

Python for Algorithmic Trading

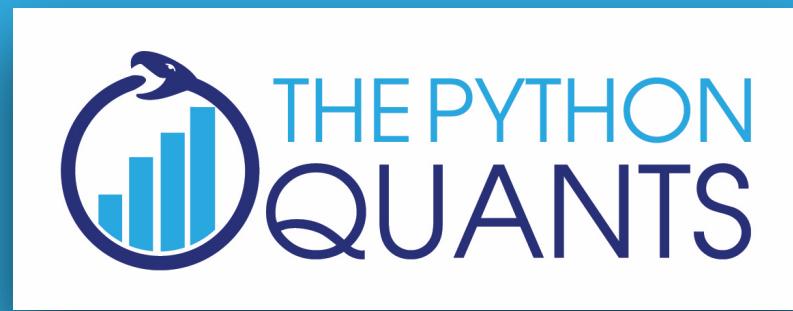
—Vectorized Backtesting, Object-Oriented Programming,
Event-Based Backtesting and Streaming Data with Python

Dr. Yves J. Hilpisch

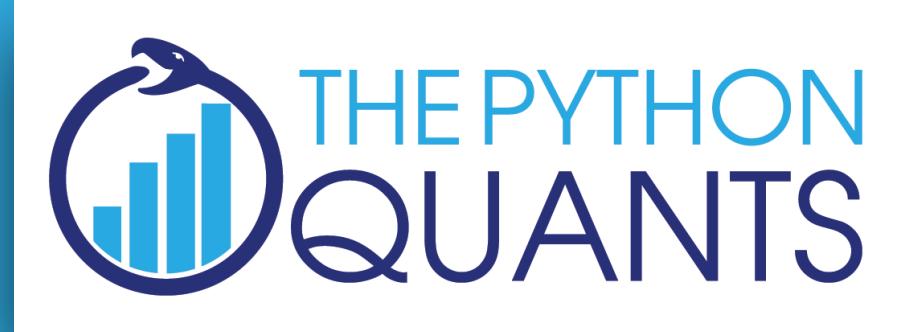
Executive Program in Algorithmic Trading

June 2020

http://bit.ly/epat_june_2020

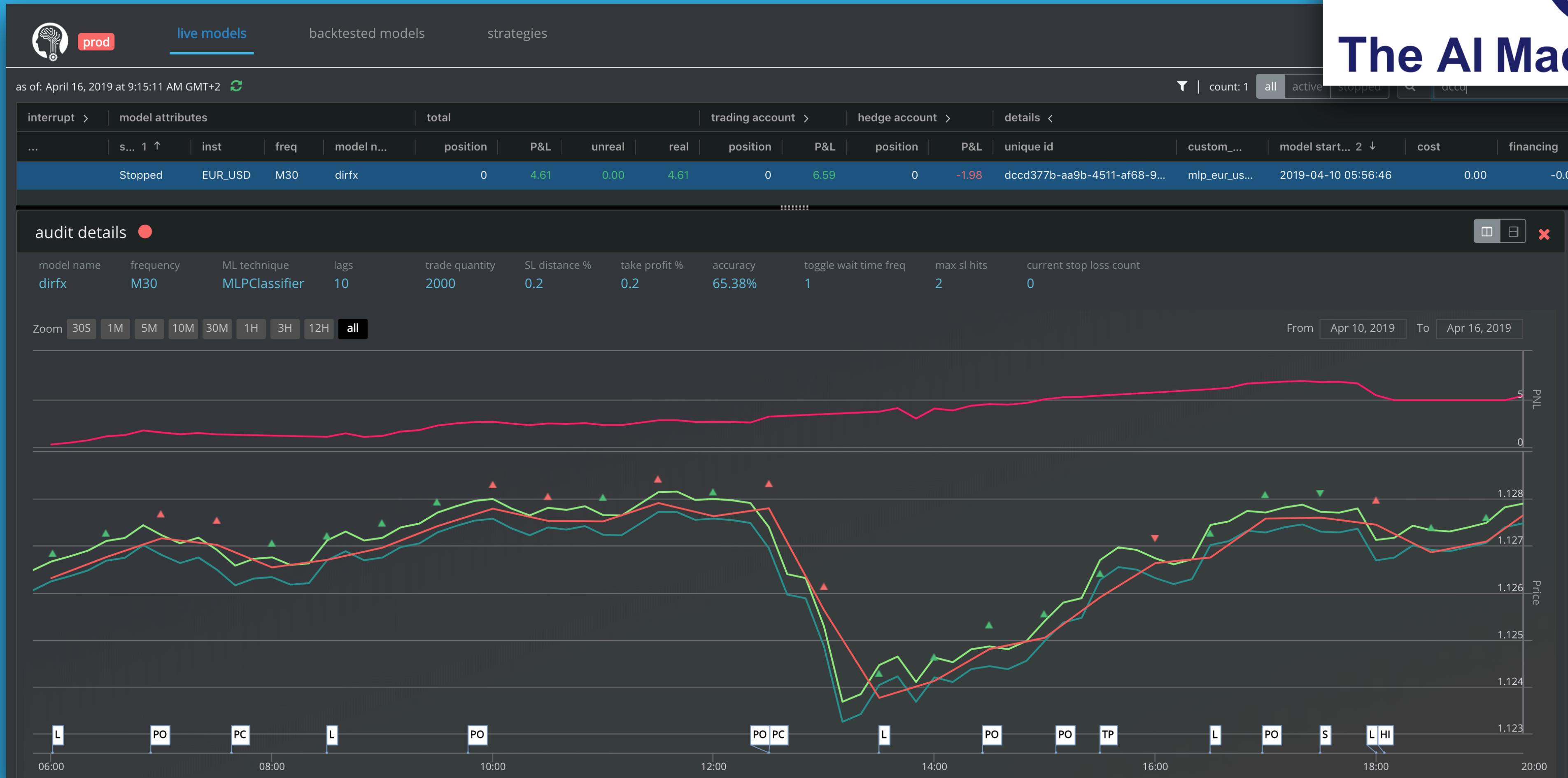


Introduction





The AI Machine



<http://aimachine.io>

16 week program

The image shows a central white brochure titled "UNIVERSITY CERTIFICATE IN PYTHON FOR ALGORITHMIC TRADING" with a blue border. To its left is a dark blue brochure with a white header section about the "PROGRAM DIRECTOR". Below the director's section is a colorful illustration of people at a conference. A small framed certificate from "The Python Quants GmbH" is placed on top of the white brochure. The bottom left corner of the white brochure features contact information for "The Python Quants GmbH" and a date of "April 2017". Above the central brochures is a large, stylized blue graphic featuring a lightbulb, books, money, and a person pointing at a chart, all set against a background of wavy lines and a globe.

**150+ hours
of instruction**

1,200 pages PDF

<http://certificate.tpq.io>

**5,000+ lines
of code**

THE PYTHON QUANTS

**UNIVERSITY CERTIFICATE
IN PYTHON FOR
ALGORITHMIC TRADING**

The Python Quants GmbH
recognized by **CIO Outlook** magazine as
TOP 10
Banking Analytics
SOLUTION PROVIDERS - 2017

An annual listing of 10 companies that are at the forefront of providing banking analytics solutions and impacting the marketplace

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

April 2017

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:
• 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.



http://certificate.tpq.io/tpq_top_algo_2019.pdf

The Python Quants

First University Certificate in Python for Algorithmic Trading

Python 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

Dr. Yves J. Hilpisch is founder and CEO of **The Python Quants** (<http://tpq.io>), a group focusing on the use of open source technologies for financial data science, artificial intelligence, algorithmic trading, and computational finance. He is also the founder and CEO of **The AI Machine** (<http://aimachine.io>), a company focused on AI-powered algorithmic trading based on a proprietary strategy execution platform.

Yves has a Diploma in Business Administration, a Ph.D. in Mathematical Finance and is Adjunct Professor for Computational Finance.

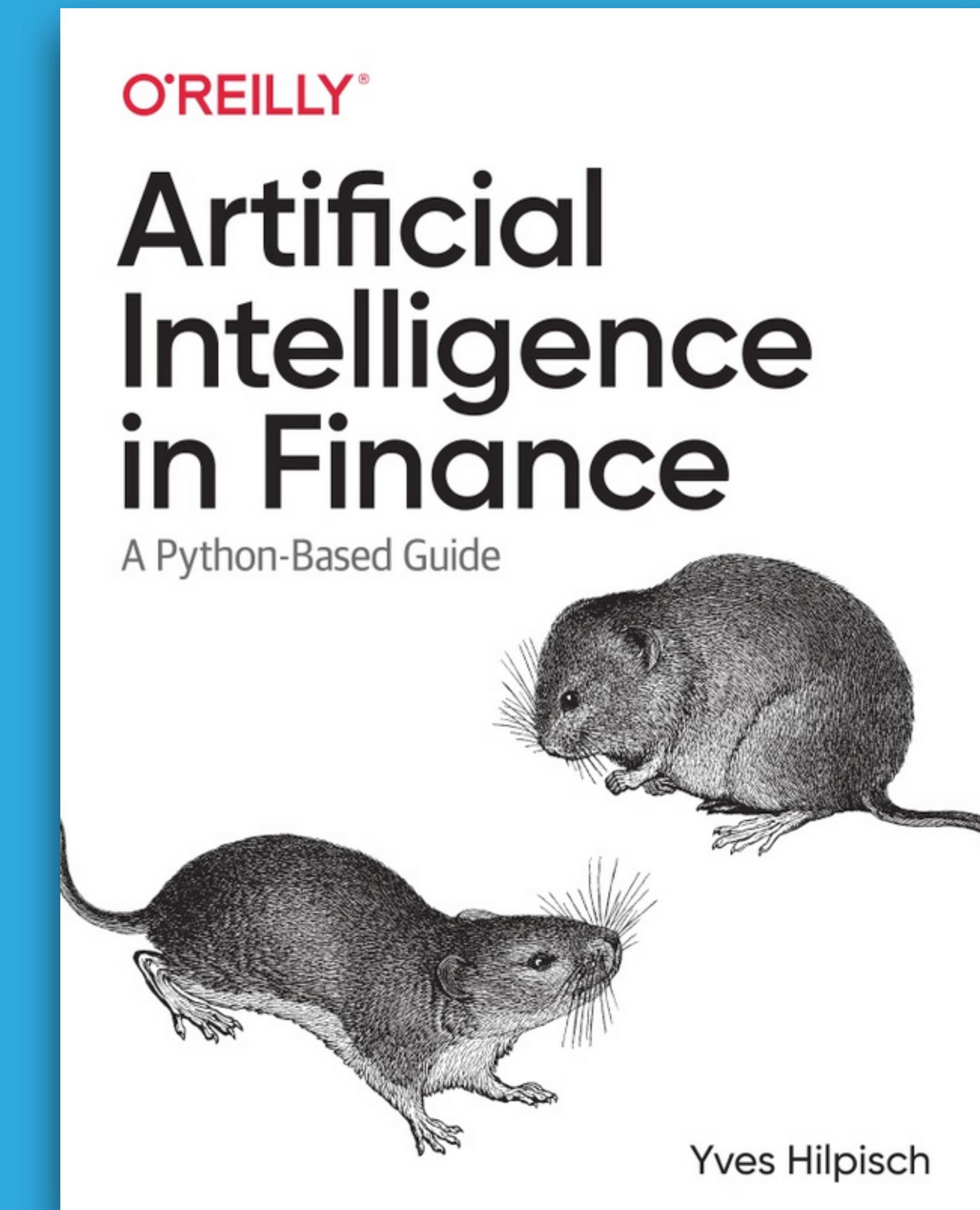
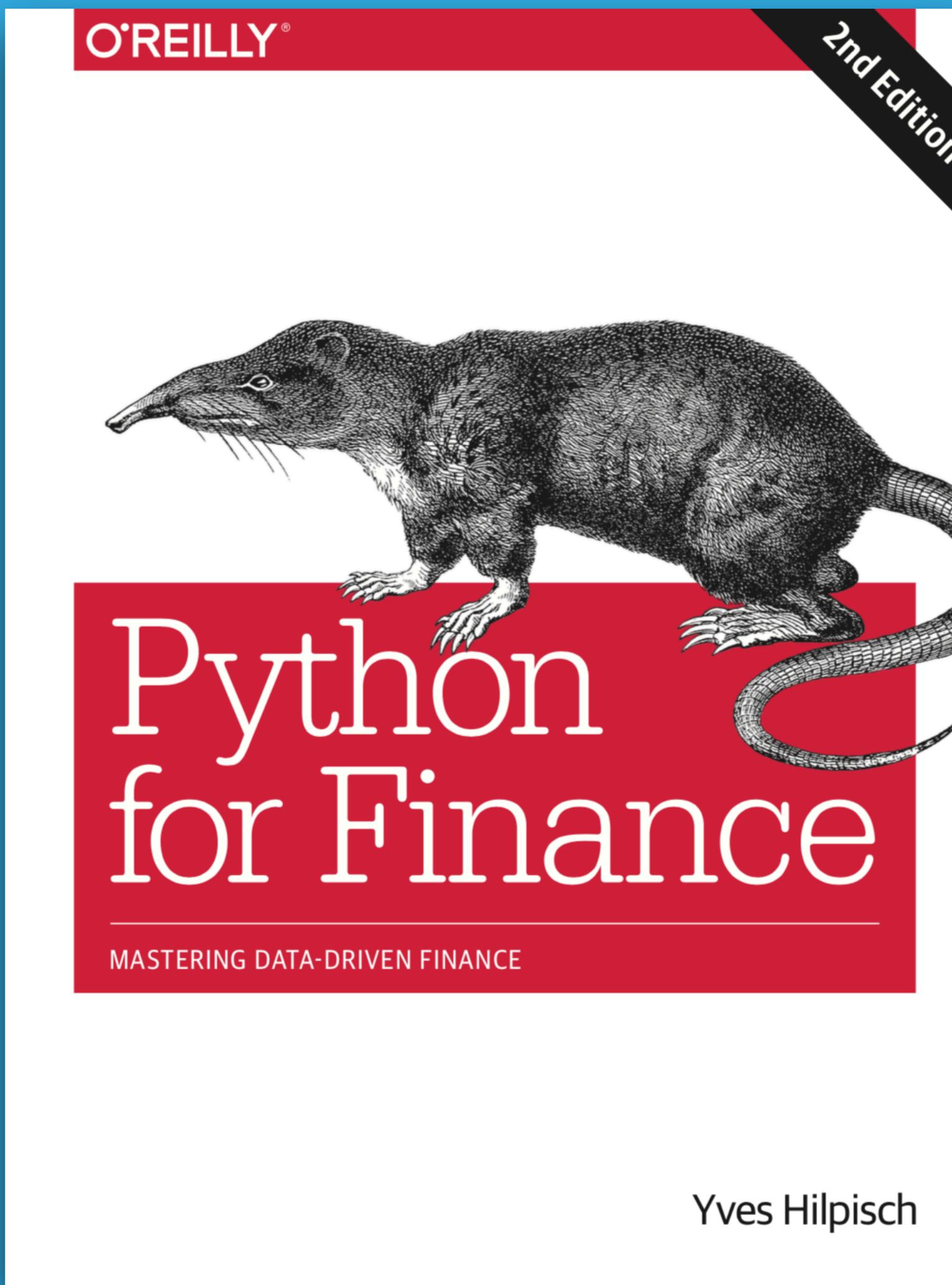
Yves is the author of five books (<https://home.tpq.io/books>):

- * Artificial Intelligence in Finance (O'Reilly, forthcoming)
- * Python for Algorithmic Trading (O'Reilly, forthcoming)
- * Python for Finance (2018, 2nd ed., O'Reilly)
- * Listed Volatility and Variance Derivatives (2017, Wiley Finance)
- * Derivatives Analytics with Python (2015, Wiley Finance)

Yves is the director of the first online training program leading to **University Certificates in Python for Algorithmic Trading** (<https://home.tpq.io/certificates/pyalgo>) and **Computational Finance** (<https://home.tpq.io/certificates/compfin>). He also lectures on computational finance, machine learning, and algorithmic trading at the **CQF Program** (<http://cqd.com>).

Yves is the originator of the financial analytics library **DX Analytics** (<http://dx-analytics.com>) and organizes Meetup group **events, conferences, and bootcamps** about Python, artificial intelligence and algorithmic trading in London (<http://pqf.tpq.io>), New York (<http://aifat.tpq.io>), Frankfurt, Berlin, and Paris. He has given **keynote speeches** at technology conferences in the United States, Europe, and Asia.

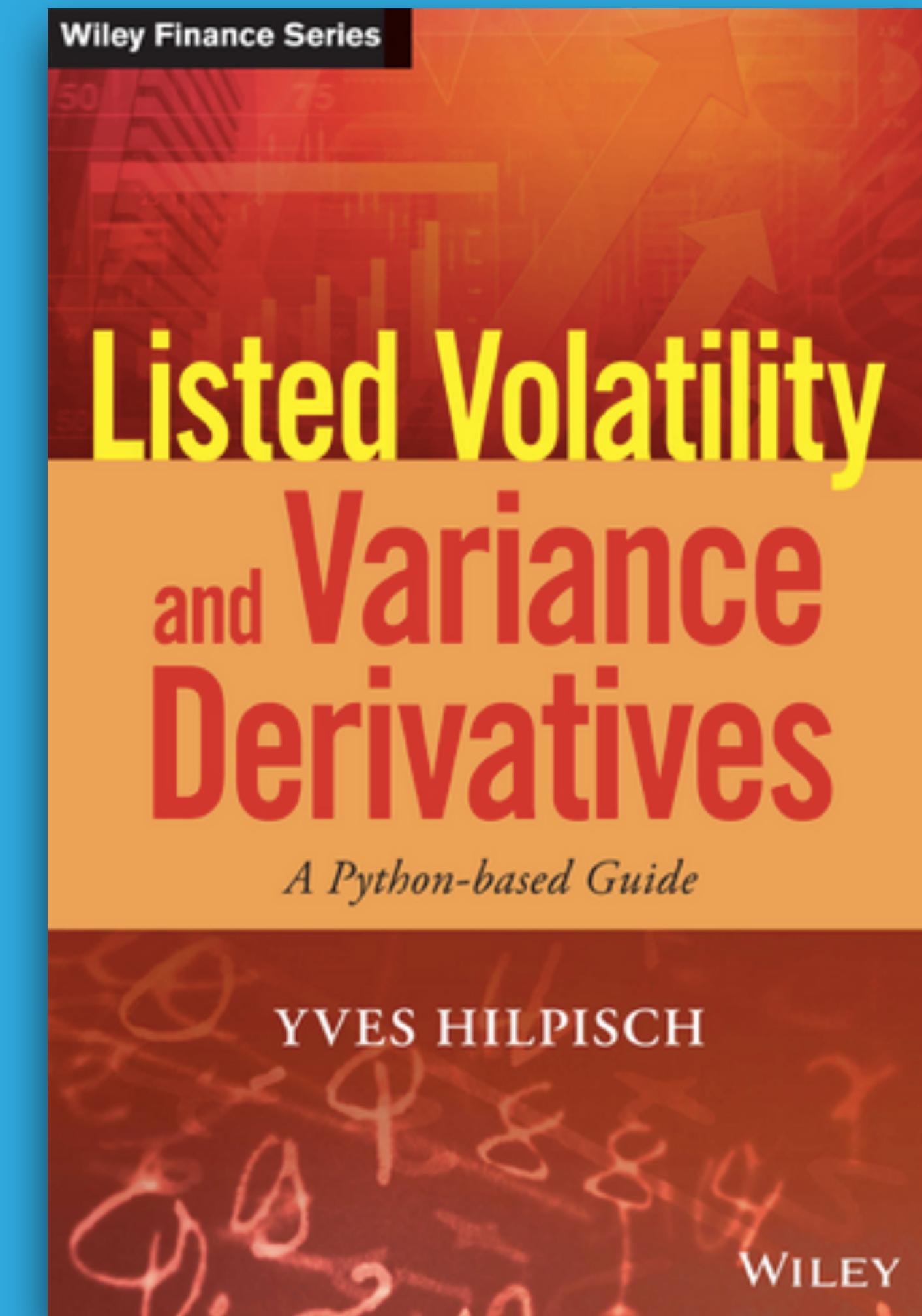
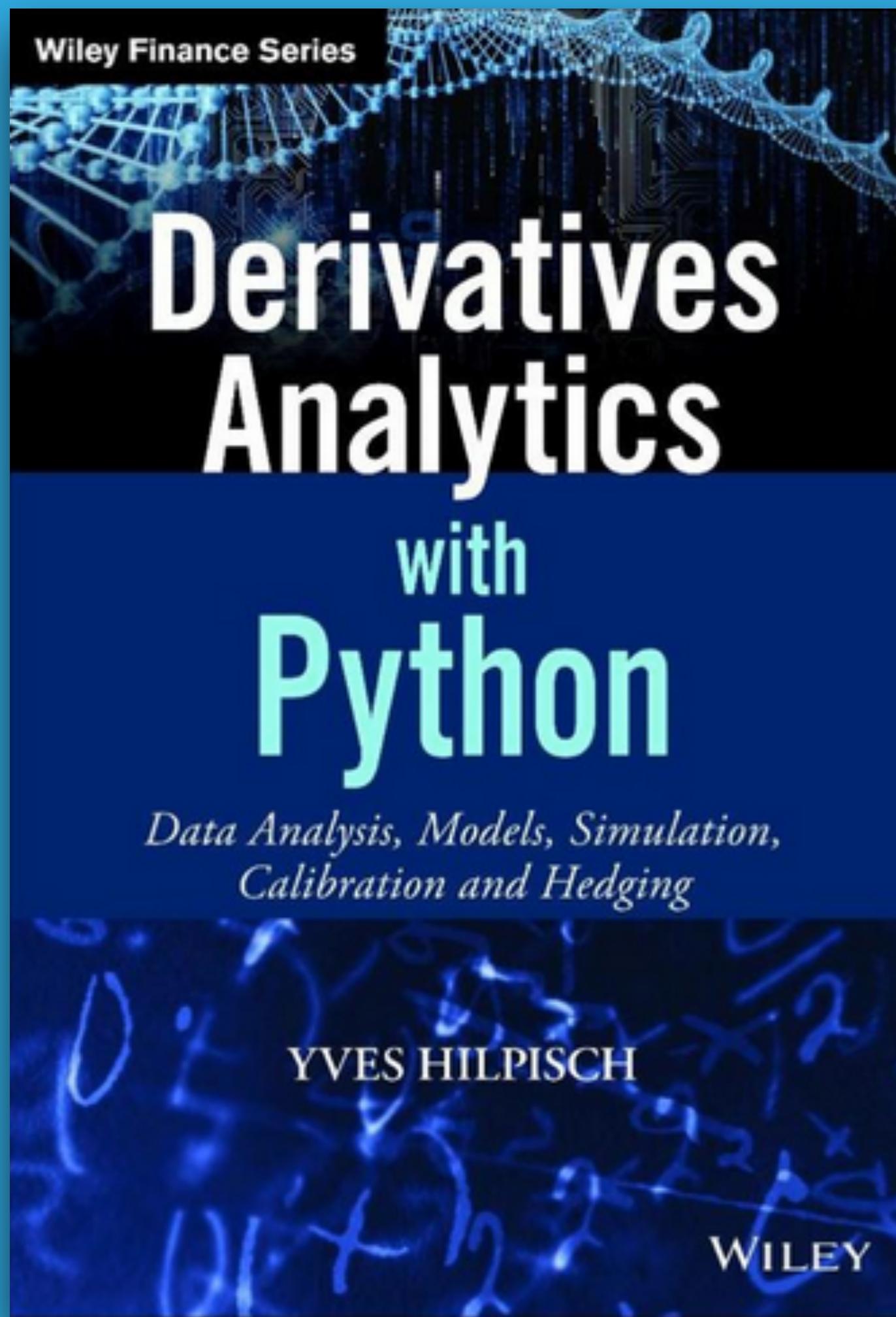
Python & AI for Finance



Next book project:
Python for Algorithmic Trading

<http://books.tpq.io>

Quant Finance with Python



<http://books.tpq.io>

Data-Driven Finance

TODAY IN PERSONAL JOURNAL

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PLUS Secondhand Stress at Work

THE WALL STREET JOURNAL.

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

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DOW JONES

Closes

A 15973.13 ▼ 52.40 0.3% NASDAQ 4060.49 ▼ 0.2% NIKKEI 15611.31 ▼ 0.25% STOXX 600 314.91 ▼ 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

A GM named its first female CEO, tapping company veteran and product chief Mary Barra to run the auto maker. **A1**

Financial regulators approved the Volcker rule, which curbs banks' risk-taking and could slash their profits. **A1**

The FDIC board approved a plan to keep parts of a failing financial firm open without a taxpayer bailout. **C3**

Finance ministers from big euro-zone nations reached an understanding on winding down failing banks. **C3**

Discovery is considering a deal for Food Network majority owner Scripps, presaging a possible wave of TV deals. **B1**

Stocks declined as investors weighed the potential impact of reduced Fed stimulus. The Dow dropped 52.40 points. **C4**

OTC stock trading was halted for about an hour because of a hardware error. **C4**

Smith & Wesson said profit fell 20% and revenue rose just 4%, as gun sales slow from their recent torrid pace. **B2**

Pacific trade talks adjourned without a deal amid discord between the U.S. and Japan. **A17**

Italy pulled out of a two-year contraction in the third quarter, posting flat GDP. **A13**

Three Swiss banks agreed to participate in a U.S. tax-evasion-disclosure program. **C5**

LightSquared can proceed with a suit against Dish over a plot purchase, a judge ruled. **B3**

Monsanto is teaming up with a Danish firm to develop useful microbes for plants. **B4**

World-Wide

Congressional negotiators struck a budget deal that would allow more domestic and military spending and include deficit-cutting measures. **A1, A8**

Ukrainian forces stormed a protesters' encampment in Kiev, hours after Western diplomats called for a nonviolent end to the political crisis. **A13**

Obama's disapproval rate rose 54%, the high for his presidency, amid the flawed health-care rollout, a Wall Street Journal/NBC poll found. **A4**

World leaders gathered to honor Mandela. In a rare encounter, Obama shook hands with Cuba's Raúl Castro. **A12**

Senate Democrats condemned an Obama appeals-court pick and the head of Freddie Mac's overseer. **A4**

A key Senate Democrat said he would back the Obama administration's request to delay new Iran sanctions. **A17**

Supreme Court justices expressed sympathy for the EPA approach to air pollution rules across state lines. **A2**

An AIDS group called for a vote to see if HIV-infected patients were discouraged from enrolling in health plans. **A6**

Uruguay's Senate voted to legalize marijuana. The president plans to sign the bill. **A15**

France's leader flew to the Central African Republic after French troops died. **A13**

Singapore police charged all Indian citizens in connection with a night of rioting. **A13**

Died: Jim Hall, 83, acclaimed jazz guitarist.

NFTS Leisure & Arts D6
Business Tech B6 Market Data C6
Corporate News B1 Opinion A1P-21
Ed. & Fin. C3 Sports D7
Art & Street C4 U.S. News A2-10
Ent. & Digital B4 World Watch B10
The Markets C4 World News A12-17

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Deal Brings Stability to U.S. Budget

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

By JANET HOOK

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 once-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.

"In divided government, you don't always get what you want," said said Mr. Ryan.

Ms. Murray joined him in welcoming the prospect that lawmakers would steer away from a crisis-driven budget process. "We have lurched from crisis to crisis, from one cliff to the next," she said. "That uncertainty was devastating to our fragile economic recovery."

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

Thousands Honor Memory of South Africa's Liberator

REST IN PEACE: A boy attended the memorial service for former South African President Nelson Mandela at a soccer stadium in Johannesburg on Tuesday that drew celebrities and dozens of heads of state, including President Obama, along with thousands of other mourners. **A12**

Longtime Insider Is GM's First Female CEO

By JEFF BENNETT
AND SARA MURRAY

DETROIT—General Motors Co. tapped product chief Mary Barra as its next chief executive, smashing a century-old gender barrier while choosing a longtime insider who grew up steeped in Detroit's car culture.

Ms. Barra will succeed Dan Akerson as CEO next month and become the first woman to run a major global auto maker. The 51-year-old joined GM 33 years ago as a college intern, eventually becoming an engineering manager before running one of its big U.S. assembly plants. She got global experience managing human resources and, more recently, the company's world-wide product development group.

She will become the 22nd woman currently running a Fortune 500 company.

Please turn to page A10

♦ Milestone is hailed, but women continue to face obstacles.... B7
♦ Heard on the Street C14

Ukrainian Forces Confront Protesters

Government security forces cracked down on protesters in Kiev hours after U.S. and EU diplomats called for a nonviolent resolution. **A13**

Reuters

PARTY DISCIPLINE

China Spins New Lesson From Soviet Fall

By JEREMY PAGE

BEIJING—The Communist Party boss in eastern China's Jiangsu province summoned local officials recently to a compulsory study session. Their task was to watch a six-part documentary on the Soviet Union's collapse.

The film begins with images of the Soviet Union in its heyday, but quickly cuts to graphic footage of unrest in China's northern neighbor in the 1990s, set to ominous music and punctuated by Russian communists lamenting their nation's fate.

When the screening in Jiangsu ended, state media reported, local party chief Luo Zijun exhorted the assembled officials to "correctly understand the lessons of history." The film's message: The Soviet Union didn't

fall apart because of the communist system itself, but because of individuals who betrayed it, especially Mikhail Gorbachev.

The film is part of an ideological campaign launched by China's new leader, Xi Jinping, to re-energize the party and enforce discipline among its members. It has been shown at dozens of political meetings since September.

The frequent showings suggest Mr. Xi believes China needs to reinforce its Leninist political system rather than limit the party's powers. Party insiders and academics say it is part of an effort to combat what is portrayed as an American conspiracy to overthrow the party through "peaceful evolution"—the spread of Western ideas via media, academia and popular culture.

The office in charge of Mr. Xi's campaign didn't respond to questions about the film, called "20th Anniversary of the Death of the Soviet Party and State: As the Russians Relate," but said the campaign drew on experiences from China and the rest of the world.

The film, which was produced by a retired Chinese major general, has drawn criticism from some Chinese scholars of Soviet history, including some within the party. They argue that Moscow's mistake was to overlook deep flaws in the Soviet political and economic systems that emerged long before Mr. Gorbachev.

The film "lacks rational analysis, is mainly aimed at defending the Stalinist system and is illogical in many places," wrote Zuo Fen.

Please turn to page A18

Bank Rule Challenges Wall Street

By JUSTIN BAER
AND JULIE STEINBERG

Abroad new government rule to limit risk-taking by Wall Street will force banks to rethink virtually every aspect of their trading activities, setting the stage for more tumult at the largest U.S. financial institutions.

The so-called Volcker rule, proposed by five financial regulatory agencies on Tuesday, could cap as much as \$10 billion total in yearly pretax profit from the eight largest U.S. banks through lower revenue and higher compliance costs, according to estimates from Standard & Poor's.

This 953-page edict, part of the 2010 Dodd-Frank financial overhaul, codifies and restricts the way banks trade securities. It curbs banks' ability to bet with their own capital and forces them to "ring-fence" their trading units.

Please turn to page A6

Here's Your Holiday Bonus, Now Start Running

* * *

Workers Win All-They-Can-Grab Sprees From Companies; 'Supermarket Sweep'

By RACHEL FEINTZIG

On Thursday, Alan Comley will get the holiday gift he never knew he always wanted: two minutes at a Texas Costco.

The 27-year-old wasn't even a member of the wholesale warehouse store until a few days ago. But his employer, coupon website RetailMeNot Inc., takes a cue from the game show "Supermarket Sweep" when it comes to rewarding employees. As a prize for his work as a software engineer,

Mr. Comley will have 120 seconds to run unbridled through the big-box store's aisles, grabbing a plasma television, a videogame console and almost anything else that he can hoist onto his cart.

"I'm looking to break a record," he says.

At a time of year when many workers anticipate a Christmas bonus check or a holiday ham, some companies say one of the best ways to reward outstanding performance and inspire employee loyalty is a chance to shop 'till they drop.

Jordan Nicholas, Elliott Inc., a Florida company that runs several restaurants, unleashes high performers on a Lakeland, Fla., Winn-Dixie, where they get two to four minutes to fill their carts as co-workers race alongside. Still other companies hit the mall—one gives workers \$150 and an hour to buy what they like, while an Ohio health-care system awards 20-year employees a \$300 trip to a shopping center, after which they strut down a mall.

Please turn to page A18

IXUS ITOT IJV AGG

IEFA iShares Core ETFs ILTB

IEMG IJH IJR ISTB

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US Stocks
US Bonds

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United States | NASDAQ Global Select Consolidated | Phones & Handheld Devices

④ 333.46 c USD Vol 141,753 CAM 64 CCR 97 Updated: 09-Jun-2020 15:11:08 Valuation VOV

Overview News & Research Price & Charts Estimates Financials ESG Event Ownership Debt & Credit Peers & Valuation Derivatives Filings

PRICE PERFORMANCE >

Open	AAPL.O : 333.4	
Prev. Close	④ 333.46	
Bid / Ask	④ 332.02 / 332.15	
VWAP		
Turnover	--	
Volume	④ 141,753	
Short Interest	0.775%	
YTD	④ 13.56%	
Beta (5Y Monthly)	1.154	
Mkt Cap - Default	USD	1.445T
PE (LTM)	26.141	
Div Yield	0.984%	
DR	BRL	AAPL34.SA (1:0.1)
DR Type	--	
DR Bank	--	
Free Float	4.33B	Asset Type
Outstanding	4.33B	Share Class
IPO Date	12-Dec-1980	Lot Size
100		
△ 1 Week 0.43		

STARMINE MODELS >

Bullish	Bearish		
Price Momentum	96	Intrinsic Valuation	27
Smart Holdings	91	Relative Valuation	25
Short Interest	93	Insider	19

NEWS >

09-Jun-2020

- 14:11:55 Reuters Insider - Coronavirus may forever change how Big Tech works CNBC
- 14:11:32 Now on CNBC LIVE US: Apple Inc CNBC
- 13:11:28 Apple Inc. (NASDAQ:AAPL) Stake Reduced by Mitsubishi UFJ Kokusai Asset Manage... TICR...
- 13:11:24 Meitav Dash Investments Ltd. Sells 4,559 Shares of Apple Inc. (NASDAQ:AAPL) TICR...
- 13:10:24 Fosun International Ltd Has \$3.14 Million Stake in Apple Inc. (NASDAQ:AAPL) TICR...
- 12:32:58 Apple iPad Pro 2020 vs Microsoft Surface Pro X: Replacing laptops for most MIN...
- 12:32:22 MEDIA-Apple plans to announce move to its own Mac chips at WWDC- Bloomberg ... RTRS
- 12:10:43 Carderock Capital Management Inc. Has \$10.32 Million Position in Apple Inc. (NASD... AME...
- 12:10:14 Analyst IMS Investment Management Services Ltd. Has \$6.09 Million Holdings in Ap... AME...
- 11:30:55 Now on CNBC LIVE US: Apple Inc CNBC

RESEARCH >

Contributor	Internal
08-Jun-2020	Equiti Global Arabic Smart Report
05-Jun-2020	Equiti Global Arabic Smart Report
04-Jun-2020	Jefferson Research Financial Sonar Report. A detailed analysis of the
01-Jun-2020	Comprehensive Technical and Fundamental Analysis for AAPL. This re
01-Jun-2020	Equiti Global Arabic Smart Report
29-May-2020	Bankruptcy: What, How and So-What? JCPenney, Hertz, & More
29-May-2020	Qualcomm, Qorvo & Jabil: Apple Suppliers Have Been Left Behind Fr

EVENTS >

Upcoming Past

28-Jul-2020

- NTS Q3 2020 Apple Inc Earnings Release

PEERS >

FV/

```
In [28]: data = ek.get_timeseries('AAPL.O',
                                fields='*',
                                start_date='2019-06-28 16:00:00',
                                end_date='2019-06-28 17:00:00',
                                interval='tick')
```

```
In [29]: data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 20530 entries, 2019-06-28 16:00:00.132000 to 2019-06-28 16:59:58.984000
Data columns (total 2 columns):
VALUE      20499 non-null float64
VOLUME     20530 non-null float64
dtypes: float64(2)
memory usage: 481.2 KB
```

```
In [30]: data.head()
```

```
Out[30]:
```

	AAPL.O	VALUE	VOLUME
	Date		
1	2019-06-28 16:00:00.132	198.64	100.0
2	2019-06-28 16:00:00.132	198.64	100.0
3	2019-06-28 16:00:00.132	198.64	10.0
4	2019-06-28 16:00:00.133	198.64	400.0
5	2019-06-28 16:00:00.133	198.64	1300.0

```
In [31]: news = ek.get_news_headlines('R:TSLA.O PRODUCTION',
                                     date_from='2019-07-01',
                                     date_to='2019-07-19',
                                     count=5
                                    )
```

```
In [32]: news
```

Out[32]:

	versionCreated		text	storyId	sourceCode
2019-07-18 07:37:32.841	2019-07-18 07:37:32.841		Tesla takes production global	urn:newsml:reuters.com:20190718:nNRA98d8a7:1	NS:GLOBML
2019-07-16 15:55:30.319	2019-07-16 15:55:30.319	Reuters Insider - Tesla workers say they use s...	Reuters Insider - Tesla workers say they use s...	urn:newsml:reuters.com:20190716:nRTV7qNh5s:1	NS:CNBC
2019-07-11 14:20:18.249	2019-07-11 14:20:18.249	Auto Stock Roundup: TSLA to Raise Production, ...	Auto Stock Roundup: TSLA to Raise Production, ...	urn:newsml:reuters.com:20190711:nNRA96h0jy:1	NS:ZACKSC
2019-07-11 13:15:45.895	2019-07-11 13:15:45.895	Tesla (TSLA) Prepares to Increase Production i...	Tesla (TSLA) Prepares to Increase Production i...	urn:newsml:reuters.com:20190711:nNRA96ghdy:1	NS:ZACKSC
2019-07-11 08:36:17.569	2019-07-11 08:36:17.569	Tesla signals it's in hiring mode The company ...	Tesla signals it's in hiring mode The company ...	urn:newsml:reuters.com:20190711:nNRA96d7au:1	NS:LATIME

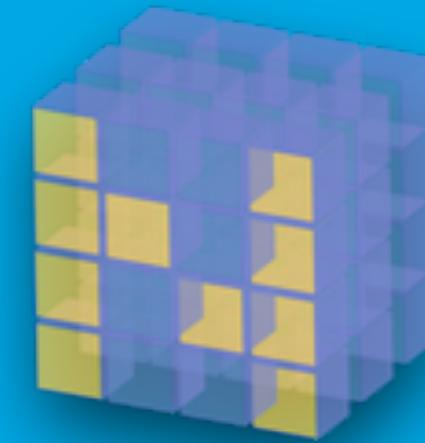
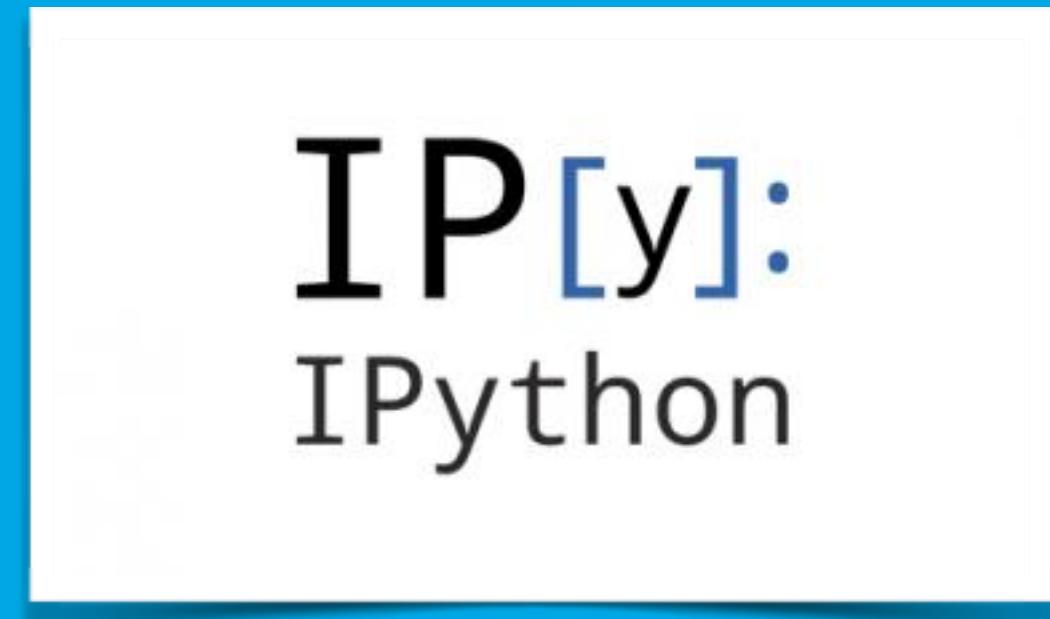
```
In [33]: storyId = news['storyId'][0]
```

```
In [34]: from IPython.display import HTML
```

```
In [35]: HTML(ek.get_news_story(storyId))
```

Out[35]: A new Tesla factory is seen under construction in Shanghai on Tuesday. The electric-car manufacturer is building its first overseas car factory to accelerate its annual production

Infrastructure



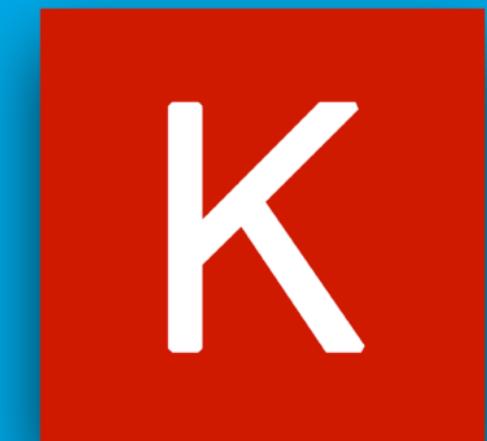
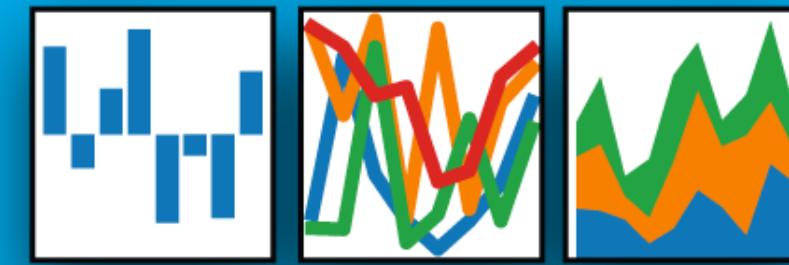
NumPy

matplotlib



pandas

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



Keras

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.¹

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

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

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”

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.

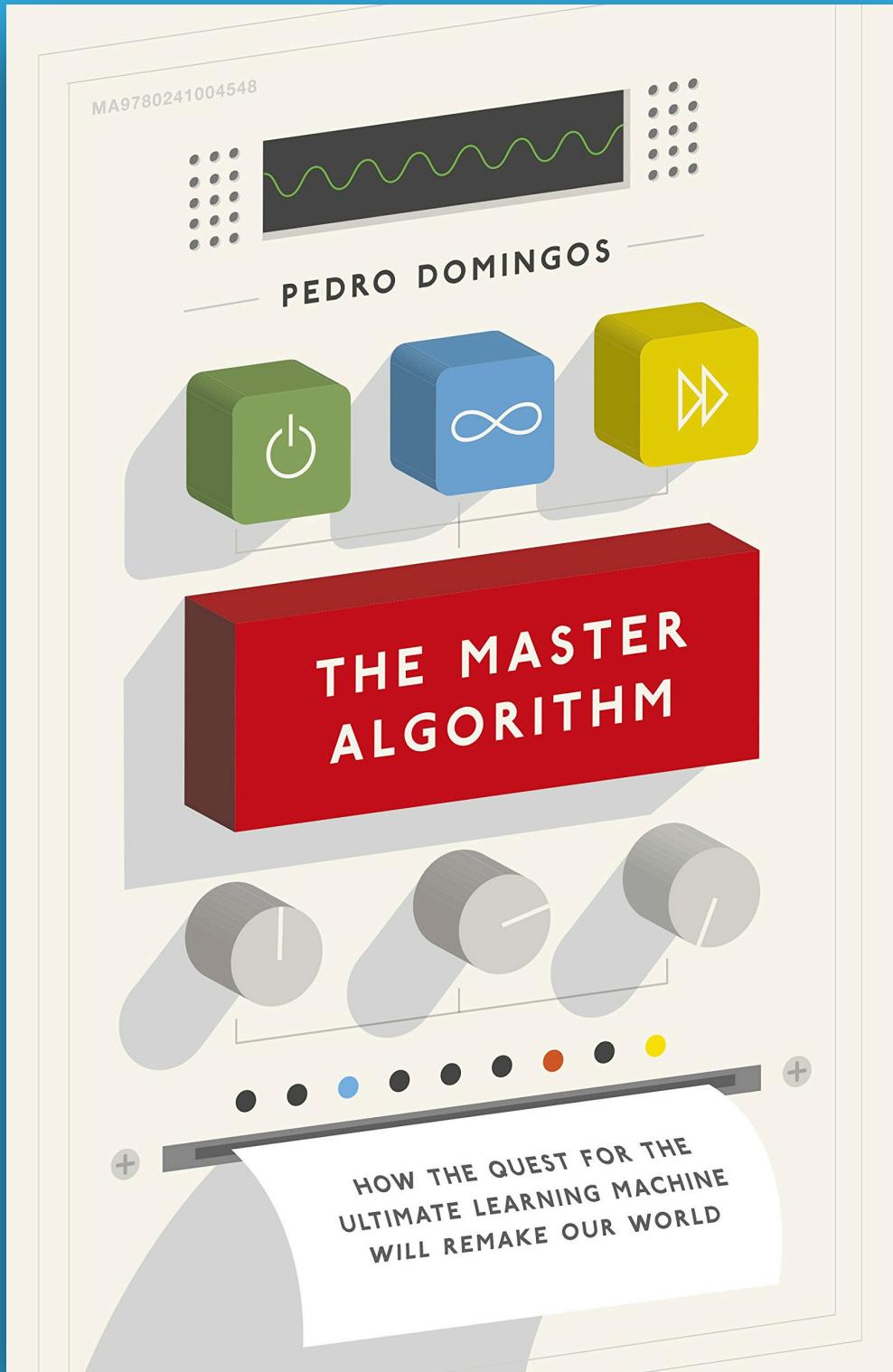
AI-First Finance

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"

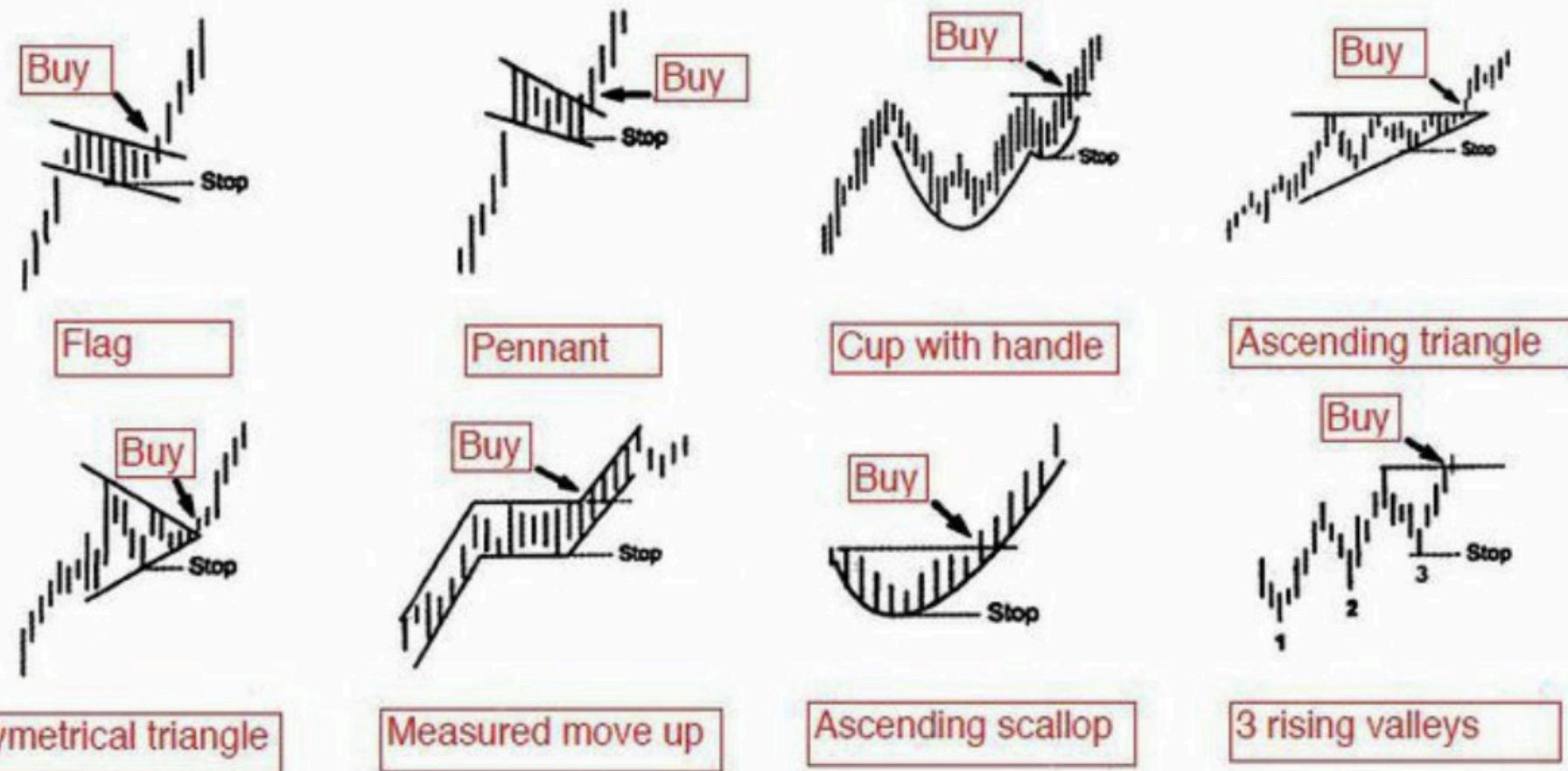


“The grand aim of science is to cover the greatest number of experimental facts by logical deduction from the smallest number of hypotheses or axioms.”

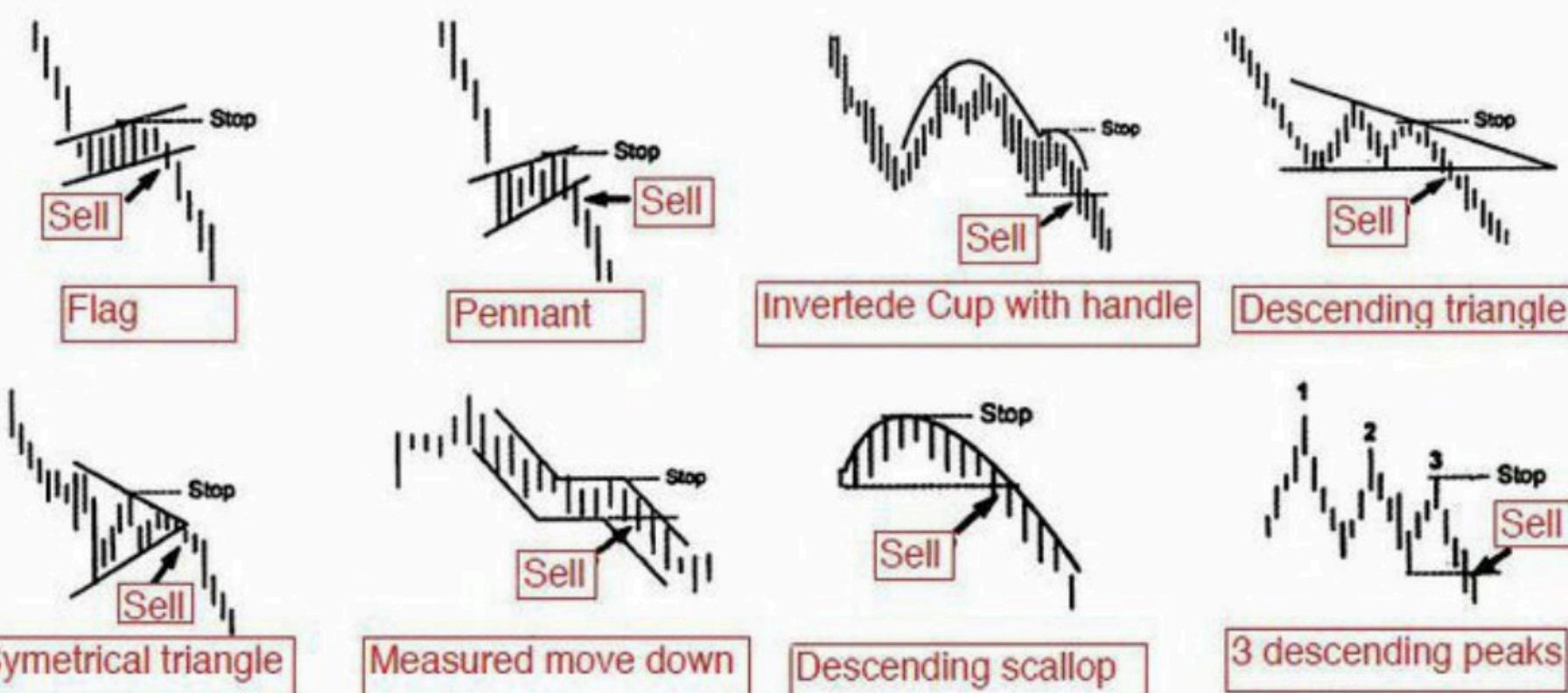
— Albert Einstein

“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.”

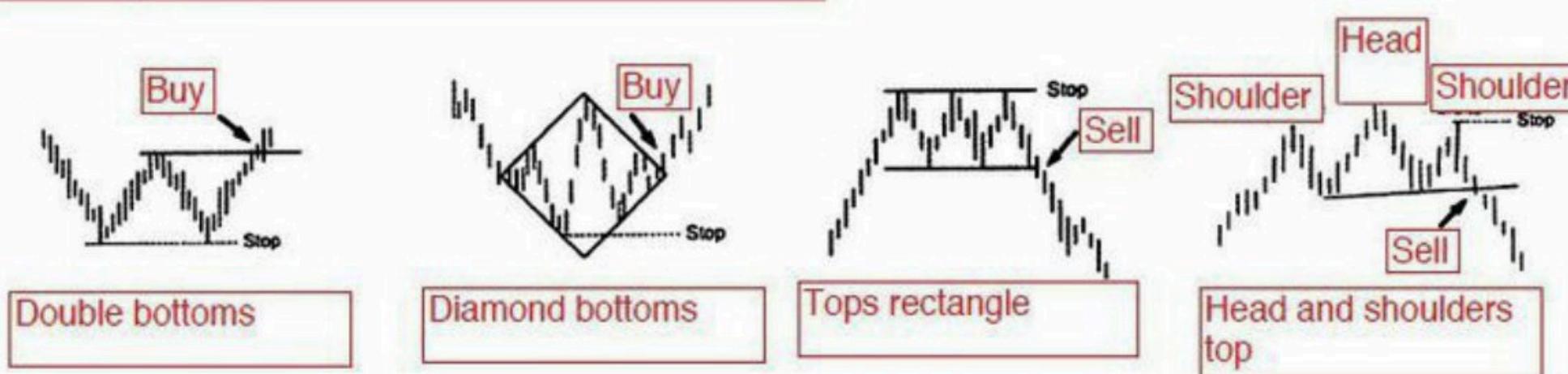
Bullish patterns (going up)



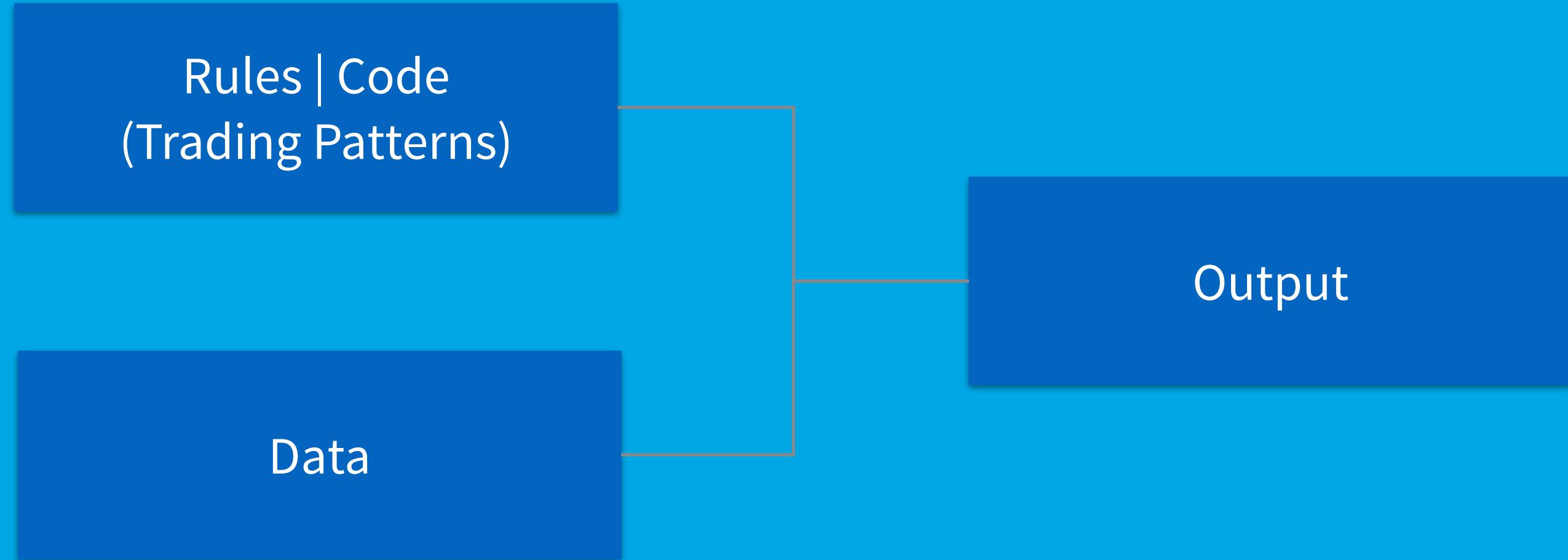
Bearish patterns (going down)



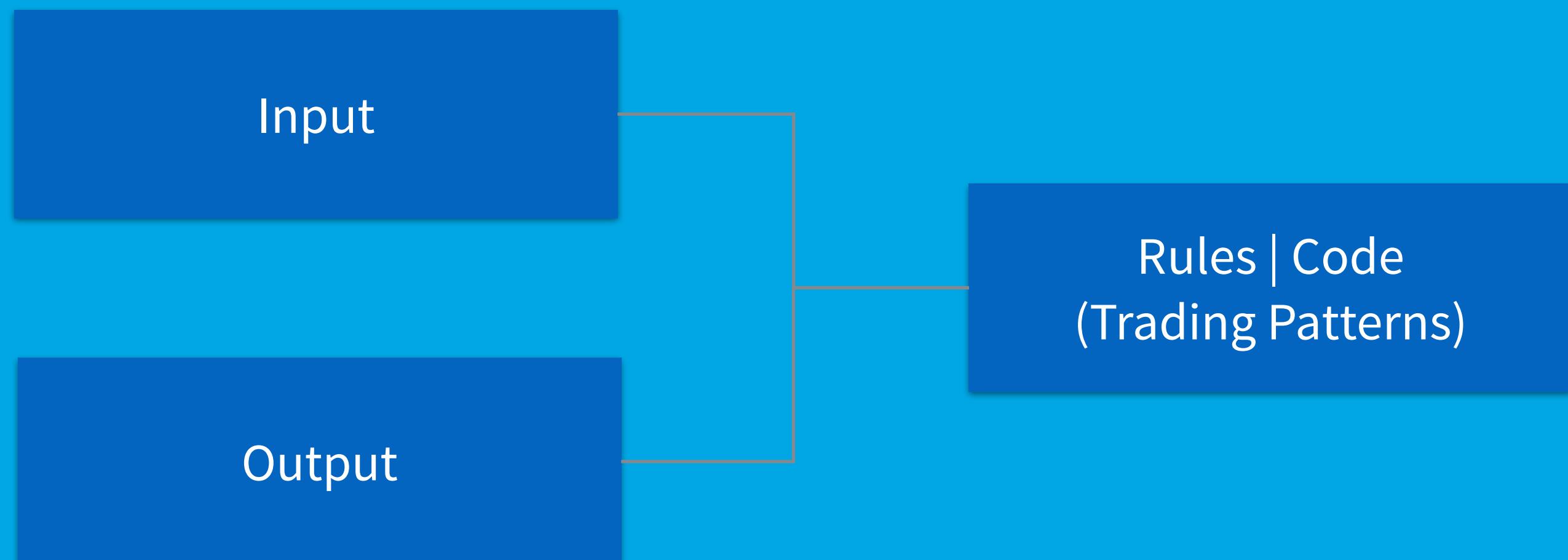
Reversal patterns



Programming.



Machine Learning.



Financial Markets

“normative economics = assumptions, axioms, etc.”

x



y

“non-linear, complex, changing”

Finance History

“positive economics = data, relationships, etc.”



f(•)

(too) “simple and elegant theories”

“hardly any supporting empirical evidence”

f(x) ≠ y

“brain-driven & beauty myth”

x

m(•, a, b)

“general, parametrizable, trainable algorithms”

“might show good performance, but black box”

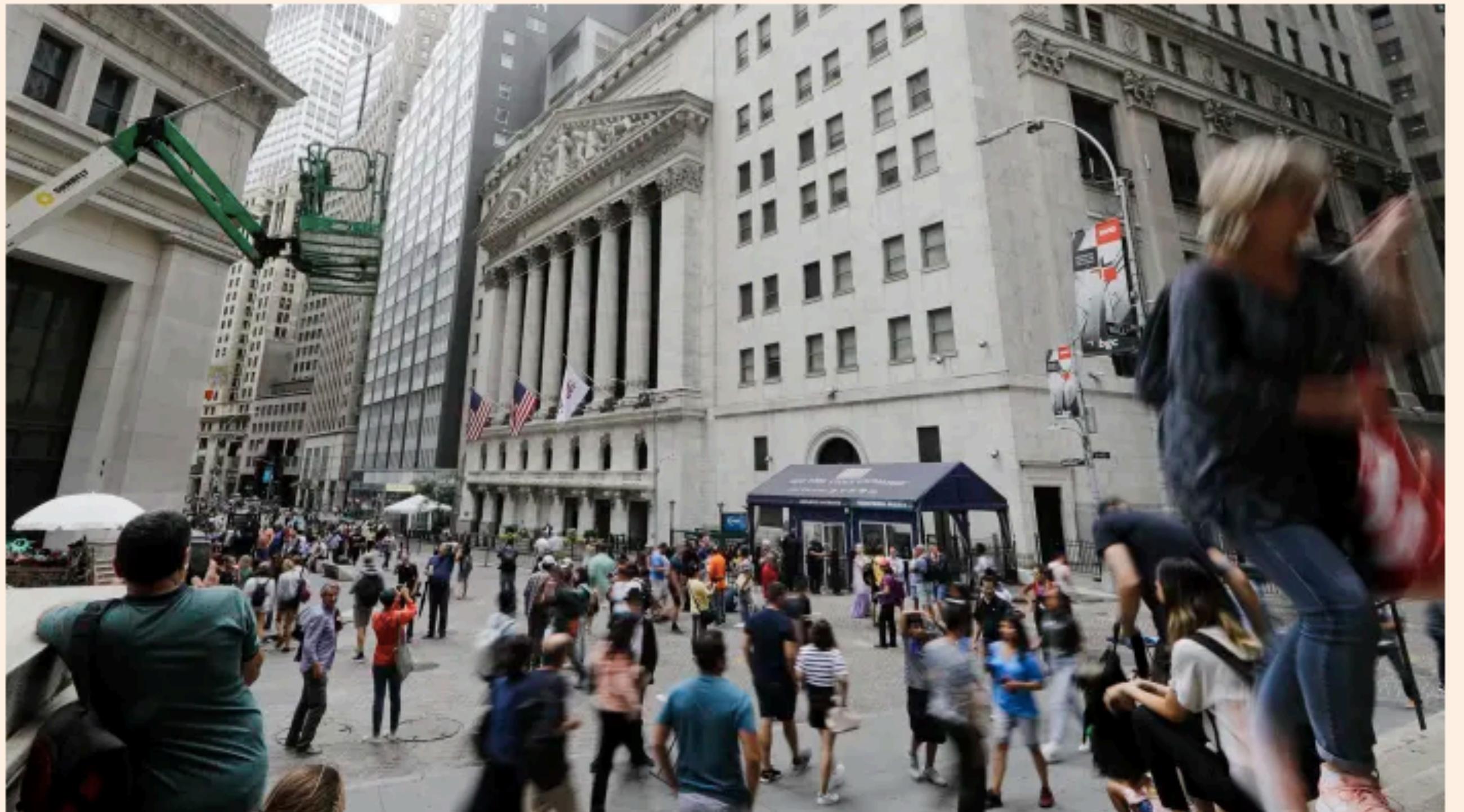
m(x, a*, b*) ≈ y

“data-driven & AI-first”

AI in Finance = finaince

How investment analysts became data miners

Banks battle for audiences with new information sets, 'charticles' and podcasts



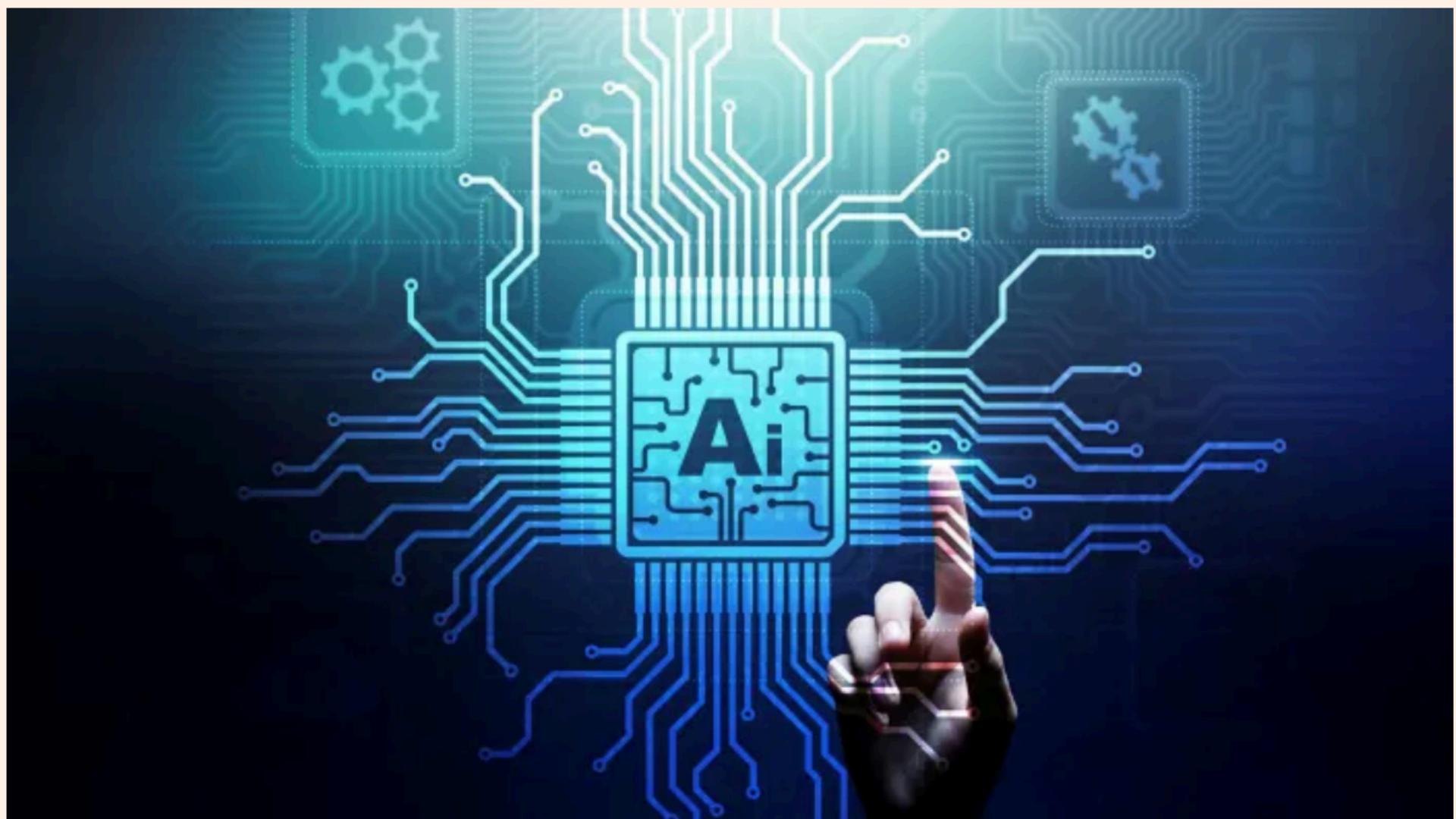
© AP

Will bots replace humans in active equity investment?

Machine learning will implement quant analysis to find the right stocks

ROBERT POZEN

+ Add to myFT



ML can identify outperforming equities based on patterns that would have not been selected by humans © Dreamstime

Overview



INFRASTRUCTURE

Python environment, Jupyter Notebook,
first steps, vectorized backtesting

VECTORIZED BACKTESTING

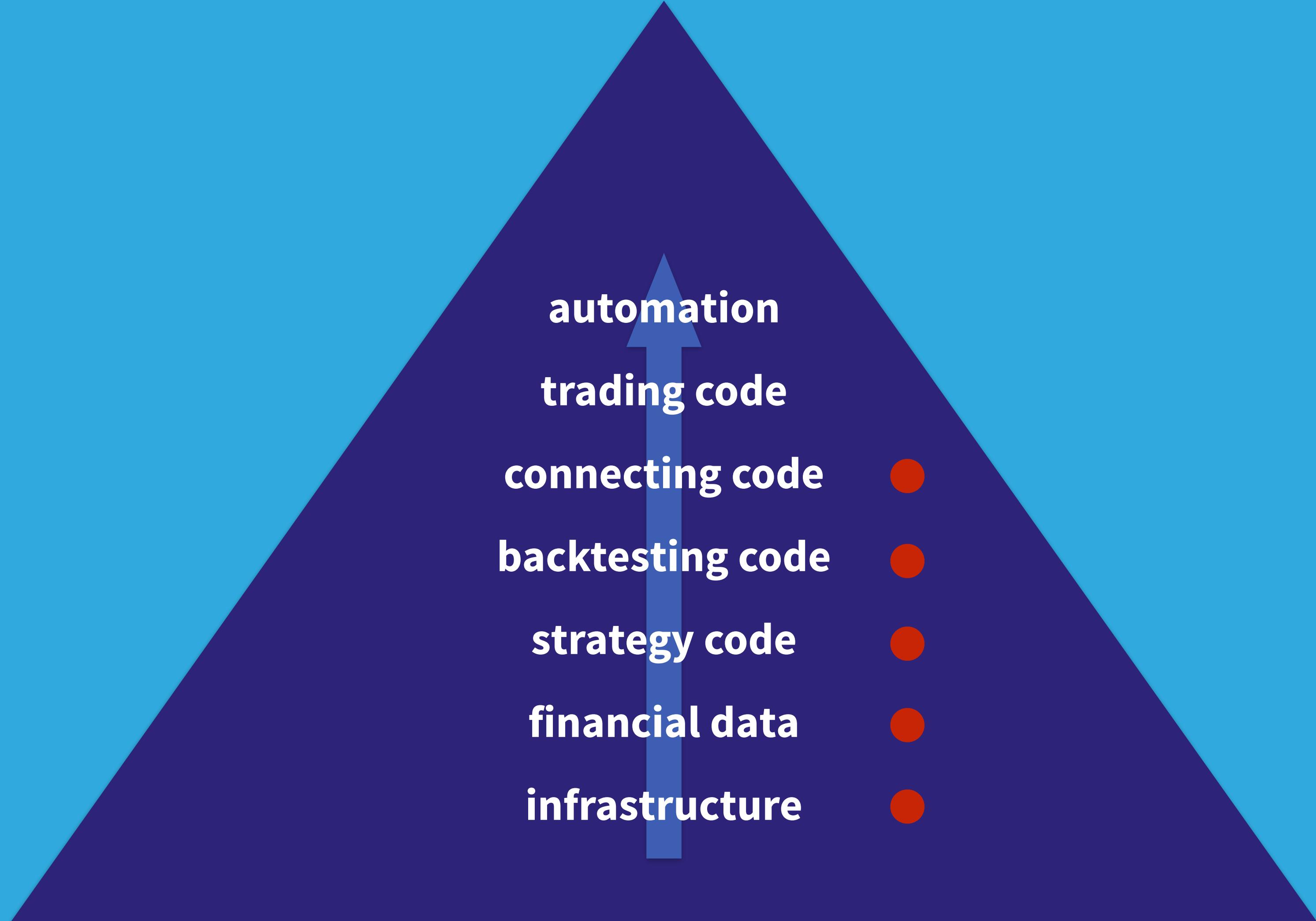
interactive code,
OOP and Python classes

EVENT-BASED BACKTESTING

base backtesting class,
strategy backtesting class

REAL-TIME DATA

simulated streaming (“real-time”) data,
data processing, online algorithms



Why Object Orientation?

Some human aspects:

- **natural way of thinking**
 - a “house”
 - a “person”
 - a “person” in a “house”
- **mastering complexity**
- **nicer user interfaces**
- **pythonic way ...**

Some technical aspects:

- **abstraction**
- **modularity**
- **re-usability**
 - **inheritance**
 - **composition**
 - **aggregation**
 - **polymorphism**
- **non-redundancy**

Free e-book about OOP in general

Lecture Notes on Object-Oriented Programming

Free e-book about Python programming & OOP

<http://python-textbook.readthedocs.io/en/1.0/>

Fluent Python (O'Reilly)

<https://learning.oreilly.com/library/view/fluent-python-2nd/9781492056348/>

The screenshot shows the index page of a documentation site for 'Object-Oriented Programming in Python' version 1.0. The left sidebar contains a navigation menu with links to various chapters: Introduction, Python basics, Variables and scope, Selection control statements, Collections, Loop control statements, Errors and exceptions, Functions, Classes, Object-oriented programming, Packaging and testing, Useful modules in the Standard Library, Introduction to GUI programming with tkinter, and Sorting, searching and algorithm analysis. The main content area displays the title 'Object-Oriented Programming in Python' and a 'Contents:' section with a hierarchical list of topics, including sections like 'Introduction', 'Python basics', and 'Variables and scope'.



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