

# Artificial Intelligence in Finance & Algorithmic Trading

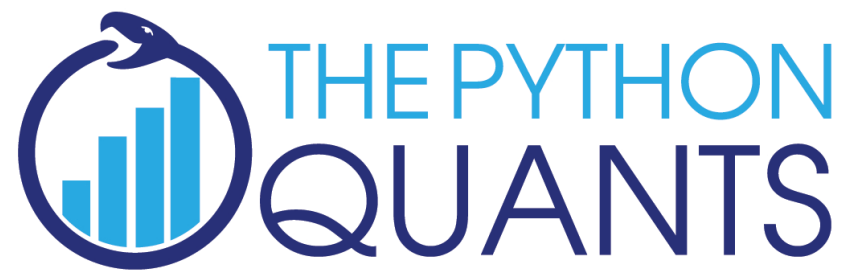
Dr. Yves J. Hilpisch

Refinitiv, New York, 06. May 2019  
Meetup Event



# The Group





## SERVICES

for financial institutions globally



## EVENTS

for Python quants & algorithmic traders



## TRAINING

about Python for finance  
& algorithmic trading



## CERTIFICATION

in cooperation with university



## BOOKS

about Python and  
finance



## PLATFORM

for browser-based  
data analytics



## OPEN SOURCE

Python library  
for financial analytics





16 week program

150+ hours  
of instruction

5,000+ lines  
of code

1,200 pages PDF

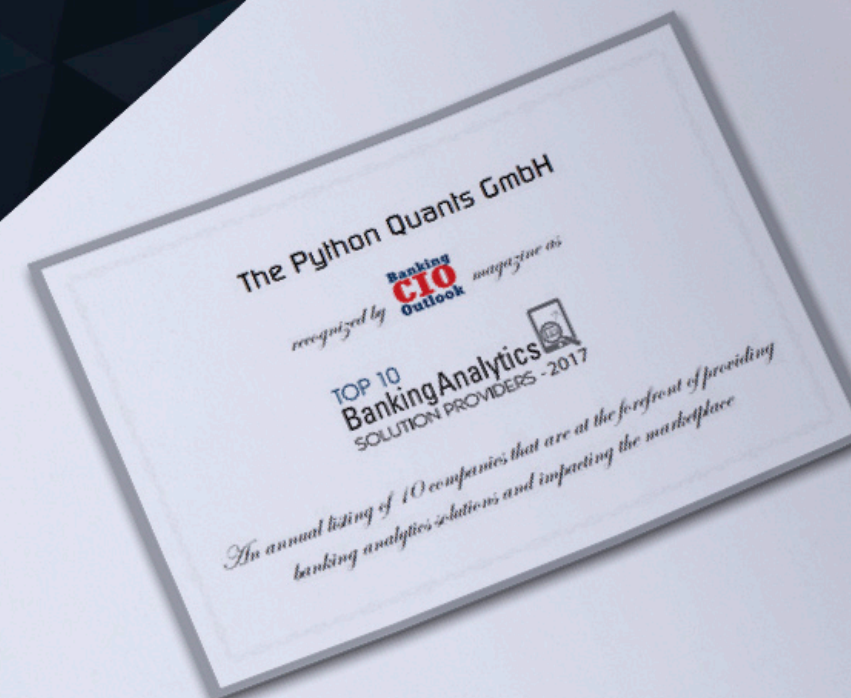
<http://certificate.tpq.io>

#### PROGRAM DIRECTOR

Dr. Yves J. Hilpisch is founder and managing partner of The Python Quants (<http://tpq.io>), a group focusing on the use of open source technologies for financial data science, algorithmic trading and computational finance. He is the author of the books:

- He is the author of the books:
  - Python for Finance (O'Reilly)
  - Derivatives Analytics with Python (Wiley)
  - Listed Volatility and Variance Derivatives (Wiley)

He has written the financial analytics library **DX Analytics** (<http://dx-analytics.com>) and organizes conferences and Meetup events about Python for finance and algorithmic trading in Frankfurt, London and New York. He has given keynote speeches at technology conferences in the United States, Europe and Asia.



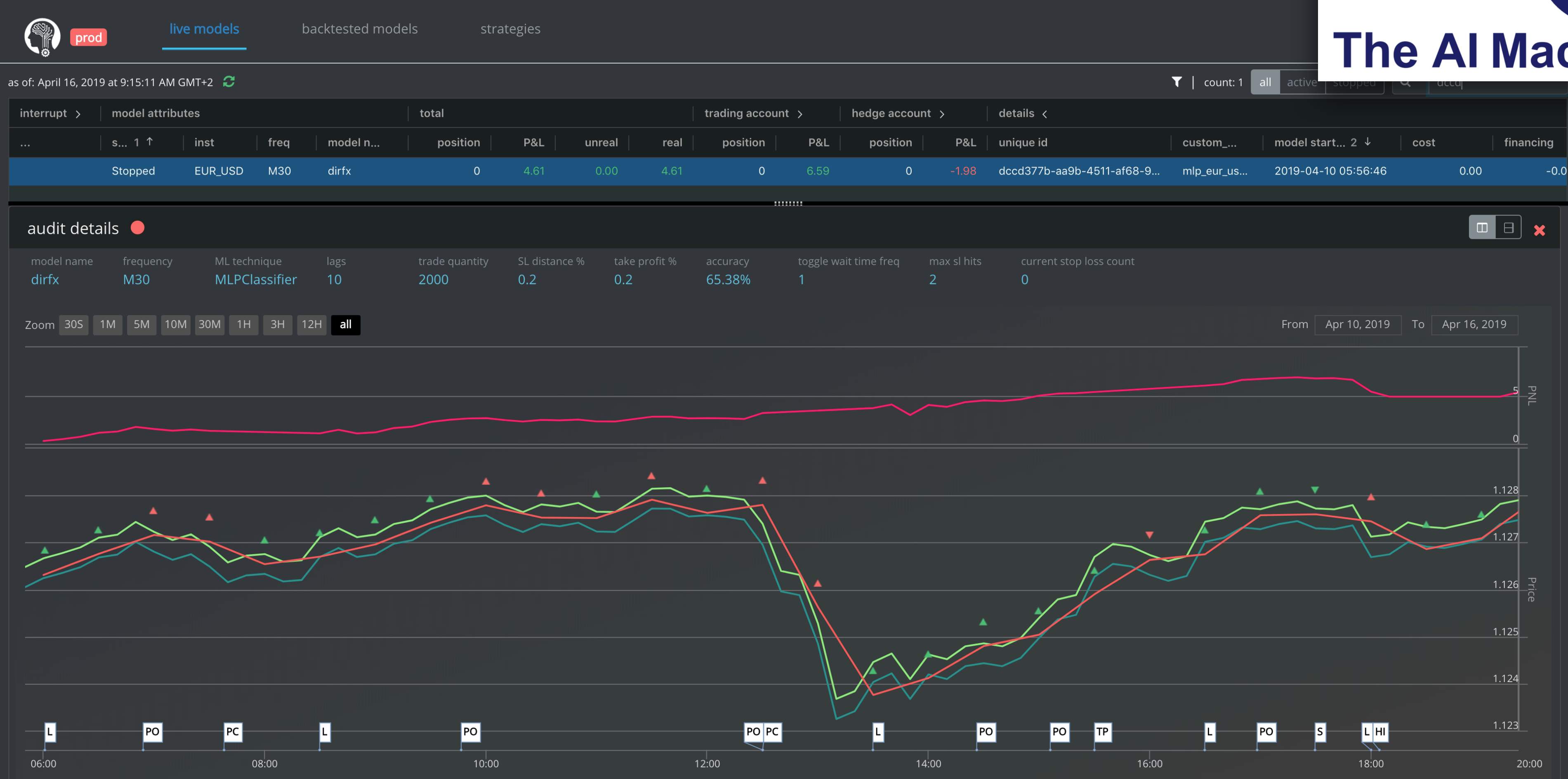
## UNIVERSITY CERTIFICATE IN PYTHON FOR ALGORITHMIC TRADING



The Python Quants GmbH  
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Germany  
T/F +49 3212 112 91 94  
<http://training.tpq.io>  
[training@tpq.io](mailto:training@tpq.io)

April 2017







recognized by **Capital Markets**  
**CIO** *magazine as*  
**Outlook**

**TOP 10**  
**ALGO TRADING**  
SOLUTION PROVIDERS - 2019

*An annual listing of 10 companies that are at the forefront  
of providing Algo Trading solutions*

[http://certificate.tpq.io/tpq\\_top\\_algo\\_2019.pdf](http://certificate.tpq.io/tpq_top_algo_2019.pdf)

**Capital Markets**  
**CIO** **TOP 10**  
**Outlook** **ALGO TRADING**  
SOLUTION PROVIDERS - 2019

## The Python Quants

### First University Certificate in Python for Algorithmic Trading

**P**ython programming has become a key skill in the financial industry. In areas such as financial data science, computational finance or algorithmic trading, Python has established itself as the primary technological platform. At the same time, the level of Python sophistication the industry is expecting from its employees and applicants is increasing steadily. The Python Quants Group is one of the leading providers of Python for Finance training programs.

Among others, The Python Quants have tailored a comprehensive online training program leading to the first University Certificate in Python for Algorithmic Trading. Be it an ambitious student with intrigue for algorithmic trading, or a major financial institution, The Python Quants, through this systematic training program, is equipping delegates with requisite skills and tools to formulate, backtest and deploy algorithmic trading strategies based on Python.

The topics covered in the training programs offered by The Python Quants are generally not found in the typical curriculum of financial engineering or quantitative finance Master programs. Dr. Yves Hilpisch, the firm's founder and managing partner, explains, "There are courses out there that show students how to apply machine learning for the formulation and backtesting of algorithmic trading strategies. However, none of them explains the difficulties or the skills required in deploying such algorithmic trading strategies in the real world. Besides providing an introductory course that teaches Python and financial concepts from scratch, we train our delegates and clients on how best to deploy algorithmic trading strategies in automated fashion in the cloud, with, among others, real-time risk management and monitoring," explains Hilpisch, an author of three books on

the topic, with "Python for Finance" (2nd ed., O'Reilly) being the standard reference in the field.

The organization's "Python for Algorithmic Trading University Certificate" consists of 200 hours of instruction, 1,200 pages of documentation and 1,000s of lines of Python code. In addition to offering both online and offline Python training, Hilpisch and his team also organize bespoke training events for financial institutions, hedge funds, banks, and asset management companies. "Most of the training is online since we have students and delegates from about 65 different countries in general. Most recently, we noticed that it's not just financial firms and students who want to deepen their algorithmic trading knowledge, but even professors of finance who want to get more involved in this popular topic," says Hilpisch.

While the Quant Platform is the most popular choice, especially for users in the financial sector who don't have access to a full-fledged, interactive, financial analytics environment, the team at The Python Quants is currently developing The AI Machine—a new platform which leverages artificial intelligence to formulate and deploy algorithmic trading strategies in a standardized manner. Hilpisch explains that it's relatively easy to write Python code for an algorithmic trading strategy, but the same can't be said about the deployment of such a strategy. "There are a few platforms out there that allow the formulation and backtesting of algorithmic trading strategies by the use of Python code. However, they usually stop exactly there. With The AI Machine, it is a single click on the 'GO LIVE' button and the strategy is deployed in real-time—without any changes to the strategy code itself," adds Hilpisch.

In 2019, The Python Quants will be introducing a new university certificate titled "Python for Computational Finance," which will focus more on original quantitative finance topics, such as option pricing, Monte Carlo simulation, and hedging. As financial institutions begin to perceive Python-based analytics as a prerequisite skill, the organization will continue to provide an "efficient and structured way of mastering all the tools and skills required in Python for Financial Data Science, Algorithmic Trading, and Computational Finance." **CM**



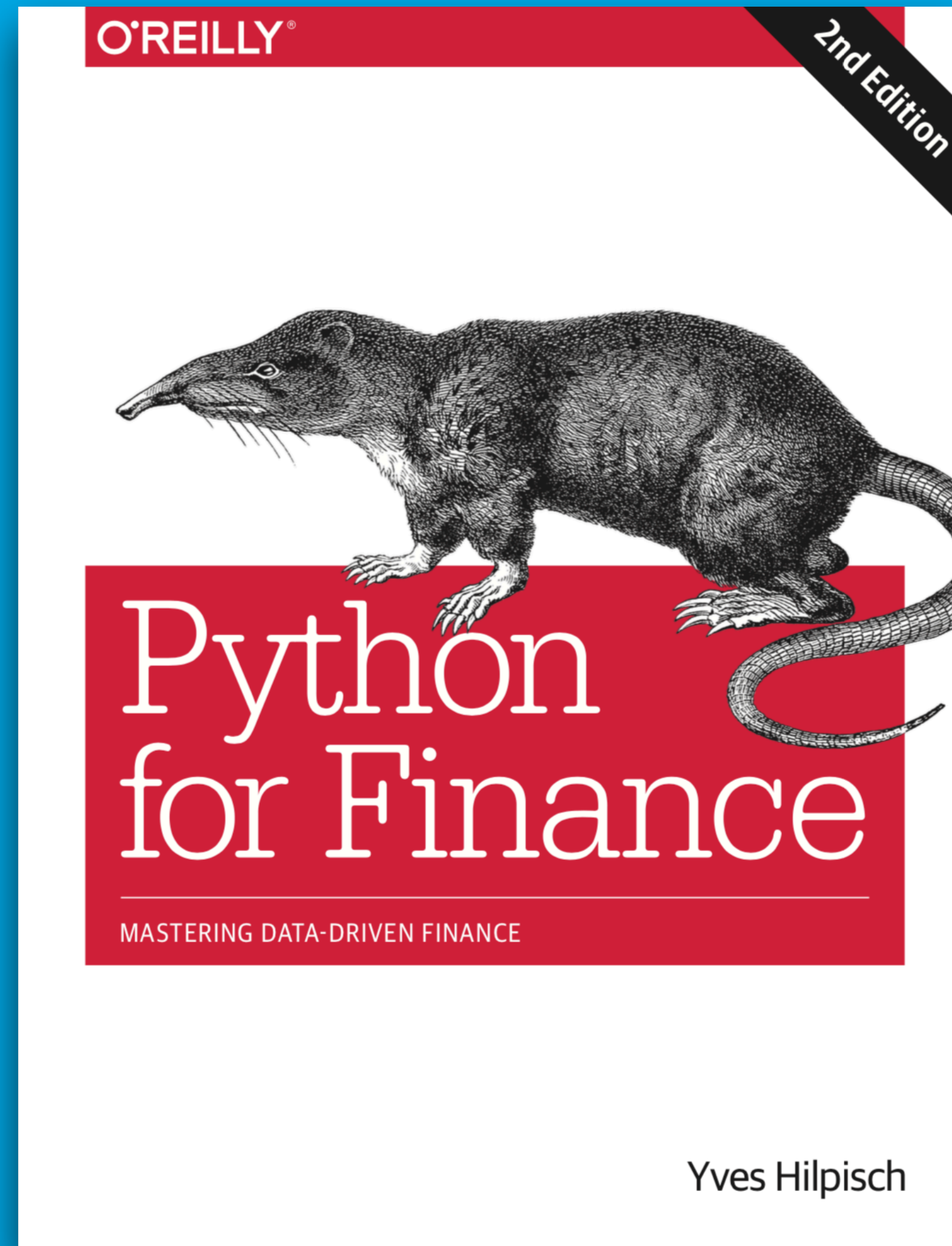
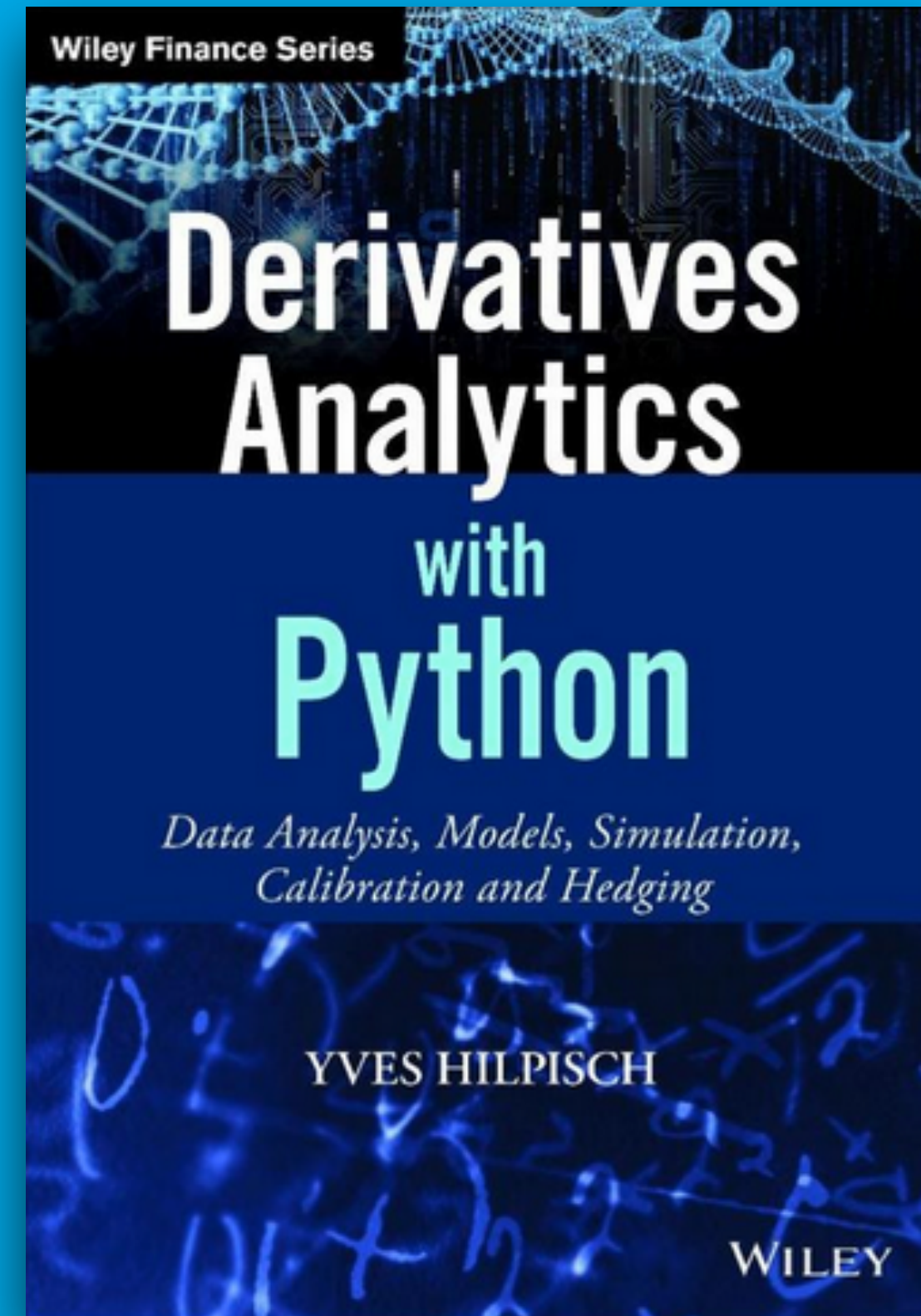
Dr. Yves Hilpisch

# About Myself

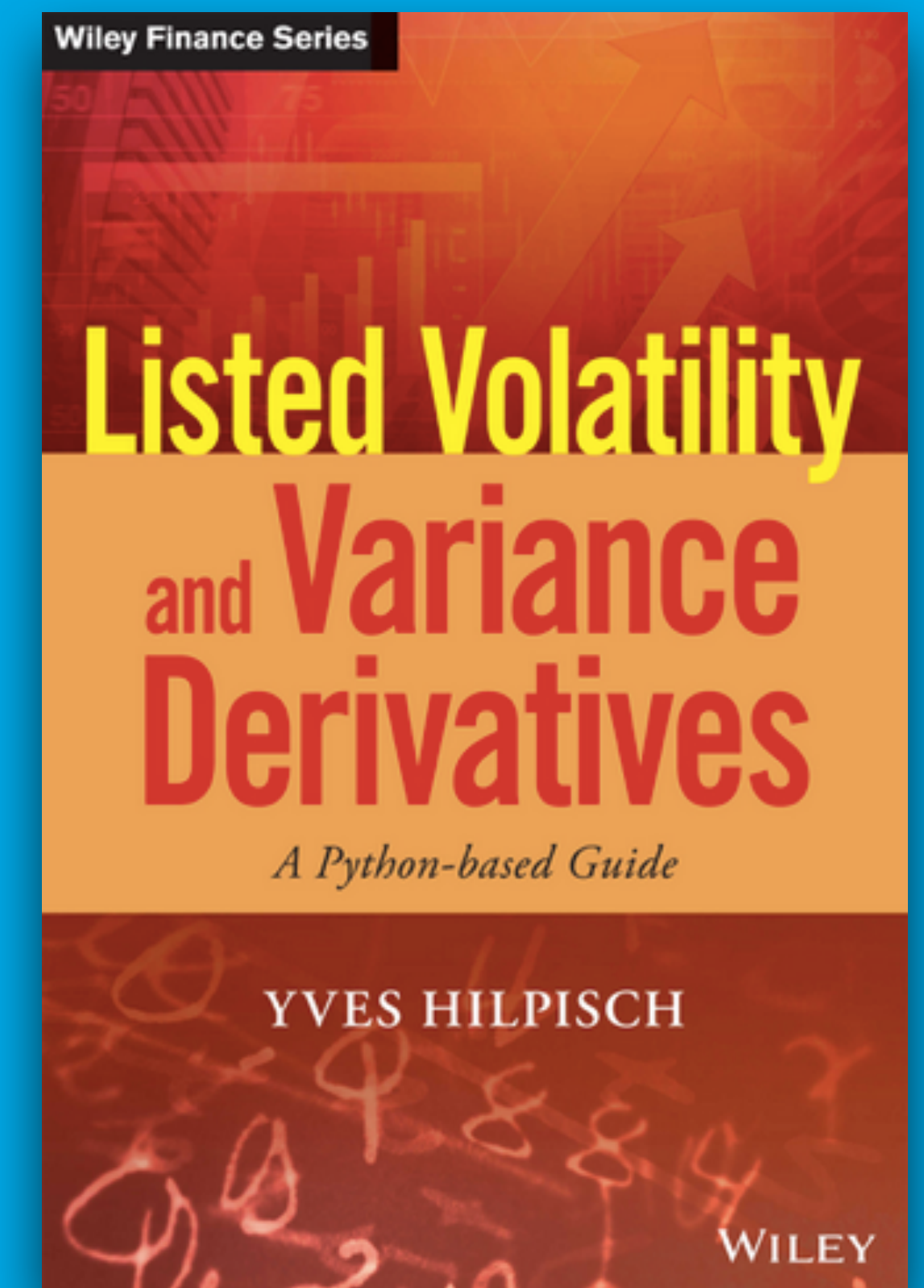






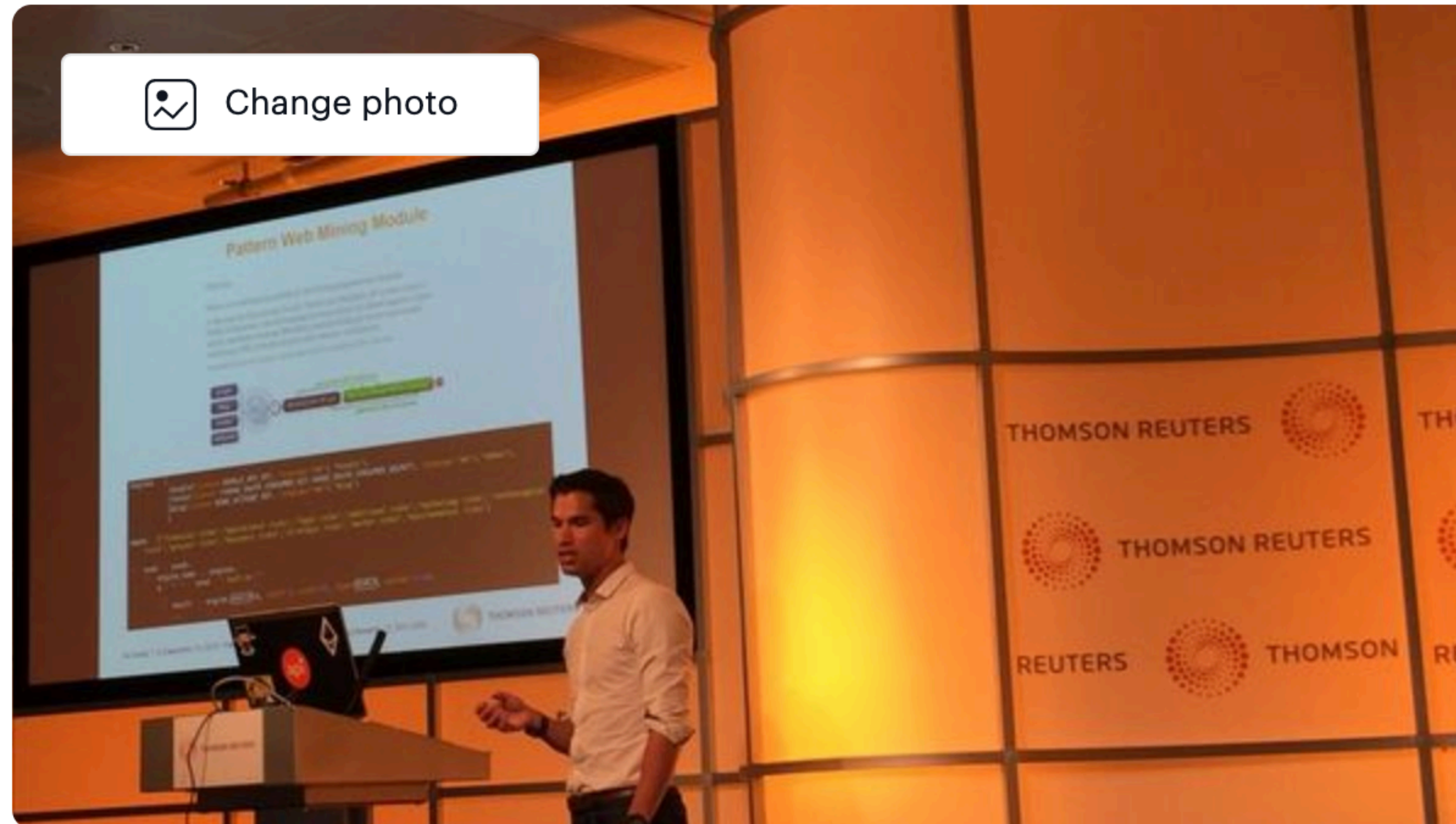


NEW book project:  
**Artificial Intelligence in Finance**  
— A Python-based Guide




<http://books.tpq.io>



 [Change photo](#)

# Python for Quant Finance

 London, United Kingdom

 2,817 members · Public group 

 Organized by **Yves Hilpisch** and **2 others**

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## What we're about

This group is about the use of Python for Quantitative Financial Applications and Interactive Financial Analytics.

## Organizers



**Yves Hilpisch** and **2 others**

[Message](#)



# Agenda

**I. Welcome**

**II. Dr. Mark Higgins (Beacon Inc.):**

**“Deep Hedging using Neural Networks in Beacon”**

**III. Dr. Hossein Adeli Jalodar (Refinitiv):**

**“Short-Term Price Prediction using Tick History Level 2 Order Book Data”**

**III. Dr. Joel Sebold (Refinitiv):**

**“Imaging and Classification of Limit Order Book  
in HPC environment using a RNN”**

**IV. Break**

**V. William Mok (Tech Trader): “Autonomous Trading with Tech Trader”**

**VI. Yves Hilpisch (TPQ | TAIM): “AI-Powered Algorithmic Trading”**

**VII. Book Raffle: “Python for Finance” (O’Reilly, 2nd edition)**

**VIII. Networking**

# AI-Powered Algorithmic Trading

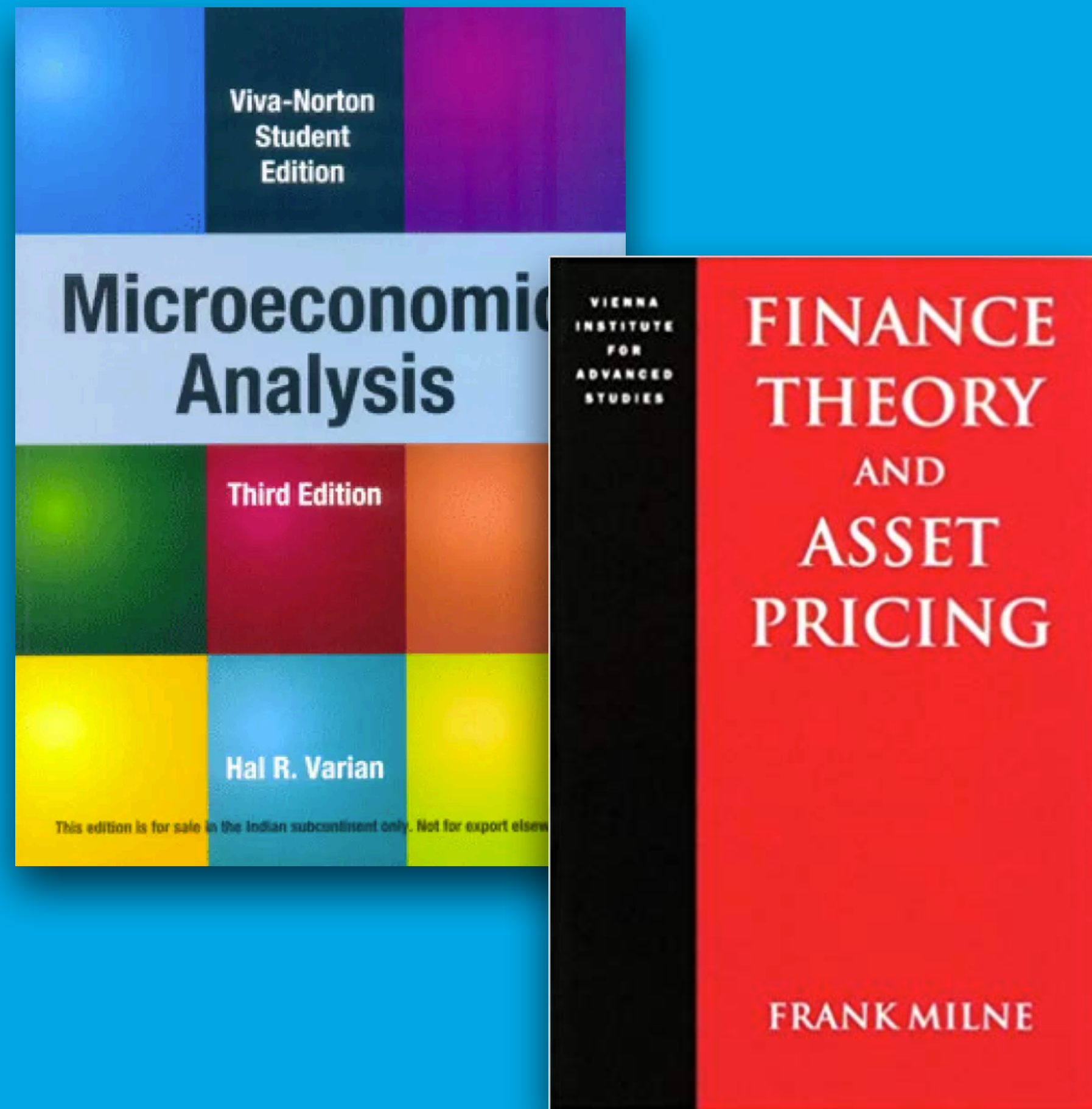
- 1. The Beauty Myth**
- 2. Data-Driven Finance**
- 3. Efficient Markets**
- 4. AI-First Finance**
- 5. Deep Learning**
- 6. The AI Machine**
- 7. Conclusions**

# The Beauty Myth

## Fundamental physics is frustrating physicists

GUTs are among several long-established theories that remain stubbornly unsupported by the big, costly experiments testing them. ...

Despite the dearth of data, the answers that all these theories offer to some of the most vexing questions in physics are so elegant that they populate postgraduate textbooks. As Peter Woit of Columbia University observes, “Over time, these ideas became institutionalised. People stopped thinking of them as speculative.” That is understandable, for they appear to have great explanatory power.

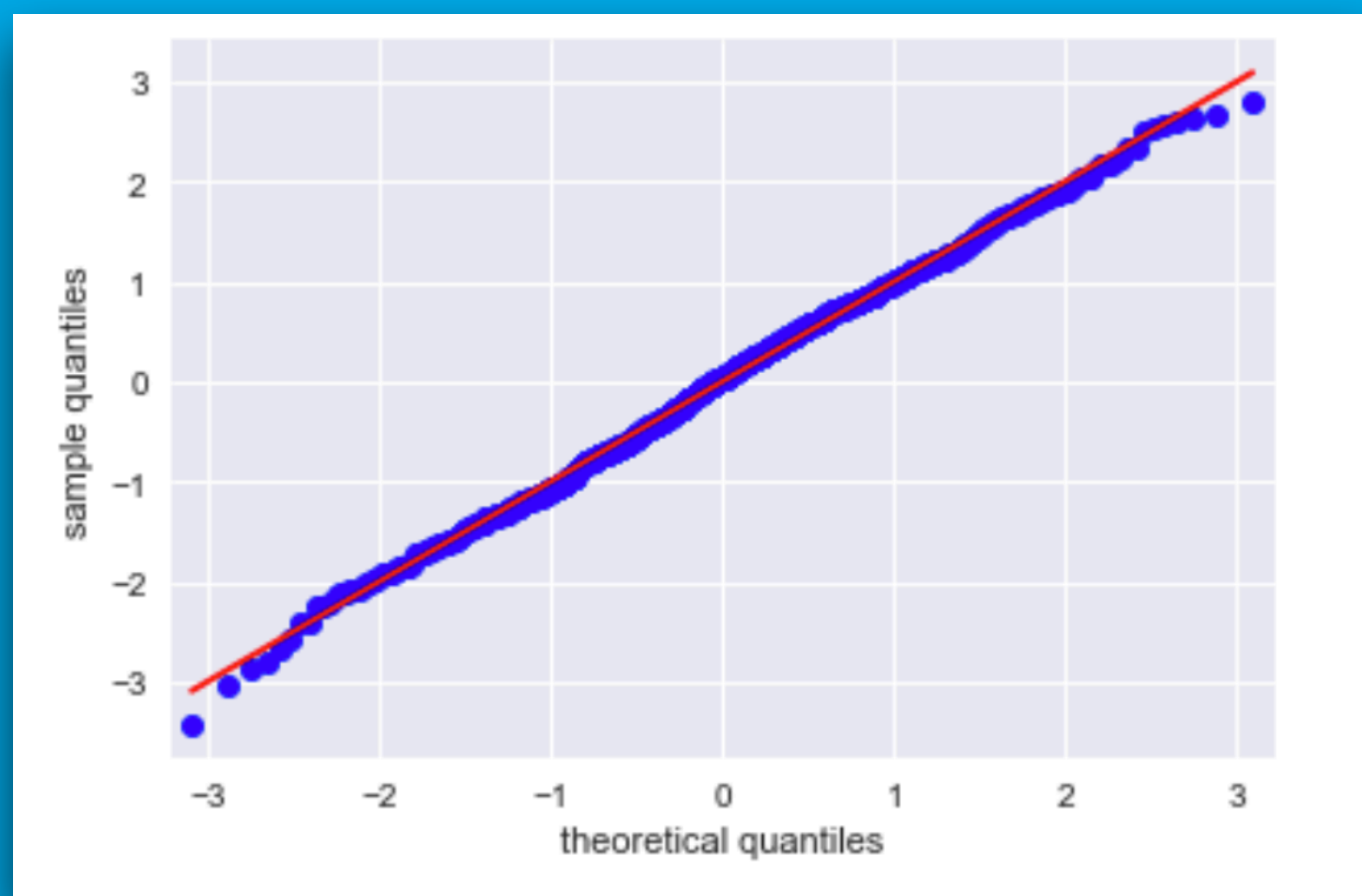


## Cornerstones of Economics

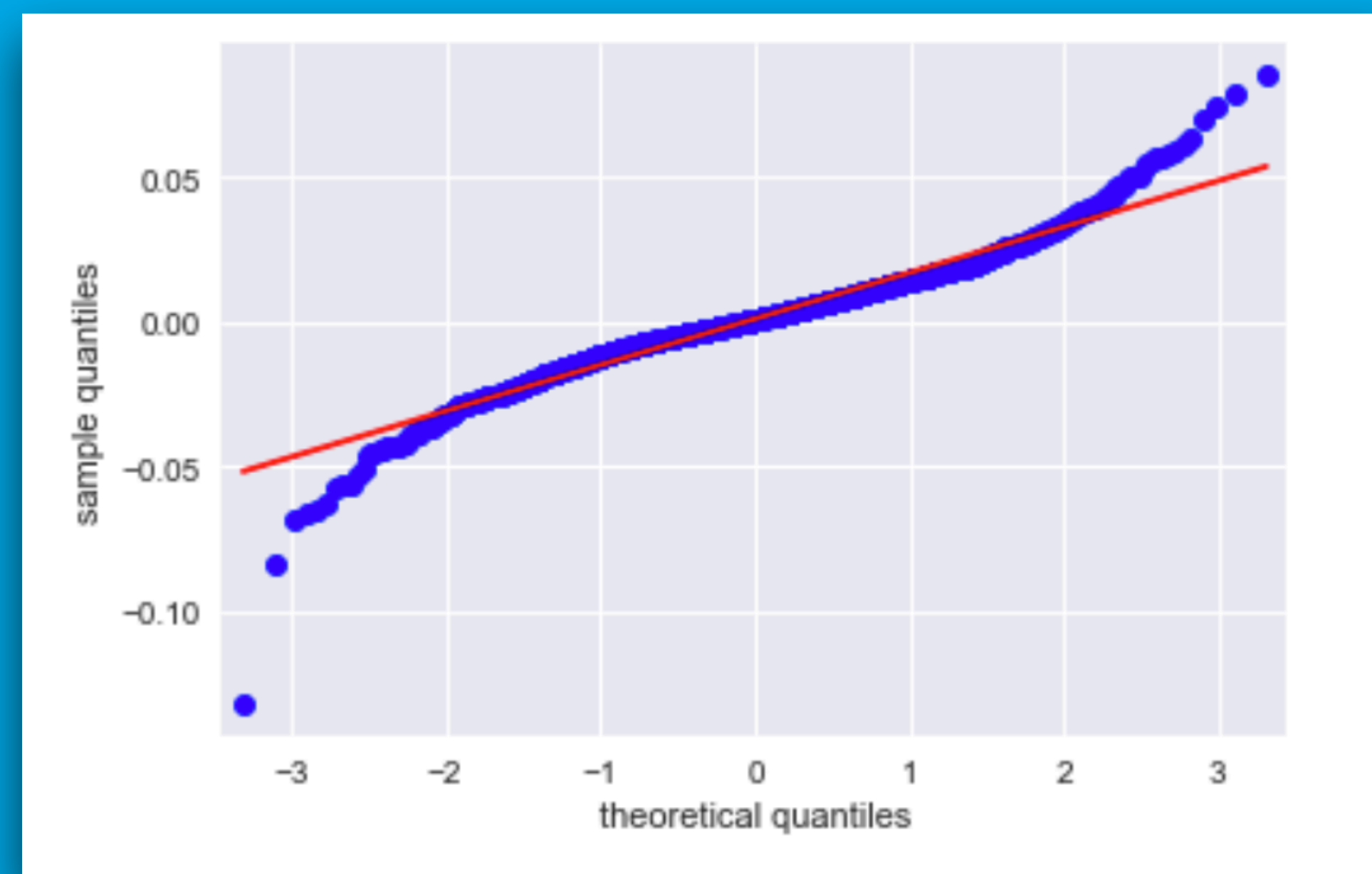
- A. Arbitrage Pricing
- B. Expected Utility
- C. Equilibrium
- D. Normal Distributions
- E. Linear Relationships
- F. Efficient Markets



# Theory



# Reality



CAPITAL ASSET PRICES: A THEORY OF MARKET  
EQUILIBRIUM UNDER CONDITIONS OF RISK\*

WILLIAM F. SHARPE†

I. INTRODUCTION

ONE OF THE PROBLEMS which has plagued those attempting to predict the behavior of capital markets is the absence of a body of positive micro-economic theory dealing with conditions of risk. Although many useful insights can be obtained from the traditional models of investment under conditions of certainty, the pervasive influence of risk in financial transactions has forced those working in this area to adopt models of price behavior which are little more than assertions. A typical classroom explanation of the determination of capital asset prices, for example, usually begins with a careful and relatively rigorous description of the process through which individual preferences and physical relationships interact to determine an equilibrium pure interest rate. This is generally followed by the assertion that somehow a market risk-premium is also determined, with the prices of assets adjusting accordingly to account for differences in their risk.

A useful representation of the view of the capital market implied in such discussions is illustrated in Figure 1. In equilibrium, capital asset prices have adjusted so that the investor, if he follows rational procedures (primarily diversification), is able to attain any desired point along a *capital market line*.<sup>1</sup> He may obtain a higher expected rate of return on his holdings only by incurring additional risk. In effect, the market presents him with two prices: the *price of time*, or the pure interest rate (shown by the intersection of the line with the horizontal axis) and the *price of risk*, the additional expected return per unit of risk borne (the reciprocal of the slope of the line).

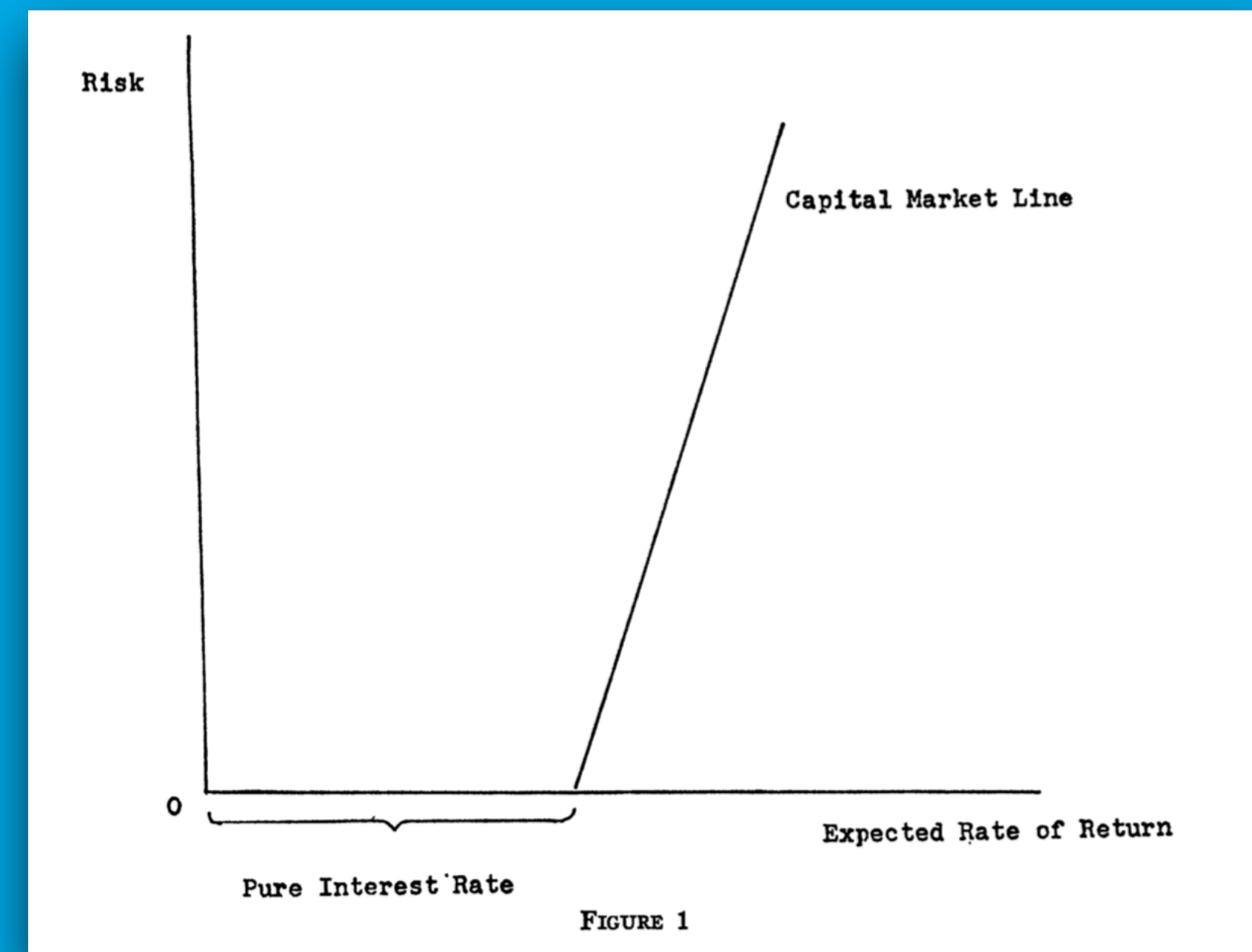
\* A great many people provided comments on early versions of this paper which led to major improvements in the exposition. In addition to the referees, who were most helpful, the author wishes to express his appreciation to Dr. Harry Markowitz of the RAND Corporation, Professor Jack Hirshleifer of the University of California at Los Angeles, and to Professors Yoram Barzel, George Brabb, Bruce Johnson, Walter Oi and R. Haney Scott of the University of Washington.

† Associate Professor of Operations Research, University of Washington.

1. Although some discussions are also consistent with a non-linear (but monotonic) curve.

$$\mu_i = r + \beta_i(\mu_M - r)$$

“Market Risk”  
“Idiosyncratic Risk”



# Data-Driven Finance



# FINANCIAL TIMES

TUESDAY 3 OCTOBER 2017

WORLD BUSINESS NEWSPAPER

MIDDLE EAST

## Mohamed El-Erian

Reasons to worry about the Fed's 'beautiful normalisation' — PAGE 20

## Torturing Theresa

Boris Johnson's bid to dictate May's Brexit strategy — JANAN GANESH, PAGE 11



## Confined in a circle

The myths that hold back women in Indian society — AMY KAZMIN, PAGE 10

## Las Vegas reels from worst US mass shooting

A casualty is carried from the scene after a gunman opened fire on concertgoers in Las Vegas on Sunday night. More than 58 people were killed and over 315 wounded, making it the deadliest mass shooting in US history.

Las Vegas police said the suspected gunman, 64-year-old Stephen Paddock, fired shots from his 32nd-floor room in the Mandalay Bay Hotel and Casino into the crowd of 22,000 people attending the Route 91 Harvest Festival.

In a video remarks, Donald Trump, the US president, called the shooting "an act of pure evil" but made no reference to guns. He plans to visit the city on Wednesday to meet the families of the victims and law enforcement officials. *Report page 2*



David Becker/Reuters

## Catalan president urges Brussels to mediate in independence clash

◆ Region seeks to avoid 'traumatic split' from Spain ◆ EU says dispute is 'internal matter'

MICHAEL STOTHARD — BARCELONA

He added: "We don't want a traumatic split, Sunday's referendum, while it is necessary, the suspension of Catalonia's

of law, which calls for of the liberal

as still left the declaration of

with Madrid

Financial Times

Secure https://www.ft.com

FTSE 100 -0.08% S&P 500 +0.37% Euro/Dollar -0.17% Pound/Dollar -0.20% Brent Crude Oil +0.33%

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# FINANCIAL TIMES

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### US banks

## Jamie Dimon hands more responsibilities to lieutenants

Wall Street's longest-serving chief executive says he is 'more like the coach now'

AN HOUR AGO

- Lehman/US bank capital: loss cause
- After the crisis, the banks are safer but debt is a danger
- Financial crisis 2008: A reporter's memories from the front lines



FT Series **Financial crisis: Are we safer now?**

## JPMorgan: defying attempts to end 'too big to fail'

AN HOUR AGO



FTSE 100	7430.54	7392.36	0.50	6 index	56,204	55,920	0.50	5 index	55,900	55,420	0.85
FTSE All Share	4302.00	4240.00	1.00	5 index	1,142	1,144	0.00	5 index	1,200	1,200	0.00
DAX	1510.44	1510.01	0.00	COMPAGNIES							
Nikkei 225	17002.65	17000.00	0.00	Oil 2	50.00	50.00	0.00	Oil 2	50.00	50.00	0.00
Hong Kong	27004.30	27000.00	0.00	Oil 2	50.00	50.00	0.00	Oil 2	50.00	50.00	0.00
FTSE All World	321.85	321.85	0.00	Oil 2	50.00	50.00	0.00	Oil 2	50.00	50.00	0.00

A Nikkei Company

## Knowledge. Integrity. Discretion.

Of all our fine properties, these are the most valuable.

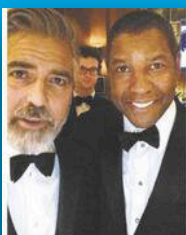
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TODAY IN PERSONAL JOURNAL

## A Celebrity Selfie Machine

PLUS Secondhand Stress at Work

# THE WALL STREET JOURNAL.

DOW JONES

Market Gains

\*\*\*\*\*

WEDNESDAY, DECEMBER 11, 2013 • VOL. CCLXII NO. 138

WSJ.com

★★★★ \$2.00

DJIA 15973.13 ▲ \$2.40 0.3% NASDAQ 4060.49 ▼ 0.2% NYSE 15611.31 ▼ 0.2% STOXX 600 3145.91 ▼ 0.7% 10-YR. TREAS. ▲ 16/32, yield 2.797% OIL \$98.51 ▲ \$1.17 GOLD \$1,262.40 ▲ \$27.10 EURO \$1.3761 YEN 102.84

## What's News

### Business & Finance

House and Senate negotiators, in a rare bipartisan act, announced a budget agreement Tuesday designed to avert another economy-rattling government shutdown and to bring a dose of stability to Congress's fiscal policy-making, over the next two years.

Sen. Patty Murray (D, Wash.) and Rep. Paul Ryan (R, Wis.),

who struck the deal after weeks of private talks, said it would allow more spending for domestic and defense programs in the near term, while adopting deficit-reduction measures over a decade to offset the costs.

Revenues to fund the higher spending would come from changes to federal employee and military pension programs, and higher fees for airline passengers, among other sources. An

extension of long-term jobless benefits wasn't included.

The plan is modest in scope, compared with past budget deals and to one-grand ambitions in Congress to craft a "grand bargain" to restructure the tax code and federal entitlement programs. But in a year and an institution characterized by gridlock, lawmakers were relieved they could reach even a minimal agreement.

The deal, which goes to the

House and Senate for approval in the coming days, marks a major change in the 2011 budget-cutting law, which set in motion 10 years of fiscal austerity, including across-the-board spending cuts known as sequestration.

The annual, discretionary spending target will be raised to

Please turn to page A8

◆ Farm groups fight limits..... A6

◆ Pension-change pushback..... A8

## Deal Brings Stability to U.S. Budget

Congressional Negotiators Avert January Shutdown and Soften Sequester Cuts; Airline Fees to Climb

By JANET HOOK

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NEWS >

EVENTS > Upcoming Past

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Open	AAPL.O 115.190000				Price USD
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Free Float	5.32B	Asset Type	Ordinary Share	 5 yr CDS	26.980 bps
Outstanding	5.33B	Share Class	--	Δ Today	-0.07%
IPO Date	12-Dec-1980	Lot Size		Δ 1 Week	-0.074
First Trade Da...	12-Dec-1980	Voting Rights	1		

	AAPL (Sep. 2016)	Growth	Industry
--	---------------------	--------	----------

## Tick Data

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                                start_date='2017-07-11 16:00:0000',  
                                end_date='2017-07-11 16:15:0000',  
                                interval='tick')
```

```
In [24]: tick.info()
```

```
<class 'pandas.core.frame.DataFrame'>  
DatetimeIndex: 1898 entries, 2017-07-11 16:00:00.686000 to 2017-07-11 16:14:59.708000  
Data columns (total 2 columns):  
VALUE      1892 non-null float64  
VOLUME     1898 non-null float64  
dtypes: float64(2)  
memory usage: 44.5 KB
```

```
In [25]: tick.tail()
```

```
Out[25]:
```

	AAPL.O	VALUE	VOLUME
	Date		
	2017-07-11 16:14:59.693	144.9900	100.0
	2017-07-11 16:14:59.693	144.9900	100.0
	2017-07-11 16:14:59.693	144.9900	100.0
	2017-07-11 16:14:59.707	144.9899	400.0
	2017-07-11 16:14:59.708	144.9899	1305.0



## News

```
In [29]: news = ek.get_news_headlines('R:.SPX AND "Trump" AND Language:LEN', count=5)
news
```

```
Out[29]:
```

	versionCreated	text	storyId	sourceCode
2017-08-18 16:46:19	2017-08-18 16:46:19	U.S. STOCKS EXTEND GAINS AFTER NEW YORK TIMES ...	urn:newsml:reuters.com:20170818:nL4N1L44L9:1	NS:RTRS
2017-08-18 15:53:08	2017-08-18 15:53:08	CORRECTED-U.S. STOCKS PARE LOSSES, TRADERS CIT...	urn:newsml:reuters.com:20170818:nL4N1L44IK:1	NS:RTRS
2017-08-18 15:16:27	2017-08-18 15:16:27	US STOCKS-Wall St lower on growing concerns ov...	urn:newsml:reuters.com:20170818:nL4N1L44F2:5	NS:RTRS
2017-08-18 11:24:30	2017-08-18 11:24:30	US STOCKS-Futures flat amid growing concerns o...	urn:newsml:reuters.com:20170818:nL4N1L43RR:5	NS:RTRS
2017-08-17 17:09:05	2017-08-17 17:09:05	US STOCKS-Wall St extends losses on Trump poli...	urn:newsml:reuters.com:20170817:nL4N1L34N1:5	NS:RTRS

```
In [30]: storyId = news.iloc[4, 2]
storyId
```

```
Out[30]: 'urn:newsml:reuters.com:20170817:nL4N1L34N1:5'
```

```
In [31]: from IPython.display import display, HTML
```

```
In [32]: display(HTML(ek.get_news_story(storyId)))
```

- Gary Cohn resignation rumors knocked down
- Wal-Mart drops after reporting margin fall
- Indexes down: Dow 0.81 pct, S&P 1.03 pct, Nasdaq 1.39 pct

Updates to early afternoon

By Sruthi Shankar and Tanya Agrawal

Aug 17 (Reuters) - U.S stocks hit session lows in early afternoon trading on Thursday as investors worried about President Donald Trump's ability to





## EXPERT OPINION

Contact Editor: **Brian Brannon**, bbrannon@computer.org

# The Unreasonable Effectiveness of Data

Alon Halevy, Peter Norvig, and Fernando Pereira, *Google*

Eugene Wigner's article "The Unreasonable Effectiveness of Mathematics in the Natural Sciences"<sup>1</sup> examines why so much of physics can be neatly explained with simple mathematical formulas

such as  $f = ma$  or  $e = mc^2$ . Meanwhile, sciences that involve human beings rather than elementary particles have proven more resistant to elegant mathematics. Economists suffer from physics envy over their inability to neatly model human behavior. An informal, incomplete grammar of the English language runs over 1,700 pages.<sup>2</sup> Perhaps when it comes to natural language processing and related fields, we're doomed to complex theories that will never have the elegance of physics equations. But if that's so, we should stop acting as if our goal is to author extremely elegant theories, and instead embrace complexity and make use of the best ally we have: the unreasonable effectiveness of data.

One of us, as an undergraduate at Brown University, remembers the excitement of having access to the Brown Corpus, containing one million English words.<sup>3</sup> Since then, our field has seen several notable corpora that are about 100 times larger, and in 2006, Google released a trillion-word corpus with frequency counts for all sequences up to five words long.<sup>4</sup> In some ways this corpus is a step backwards from the Brown Corpus: it's taken from unfiltered Web pages and thus contains incomplete sentences, spelling errors, grammatical errors, and all sorts of other errors. It's not annotated with carefully hand-corrected part-of-speech tags. But the fact that it's a million times larger than the Brown Corpus outweighs these drawbacks. A trillion-word corpus—along with other Web-derived corpora of millions, billions, or trillions of links, videos, images, tables, and user interactions—captures even very rare aspects of human

behavior. So, this corpus could serve as the basis of a complete model for certain tasks—if only we knew how to extract the model from the data.

### Learning from Text at Web Scale

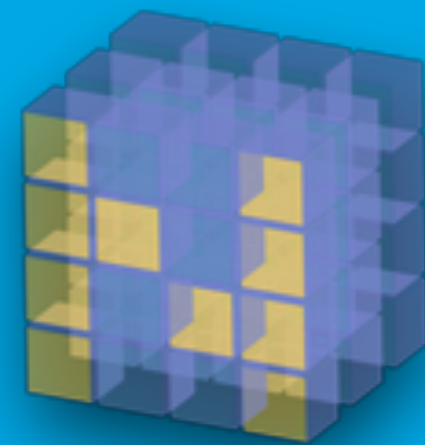
The biggest successes in natural-language-related machine learning have been statistical speech recognition and statistical machine translation. The reason for these successes is not that these tasks are easier than other tasks; they are in fact much harder than tasks such as document classification that extract just a few bits of information from each document. The reason is that translation is a natural task routinely done every day for a real human need (think of the operations of the European Union or of news agencies). The same is true of speech transcription (think of closed-caption broadcasts). In other words, a large training set of the input-output behavior that we seek to automate is available to us *in the wild*. In contrast, traditional natural language processing problems such as document classification, part-of-speech tagging, named-entity recognition, or parsing are not routine tasks, so they have no large corpus available in the wild. Instead, a corpus for these tasks requires skilled human annotation. Such annotation is not only slow and expensive to acquire but also difficult for experts to agree on, being bedeviled by many of the difficulties we discuss later in relation to the Semantic Web. The first lesson of Web-scale learning is to use available large-scale data rather than hoping for annotated data that isn't available. For instance, we find that useful semantic relationships can be automatically learned from the statistics of search queries and the corresponding results<sup>5</sup> or from the accumulated evidence of Web-based text patterns and formatted tables,<sup>6</sup> in both cases without needing any manually annotated data.

Eugene Wigner's article "The Unreasonable Effectiveness of Mathematics in the Natural Sciences" examines why so much of physics can be neatly explained with simple mathematical formulas such as  $f = ma$  or  $e = mc^2$ . Meanwhile, sciences that involve human beings rather than elementary particles have proven more resistant to elegant mathematics. Economists suffer from physics envy over their inability to neatly [and successfully] model human behavior. An informal, incomplete grammar of the English language runs over 1,700 pages. Perhaps when it comes to natural language processing and related fields, we're doomed to complex theories that will never have the elegance of physics equations. But if that's so, we should stop acting as if our goal is to author extremely elegant theories, and instead embrace complexity and make use of the best ally we have: the unreasonable effectiveness of data.



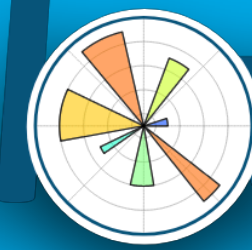


IP[y]:  
IPython

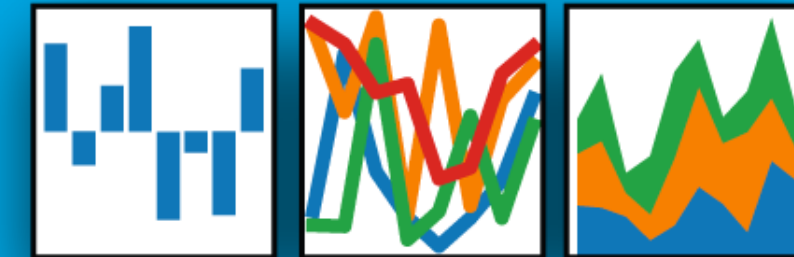


NumPy

matplotlib



pandas  
 $y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$



# Efficient Markets



## Random Walks in Stock Market Prices

Eugene F. Fama

For many years economists, statisticians, and teachers of finance have been interested in developing and testing models of stock price behavior. One important model that has evolved from this research is the theory of random walks. This theory casts serious doubt on many other methods for describing and predicting stock price behavior—methods that have considerable popularity outside the academic world. For example, we shall see later that if the random walk theory is an accurate description of reality, then the various “technical” or “chartist” procedures for predicting stock prices are completely without value.

In general the theory of random walks raises challenging questions for anyone who has more than a passing interest in understanding the behavior of stock prices. Unfortunately, however, most discussions of the theory have appeared in technical academic journals and in a form which the non-mathematician would usually find incomprehensible. This article describes, briefly and simply, the theory of random walks and some of the important issues it raises concerning the work of market analysts. To preserve brevity some aspects of the theory and its implications are omitted. More complete (and also more technical) discussions of the theory of random walks are available elsewhere; hopefully the introduction provided here will encourage the reader to examine one of the more rigorous and lengthy works listed at the end of this article.

### COMMON TECHNIQUES FOR PREDICTING STOCK MARKET PRICES

In order to put the theory of random walks into perspective we first discuss, in brief and general terms, the two approaches to predicting stock prices that are commonly espoused by market professionals. These are (1) “chartist” or “technical” theories and (2) the theory of fundamental or intrinsic value analysis.

The basic assumption of all the chartist or technical theories is that history tends to repeat

itself, i.e., past patterns of price behavior in individual securities will tend to recur in the future. Thus the way to predict stock prices (and, of course, increase one’s potential gains) is to develop a familiarity with past patterns of price behavior in order to recognize situations of likely recurrence.

Essentially, then, chartist techniques attempt to use knowledge of the past behavior of a price series to predict the probable future behavior of the series. A statistician would characterize such techniques as assuming that successive price changes in individual securities are dependent. That is, the various chartist theories assume that the *sequence* of price changes prior to any given day is important in predicting the price change for that day.<sup>1</sup>

The techniques of the chartist have always been surrounded by a certain degree of mysticism, however, and as a result most market professionals have found them suspect. Thus it is probably safe to say that the pure chartist is relatively rare among stock market analysts. Rather the typical analyst adheres to a technique known as fundamental analysis or the intrinsic value method. The assumption of the fundamental analysis approach is that at any point in time an individual security has an intrinsic value (or in the terms of the economist, an equilibrium price) which depends on the earning potential of the security. The earning potential of the security depends in turn on such fundamental factors as quality of management, outlook for the industry and the economy, etc.

Through a careful study of these fundamental factors the analyst should, in principle, be able to determine whether the actual price of a security is above or below its intrinsic value. If actual prices tend to move toward intrinsic values, then attempting to determine the intrinsic value of a security is equivalent to making a prediction of its future price; and this is the essence of the predictive procedure implicit in fundamental analysis.

### THE THEORY OF RANDOM WALKS

Chartist theories and the theory of fundamental analysis are really the province of the market

## Eugene F. Fama (1965):

“For many years, economists, statisticians, and teachers of finance have been interested in developing and testing models of stock price behavior. One important model that has evolved from this research is the theory of random walks. This theory casts serious doubt on many other methods for describing and predicting stock price behavior—methods that have considerable popularity outside the academic world. For example, we shall see later that, if the random-walk theory is an accurate description of reality, then the various “technical” or “chartist” procedures for predicting stock prices are completely without value.”—Eugene F. Fama (1965): “Random Walks in Stock Market Prices”

Reprinted from Financial Analysts Journal (September/October 1965):55–59.

## **Michael Jensen (1978): “Some Anomalous Evidence Regarding Market Efficiency”:**

“A market is efficient with respect to an information set  $S$  if it is impossible to make economic profits by trading on the basis of information set  $S$ .”

If a stock price follows a (simple) random walk (no drift & normally distributed returns), then it rises and falls with the same probability of 50% (“toss of a coin”).

**In such a case, the best predictor of tomorrow’s stock price — in a least-squares sense — is today’s stock price.**

**AI-First Finance**

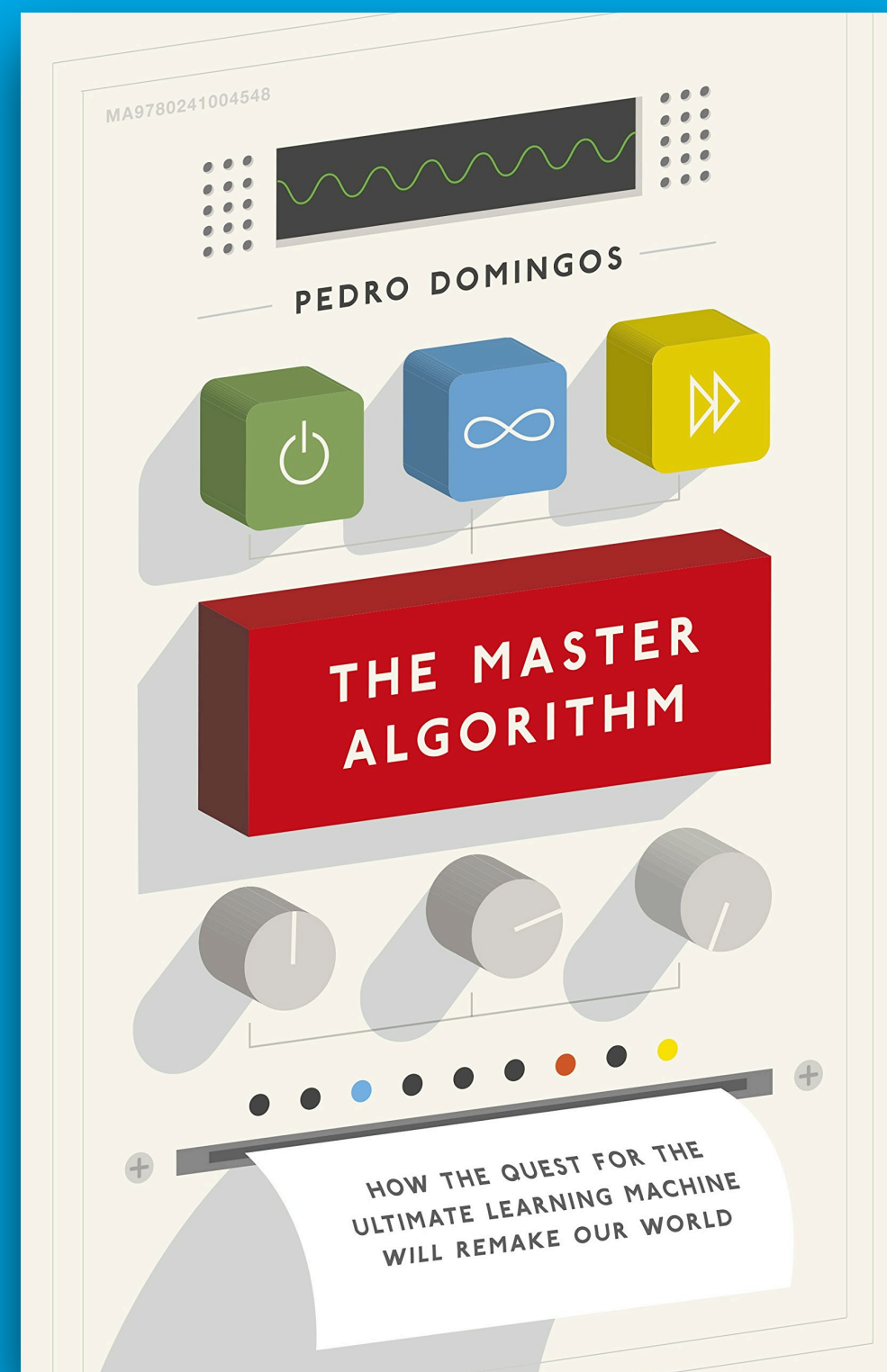


# scientific method

*noun*

a method of procedure that has characterized natural science since the 17th century, consisting in systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses.

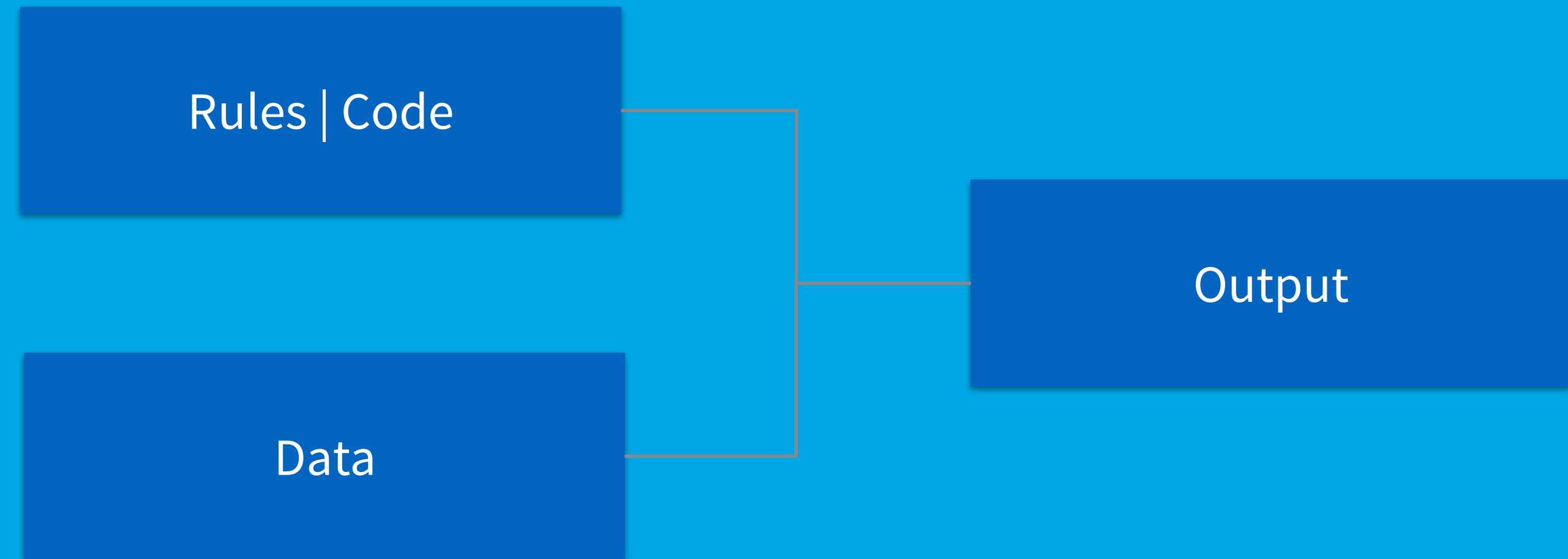
"criticism is the backbone of **the scientific method**"



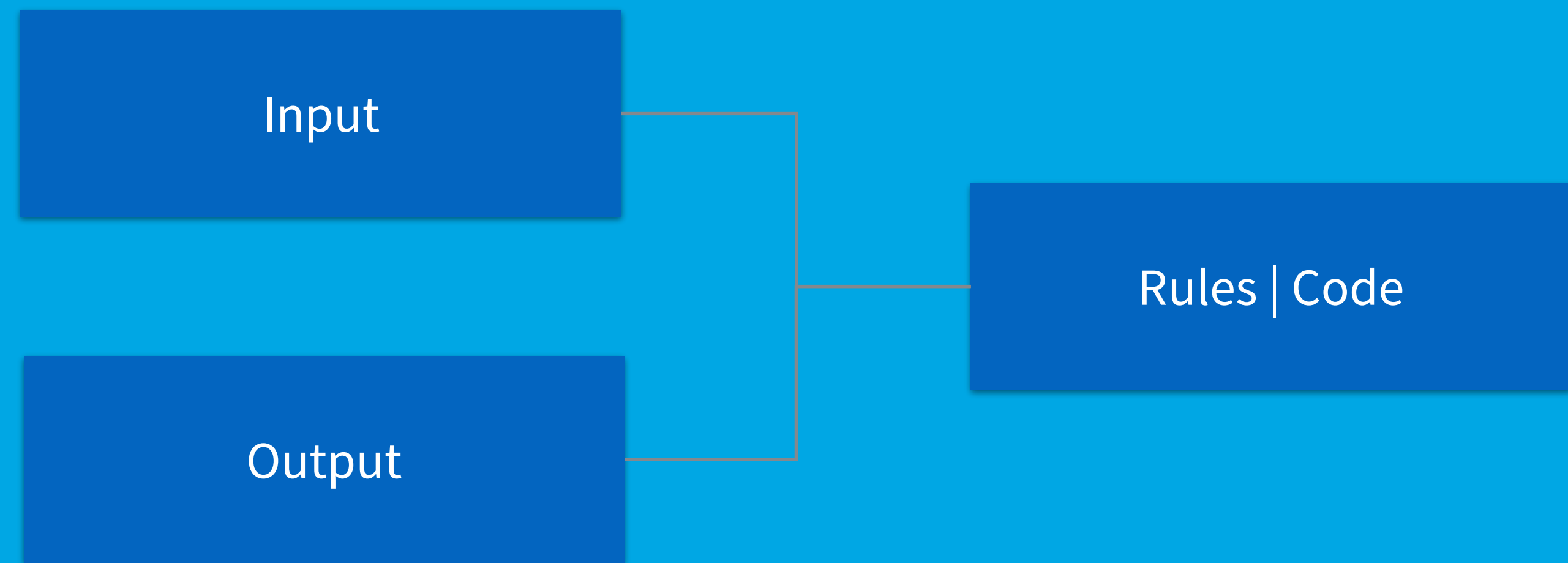
“The grand aim of science is to cover the greatest number of experimental facts by logical deduction from the smallest number of hypotheses or axioms.”  
— Albert Einstein

“Machine learning is the scientific method on steroids. It follows the same process of generating, testing, and discarding or refining hypotheses. But while a scientist may spend his or her whole life coming up with and testing a few hundred hypotheses, a machine-learning system can do the same in a second. Machine learning automates discovery. It’s no surprise, then that it’s revolutionizing science as much as it’s revolutionizing business.”

## Programming.



## Machine Learning.





Bullish patterns (going up)



Flag



Pennant



Cup with handle



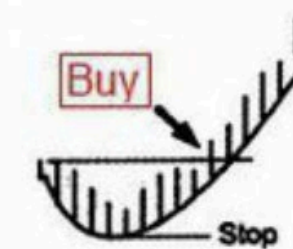
Ascending triangle



Symetrical triangle



Measured move up



Ascending scallop



3 rising valleys

Bearish patterns (going down)



Flag



Pennant



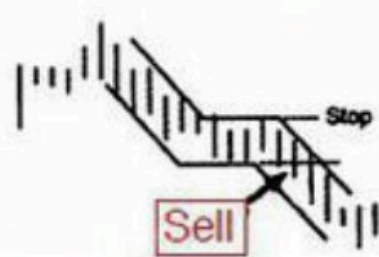
Invertede Cup with handle



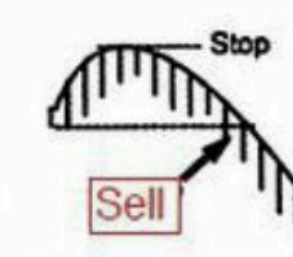
Descending triangle



Symetrical triangle



Measured move down



Descending scallop



3 descending peaks

Reversal patterns



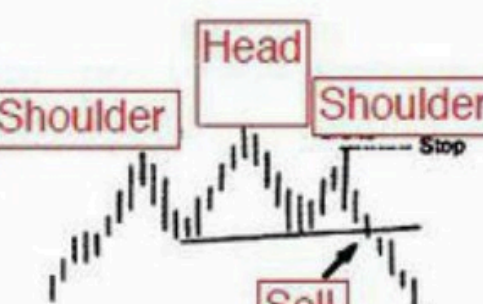
Double bottoms



Diamond bottoms



Tops rectangle



Head and shoulders top

# Financial Markets

“normative economics = assumptions, axioms, etc.”

$x$

(too) “simple and elegant theories”



$y$

“non-linear, complex, changing”

# Finance History



$f(\cdot)$

$f(x) \neq y$

“brain-driven & beauty myth”

# AI in Finance = finance

“positive economics = data, relationships, etc.”

$x$

“general, parametrizable, trainable algorithms”

$m(\cdot, a, b)$

“might show good performance, but black box”

$m(x, a^*, b^*) \approx y$

“data-driven & AI-first”



MARCOS LOPEZ DE PRADO

ADVANCES  
*in*  
FINANCIAL  
MACHINE  
LEARNING

WILEY

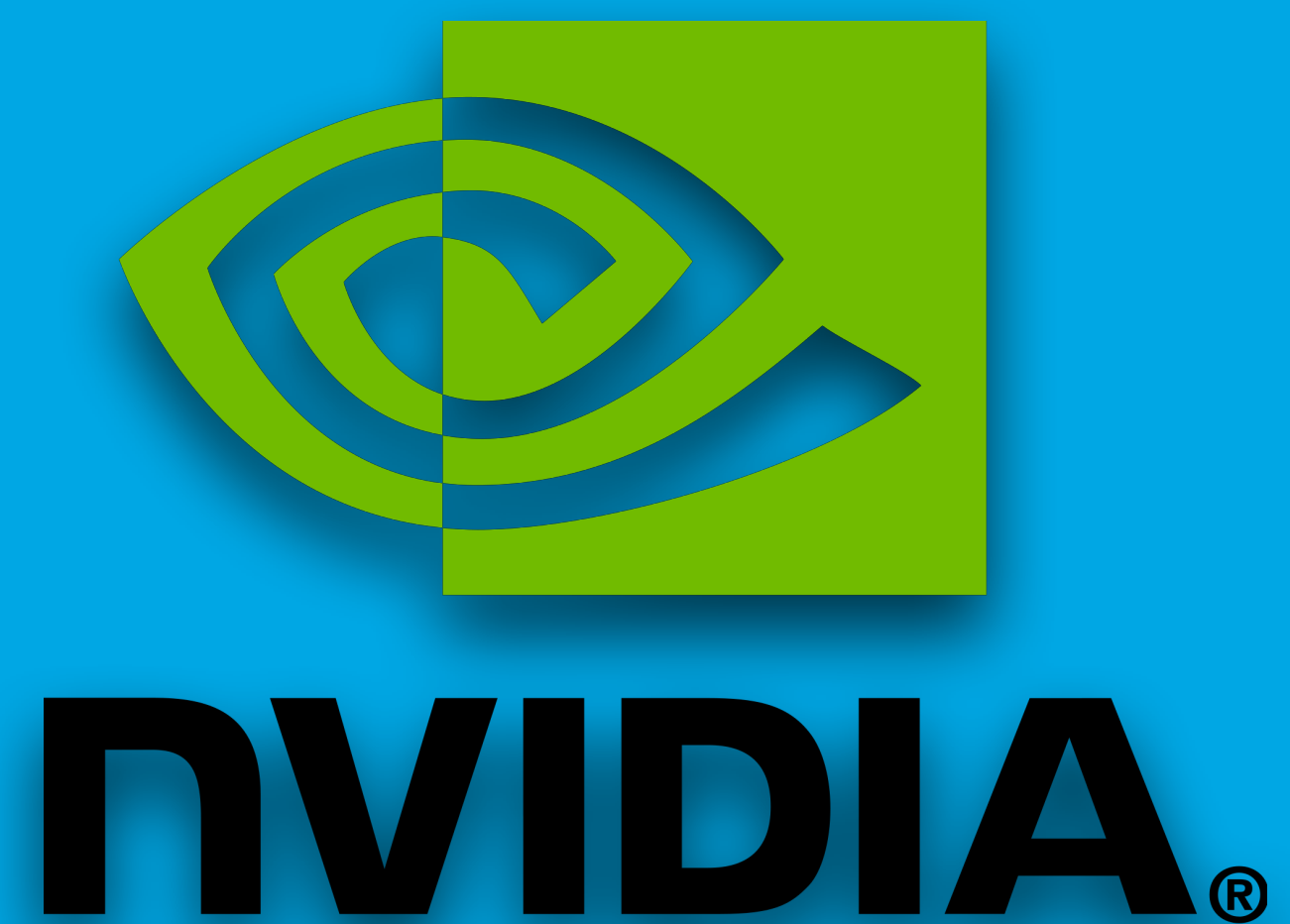
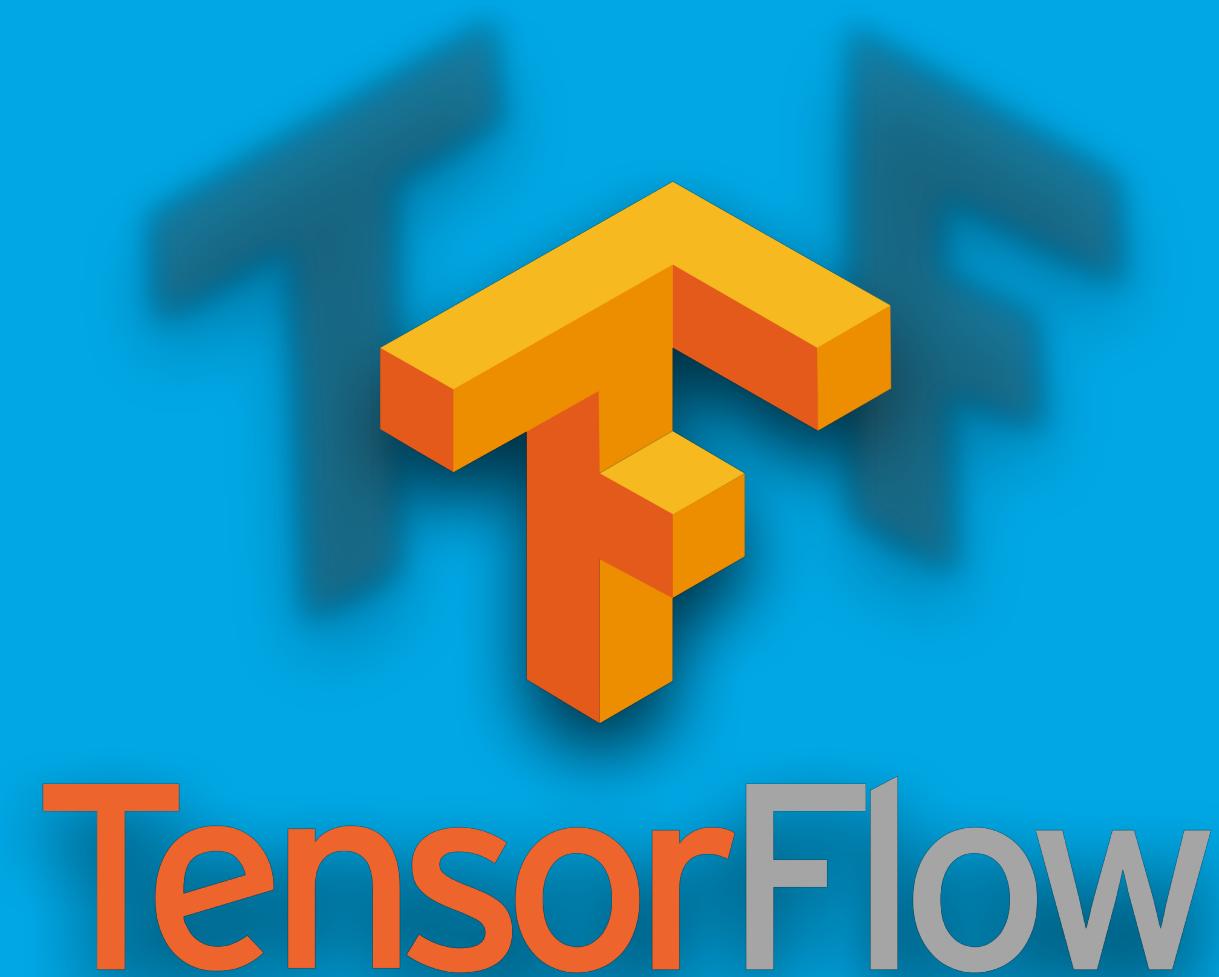
“The essential tool of econometrics is multivariate linear regression, an 18th-century technology that was already mastered by Gauss before 1794 ... It is hard to believe that something as complex as 21st-century finance could be grasped by something as simple as inverting a covariance matrix.”

“... what if economists finally started to consider non-linear functions?”

“An ML algorithm can spot patterns in a 100-dimensional world as easily as in our familiar 3-dimensional one.”

“Econometrics might be good enough to succeed in financial academia (for now), but succeeding in practice requires ML.”

*Marcos López de Prado (2018)*

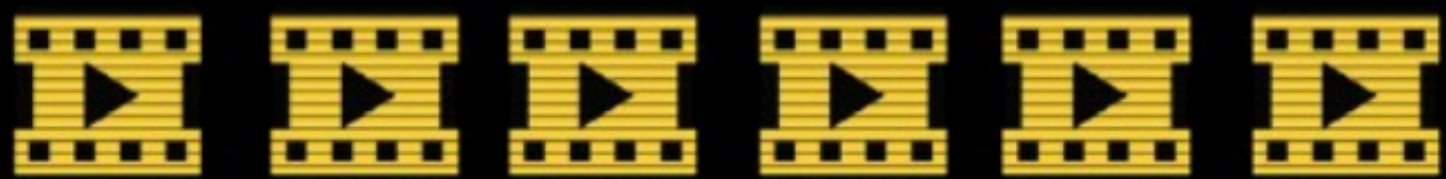


# Deep Learning

# **Deep Learning —Some Background**

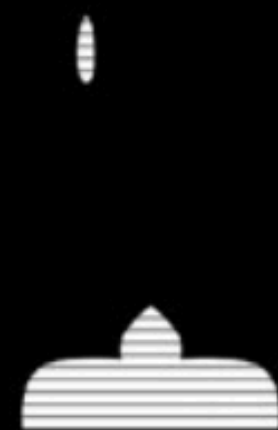


SEAN GERRISH 



  HOW SMART

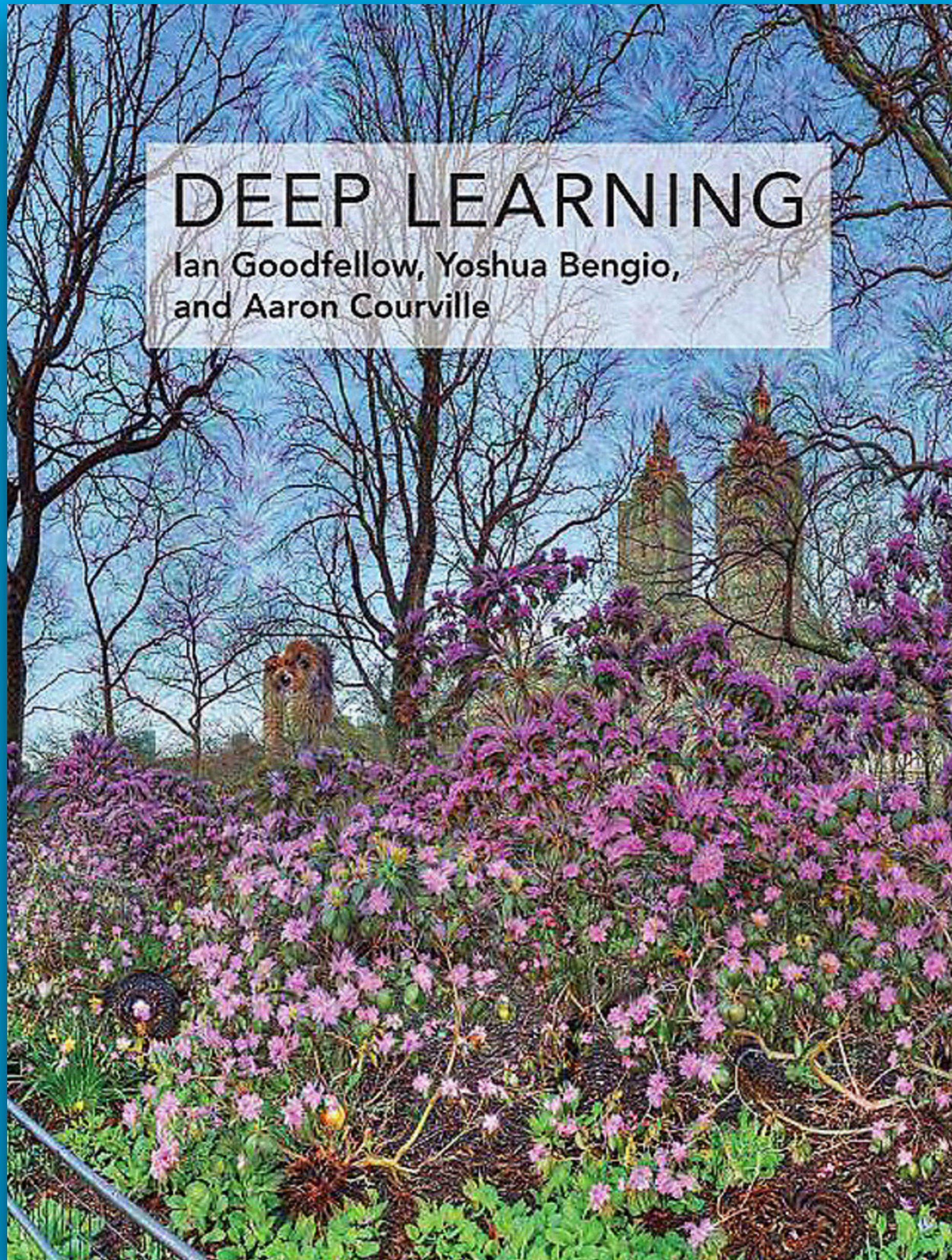
MACHINES THINK



## Success Stories about Deep Learning and Deep Reinforcement Learning:

- Self-Driving Cars
- Recommendation Engines
- Playing Atari Games
- Image Recognition & Classification
- Speech Recognition
- Playing the Game of Go





## **Mathematics of Deep Learning:**

- Applied Mathematics
- Machine Learning Basics
- Deep Feedforward Networks
- Regularization for Deep Learning
- Optimization for Training Deep Models
- Convolutional Networks
- Recurrent & Recursive Nets
- Monte Carlo Methods
- ...



# DEEP LEARNING with Python

François Chollet

 MANNING



## Practice of Deep Learning (with Python and Keras):

- What is Deep Learning?
- Mathematical Building Blocks
- Getting Started with Neural Networks
- Fundamentals of Machine Learning
- Deep Learning for Computer Vision
- Deep Learning for Text and Sequences
- Advanced Deep Learning Best Practices
- Generative Deep Learning

# **Deep Learning**

## **—Universal Approximation Theorem**

# An Overview Of Artificial Neural Networks for Mathematicians

Leonardo Ferreira Guilhoto

## Abstract

This expository paper first defines what an Artificial Neural Network is and describes some of the key ideas behind them such as weights, biases, activation functions (mainly sigmoids and the ReLU function), backpropagation, etc. We then focus on interesting properties of the expressive power of feedforward neural networks, presenting several theorems relating to the types of functions that can be approximated by specific types of networks. Finally, in order to help build intuition, a case study of effectiveness in the MNIST database of handwritten digits is carried out, examining how parameters such as learning rate, width, and depth of a network affects its accuracy. This work focuses mainly on theoretical aspects of feedforward neural networks rather than providing a step-by-step guide for programmers.

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“In the mathematical theory of artificial neural networks, the universal approximation theorem states that a feed-forward network with a single hidden layer containing a finite number of neurons can approximate continuous functions on compact subsets of  $\mathbb{R}^n$ , under mild assumptions on the activation function. The theorem thus states that simple neural networks can represent a wide variety of interesting functions when given appropriate parameters; however, it does not touch upon the algorithmic learnability of those parameters.”

—[https://en.wikipedia.org/wiki/Universal\\_approximation\\_theorem](https://en.wikipedia.org/wiki/Universal_approximation_theorem)

# The AI Machine

## —Demo

# Conclusions



1. Finance has long been driven by the “**beauty myth**” — elegant but too simplistic models, equations and approaches.
2. The availability of **big financial data** (historical—streaming, structured—unstructured) gave rise to data-driven finance.
3. It might be assumed that the “**unreasonable effectiveness of big data**” holds true in the financial domain as well.
4. Due to the availability of big data (e.g. billions of hours of virtual car driving), **Artificial Intelligence** (AI) is changing almost every area of our lives.
5. It is to be assumed that in the same way the **combination of data-driven and AI-first finance** will change the field for good.



# The Python Quants GmbH

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