

Python for Algorithmic Trading

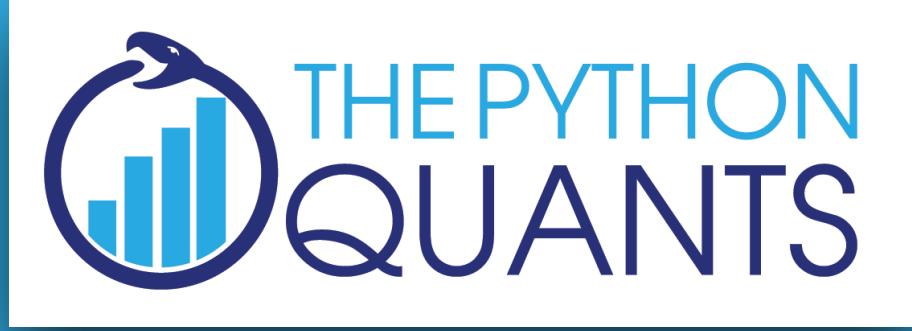
–Vectorized Backtesting, Object-Oriented Programming,
Event-Based Backtesting, and Streaming Data with Python

Dr. Yves J. Hilpisch
Executive Program in Algorithmic Trading
September 2023

https://bit.ly/epat_sep_2023



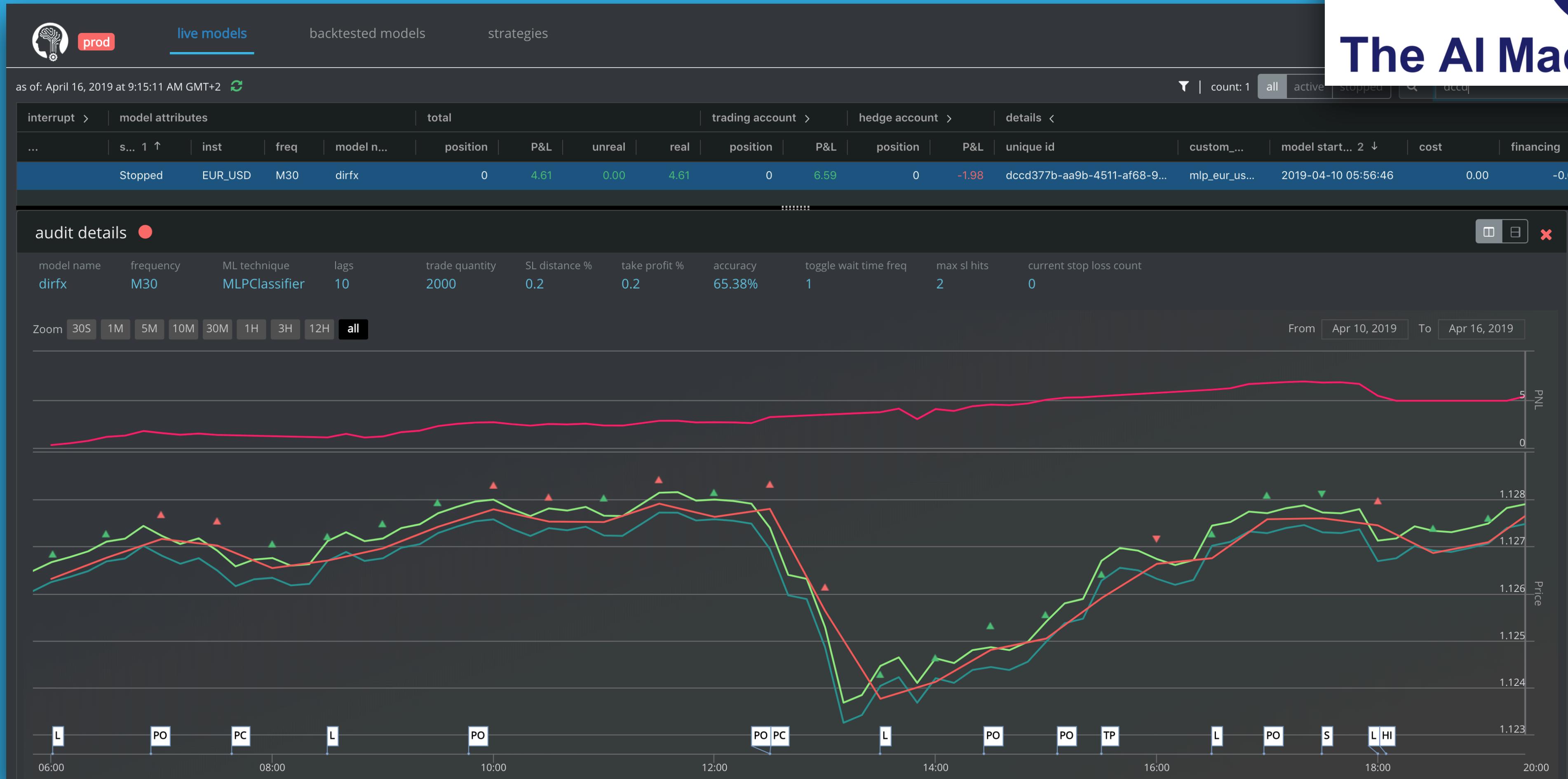
Introduction



<http://tpq.io>



The AI Machine



<http://aimachine.io>

Dr. Yves J. Hilpisch is the 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 six books (<https://home.tpq.io/books>):

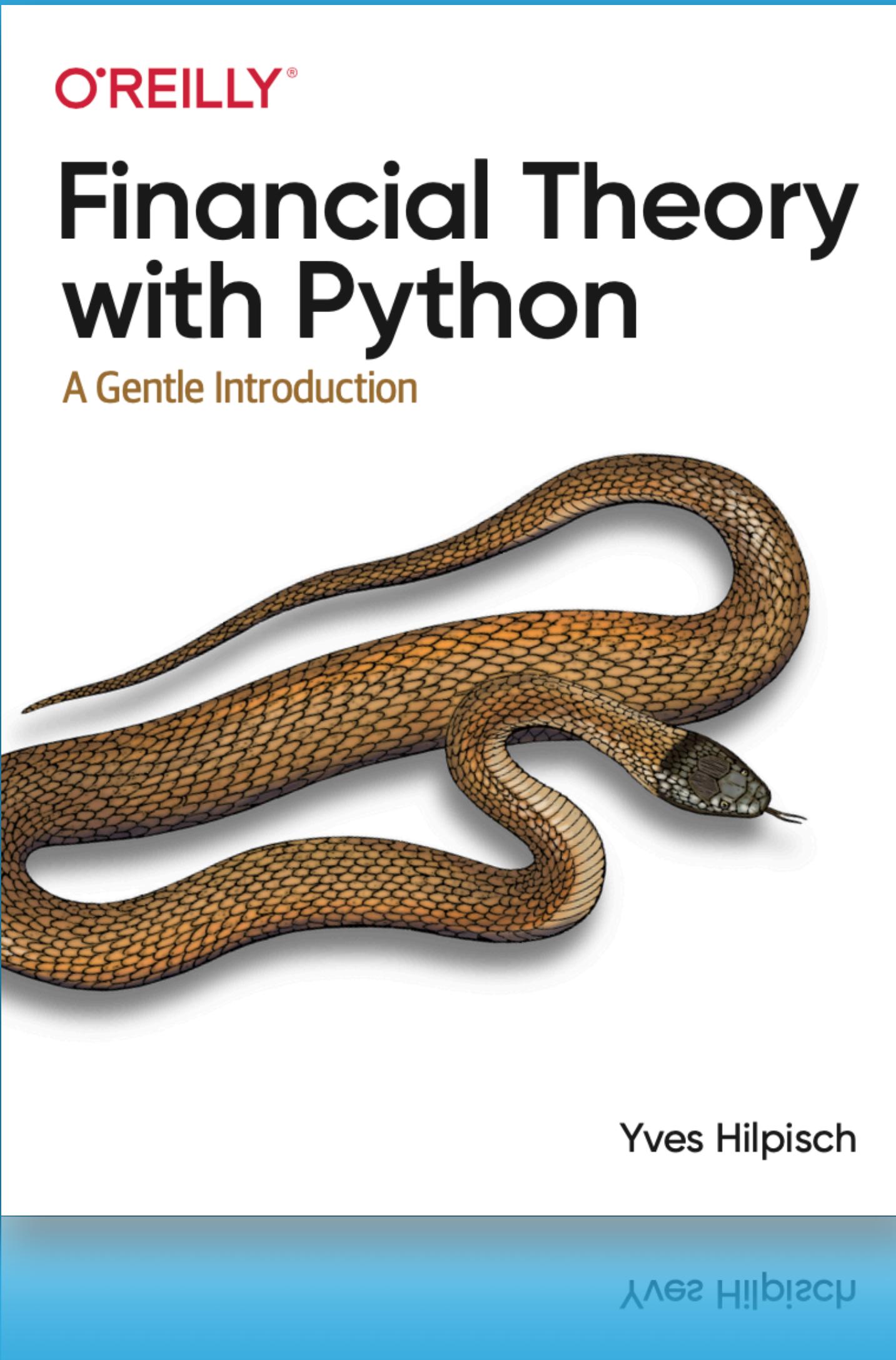
- * Financial Theory with Python (2021, O'Reilly)
- * Artificial Intelligence in Finance (2020, O'Reilly)
- * Python for Algorithmic Trading (2020, O'Reilly)
- * Python for Finance (2018, 2nd ed., O'Reilly)
- * Listed Volatility and Variance Derivatives (2017, Wiley Finance)
- * Derivatives Analytics with Python (2015, Wiley Finance)



Yves is the director of the first online training program leading to **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.

Financial Theory with Python – A Gentle Introduction



Finance with Python and Python environments

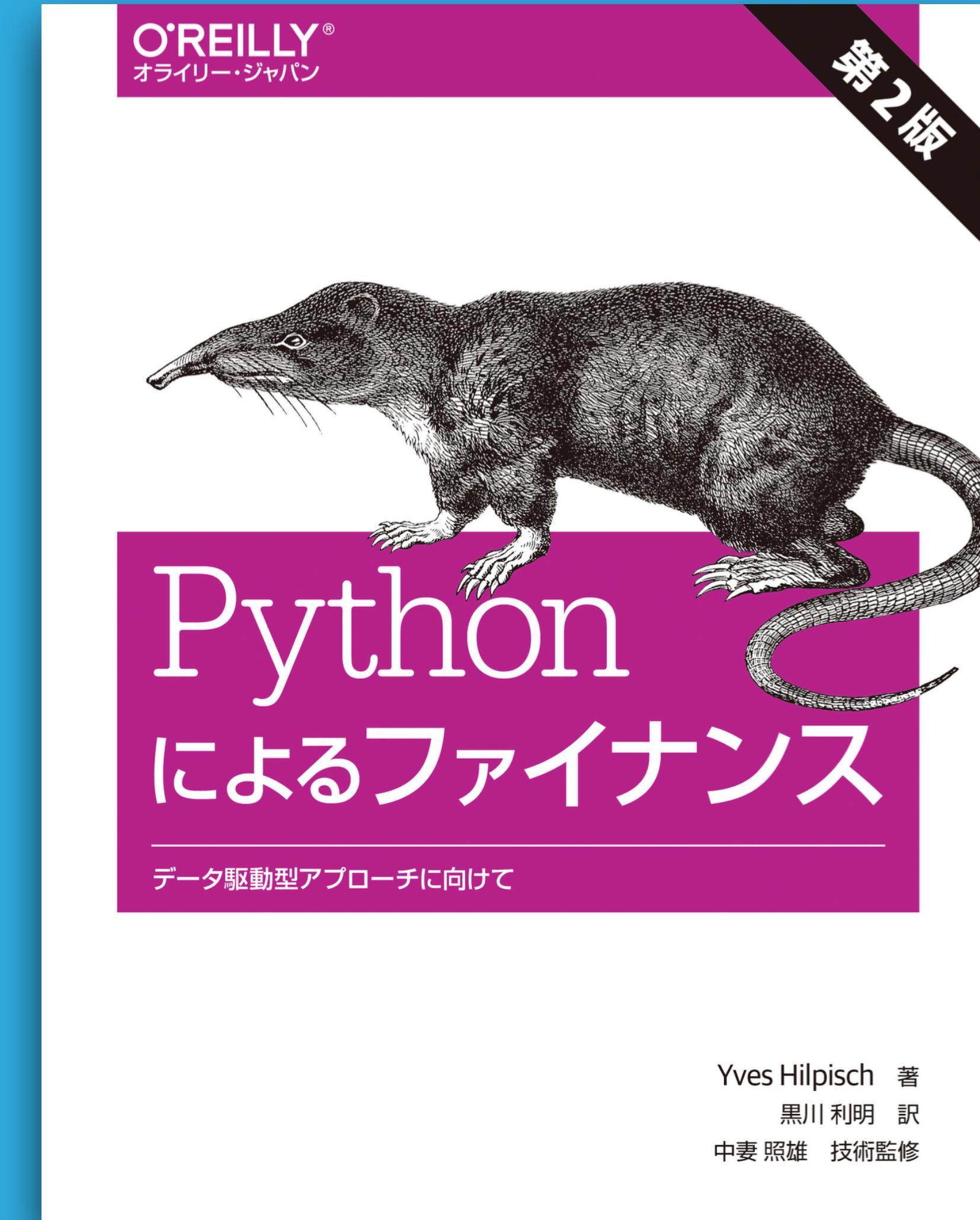
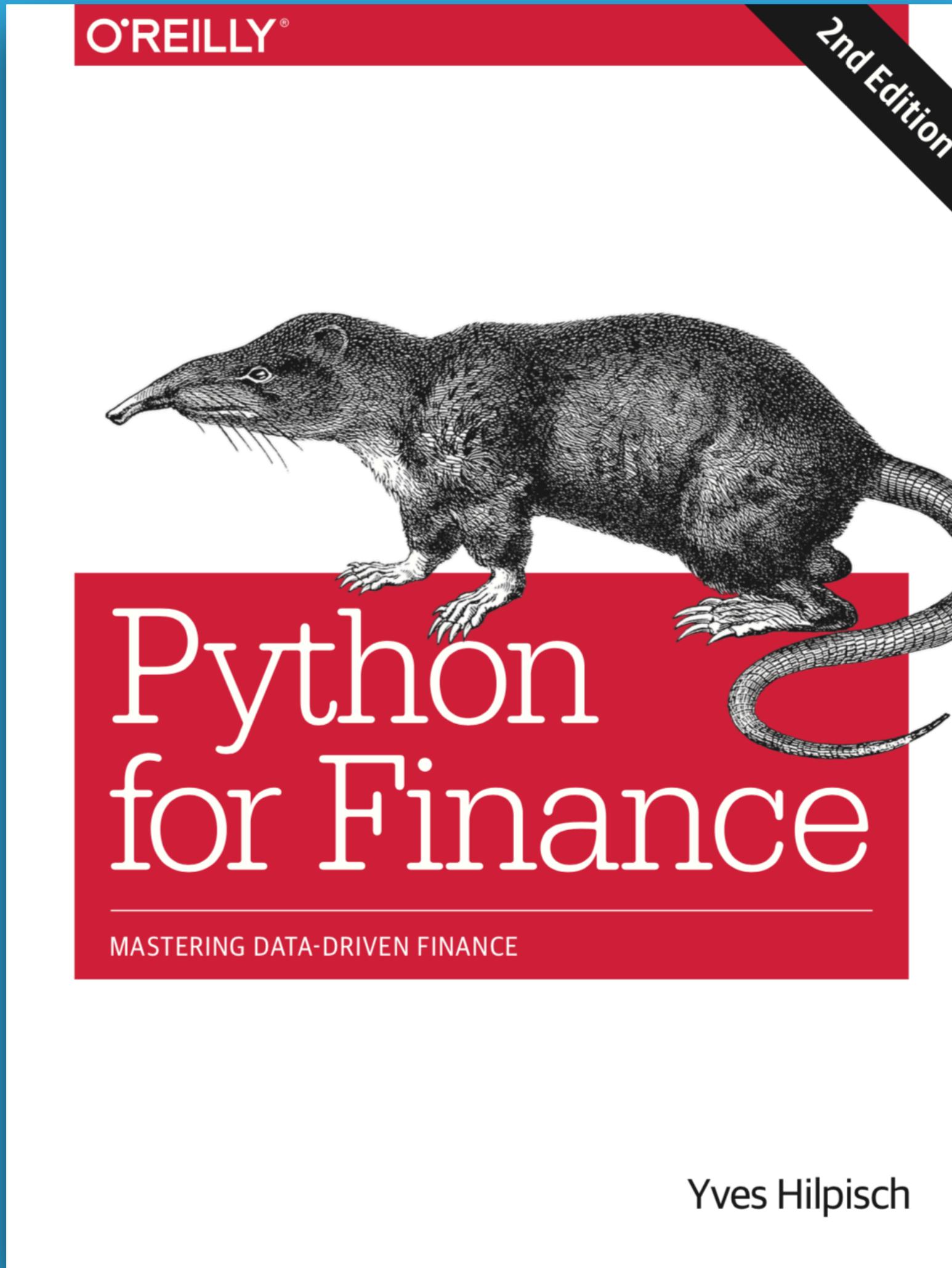
Basic Finance Concepts and Models:

- Risk–Return
- Pricing of Instruments
- Expected Utility Theory
- Mean–Variance Portfolio Theory
- Capital Asset Pricing Model
- Portfolio Optimization

Basic Python Concepts and Packages:

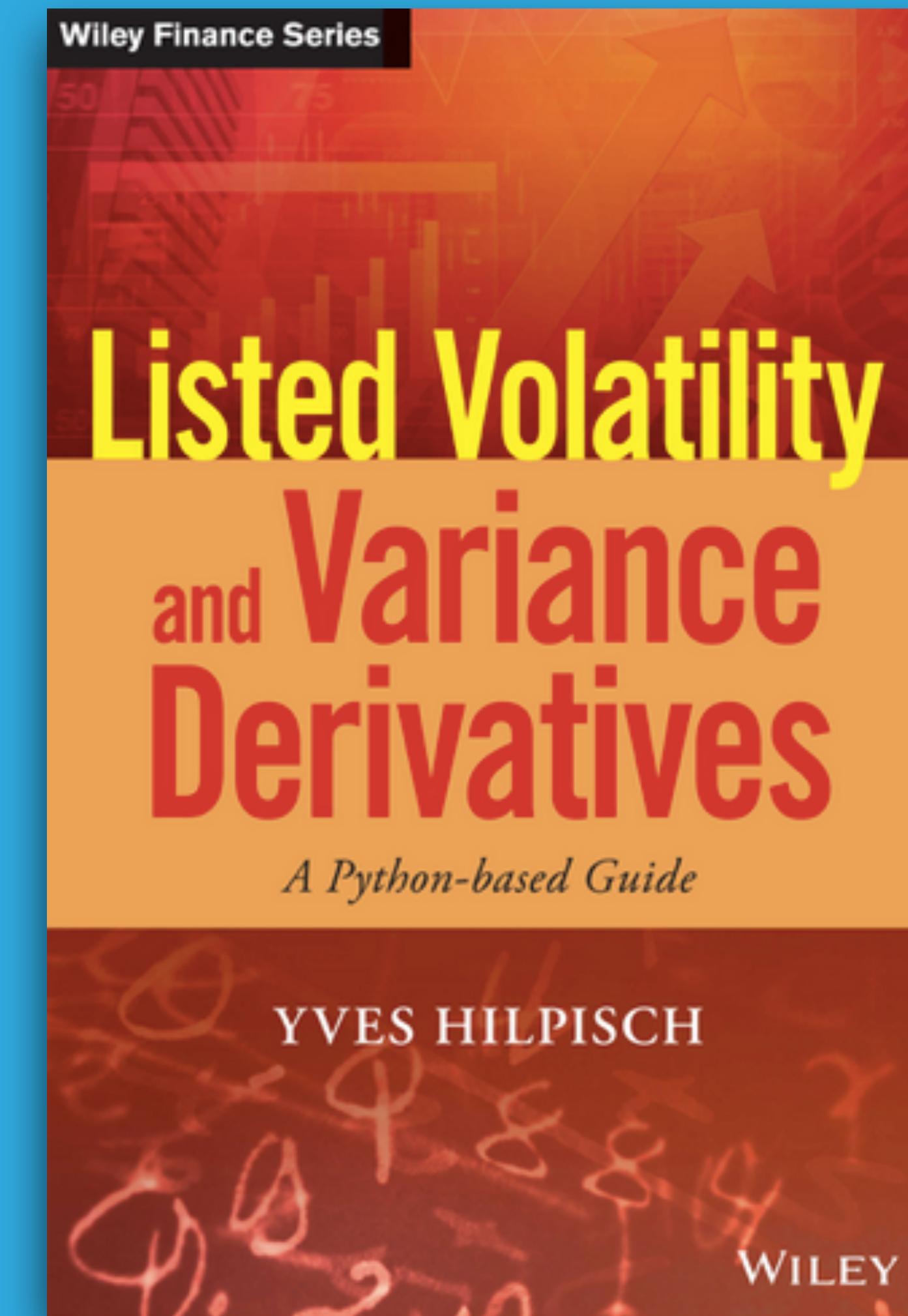
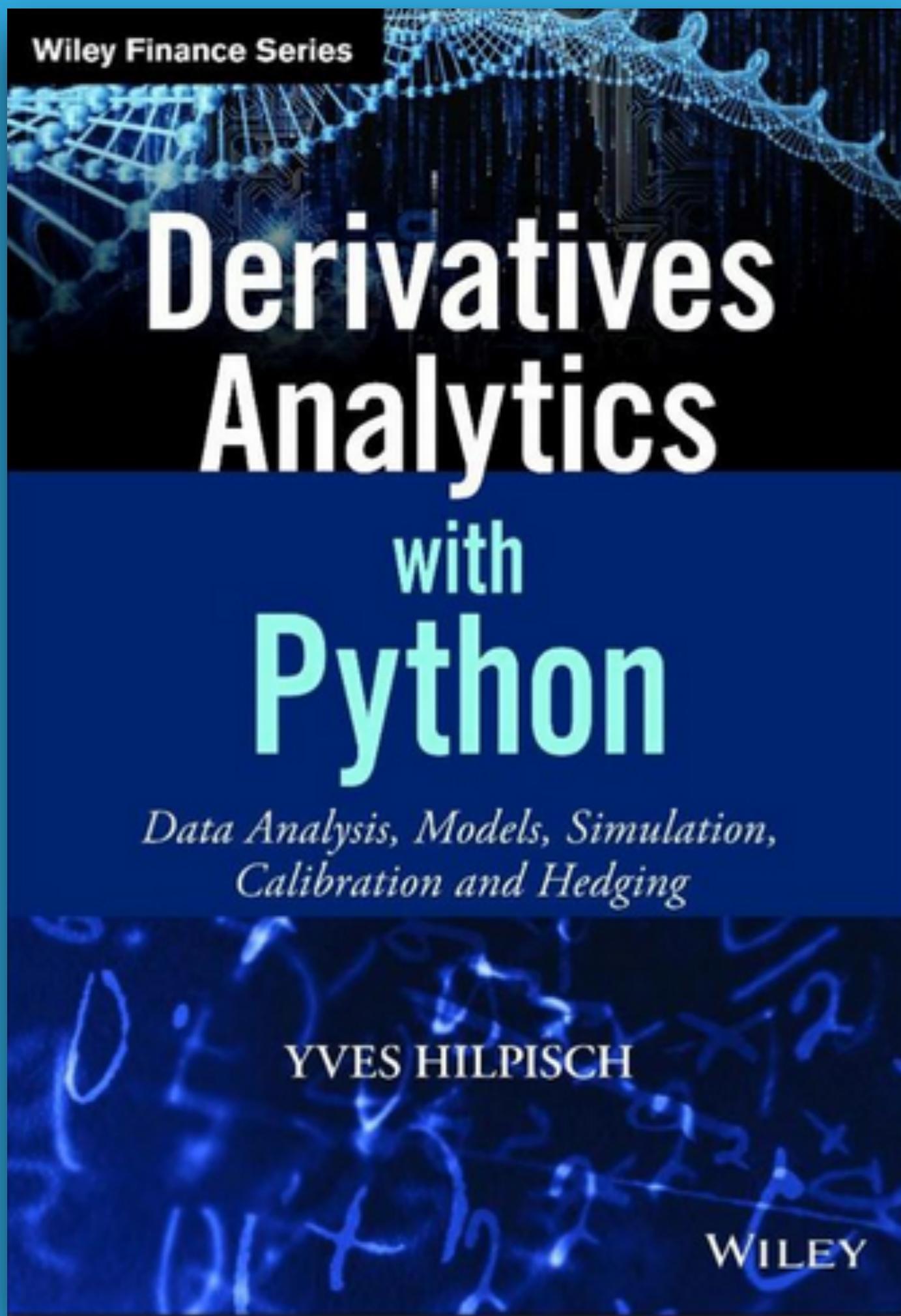
- Major Python Idioms
- NumPy Package
- SciPy & SymPy Packages

Python for Finance



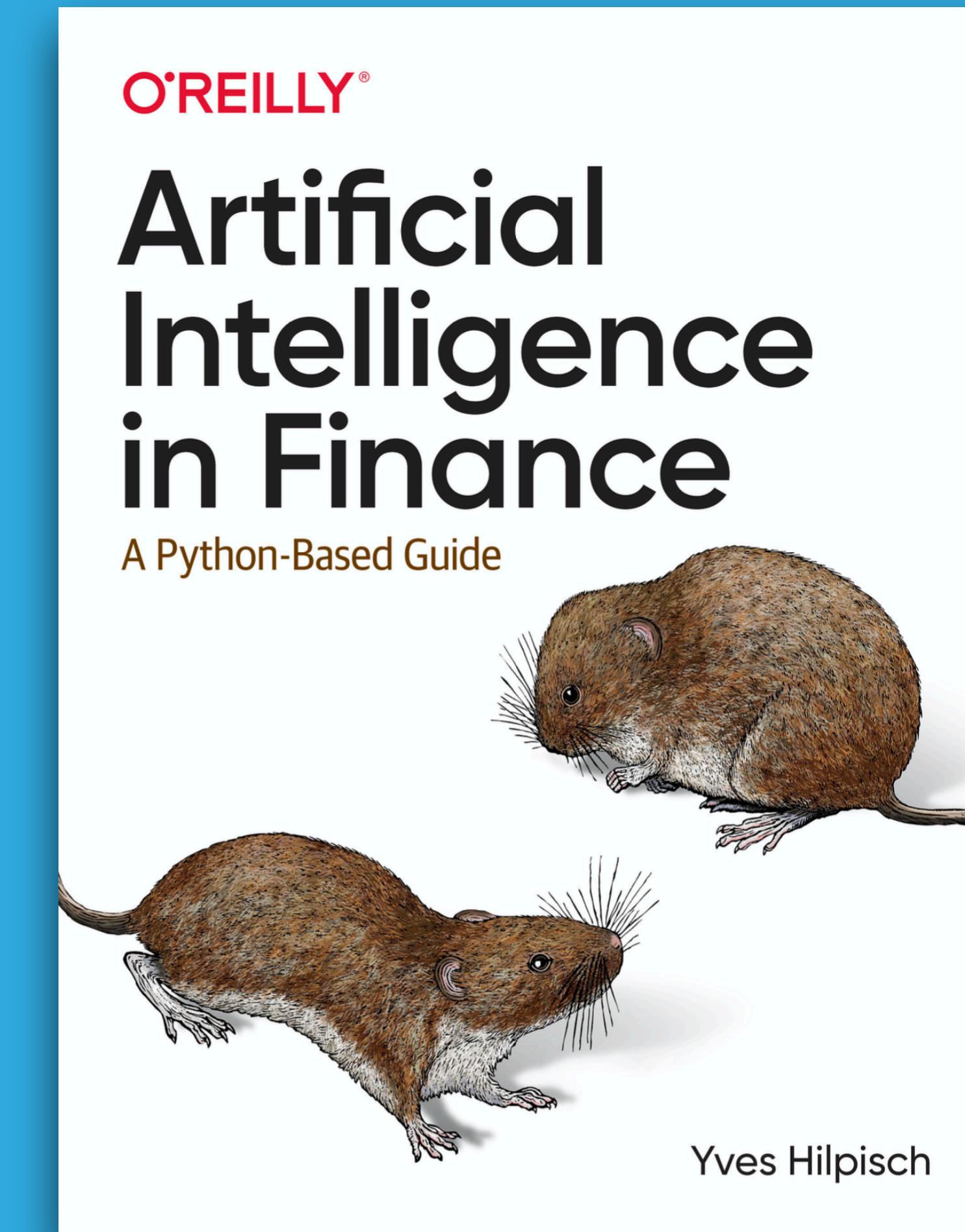
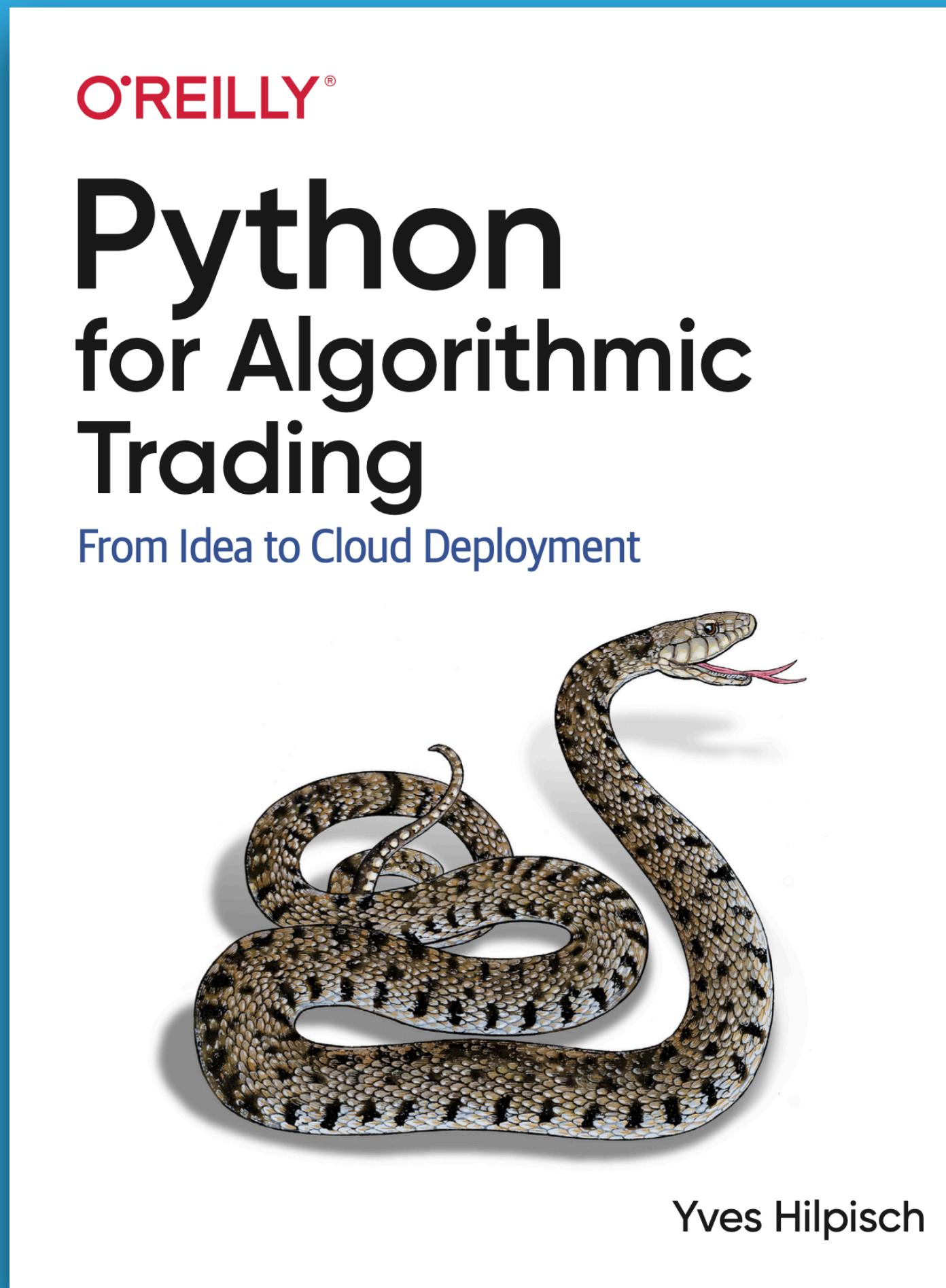
<http://books.tpq.io>

Quant Finance with Python



<http://books.tpq.io>

Python & AI for Finance & Trading



<http://books.tpq.io>

(pro)

quants@dev

~ \$

Community of
professional & aspiring
quant developers &
quant researchers.

850+ Members
and growing.

Webinar series
“Reinforcement Learning
in Finance” on
<https://youtube.com/@dyjh>

https://bit.ly/quants_dev

Data-Driven Finance

THE WALL STREET JOURNAL.

DOW JONES | News Corp ****

WEDNESDAY, NOVEMBER 10, 2021 ~ VOL. CCLXXVIII NO. 112

WSJ.com

★★★★ \$5.00

DJIA 36319.98 ▼ 112.24 0.3%

NASDAQ 15886.54 ▼ 0.6%

STOXX 600 482.71 ▼ 0.2%

10-YR. TREAS. ▲ 19/32, yield 1.431%

OIL \$84.15 ▲ \$2.22

GOLD \$1,830.20 ▲ \$2.80

EURO \$1.1596

YEN 112.88

What's News

Business & Finance

General Electric, the company that for more than a century stood as a beacon of U.S. manufacturing might and management prowess, will split into three public companies, drawing the curtain on an era of business—the dominance of industrial conglomerates. **A1, A12, A13**

♦ **U.S. stocks fell back**, from record levels, with the Nasdaq, S&P 500 and Dow declining 0.6%, 0.4% and 0.3%, respectively. **B12**

♦ **Rivian priced** its highly anticipated IPO at \$78 a share, well above its raised expectations, valuing the electric-vehicle maker at more than \$77 billion on a fully diluted basis. **B1**

♦ **Panera plans** to go public and has secured an unconventional investment from restaurateur Danny Meyer's SPAC. **BI**

♦ **Semiconductor makers** have earmarked less than 17% of the roughly \$146 billion the industry will devote to capital spending this year to legacy chips, Gartner estimates. **B1**

♦ **Hertz**, which emerged from bankruptcy this summer, listed on the Nasdaq, with shares closing down nearly 10% in the first day of trading. **BI**

♦ **DoorDash** said it agreed to acquire European food-delivery company Wolt in a deal valued at over \$8 billion. **B3**

♦ **Presto is close** to a deal to combine with a SPAC and go public in a merger that would value the restaurant-technology firm at about \$1 billion. **B3**

♦ **Videogame company** Unity agreed to pay \$1.63 billion for major parts of visual-effects studio Weta. **B4**

World-Wide

♦ **Nicaragua**, after a presidential election the U.S. called fraudulent, is now widely seen to have become Latin America's third dictatorship and part of a broader trend of democratic backsliding across the region, U.S. officials and political analysts said. **A1**

♦ **Ports snarled** with supply-chain problems will be able to redirect money from other federally funded projects to help ease the logjams under a plan outlined by the Biden administration. **A2**

♦ **The Oklahoma Supreme Court** overturned a ruling that held J&J liable for contributing to the state's opioid-addiction crisis. **A2**

♦ **Pfizer and partner BioNTech** asked U.S. health regulators to expand the authorization of their Covid-19 booster to people as young as 18 years old. **A3**

♦ **A federal judge** said records from the Trump White House can be turned over to the House committee investigating

GE Breakup Marks End of an Era

Over the past four decades, GE's revenue swelled and ebbed under four CEOs as it focused on different businesses, including a shift away from consumer goods and a bet on finance.

GE's revenue by segment

Adjusted for inflation

Share and index performance since 1980

Index	Performance (%)
Dow Industrials	4,230%
GE	1,272%

Notes: Segment categorizations for GE's annual revenue were taken as initially reported in the company's annual reports from 1980 to 2020 and adjusted for inflation. The graphic excludes corporate items and eliminations that GE reported in some years. Revenue from GE Capital is included starting in 1988 when GE began reporting consolidated revenues that included the finance business in its annual report. In prior years, GE reported earnings from the subsidiary, which was called GE Credit Corp.

Sources: SEC filings, staff reports (revenue); FactSet (share price)

Elliot Bentley, Erik Brynildsen and Luis Santiago/
THE WALL STREET JOURNAL

1980

1990

2000

2010

2020

Tax Bill Looms as Musk Eyes Share Sale

Elon Musk's pledge to sell 10% of his Tesla Inc. stock highlights the complex financial web the world's richest man has spun around his personal fortune.

By Rebecca Elliott,
Richard Rubin
and Theo Francis

Selling a stake valued at about \$17 billion could provide Mr. Musk, who has at times said he was cash-poor, with a sizable liquidity infusion. It could also go a long way toward helping the billionaire pay a bill likely coming due from the Internal Revenue Service. Completing these moves before year-end would help Mr. Musk avoid a possible tax increase.

Mr. Musk is worth about \$300 billion on paper, according to the Bloomberg Billionaires Index, with the majority of that wealth tied up in Tesla and his rocket company, Space Explorations. *Please turn to page A2*

♦ **Tesla's valuation punishes the wary.** **B1**

♦ **James Mackintosh: Own Tesla stock? Do like Musk.** **B1**

Facebook Rife With Stolen Content

By KEACH HAGEY
AND JEFF HORWITZ

Facebook has allowed plagiarized and recycled content to flourish on its platform despite having policies against it, the tech giant's researchers warned in internal memos.

About 40% of the traffic to Facebook pages at one point in 2018 went to pages that stole or repurposed most of their content, according to a research report that year by Facebook senior data scientist Jeff Allen, one of a dozen internal communications re-

viewed by The Wall Street Journal. Pages are used by businesses and organizations to disseminate content on Facebook, while individual users put content on what Facebook calls "profiles."

The researchers also wrote Facebook has been slow to crack down on copyright infringement for fear of opening itself to legal liability. "What's the easiest (lowest

the facebook files

Latest in a series

effort) way to make a big Facebook Page?" Mr. Allen wrote in an internal slide presentation the following year. "Step 1: Find an existing, engaged community on [Facebook]. Step 2: Scrape/Aggregate content popular in that community. Step 3: Repost most popular content on your Page."

Mr. Allen, who left Facebook in late 2019, wrote that Facebook pages seeking big follow-

ings simply had to ask one question of the content they were considering recirculating: "Has it gone viral in the past?"

Posting unoriginal content continues to be a formula for success on Facebook, according to data the company has

Please turn to page A6

Meta Curbs Targeted Ads

Personalized advertising on politics is dropped. **A6**

THE
FUTURE
OF
EVERYTHING
THE (ALMOST)
CAR-FREE CITY
R1-10

A \$115,000 USC Degree Yields Low Pay, Huge Debts

By LISA BANNON AND ANDREA FULLER

Over the past decade, the University of Southern California has used a for-profit company to help enroll thousands of students in its online social-work master's program.

The nonprofit school used its status-symbol image to attract students across the country, including low-income minority students it targeted for recruitment, often with aggressive tactics. Most students piled on debt to afford the tuition, which last year

reached \$115,000 for the two-year degree. The majority never set foot on the posh Los Angeles campus but paid the same rate for online classes as in-person students.

Recent USC social-work graduates who took out federal loans borrowed a median \$112,000. Half of them were earning \$52,000 or less annually two years later, a Wall Street Journal analysis of newly released U.S. Education Department data found. Compared with other master's-degree programs

Please turn to page A14

Democracy Loses Favor

Is Santa

From print ...

Financial Times  ft.com

FTSE 100 **-0.01%** S&P 500 **-0.00%** Euro/Dollar **+0.04%** Pound/Dollar **+0.25%** Brent Crude Oil **+0.96%** 10 Year US Gov **+2.50%** Visit Markets Data

FINANCIAL TIMES

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US-China relations

Biden urges Xi not to allow competition to 'veer into conflict'

Leaders hold first virtual meeting as ties between US and China fray over Taiwan

● UPDATED 43 MINUTES AGO

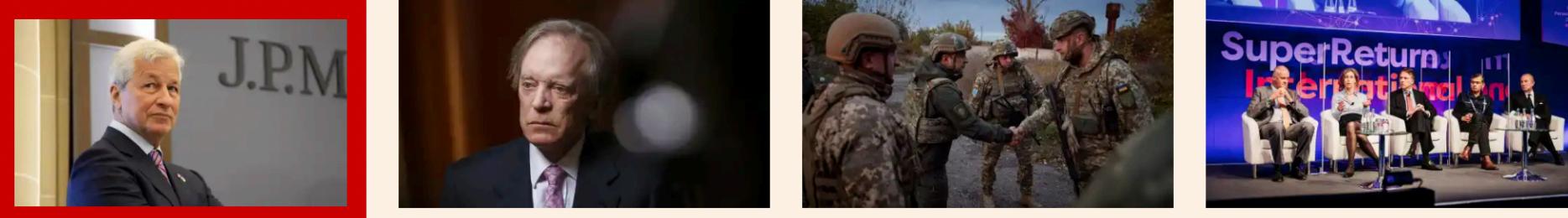
- Biden and Xi to tackle Taiwan and nuclear build-up in virtual meeting
- Australia vows to help US defend Taiwan from Chinese attacks
- Joe Biden and Xi Jinping to hold virtual summit on Monday



The Big Read

Investors pivot to India after China's tech crackdown

4 HOURS AGO



VIRTUAL MEETING

The White House said the U.S. and Chinese presidents discussed a variety of topics including Afghanistan, North Korea and Iran, as well as human rights, climate change and concerns over Taiwan.  492  7 min read

- ▶ How U.S. Plays Catch-Up on China's Push for Influence

President Signs Infrastructure Bill Into Law

The passage of the \$1 trillion bill to repair roads and bridges, upgrade the electrical grid and expand access to broadband internet marks a rare bipartisan policy win for the White House.  6 min read

- What's in the Bill? From Amtrak to Roads to Water Systems

... to the Web ...

... to the Web ...

Feedback 

Market Data  About WSJ

S&P 500 **29808.12** 0.11% U.S. 10 Yr 1/32 Yield **1.616%** ▲ Crude Oil **81.53** 0.80% ▲ Euro **1.1373** 0.05% ▲ DJIA **36087.45** 0.04% ▼ Yves Hilpisch ▾

THE WALL STREET JOURNAL.

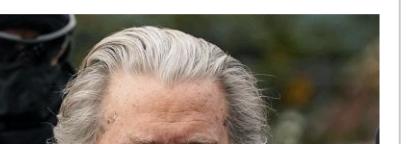
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I.S. Politics Economy Business Tech Markets Opinion Books & Arts Real Estate Life & Work WSJ. Magazine Sports Search 


Beto O'Rourke Announces Bid for Texas Governor
④ 4 min read


America's Infrastructure Struggles With New Weather Forecast
Historically anomalous heat and rain have overwhelmed systems designed to withstand old meteorological patterns, and climatologists expect still worse with climate change.
"We've never seen destruction like this before."
523  Long read


Kyle Rittenhouse Homicide Trial Wraps Up ⑤ 5 min read


Shell to Move Headquarters to London Amid

US EUROPE ASIA FX RATES FUTURES
1D 5D 3M 6M 1Y

DJIA	36087.45	-12.86	-0.04%
S&P 500	4682.80	-0.05	-0.00%
Nasdaq	15853.85	-7.11	-0.04%
Russell 2000	2400.93	-10.84	-0.45%
DJ Total Mkt	48582.45	-17.28	-0.04%

[View Watchlist](#) [View All Market Data →](#)

OPINION 

America Will Be Number One—in Taxes
By The Editorial Board | Review & Outlook

APLIB

MARKETS COMPANY NEWS CHARTING PORTFOLIOS & MONITORS SEARCH TOOLS

AAPL.OQ ▾ APPLE INC

United States | NASDAQ Stock Exchange Global Select Market | Phones & Handheld Devices

Overview News & Research Price & Charts Estimates Financials ESG Event Ownership

BUSINESS SUMMARY >

Apple Inc. designs, manufactures and markets smartphones, personal computers, tablets, wearables and a variety of related services. The Company's products include iPhone, Mac, iPad, and Wearables, Home and Auto. The Company's line of smartphones based on its iOS operating system. Mac is the Company's line of personal computers based on its macOS operating system. iPad is the Company's line of multi-purpose tablets based on its iPadOS operating system. Home and Accessories includes AirPods, Apple TV, Apple Watch, Beats products, HomePod, iPod touch and third-party accessories. AirPods are the Company's wireless headphones that interact with Siri. Apple Watch is the Company's line of smart watches. Its services include Advertising, AppleCare, Cloud Services, Digital Content and Payment. Customers are primarily in the consumer, small and mid-sized business, education, enterprise and government sectors.

NEWS > 16-Nov-2021 08:51:09 05:40:45 04:00:00 01:48:19 01:10:00 00:29:52

Refinitiv Newscasts - Evidence of Belarus providing migrants tourist visas S. Korea's new law on in-app payment is 'monumental': CAF chief KILL Singtel in Partnership with Apple Inc, Selects Nextech AR Solutions To Showcase Augmented Reality Apple Pty Ltd. - "Disney Melee Mania" coming this December exclusively on Apple Arcade iPhone Black Friday Deals 2021: Best Early Apple iPhone Sales Reported by The Consumer Project UPDATE 1-Buffett's Berkshire cuts U.S. drugmaker stakes, invests in drug royalty company

15-Nov-2021 23:52:47 23:39:51 23:27:41 23:12:15 EVENTS > UPCOMING

EXCLUSIVE-Engine No. 1 partner leaves hedge fund after successful challenge of Exxon Jamf Announces Upcoming Conference Participation Black Friday 2021 deals at Best Buy are here, with huge savings on Samsung, Apple and more How to connect any AirPods to your iPhone

18-Nov-2021 NTS AAPL34.SA Final Cash Dividend of gross BRL 0.123473 paid on Nov 18, 2021 going ex- 19-Nov-2021 NTS AAPLNLB Final Cash Dividend of gross CAD 0.033913 paid on Nov 19, 2021 going ex-

APLIB

MARKETS COMPANY NEWS CHARTING PORTFOLIOS & MONITORS SEARCH TOOLS DEVELOPMENT AND ADMIN TOOLS MY LAYOUTS

AAPL.O ▾ APPLE INC

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

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

PRICE PERFORMANCE >

Open Prev. Close ① 123.08 Bid / Ask ① 123.24 / 123.35 VWAP Turnover Volume ① 13,358 Short Interest YTD Beta (5Y Monthly) Mkt Cap - Default ① USD 2.093T PE (LTM) 37.676 Div Yield 0.666% DR BRL AAPL34.SA (1:0.1) DR Type DR Bank 52Wk: 53.153 23-Mar Daily Last 137.980 02-Sep

52Wk: 53.153 23-Mar Daily Last 137.980 02-Sep

Next Earnings Report: 26-Jan-2021

RECOMMENDATIONS >

Mean AAPL Strong Buy 11 Buy 19 Hold 8 Sell 1 Strong Sell 1

Price Target (Mean) USD 125.92 Upside 2%

STARMINER MODELS >

Bullish Price Momentum ⑨7 Analyst Revisions ⑦9 Smart Holdings ⑦7 Short Interest ⑨5 Earnings Quality ⑨5 Credit Risk - Combined ⑨6 Credit Risk - Smart Ratios ⑨2 Credit Risk - Structural ⑧8 Credit Risk - Text Mining ⑧5 Combined Alpha Model ⑦2

Highlights All Models

NEWS > 03-Dec-2020 10:15:43 BUSINESS Apple sued over old iPhones in Europe Tech giant i... LATIME 10:13:01 《外企動向》蘋果因舊款手機電池問題在歐洲多國面臨訴訟 HKETNN 10:12:11 《外企動向》蘋果因舊款手機電池問題在歐洲多國面臨訴訟 HKETNN 09:49:33 USPTO ISSUES TRADEMARK: WORKS WITH APPLE IBEACON USFED 09:16:24 Analysts' Weekly Ratings Updates for Apple (AAPL) TICREP 09:11:02 Analysts' Weekly Ratings Updates for Apple (AAPL) AMEBAN 09:00:25 《A股焦点》欧菲光：被苹果移出相机模块供应链消息不属实 HKETNN 08:59:39 《A股焦点》欧菲光：被苹果移出相机模块供应链消息不属实 HKETNN 07:13:26 Dow Jones Selected Stocks 1710 - December 03 AAP 06:47:44 RPT-Hong Kong-Le magnat Jimmy Lai détenu pour des accusa... RTRS

RESEARCH > Contributor Internal

03-Dec-2020 Equiti Global Arabic Smart Report Equiti 02-Dec-2020 Trefis Report: Apple - \$99.92 Trefis Price Estimate Trefis 02-Dec-2020 Equiti Global Arabic Smart Report Equiti 01-Dec-2020 Comprehensive Technical and Fundamental Analysis... Stock Trade... 01-Dec-2020 Equiti Global Arabic Smart Report Equiti 30-Nov-2020 Equiti Global Arabic Smart Report Equiti 29-Nov-2020 "The Economy Matters" Report for AAPL: the econo... MacroRisk ...

EVENTS > Upcoming Past

26-Jan-2021 NTS Q1 2021 Apple Inc Earnings Release 25-Feb-2021 18:00:00 Apple Inc Annual Shareholders Meeting PEERS >

Company Name Mkt Cap % Chan... Reven... EBITD... EV/ ...

Apple Inc 2.09T 274.52B 28.17% 23.39 HP Inc 31.34B 1.97% 56.64B 8.40% 6.63

... to the Terminal ...

Tick Data

```
[4]: %%time  
data = ek.get_timeseries('AAPL.O',  
                         start_date='2021-11-15 15:00:00',  
                         end_date='2021-11-15 15:30:00',  
                         interval='tick',  
                         fields=['*'])
```

CPU times: user 120 ms, sys: 14.5 ms, total: 135 ms
Wall time: 2.7 s

```
[5]: data.info()
```

```
<class 'pandas.core.frame.DataFrame'>  
DatetimeIndex: 41213 entries, 2021-11-15 15:00:00.004000 to 2021-11-15 15:29:59.936000  
Data columns (total 2 columns):  
 #   Column    Non-Null Count  Dtype     
 ---  --        --        --      --  
 0   VALUE     41145 non-null   Float64  
 1   VOLUME    41213 non-null   Int64  
 dtypes: Float64(1), Int64(1)  
 memory usage: 1.0 MB
```

```
[14]: data.tail()
```

```
[14]:          AAPL.O    VALUE  VOLUME  
             Date  
---  
2021-11-15 15:29:59.134  150.4456      10  
2021-11-15 15:29:59.313  150.445       1  
2021-11-15 15:29:59.588  150.4409      150  
2021-11-15 15:29:59.745  150.445       1  
2021-11-15 15:29:59.936  150.4488      5
```

... to powerful APIs.

Apple Event on 18. October 2021 (<https://www.apple.com/de/apple-events/october-2021/>).

```
[9]: headlines = ek.get_news_headlines(query='R:AAPL.0 macbook',
                                         count=5,
                                         date_from='2021-10-18',
                                         date_to='2021-10-19')
```

```
[10]: headlines
```

	versionCreated	text	storyId	sourceCode
2021-10-18 23:30:18.401	2021-10-18 23:30:18.401000+00:00	Apple is finally fixing the things people hate...	urn:newsml:reuters.com:20211018:nNRAh2psl1:1	NS:WASHPO
2021-10-18 23:10:18.012	2021-10-18 23:10:18.012000+00:00	Apple event – live: Macbook Pro and other new ...	urn:newsml:reuters.com:20211018:nNRAh2kj3a:1	NS:INDEPE
2021-10-18 21:41:19.927	2021-10-18 21:41:19.927000+00:00	New MacBook Pro features ultra-fast chips, ret...	urn:newsml:reuters.com:20211018:nNRAh2u38b:1	NS:EFEING
2021-10-18 21:33:50.860	2021-10-18 21:33:50.860000+00:00	Apple Event: MacBook Pro 2021 alleged pictures...	urn:newsml:reuters.com:20211018:nNRAh2u1wj:1	NS:TIMIND
2021-10-18 21:33:50.623	2021-10-18 21:33:50.623000+00:00	Apple launches new MacBook Pro: Price, specs a...	urn:newsml:reuters.com:20211018:nNRAh2u1vv:1	NS:TIMIND

... to powerful APIs.

```
[11]: story = headlines.iloc[0]

[12]: story

[12]: versionCreated      2021-10-18 23:30:18.401000+00:00
      text             Apple is finally fixing the things people hate...
      storyId          urn:newsml:reuters.com:20211018:nNRAh2psl1:1
      sourceCode        NS:WASHPO
      Name: 2021-10-18 23:30:18.401000, dtype: object
```

```
[13]: news_text = ek.get_news_story(story['storyId'])
```

```
[14]: from IPython.display import HTML
```

```
[15]: HTML(news_text)
```

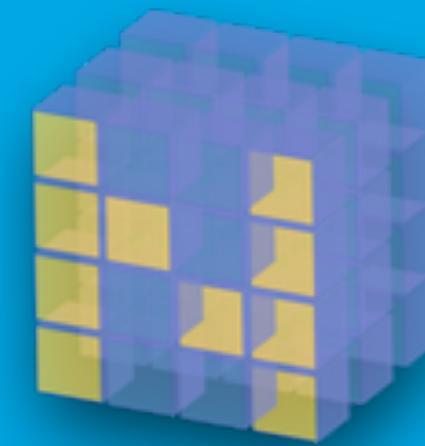
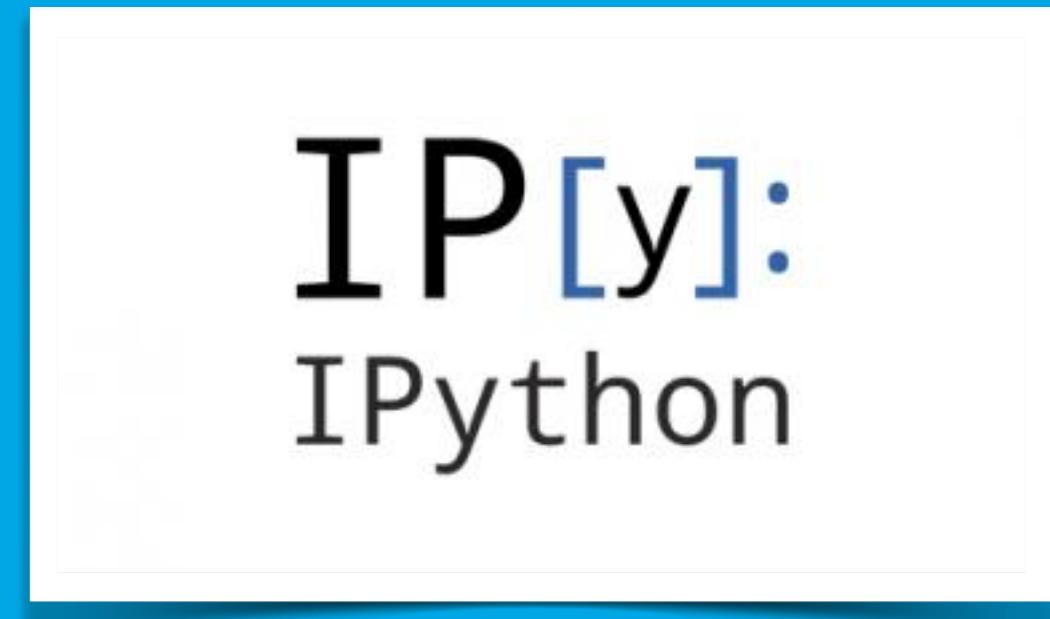
[15]: The demise of MagSafe charging. An inelegant Touch Bar. Limited selection of ports. The laundry list of complaints about Apple's laptops has steadily grown over the past five years. Now, Apple is finally walking back those changes.

On Monday, the Cupertino, Calif., company unveiled a pair of new MacBook Pro laptops, powered by its latest homegrown processors and free of the many limitations that plagued earlier models. It also showed off a set of updated AirPods and colorful HomePod mini smart speakers. Riding high from record Mac sales last year, Apple made sure to make its new MacBooks the star of its virtual event Monday.

Still, computers that run Apple's MacOS software account for only a fraction of the overall PC landscape — just over 7 percent as of the end of the second quarter, according to market research firm IDC. Its market share has slipped from 8 percent in the first quarter and 7.6 percent a year earlier, IDC data showed. The changes on display Monday seem to be geared more toward

... to powerful APIs.

Infrastructure



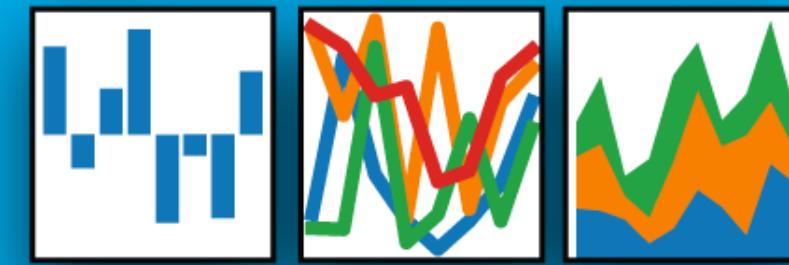
NumPy

matplotlib



pandas

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



Keras

Resources & Links

https://bit.ly/epat_sep_2023



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.”

Efficient Markets—Simple Illustration

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.

“...the existence of a single successful prediction model is sufficient to demonstrate violation of the EMH.

Acknowledging this point, we provide suggestions to the sort of forecasting procedure that could work even if the EMH is correct.

Consideration needs to be turned to quickly changing models that can detect and utilize any instances of temporary forecastability that might arise and quickly disappear as learning opportunities arise and close down.”

Timmermann, Allan and Clive Granger (2004): “Efficient Market Hypothesis and Forecasting.”

“A market is efficient with respect to the information set, $S(t)$, search technologies, $T(t)$, and forecasting models, $M(t)$, if it is impossible to make economic profits by trading on the basis of signals produced from a forecasting model in $M(t)$ defined over predictor variables in the information set $S(t)$ and selected using a search technology in $T(t)$.”

Timmermann, Allan and Clive Granger (2004): “Efficient Market Hypothesis and Forecasting.”

Overview



INFRASTRUCTURE

Python environment, Jupyter Lab,
first steps, efficient markets

VECTORIZED BACKTESTING

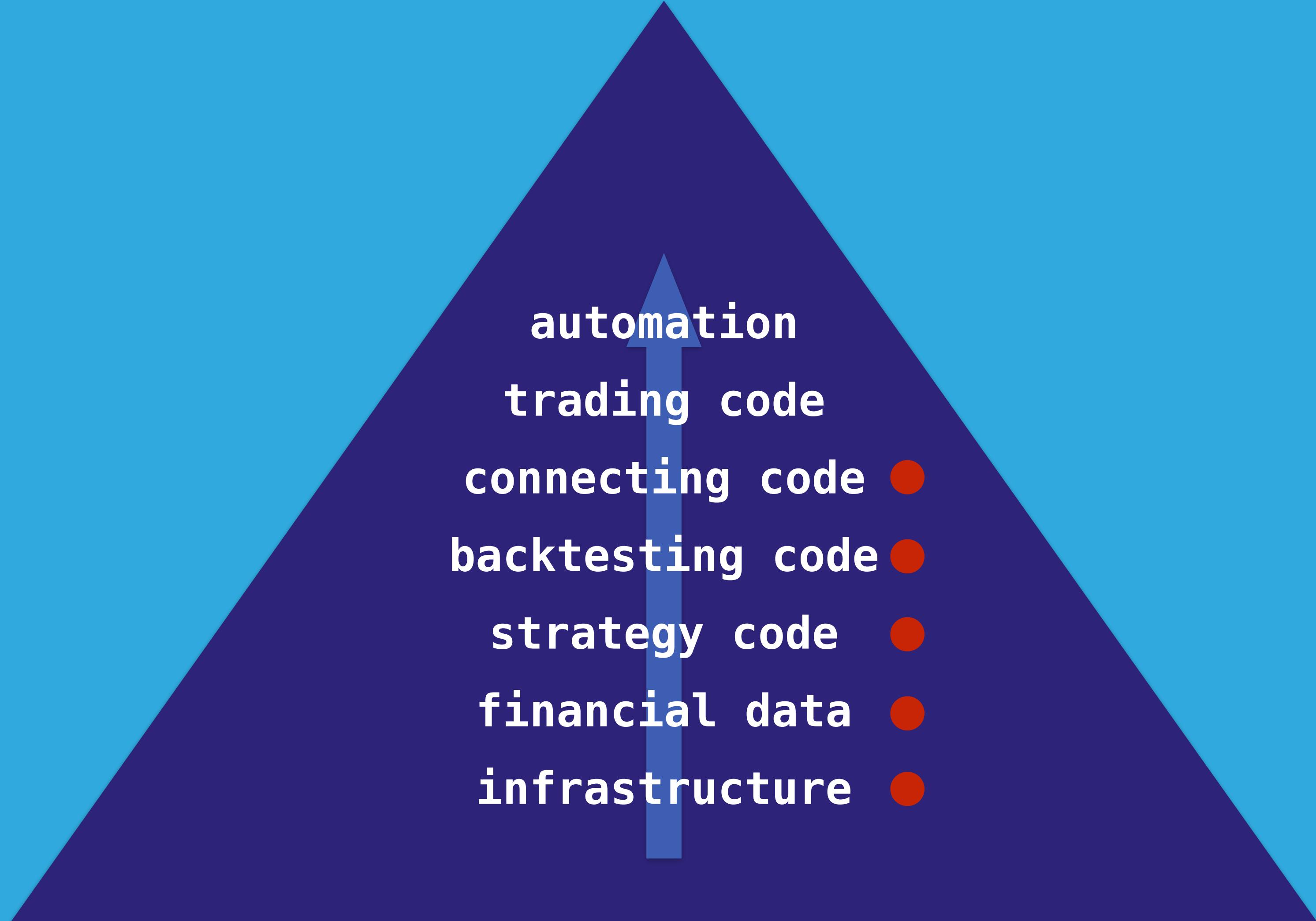
interactive code,
OOP and Python classes

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>



The screenshot shows a documentation page 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 'Object-Oriented Programming in Python' chapter, which includes a 'Contents:' section with a hierarchical list of topics such as Introduction, Python basics, Variables and scope, and so on.



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