

References:
Nuti, G., Mirghaemi, M., Treleaven, P., & Yingsaeree, C. (2011). Algorithmic trading. *Computer*, *44*(11), 61-69.

FEW TOPICS IN ECONOPHYSICS FOR PHYSICISTS

- Gravity model for international trade.
- Hysteresis curve to explain unemployment and international trade.
- Use of thermodynamics in understand inflation.
- Uncertainty principle to understand behavioral economics.

PHYNANCE ASSOCIATION

A students led initiative to encourage and popularise the idea of researching in the area of economics and finance with the help of quantitate thinking.

www.phynanceassociatio.wixsite.com/website

THANK YOU FOR YOUR KIND PATIENCE…

QUESTIONS?