

# A Story of Three Stocks: Apple, Microsoft, and a Collapsed Bank (2018–2024)

In this notebook we will **walk through**:

1. Three US stocks:
  - Apple (AAPL) – large tech
  - Microsoft (MSFT) – large tech
  - First Republic Bank (FRC) – a regional bank that eventually **collapsed** in 2023
2. Building and explaining key **price-based metrics**:
  - OHLC, candlesticks, volume
  - Moving averages (SMA/EMA)
  - RSI (Relative Strength Index)
  - MACD (Moving Average Convergence Divergence)
  - Bollinger Bands
  - ATR (Average True Range)
  - OBV (On-Balance Volume)
3. Connecting what we see on the charts to **global events**:
  - 2018 market correction
  - 2020 COVID shock and tech rally
  - 2022 interest-rate hikes and 2023 regional bank stress
  - 2023 tech/AI optimism
4. **Comparing AAPL, MSFT, and FRC** with basic statistics and visual reasoning.

We will see how:

- AAPL and MSFT behaved like **strong, large tech winners**, and
- FRC behaved very differently, ending with a **severe collapse**, especially around the 2023 US regional banking crisis.

## 3. Basic Price Picture and OHLC

For each trading day we have:

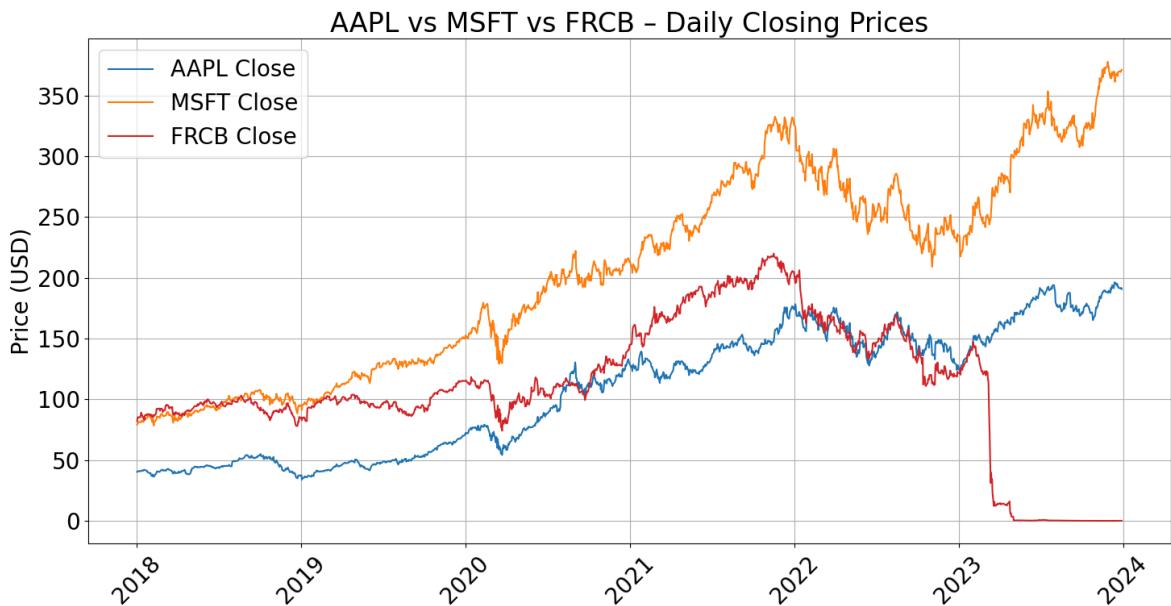
- **Open (O)** – first traded price of the day
- **High (H)** – highest traded price during the day
- **Low (L)** – lowest traded price during the day
- **Close (C)** – last traded price of the day
- **Volume** – number of shares traded that day

We start with line charts of daily **closing prices**:

- First comparing AAPL and MSFT (two strong tech stocks).

- Then showing FRC separately, because its price eventually becomes very small compared to the tech giants (a sign of severe trouble / collapse).

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## 4. Helper Functions for Indicators

We now mention functions to compute the indicators we will use later:

- Simple Moving Average (**SMA**)
- Exponential Moving Average (**EMA**)
- RSI** (Relative Strength Index)
- MACD** (Moving Average Convergence Divergence)
- Bollinger Bands**
- ATR** (Average True Range)
- OBV** (On-Balance Volume)
- A function to plot **candlesticks**.

We will explain **what each indicator means** in separate sections below.

## 5. Candlesticks and Volume: Who Won Each Day?

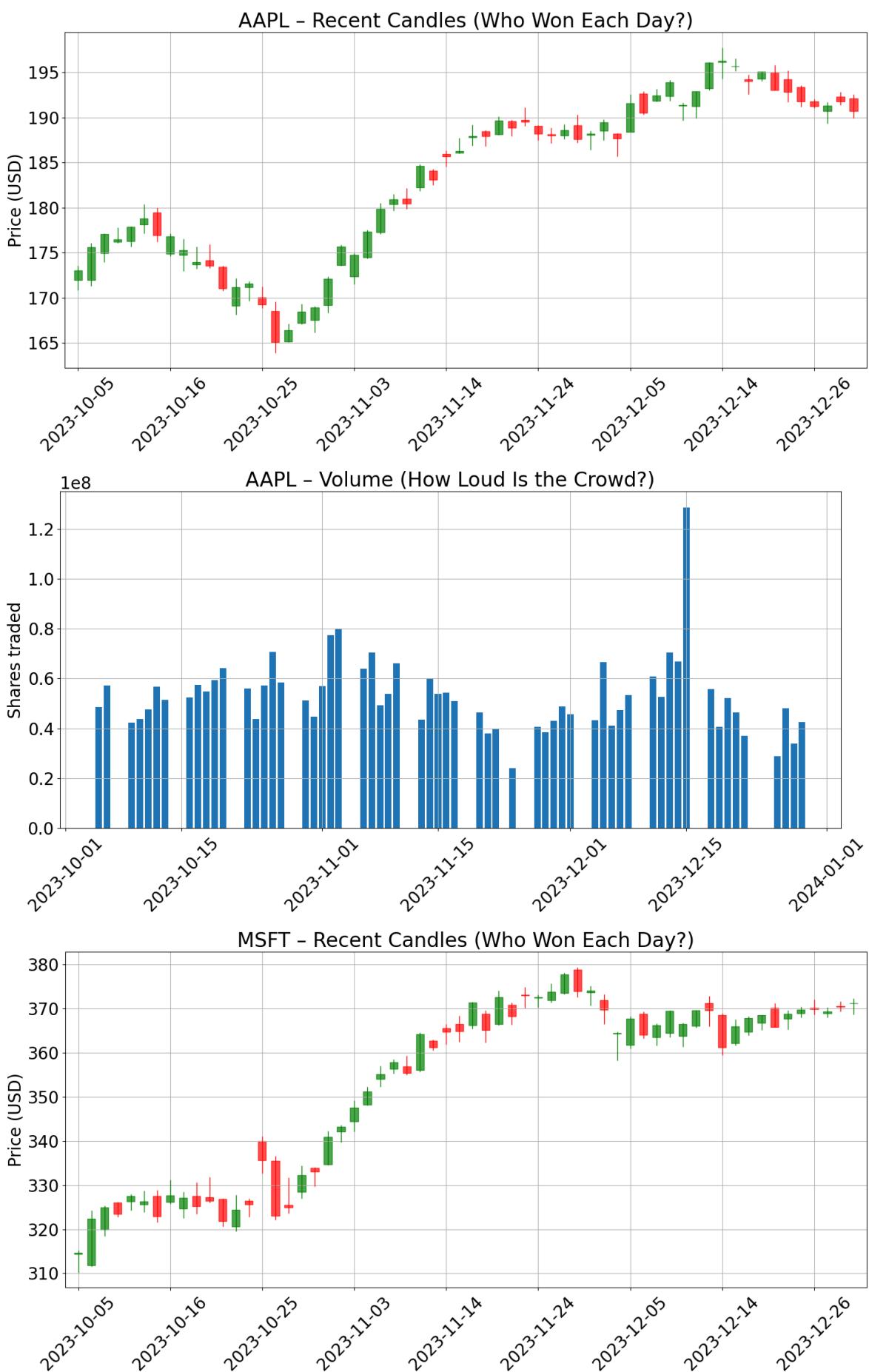
For each day:

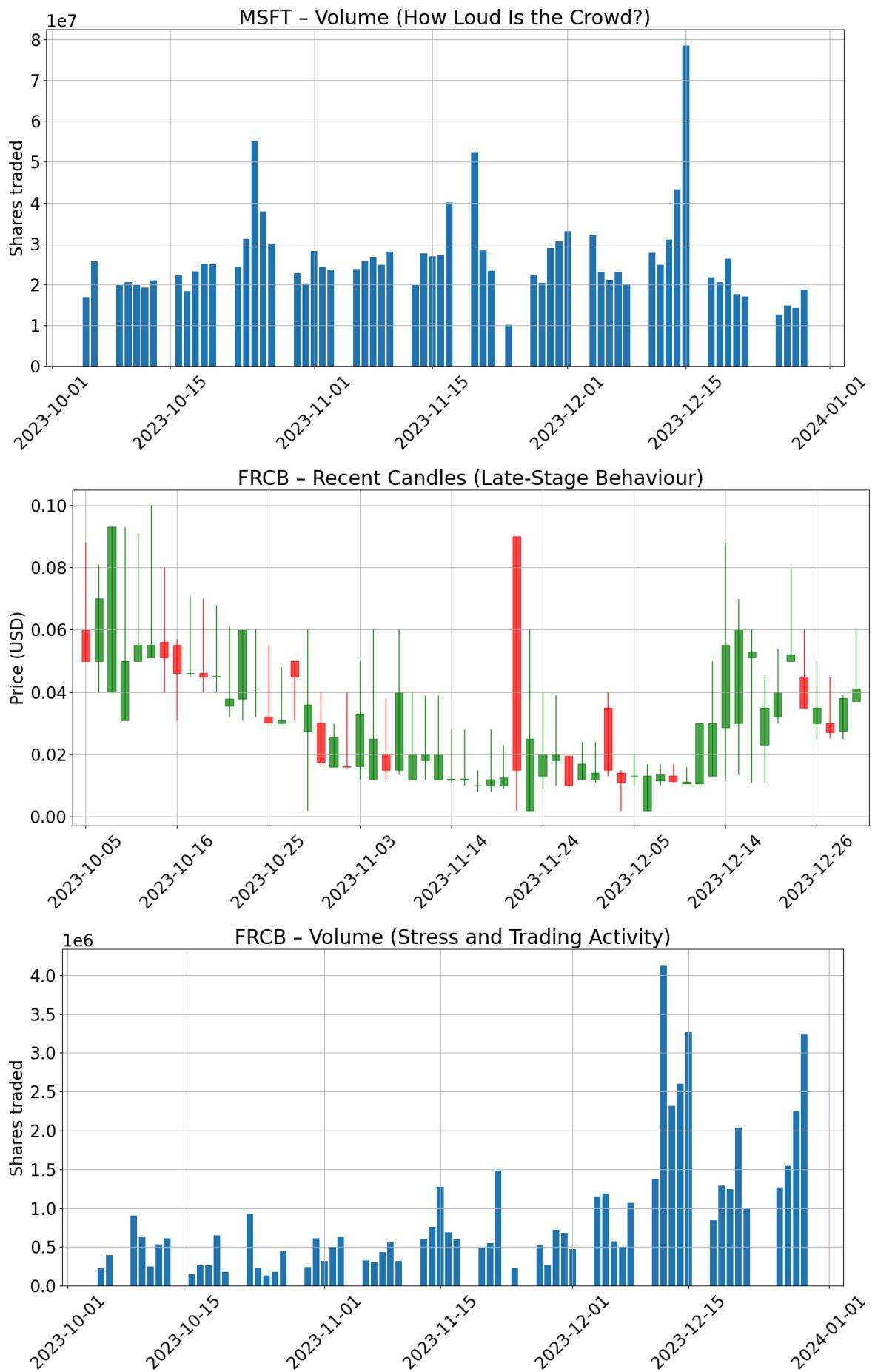
- If **Close > Open**, buyers pushed the price **up** by the end of the day  
→ candle is usually drawn **green** (buyers “won” the day).
- If **Close < Open**, sellers pushed the price **down**  
→ candle is **red** (sellers “won” the day).

The **wicks** show the full range from **Low** to **High**.

Below we plot about 60 recent days of candlesticks for each stock, with volume.

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## 6. Moving Averages: Smoothing the Wiggles

The daily closing price jumps up and down like a child hopping.

A **moving average** draws a **smooth line** through these hops so we can see the overall direction (the **trend**) more clearly.

For a simple moving average over  $N$  days (SMA  $N$ ):

$$\text{SMA}_t = \frac{1}{N} \sum_{k=t-N+1}^t P_k,$$

where  $P_k$  is the closing price on day  $k$ .

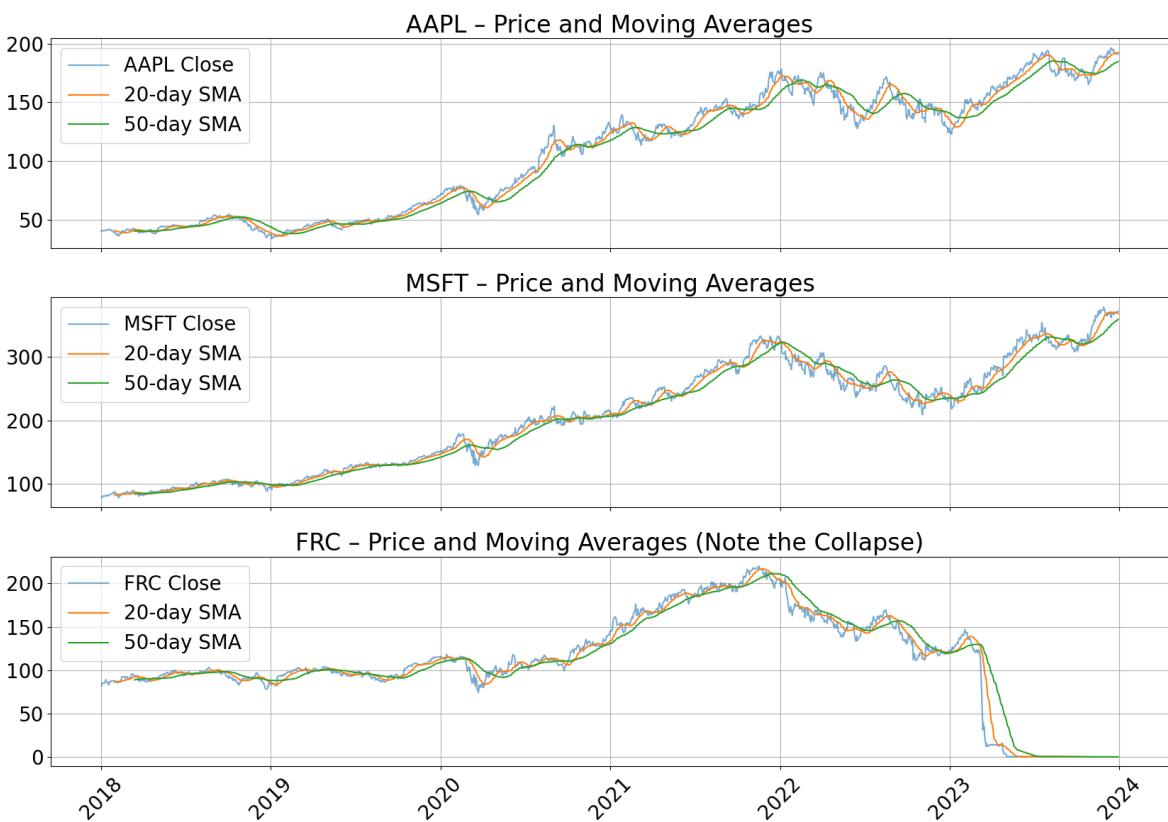
In this notebook we use:

- **20-day SMA** – short-term view (reacts faster)
- **50-day SMA** – medium-term view (reacts slower)

Typical reading:

- Price above both SMA 20 and SMA 50 → trend is **up**.
- Price below both → trend is **down**.
- SMA 20 crossing above SMA 50 → **golden cross** (often bullish).
- SMA 20 crossing below SMA 50 → **death cross** (often bearish).

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## 7. RSI – Is the Price Running Too Fast?

**RSI (Relative Strength Index)** compares **average up-moves** and **average down-moves** over a recent window (often 14 days).

For each day  $t$  with closing price  $P_t$ :

$$\Delta_t = P_t - P_{t-1}.$$

Define daily **gains** and **losses**:

$$\text{Gain}_t = \begin{cases} \Delta_t & \text{if } \Delta_t > 0, \\ 0 & \text{otherwise,} \end{cases} \quad \text{Loss}_t = \begin{cases} -\Delta_t & \text{if } \Delta_t < 0, \\ 0 & \text{otherwise.} \end{cases}$$

Average them over the last  $N$  days:

$$\text{AvgGain}_t = \frac{1}{N} \sum_{k=t-N+1}^t \text{Gain}_k, \quad \text{AvgLoss}_t = \frac{1}{N} \sum_{k=t-N+1}^t \text{Loss}_k.$$

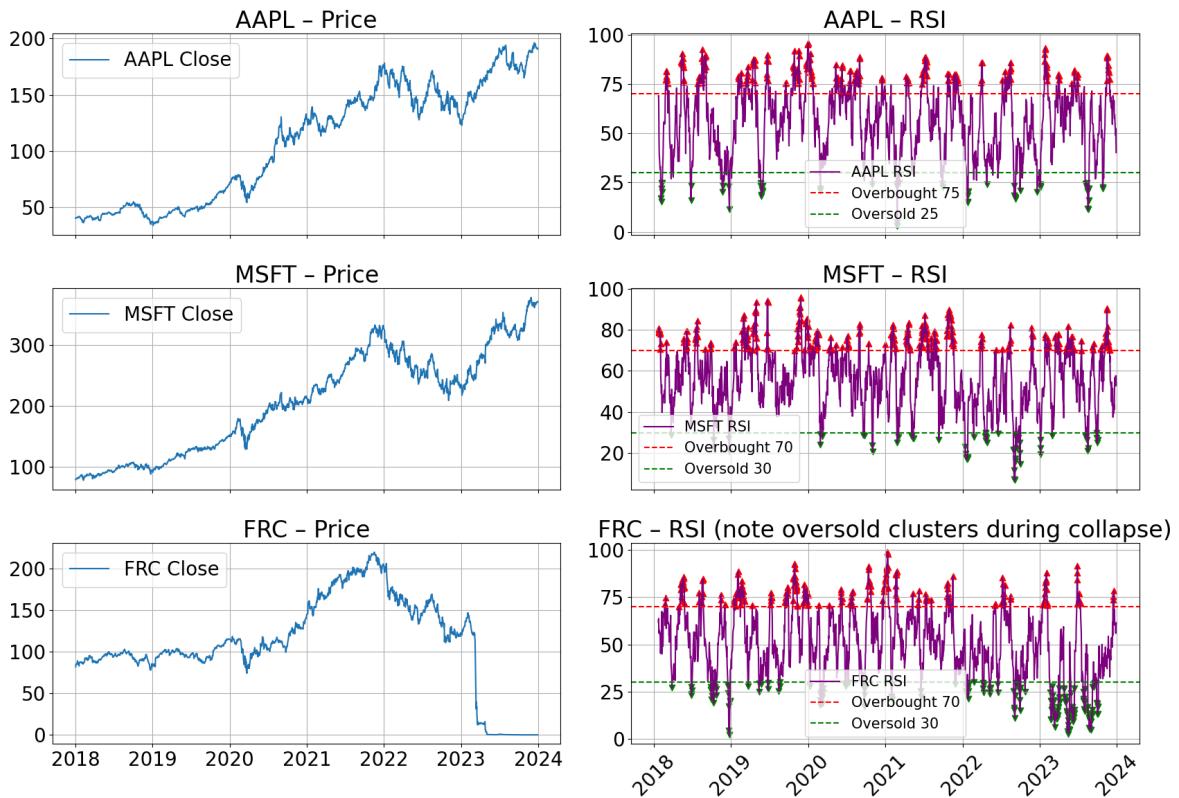
Then

$$\text{RSI}_t = \frac{\text{AvgGain}_t}{\text{AvgLoss}_t}, \quad \text{RSI}_t = 100 - \frac{100}{1+\text{RSI}_t}.$$

Interpretation:

- RSI near **100** → recent gains dominate (strong upward momentum).
- RSI near **0** → recent losses dominate (strong downward momentum).
- RSI above **70** → “overbought” (price has run up fast recently).
- RSI below **30** → “oversold” (price has fallen fast recently).

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## 8. MACD – When Does the Trend Change Its Mind?

**MACD (Moving Average Convergence Divergence)** compares a **fast** and a **slow** exponential moving average (EMA) of price.

For an EMA of span  $n$ :

$$\text{EMA}_t = \alpha P_t + (1 - \alpha) \text{EMA}_{t-1}, \quad \alpha = \frac{2}{n+1}.$$

Standard MACD settings:

- Fast EMA span: 12
- Slow EMA span: 26
- Signal EMA span (of MACD): 9

We compute:

$$\text{FastEMA}_t = \text{EMA}_{12}(P_t), \quad \text{SlowEMA}_t = \text{EMA}_{26}(P_t), \quad \text{MACD}_t = \text{FastEMA}_t - \text{SlowEMA}_t$$

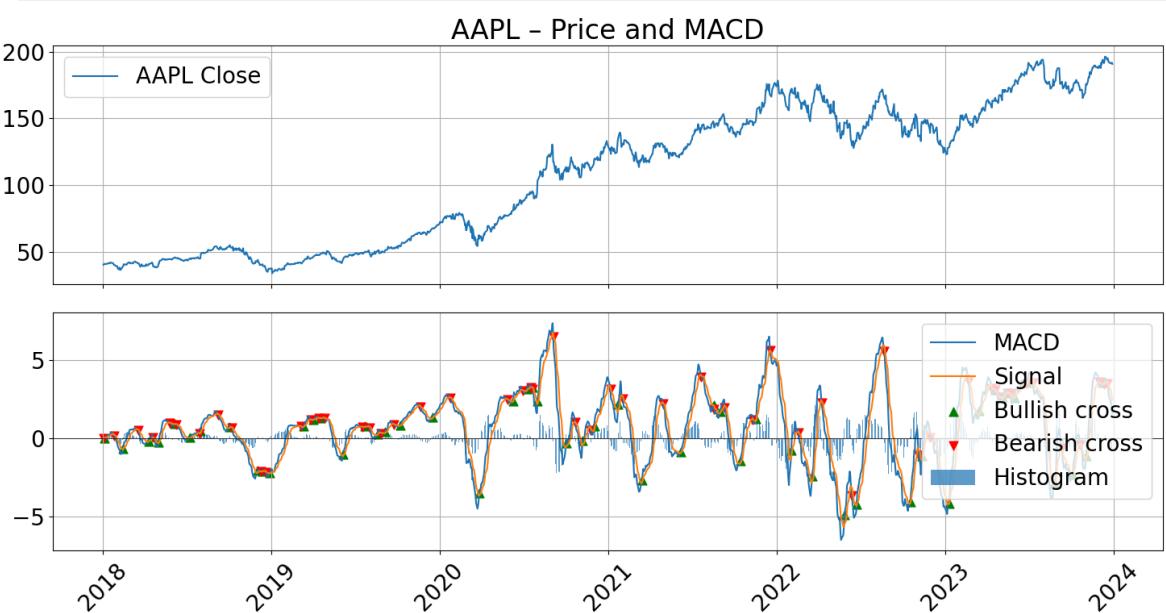
Then the **Signal line**:

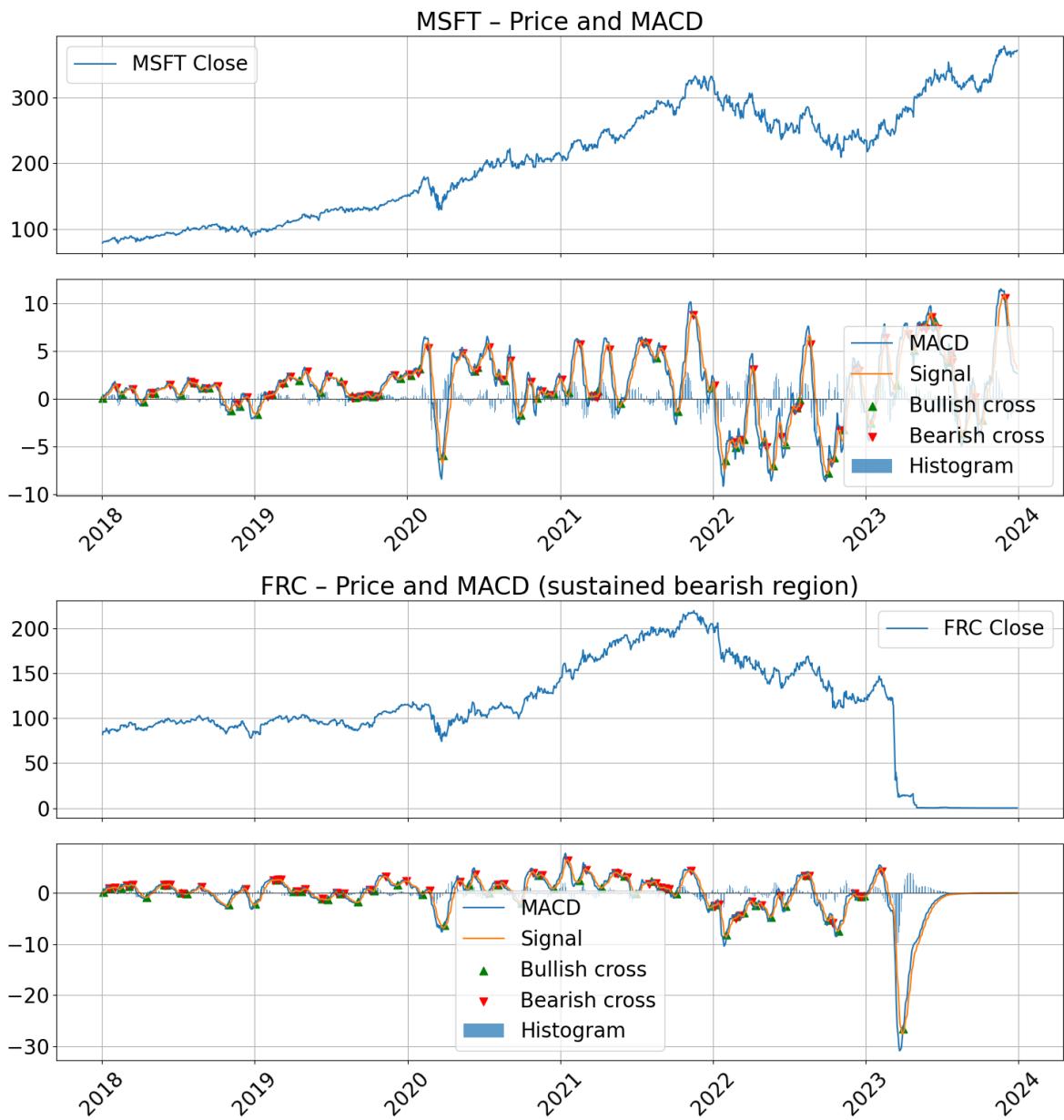
$$\text{Signal}_t = \text{EMA}_9(\text{MACD}_t).$$

Reading MACD:

- $\text{MACD}_t > 0$ : fast EMA above slow EMA → bullish bias.
- $\text{MACD}_t < 0$ : fast EMA below slow EMA → bearish bias.
- MACD crossing **above** Signal → **bullish cross** (trend may be turning up).
- MACD crossing **below** Signal → **bearish cross** (trend may be turning down).

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## 9. Bollinger Bands – How Wide Is the Road?

Bollinger Bands draw a kind of **road** around the price:

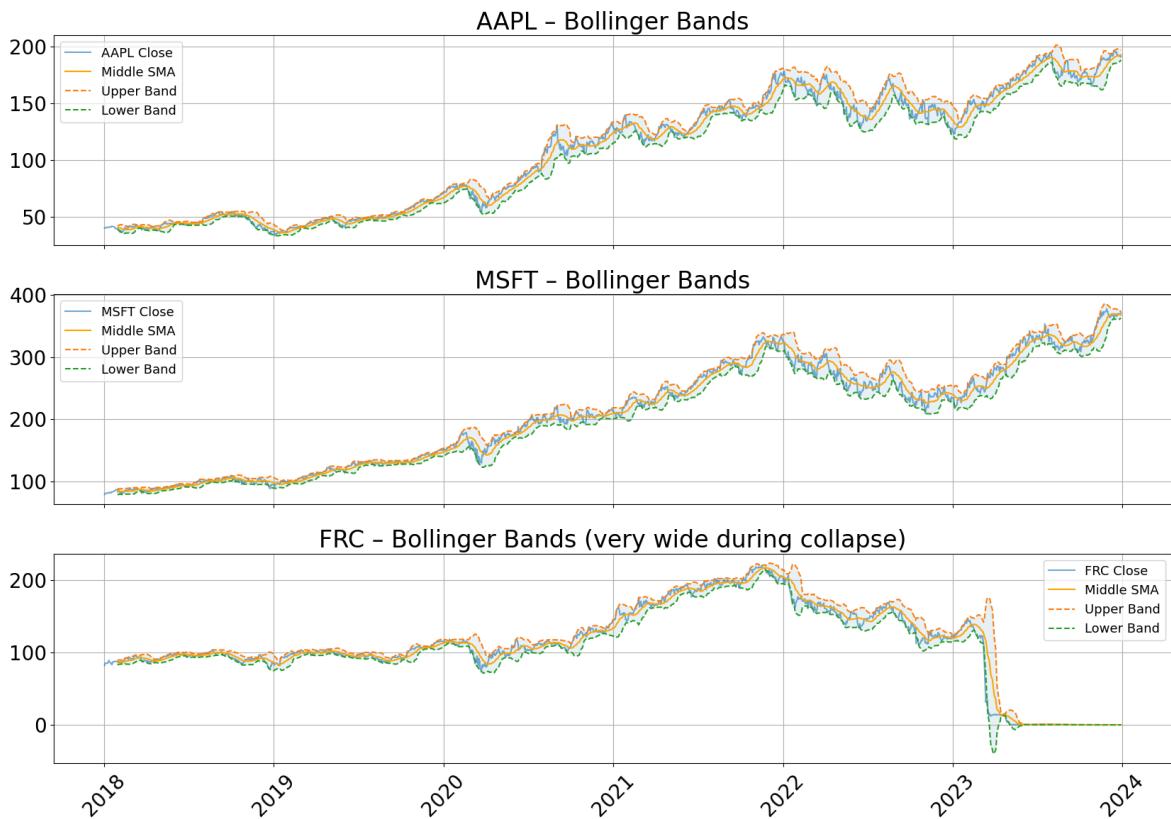
- Middle: a moving average (usually 20-day SMA).
- Upper band: middle +  $2 \times$  (rolling standard deviation).
- Lower band: middle -  $2 \times$  (rolling standard deviation).

When the bands are:

- **Narrow** → price is quiet (low volatility).
- **Wide** → price is jumping around (high volatility).

Strong moves can **hug** the upper or lower band during trends, and shocks (like the COVID crash or banking stress) often cause the bands to **suddenly widen**.

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## 10. ATR – How Far Does Price Travel in a Day?

**Average True Range (ATR)** measures how big the **typical daily move** is, including gaps from one day to the next.

For day  $t$ , let

- $H_t$ : high price of day  $t$
- $L_t$ : low price of day  $t$
- $C_t$ : close price of day  $t$
- $C_{t-1}$ : close price of the previous day

The **True Range (TR)** is:

$$\text{TR}_t = \max(H_t - L_t, |H_t - C_{t-1}|, |L_t - C_{t-1}|).$$

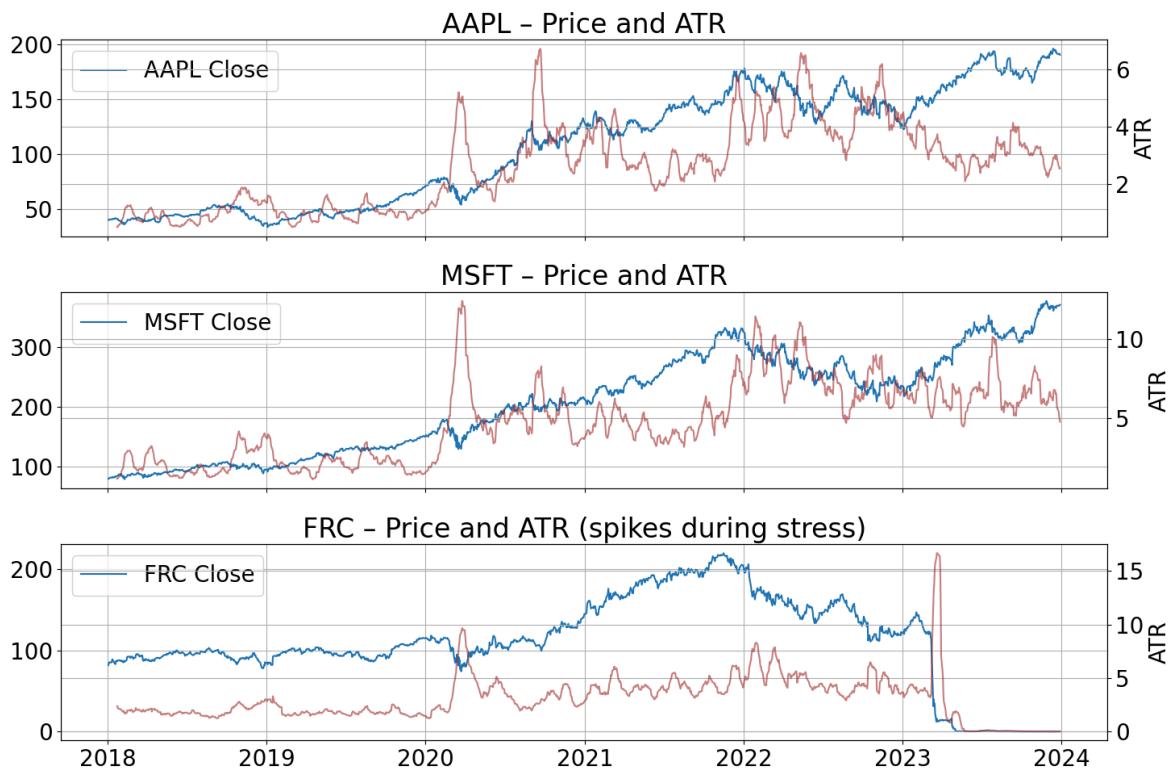
The ATR over  $N$  days (e.g. 14) is:

$$\text{ATR}_t = \frac{1}{N} \sum_{k=t-N+1}^t \text{TR}_k.$$

- High ATR  $\rightarrow$  large typical daily moves (high volatility).
- Low ATR  $\rightarrow$  small typical daily moves (low volatility).

During a **crash** or period of stress, ATR usually spikes as price jumps around.

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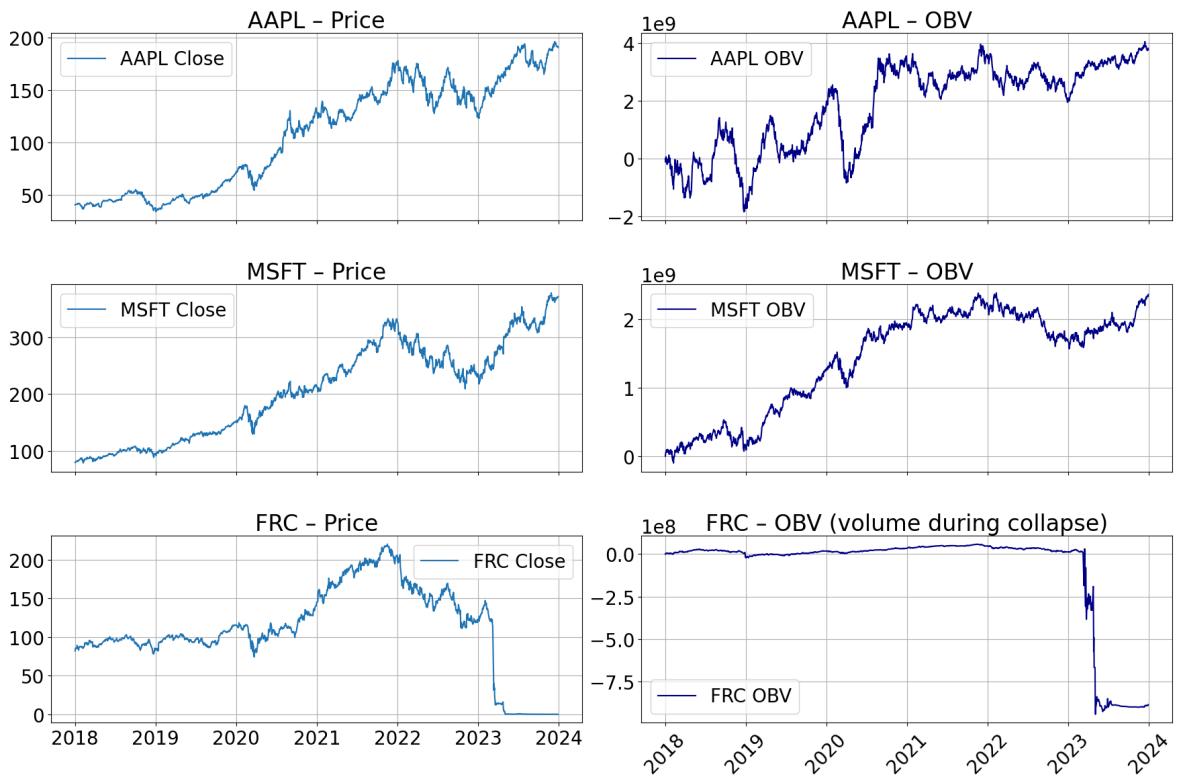
## 11. OBV – Is the Crowd Walking With the Price?

**On-Balance Volume (OBV)** checks whether **volume agrees with price direction**.

Starting from  $OBV_0 = 0$ , for each day  $t$ :

- If  $C_t > C_{t-1} \rightarrow$  OBV adds today's volume.
- If  $C_t < C_{t-1} \rightarrow$  OBV subtracts today's volume.
- If  $C_t = C_{t-1} \rightarrow$  OBV stays the same.
- Price up + OBV up  $\rightarrow$  many traders are joining the up-move (healthy trend).
- Price up + OBV flat/down  $\rightarrow$  fewer traders are joining (weaker trend).
- Price down + OBV down  $\rightarrow$  strong selling with volume.

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## 12. Global Events and Market Behaviour (2018–2024)

Between 2018 and 2024, several major events influenced the US stock market. Our three stocks **feel** these events in different ways:

- AAPL and MSFT are large, diversified tech companies. They tend to be sensitive to **growth expectations**, **interest rates**, and **technology sentiment** (cloud, AI, devices, etc.).
- FRC is (historically) a regional bank, more exposed to: **interest-rate changes**, **funding and deposit conditions**, and **confidence in the banking system**.

Let's walk through some key phases and how they typically show up in the data.

### 12.1 Late 2018 – Market Correction

- Context: Worries about **global growth** and **rate hikes** by the US Federal Reserve.
- Many risk assets sold off, including US equities.

On the charts you typically see:

- AAPL/MSFT:
  - Price breaking **below** moving averages (trend turning down).
  - RSI dipping towards or below **30** (oversold).
  - MACD turning negative, with bearish crosses.
  - Bollinger Bands widening as volatility jumps.
- FRC (and other financials):
  - Sensitive to changing views about growth and rates, often showing similar risk-off behaviour (downward pressure and higher volatility).

## 12.2 Early 2020 – COVID-19 Shock

- Context: Rapid global spread of COVID-19 → lockdowns, economic shutdowns, extreme uncertainty.
- Markets fell sharply in February–March 2020.

On the charts:

- All three stocks show **sharp drops** around March 2020:
  - Large red candles with long wicks.
  - ATR spikes sharply (daily move size jumps).
  - Bollinger Bands suddenly become very wide.
  - RSI dives into oversold territory.
- OBV often falls (large down moves on significant volume) as investors rush to sell.

## 12.3 Mid/Late 2020–2021 – Recovery and Tech Rally

- Context: Massive monetary and fiscal stimulus, **ultra-low interest rates**, and a rapid shift toward **work-from-home** and **cloud** services.
- Big tech companies, including AAPL and MSFT, benefit from strong demand for devices, software, and cloud infrastructure.

On the charts for AAPL/MSFT:

- Prices recover and move into **strong uptrends**:
  - Price spends long periods **above** the 50-day SMA.
  - MACD stays above zero with repeated bullish crosses.
  - RSI spends more time in the upper half (50–70), occasionally touching overbought.
  - OBV trends upward, showing sustained buying interest.
- FRC also participates in the recovery, but its long-term risk profile remains different (banking vs tech).

## 12.4 2022 – Inflation and Aggressive Rate Hikes

- Context: Inflation rises to multi-decade highs.  
Central banks raise interest rates quickly to fight inflation.
- Higher rates can:
  - Hurt the present value of **future tech earnings** (pressure on growth and tech).
  - Affect banks in complex ways (net interest income vs funding costs and risks in bond portfolios and deposits).

On the charts:

- AAPL/MSFT:
  - More **sideways or downtrending** phases.
  - More frequent whipsaws in moving averages and MACD.

- ATR and Bollinger bandwidth pick up again as markets adjust to a new rate regime.
- FRC and other banks:
  - The combination of higher rates and concerns about bond portfolios and deposits contributes to vulnerability that will later show up dramatically in 2023.

## 12.5 2023 – Tech/AI Optimism vs Regional Bank Stress

- Tech/AI side:
  - Strong narrative around **AI** and **cloud** benefits large tech.
  - AAPL/MSFT enjoy renewed optimism; MSFT in particular is closely associated with AI and cloud services.
  - On the charts, you often see:
    - Price climbing back above moving averages.
    - MACD back above zero, new bullish crosses.
    - OBV rising again during rallies.
- Regional banks and FRC:
  - In early 2023, some US regional banks face intense pressure and loss of confidence (including deposit outflows and concern about asset values).
  - FRC's stock price experiences **extreme volatility** and a **severe downward move**.

On the charts for FRC:

- Price collapses towards very low levels.
- ATR and Bollinger Bands become extremely large, showing chaotic trading.
- RSI spends significant time near **oversold** levels.
- OBV trends sharply downward, reflecting heavy selling pressure on large volume.

In contrast, AAPL and MSFT, although not immune to general market swings, do not experience the same kind of near-total collapse during this time.

## How to Read the Indicators with Global Events in Mind

The indicators themselves do **not** know about "COVID" or "rate hikes" or "banking stress". They only see **price** and **volume**. But:

- Sharp global shocks → show up as **fast, large moves** (spikes in ATR, wide Bollinger Bands, big candles, RSI extremes).
- Prolonged optimism or pessimism → show up as **sustained trends** (price vs moving averages, MACD alignment, persistent OBV direction).
- Sector-specific stress (like regional banks in 2023) → shows up as **very asymmetric behaviour**:
  - Some stocks (AAPL/MSFT) recover or even benefit from new narratives.

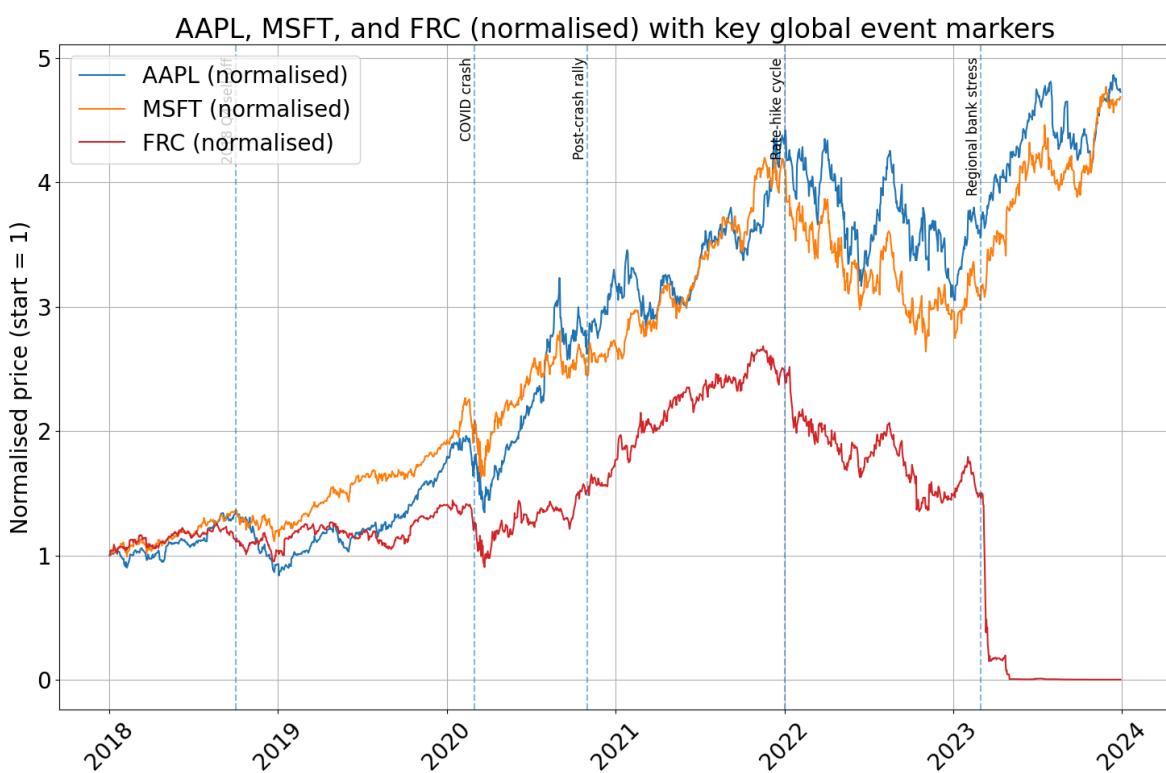
- Others (like FRC) experience **one-sided collapses**, with indicators locked in “stress mode” (high ATR, low RSI, falling OBV).

In the next plot, we add **event markers** to a normalised price chart to see these phases side by side.

## 12.6 Normalised Price and Event Markers

To compare the **paths** of AAPL, MSFT, and FRC, we normalise all prices to 1.0 at the start and add vertical lines for key global event periods.

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## 13. Comparing the Three Stocks: Returns, Volatility, and Correlation

Now we compute some simple summary statistics for AAPL, MSFT, and FRC over this period:

- **Total return:** how much each stock grew overall from 2018-01-01 to 2024-01-01 (for FRC, effectively until trading stops).
- **Annualised volatility:** how much the daily returns wiggle, scaled to a yearly number.
- **Average ATR and ATR as % of price:** typical daily move in absolute and relative terms.
- **Correlation of daily returns:** how often they move in the same direction on a given day.

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Correlation matrix of daily returns (AAPL, MSFT, FRC):

	AAPL	MSFT	FRC
AAPL	1.000000	0.749859	0.100470
MSFT	0.749859	1.000000	0.098216
FRC	0.100470	0.098216	1.000000

Out[ ]:

	Total_return_%	Ann_vol_%	Avg_ATR	Avg_ATR_%_of_price
AAPL	372.780807	31.677000	2.630556	2.466561
MSFT	368.708092	30.123854	4.804557	2.333081
FRC	-99.949985	168.091412	3.090851	13.621278

## 13.1 How to Read the Comparison Table

In the result above, you will see:

- A **summary table** with one row for AAPL, MSFT, and FRC.
- A **correlation matrix** showing how closely their daily returns move together.

You can now make statements such as:

### 1. Which stocks rewarded buy-and-hold more?

- AAPL and/or MSFT likely have much higher **Total\_return\_%** than FRC, which captures FRC's eventual collapse.

### 2. Which stock was more volatile day-to-day?

- Compare **Ann.vol\_%** and **Avg\_ATR\_%\_of\_price**.
- FRC may show very high volatility, especially around its crisis period.

### 3. Do they mostly move together?

- AAPL and MSFT daily returns are often **strongly positively correlated**, reflecting their shared exposure to tech and macro factors.
- FRC may be less correlated, especially around its banking-specific stress, where its price collapsed while large tech was more resilient.

### 4. How do the indicators support this story?

- For AAPL/MSFT, over much of the period you see:
  - Long stretches of price above SMA 50, positive MACD, rising OBV during rallies.
  - RSI moving between 30 and 70, with occasional overbought signals during strong trends.
- For FRC, especially near the end:
  - Persistent downtrend (price below moving averages).
  - MACD staying negative, RSI often oversold.
  - ATR and Bollinger Bands very wide, indicating chaotic trading.
  - OBV dropping sharply, showing heavy selling pressure.

Putting this together, you might conclude something like:

"Over this period, AAPL and MSFT behaved like strong, volatile but generally upward-trending tech leaders, delivering positive long-term returns and showing clear uptrend phases around tech/AI optimism. FRC, in contrast, ultimately suffered a severe collapse during the 2023 regional banking stress. Indicators such as ATR, Bollinger Bands, RSI, and OBV show FRC stuck in a prolonged 'stress mode' (high volatility, oversold conditions, and persistent heavy selling), while AAPL and MSFT recovered from shocks and resumed uptrends."

## 14. Wrap-Up

In this notebook we:

- Loaded **real data** for three stocks (AAPL, MSFT, FRC) from 2018–2024.
- Built and **defined** common technical indicators: OHLC/candles, Volume, SMA/EMA, RSI, MACD, Bollinger Bands, ATR, OBV.
- Linked indicator behaviour to major **global events**: 2018 correction, 2020 COVID shock, 2022 rate hikes, 2023 tech rally and regional bank stress.
- Computed simple statistics to **compare** the three stocks in terms of returns, volatility, and correlation.

The aim is to show how the **same set of tools** can tell very different stories:

- For strong, resilient large-cap tech names like AAPL and MSFT.
- For a stock that ultimately **collapsed**, like FRC, where indicators reflect stress, heavy selling, and extreme volatility.