

Wall Street

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APPLICATIONS OF MACHINE LEARNING IN FINANCIAL MARKETS

Netflix short intro: <https://www.youtube.com/watch?v=ZCFkWDdmXG8>

General Context

Wall Street and its index (Dow Jones, Nasdaq, S&P 500)

Main projects:

- Can we predict the price of shares/currencies/commodities?
- Binary: does it increase or decrease?
- Ternary: does it increase, decrease, or stable?

Some possible assumptions:

- The evolution of a share price is a random walk.
- We cannot predict the main trend.

Example: Dec 11th 2020: JP Morgan predicts S&P 500 will reach 4400 in Dec 2021. Reached in August 2021!



Financial Markets

Many jobs related to this domain

- Financial analysts
- Financial managers
- Financial advisors

Main features:

- Important markets (to know some vocabulary, type of data, forms)
- Unstable (volatility, standard deviation, variance)
- Hard to forecast
- Don't know the future
- But we can make money (predicting the right evolution)!



Financial Markets

Hard problems

Auction markets (in general) are more and more ubiquitous.

Can we replace a banker / trader by a computer?

- Robot trader
- Emotional aspects hurt (or could hurt) effectiveness
- Unstable

Evaluation:

- Accuracy rate
- Performance measured in \$

Vocabulary

Real asset: tangible asset (with intrinsic value) (security, real estate, land, equipment).

Security: fungible, negotiable financial instrument (share, bond, option).

Stock (share): financial asset (paper or liquid asset), partial ownership of a company.

Bond: loan from the holder to a company (fixed interest rate over time).

Equity (shareholder's equity): amount of money that would be returned to a company's shareholders if all of the assets were liquidated (see balanced sheet) (but in general means common stock).

Revenue: income generated from a normal business.

Portfolio: a range of investments (real assets) held by a person / organization.

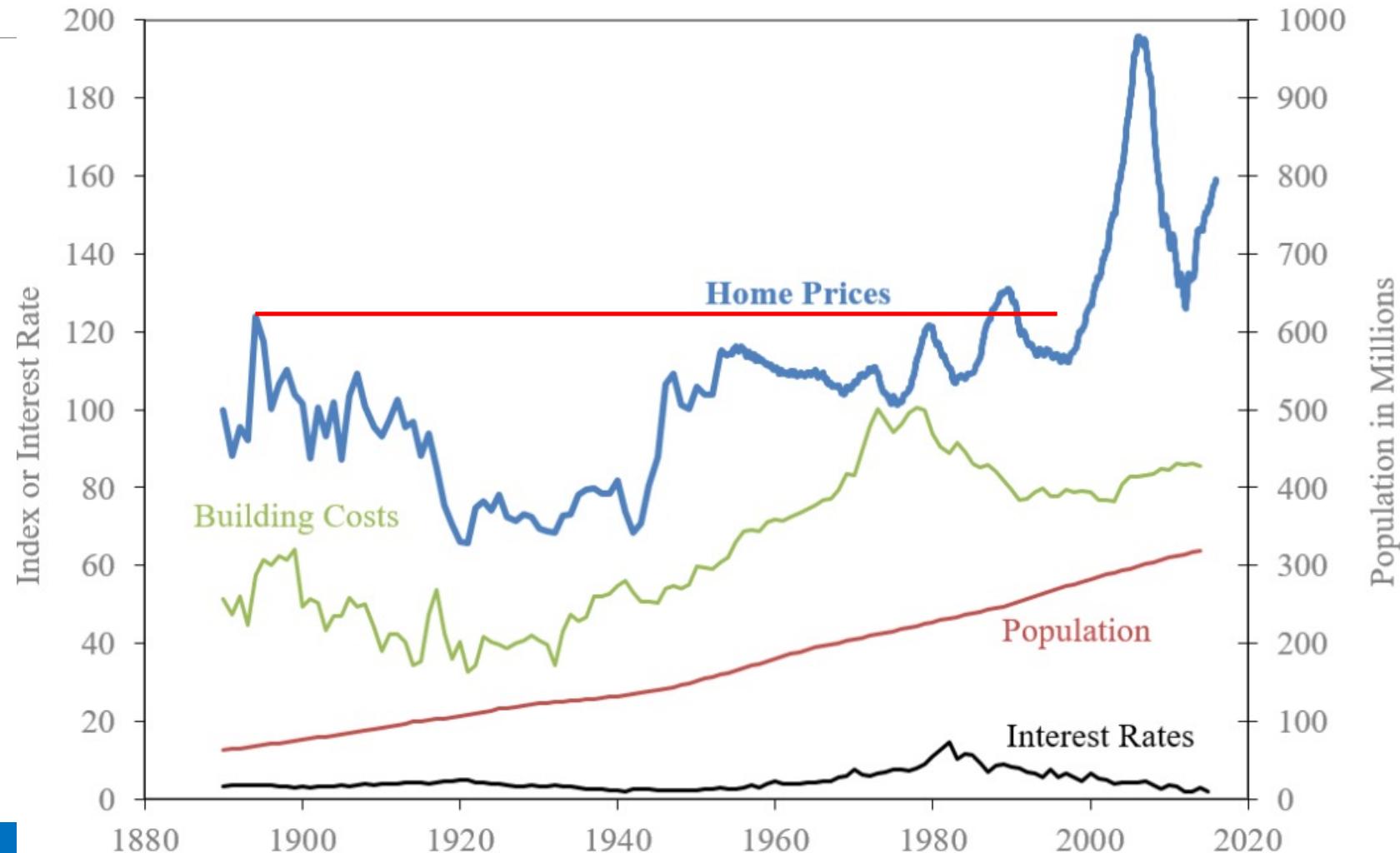
Real Estate

Buying a house is a good investment.

Its price is increasing with time. Sure?

No always true in long period in US.

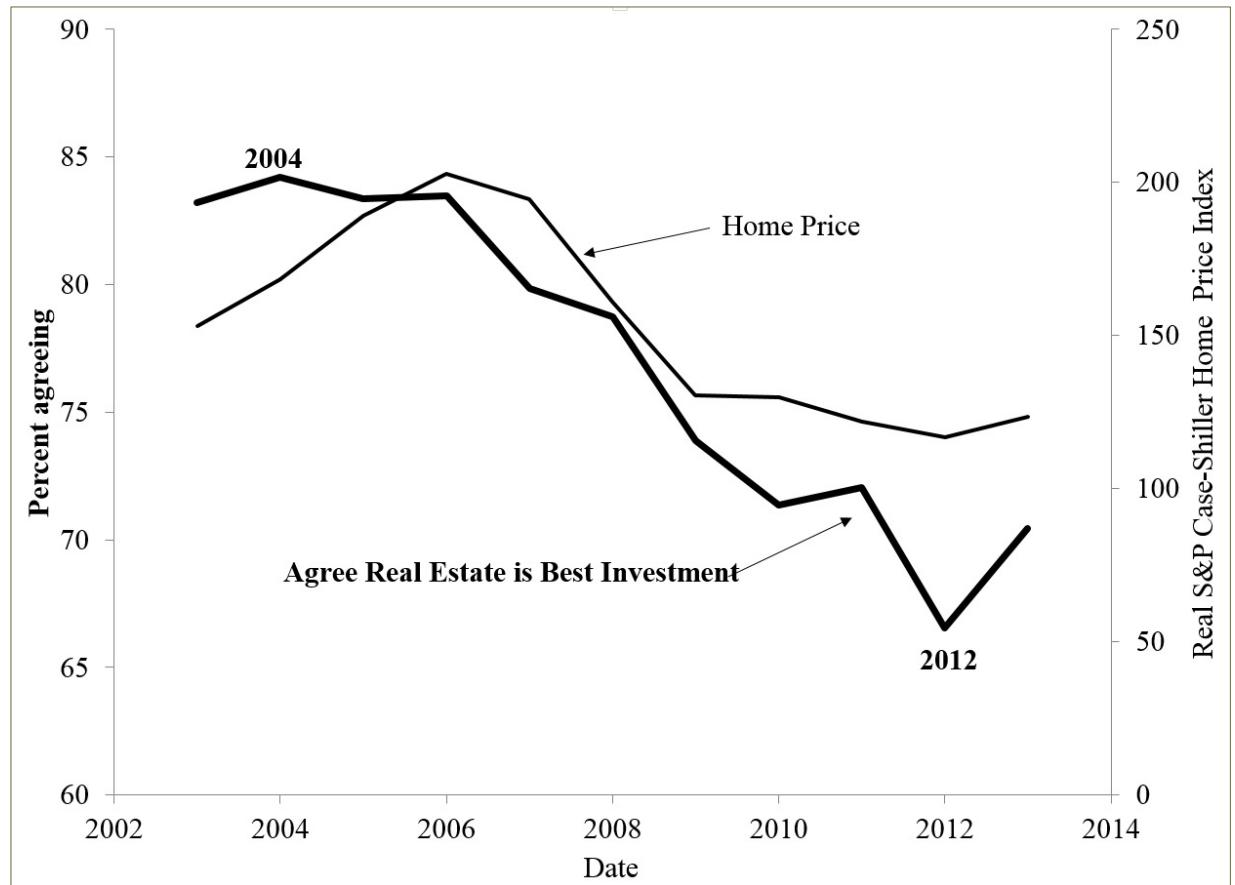
Different in CH.



Real Estate

Is real estate a good investment?

The feeling is correlated with the house price.



Security

Stocks / shares

Bonds

Currencies

Fonds

Derivatives

Structured products

Cryptocurrencies (Bitcoin, Ethereum, Litecoin, ...)

National Importance

SCHWEIZERISCHE NATIONALBANK
BANQUE NATIONALE SUISSE
BANCA NAZIONALE SVIZZERA
BANCA NAZIONALE SVIZZERA
SWISS NATIONAL BANK



Portfolio in US shares
in both value and number of shares

	Valeur en milliards de dollars	Nombre d'actions en millions
APPLE	9,38	68,46
MICROSOFT	7,91	29,22
AMAZON	6,00	1,75
FACEBOOK	3,41	9,81
ALPHABET*	3,01	1,20
ALPHABET*	2,99	1,23
TESLA	2,13	3,13
NVIDIA	2,02	2,52
JOHNSON & JOHNSON	1,77	10,72
VISA	1,62	6,92
UNITEDHEALTH GROUP	1,55	3,87
HOME DEPOT	1,40	4,39
PROCTER AND GAMBLE	1,35	10,04
PAYPAL	1,32	4,54
MASTERCARD	1,32	3,62
DISNEY WALT	1,30	7,40
ADOBE SYSTEMS	1,14	1,95

Currencies

USD

YEN

EUR

CHF

GBP

Forex: currencies market

In ISO format (#4217)

Other countries are also using the name *dollar*? They are: AUD, CAD, HKD, TWD, ...

Easy to Win Money?

Asset-Class Winners and Losers



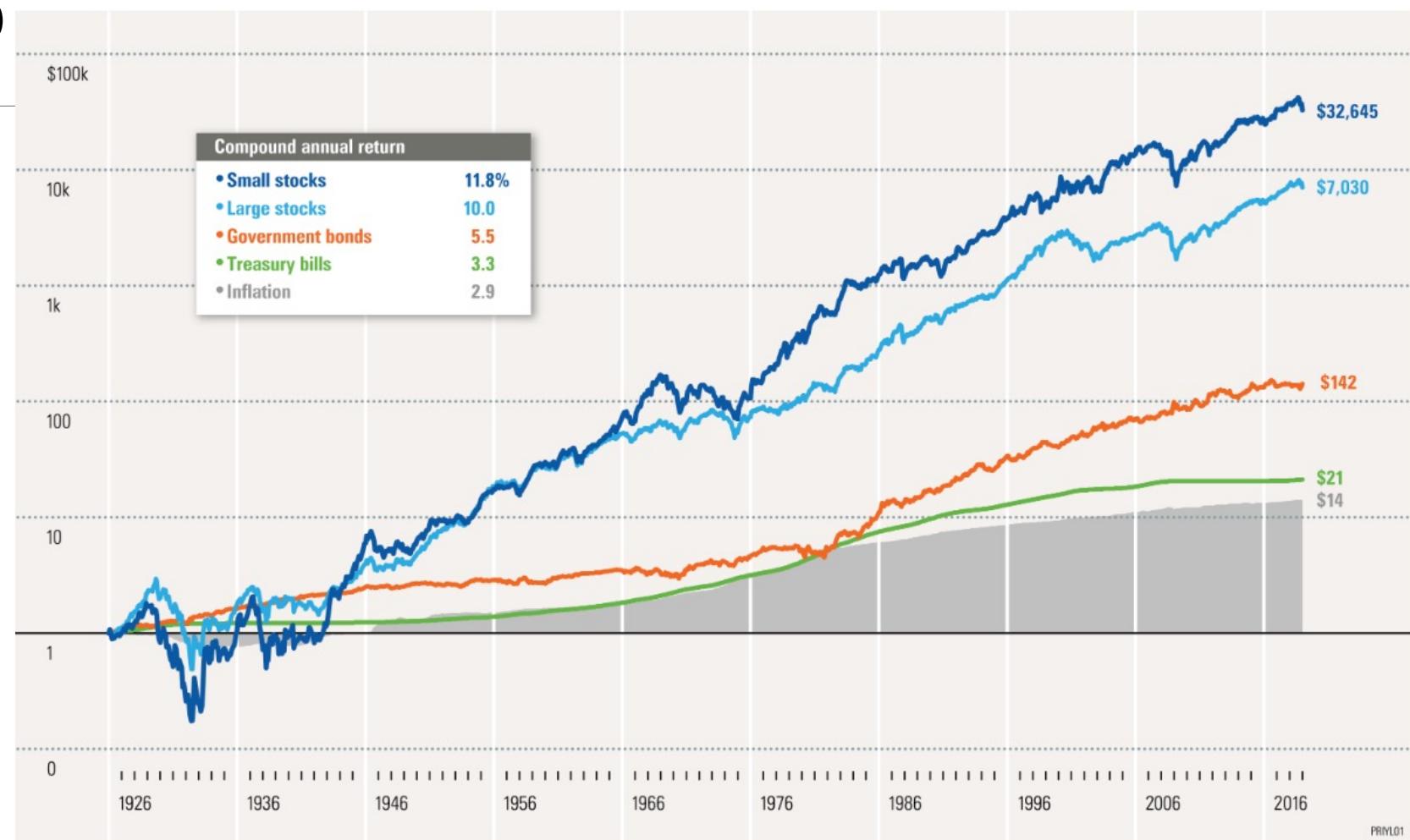
Past performance is no guarantee of future results. This is for illustrative purposes only and not indicative of any investment. An investment cannot

PR1YLO9

PR1YLO9

Easy to

Ibbotson® SBBI® Stocks, bonds, bills, and inflation 1926–2018

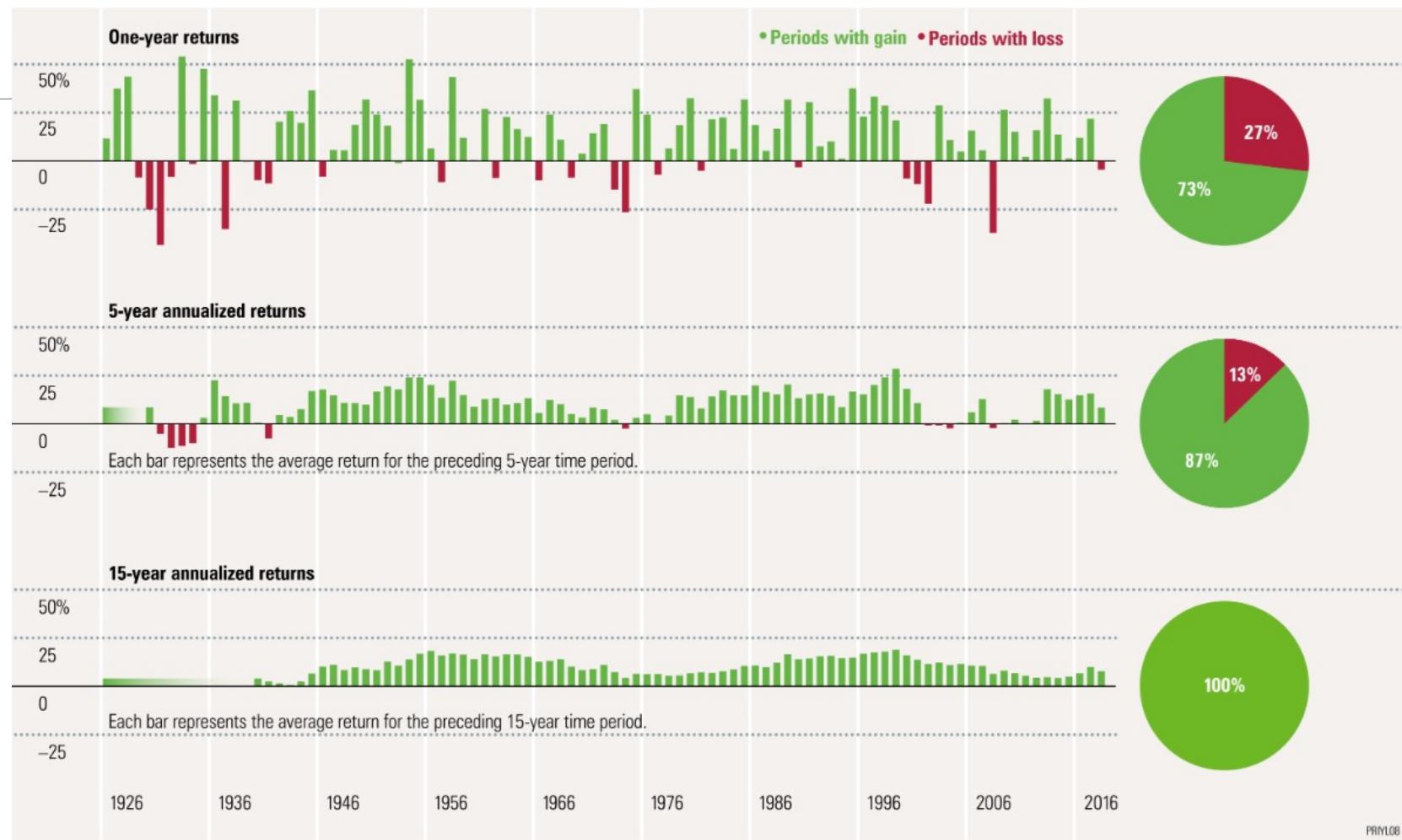


Past performance is no guarantee of future results. Hypothetical value of \$1 invested at the beginning of 1926. Assumes reinvestment of income and no transaction costs or taxes. This is for illustrative purposes only and not indicative of any investment. An investment cannot be made directly in an index. © Morningstar. All Rights Reserved.

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Easy to

Risk of Stock Market Loss Over Time 1926–2018



Past performance is no guarantee of future results. This is for illustrative purposes only and not indicative of any investment. An investment cannot be made directly in an index. © Morningstar. All Rights Reserved.

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Important Stock Markets

New York (Wall Street) Dow Jones industrial (30 companies)

Standard & Poor's 500

NASDAQ composite (1971, electronic)

London (FTSE-100)

Tokyo (Nikkei 225)

Frankfurt (Dax 30)

Paris (CAC 40)

Zurich (SMI (20 blue-chip stock), SPI (230))

$$Index = \sum_{i=1}^m \frac{w_i \cdot P_i}{Denum}$$

Index is a benchmark of the underlying stock exchange market.

Stock Market

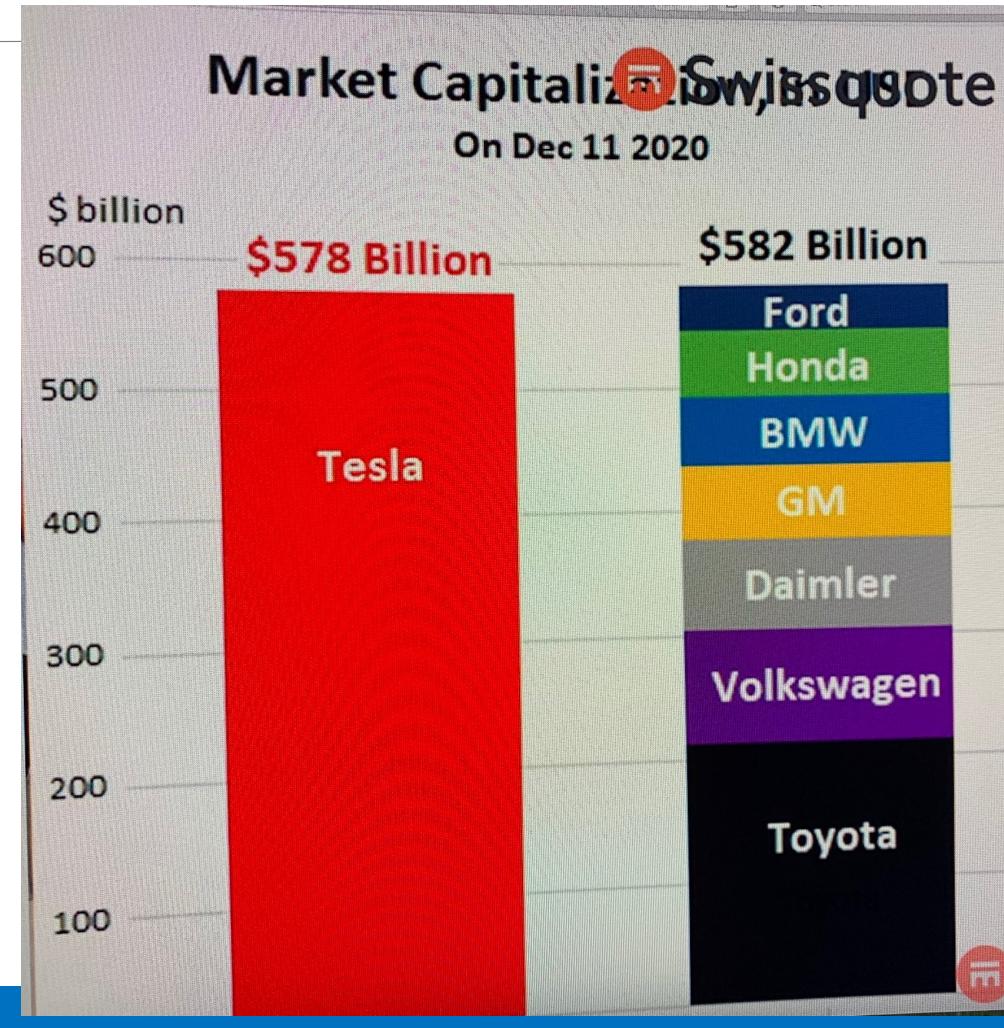
To define the blue chips (big companies), one can define them by computing their market capitalization (share price x number of shares).

In CH, the largest are:

Nestlé, Novartis, Roche, UBS, ...

In US, the largest are:

Apple, Microsoft, Amazon, Alphabet, Facebook, Tesla



Different Sectors

Finance & Insurance

JPMorgan, Citigroup, Moody's Co.

Chemistry

Dow, DuPont de Nemours

Pharma & Medicine

Johnson & Johnson, CVS Health Corp.

Logistics

United Parcel Service, XPO Logistics

Technology

Apple, Google, Microsoft

Telecommunications

AT&T, Verizon Communications

Energy

Exxon-Mobil, Valero Energy Corp.

Construction

AECOM, McDermott

Transportation & Tourism

American Airlines, Hilton Worldwide Holdings

Services

Walmart, Cosco, IBM, Amazon

Real-Estate

American Tower, Prologis

Foods

Coca-Cola, Kraft Heinz Corp.

Cars

Ford, GM, Tesla

Industrial

Boeing, General Electrics

Share Price

Unstable price

Different temporal solutions

Minute

Hour

Day

Week

Month

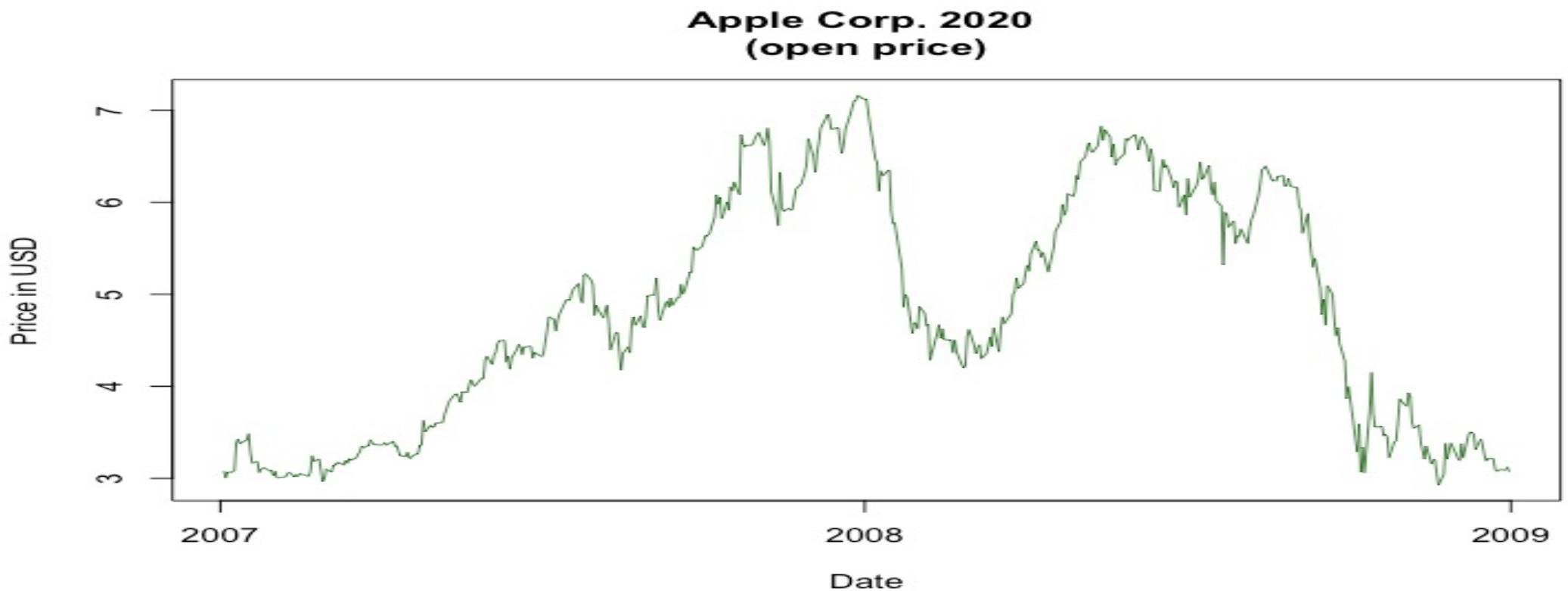
Year

Similar general pattern



Share Price

The price of a share over the time (per day) in USD. Some variation...



Share Price

Change from shares to bonds, currencies (forex), commodities, funds, crypto, derivatives, ...



Variation

On Monday, Dec. 21st 2020

normal day

In UK, a new variant of COVID-19
was found (new info).

On Tuesday, clear decrease.

Monday

Tuesday

SMI SMI® PR	10'402.90 CHF 0.94 % >	SMI SMI® PR	10'388.25 CHF -1.29 % >
LHN LAFARGEHOLCIM N	47.26 CHF 1.46 % >	LHN LAFARGEHOLCIM N	46.63 CHF -2.87 % >
NOVN NOVARTIS N	78.54 CHF 0.45 % >	NOVN NOVARTIS N	79.47 CHF -1.29 % >
ROG ROCHE GS	305.60 CHF 0.89 % >	ROG ROCHE GS	307.95 CHF -0.65 % >
SREN SWISS RE N	81.34 CHF 1.62 % >	SREN SWISS RE N	80.12 CHF -3.24 % >
ZURN ZURICH INSURANCE N	365.40 CHF 1.58 % >	ZURN ZURICH INSURANCE N	358.90 CHF -2.61 % >
CHSRI UBSETF MSCI SWITZER SRI CHF DIS	15.556 CHF 1.42 % >	CHSRI UBSETF MSCI SWITZER SRI CHF DIS	15.52 CHF -0.81 % >
SPIX SPI® PR	677.634 CHF 0.89 % >	SPIX SPI® PR	676.452 CHF -1.20 % >
PSREF PATRIMONIUM CH RE	188.50 CHF 0.80 % >	PSREF PATRIMONIUM CH RE	185.70 CHF -0.70 % >
SLHN SWISS LIFE HOLDING AG N	401.00 CHF 1.67 % >	SLHN SWISS LIFE HOLDING AG N	392.80 CHF -2.99 % >
NESN NESTLE N	101.50 CHF 1.14 % >	NESN NESTLE N	101.46 CHF -0.82 % >
SCMN	469.70 CHF 0.51 % >	SCMN	467.10 CHF -1.18 % >

Variation inside a day

August 23th 2021.

Migros decides to stop its collaboration with Cembra Money Bank for its credit card.

The share of Cembra drops to CHF 66.9 (-31%).



Variation inside a day

For each stock, one can find an orderbook with all offers and demands.

A view on a *perfect market* (?).

One can see the prices, the number of transactions, and the number of individuals.

At 9:43:44, the last transaction was done at CHF 100.02.

Now 9 individuals offer 1,814 Nestlé shares at CHF 100.06.

More interest for round prices!

Retour

NESN



Dernier prix: 09:43:45

100.02 CHF

NESTLE N

Carnet d'ordres

-0.22 %

Trade

09:41:55	3'776 (9)	100.14
09:43:29	5'390 (20)	100.12
09:42:47	1'829 (11)	100.10
09:43:41	991 (8)	100.08
09:43:44	1'814 (9)	100.06
09:43:40	2'810 (10)	100.02
09:42:35	154'762 (326)	100.00
09:42:50	5'324 (17)	99.99
09:43:13	3'650 (15)	99.98
09:42:53	1'859 (10)	99.97
09:41:29	1'492 (9)	99.96

Machine Learning in Finance

1. *Price prediction & Trend prediction*
2. Hedging
3. Portfolio construction
4. Structural breaks / outlier detection
5. Identifying good features
6. Identify the best bet size (how much money)
7. Credit ratings, recommendation
8. Sentiment analysis
9. Detection of false investment
10. Predict black swans?

Practical Machine Learning Applications

Practical exercises for this year.

Focus on a few large companies (Apple, Microsoft, Alphabet, Amazon, ...)

Projects:

- Predict the *daily return* of a share for the next day, after a gap of $n=5$ (10) days (*trend*), ...
- Binary: does this price increase or decrease? Does the trend go up or down?
- Ternary: does it increase, decrease, or be stable?

What must be predicted:

- Daily return for the next day / after $n=5$ /10 days (market tendency: bull/bear/stable)

Different methods:

- My feelings and intuitions?
- Start with simple approaches.
- Then try more advanced methods.

Trend in the Market

Do we live in a bull or bear market?

Never trade against the main trend!



Stock Market Data

Apple's share from Yahoo! finance (AAPL)

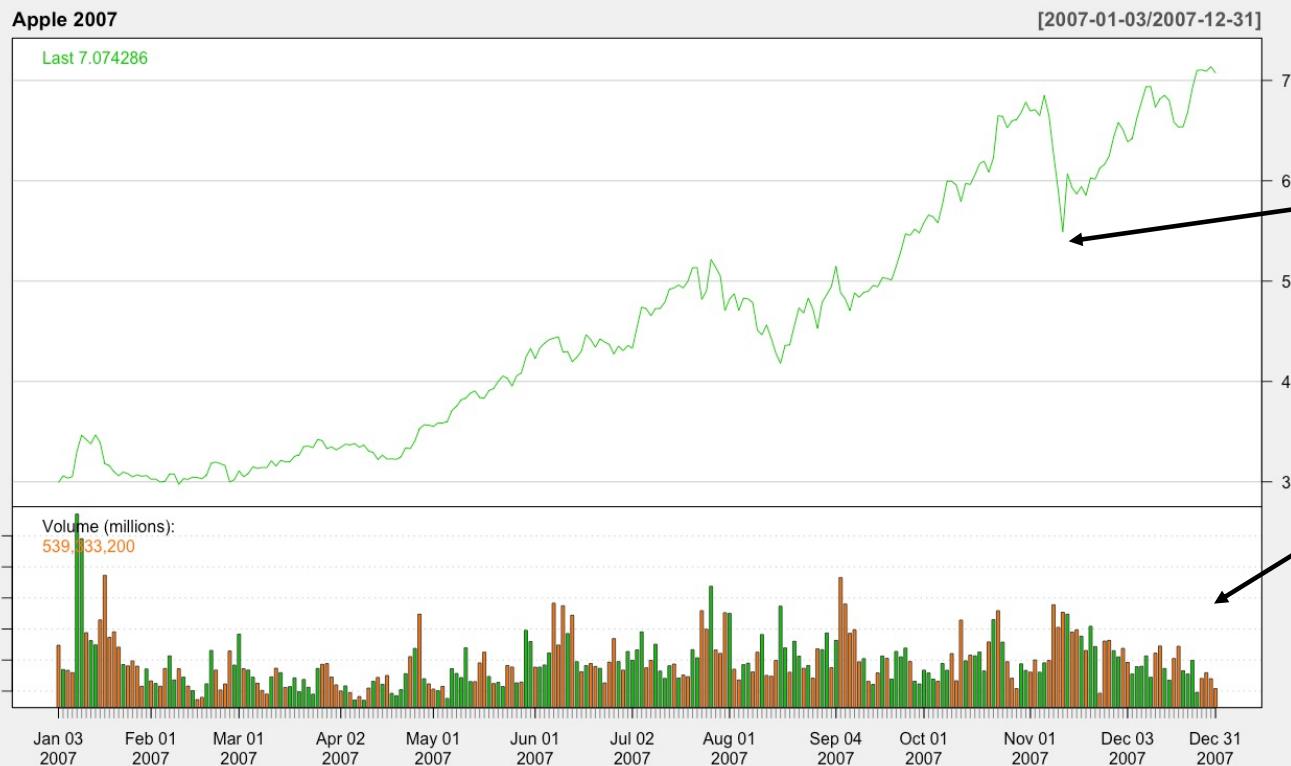
Date	AAPL.Open	AAPL.High	AAPL.Low	AAPL.Close	AAVolume	AAPL.Adjusted
2007-01-03	3.081786	3.092143	2.925000	2.992857	1238319600	2.581791
2007-01-04	3.001786	3.069643	2.993572	3.059286	847260400	2.639096
2007-01-05	3.063214	3.078571	3.014286	3.037500	834741600	2.620302
2007-01-08	3.070000	3.090357	3.045714	3.052500	797106800	2.633242
2007-01-09	3.087500	3.320714	3.041071	3.306072	3349298400PL.	2.851985
2007-01-10	3.383929	3.492857	3.337500	3.464286	2952880000	2.988469

One day = four prices but the most important are the open and close ones (representing larger volumes). We ignore the over-the-counter (OTC) transactions (mainly on derivatives).

Stock Market Data

How to represent the Apple's share?

Select one column?



Date	AAPL.Close	AAPL.Volume
2007-01-03	2.992857	1238319600
2007-01-04	3.059286	847260400
2007-01-05	3.037500	834741600
2007-01-08	3.052500	797106800
2007-01-09	3.306072	3349298400
2007-01-10	3.464286	2952880000

Prediction: Daily Return

Daily return (r): difference in percentage between the price at time $t+1$ and at time t

$$r_{t+1} = \frac{p_{t+1} - p_t}{p_t}$$

Date	AAPL.Close
2007-01-03	2.992857
2007-01-04	3.059286
2007-01-05	3.037500
2007-01-08	3.052500
2007-01-09	3.306072
2007-01-10	3.464286

Date	daily.returns
2007-01-03	0.000
2007-01-04	0.0222
2007-01-05	-0.0071
2007-01-08	0.0050
2007-01-09	0.0831
2007-01-10	0.0479

$$r = \frac{3.059286 - 2.992857}{2.992857} = 0.0222 = 2.22\%$$

Prediction: Daily Return

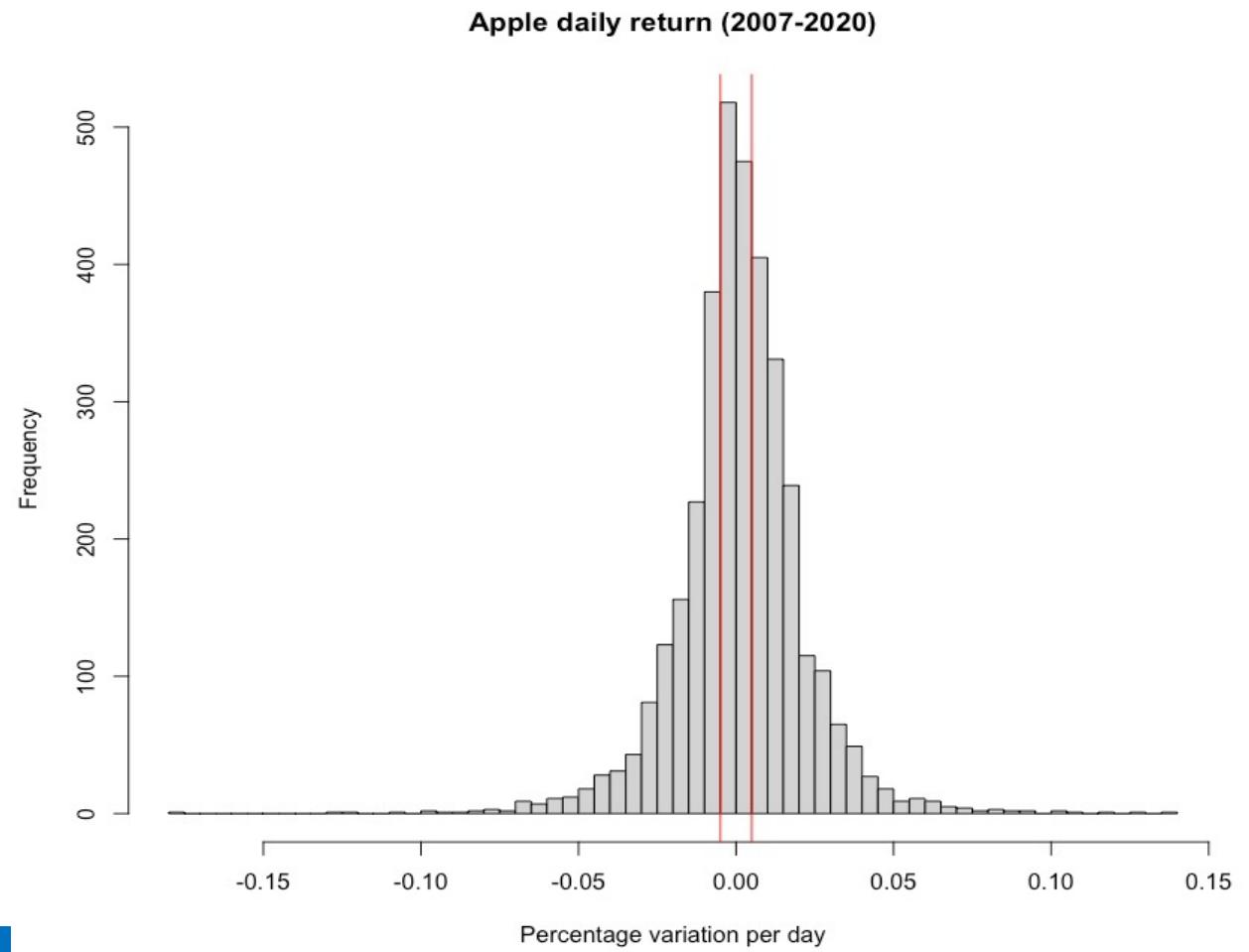
Difference in percentage
between the price at day $t+1$
and t .

Goes up or down...

Flat if in the range of ± 0.005 or
 $\pm 0.5\%$.

Classification: up, down, flat.

Regression: the percentage of
variation r .



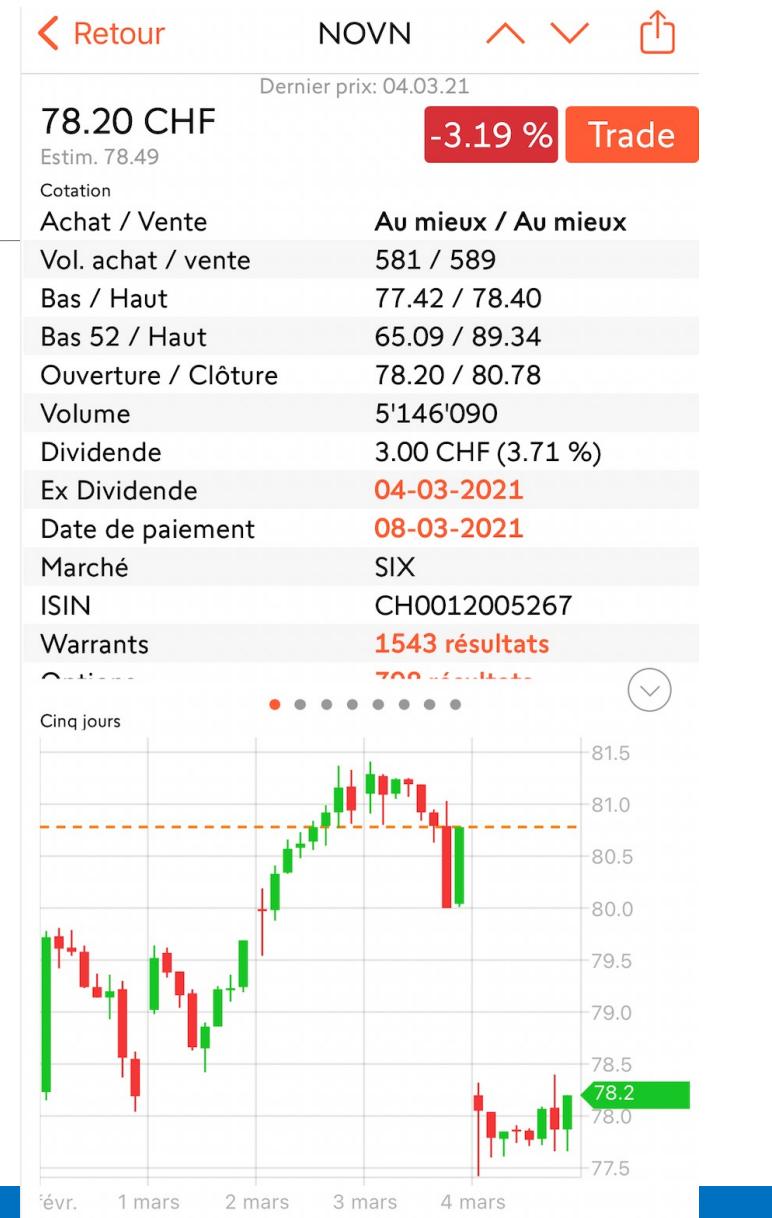
Quotation Error?

Variation from one day to the next defined the quotation *gap*.

A gap could be positive or negative.

Can represent different events...

But here due to the dividend paid.



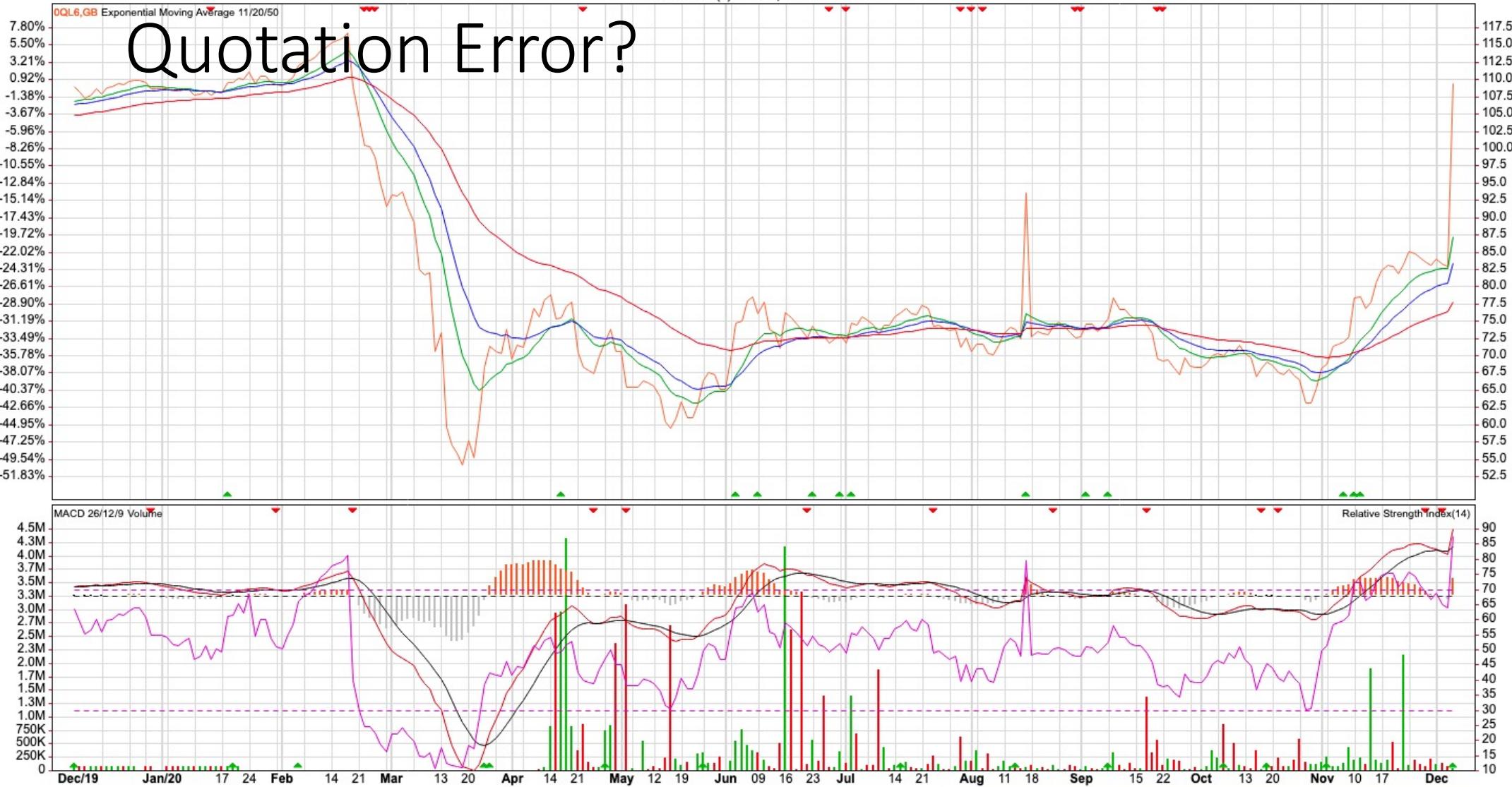
Task 1

Select your company (e.g., Apple=APPL).

Collect the daily share price over a long period.

1. Verify / clean the data.

109.49969 (-) 71.62 / 71.64 16 x 16



Quotation Error?

Error in the information system?

Swiss Re (SREN) at CHF 0!

or Zurich Insurance (ZURN) at CHF 0.0001!

SMI	11'135.37	CHF	0.13 %	>
SMI® PR				
HOLN	54.16	CHF	0.18 %	>
Estim. 54.94				
NOVN	80.15	CHF	-0.42 %	>
Estim. 79.71				
ROG	304.70	CHF	0.41 %	>
Estim. 304.65				
SREN	0.00	CHF	-100.00 %	>
Estim. 87.00				
ZURN	0.0001	CHF	-100.00 %	>
Estim. 379.00				
CHSRI	17.772	CHF	0.60 %	>
UBSETF MSCI SWITZE SRI CHF DIS				
NESN	109.62	CHF	0.72 %	>
Estim. 109.12				
SCMN	505.80	CHF	0.40 %	>
Estim. 506.00				
CFR	94.18	CHF	-0.17 %	>
Estim. 93.52				
UHR	294.00	CHF	1.31 %	>
Estim. 294.00				

Quotation Error?

Error in the information system?

Zurich Insurance (ZURN) decrease of CHF 381.899! A real crash ... Bankruptcy?

Save yourself if you can!

Retour ZURN ⌂

Dernier prix: 12.05.21

0.0001 CHF

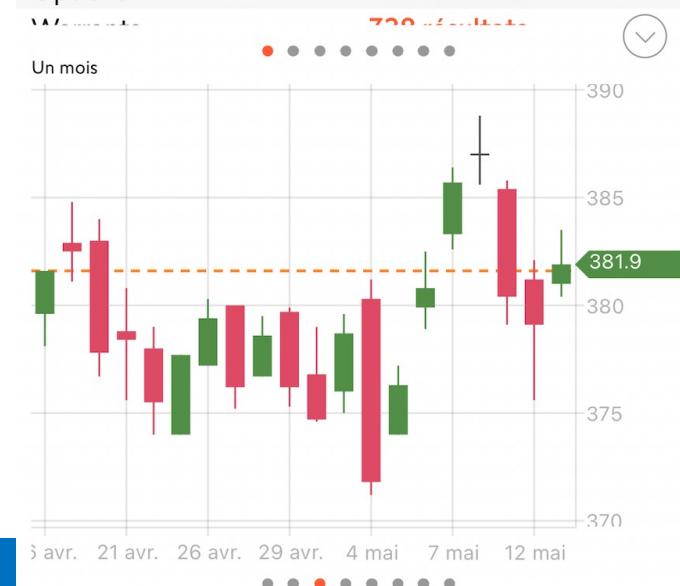
Estim. 379.00

-381.8999

Trade

Cotation

Achat / Vente	Au mieux / Au mieux
Vol. achat / vente	96 / 1'042
Bas / Haut	380.50 / 383.70
Bas 52 / Haut 52	280.20 / 411.30
Ouverture / Clôture	383.00 / 381.90
Volume	219'766
Dividende	20.00 CHF (5.24 %)
Ex Dividende	09-04-2021
Date de paiement	13-04-2021
Marché	SIX
ISIN	CH0011075394
Options	770 résultats



Task 1

Select your company (e.g., Apple=APPL).

Collect the daily share price over a long period.

1. Verify / clean the data.
2. Summary of the data (stock price and daily return)
 1. Trend?
 2. Summary values
 3. Variability
3. Model the data (follow a Gaussian distribution?)

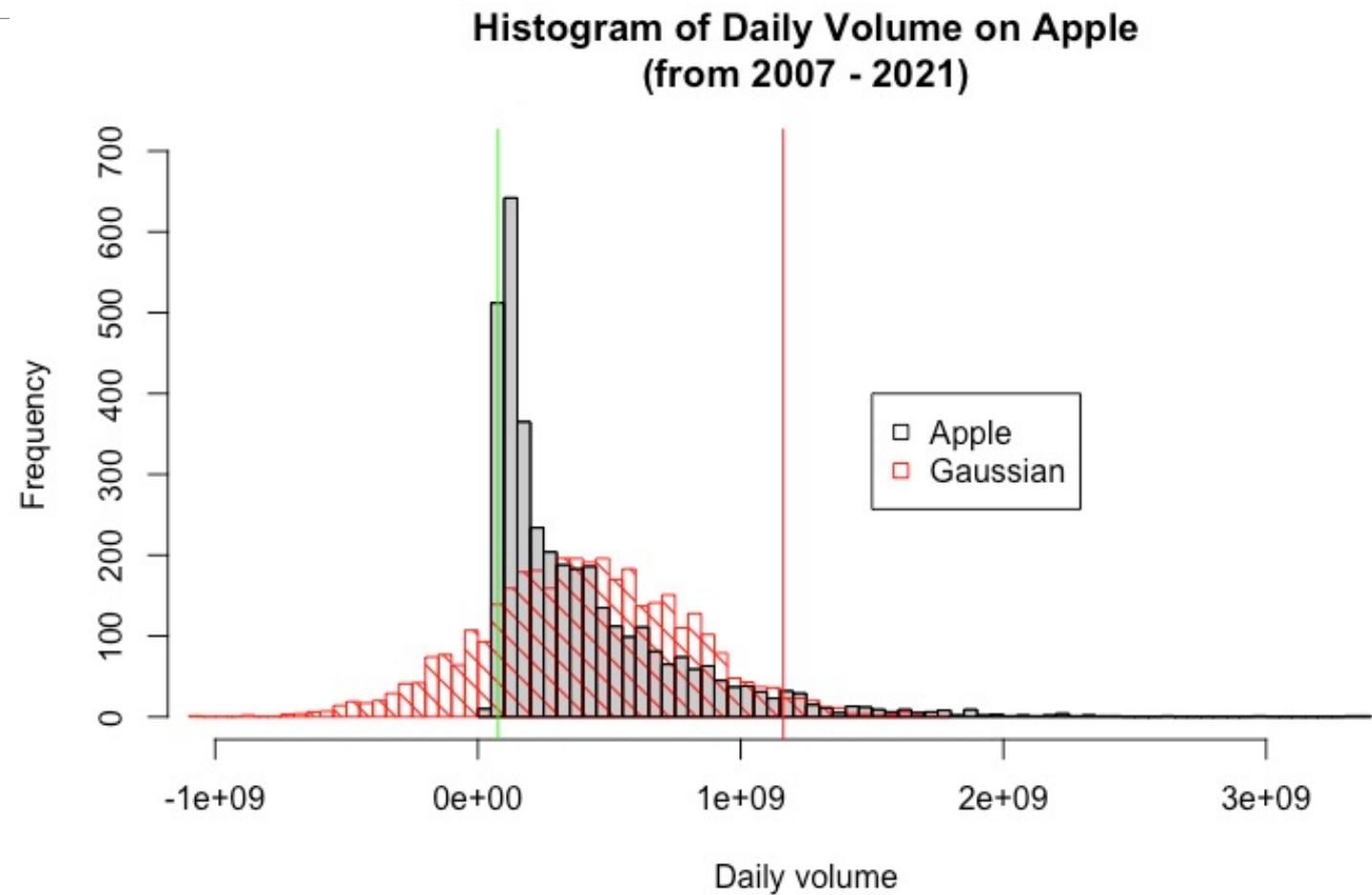
Volume

Model the volume with an histogram (black)

Compare with a Gaussian distribution (red)

Limit 2.5% in green

97.5% in red



References

Encyclodepia: <https://www.investopedia.com/>

Data: <https://finance.yahoo.com/>

Ebooks from Swissquote:

<https://en.swissquote.com/trading/investment-products/themes-trading/ebook>

Video from Swissquote:

<https://en.swissquote.com/forex/education/learning-center>

GameStop Story

A company with problems (no profit) (e.g., GameStop, shop selling games in US).

A small amount of shares in the market (float = 70 M / APPL= 17 G).

Wall Street (hedge funds) shorts this share (derivative put option).

They don't have the share but “sell” them in advance at a lower price...

A group (WallStreetBets) in Reddit wants to “punish” these hedge funds.

The group organizes through Robinhood (trading website) a defense of GameStop.

Instead to decrease, the GameStop share increases.

Hedge funds loose billions of \$.

GameStop Story

How short selling of stock works

In this example, an investor named John is trying to short a stock. That means he's making a bet that the price of the stock will go down. Here are the steps.

1. Borrow shares and sell them

John borrows one share from a brokerage and sells it for \$30, the current stock price.



2. After price drops, buy shares

John still owes the brokerage one share, so he buys one at the new price of \$5. Then he returns the share, "closing" his position.

3. Profit

John makes a **\$25 profit**, minus the brokerage's transaction fees.

But if the stock price goes up instead

1. Borrow shares and sell them

Again, John borrows one share from a brokerage and sells it for \$30.



2. As price increases, buy shares

John still owes the brokerage one share. Nervous that the stock will continue to rise, he buys one at the new price of \$50. Then he returns the share.

3. Loss

John loses **\$20**, plus transaction fees.