



# Adaptive and Explainable Margin Trading via Large Language Models on Portfolio Management

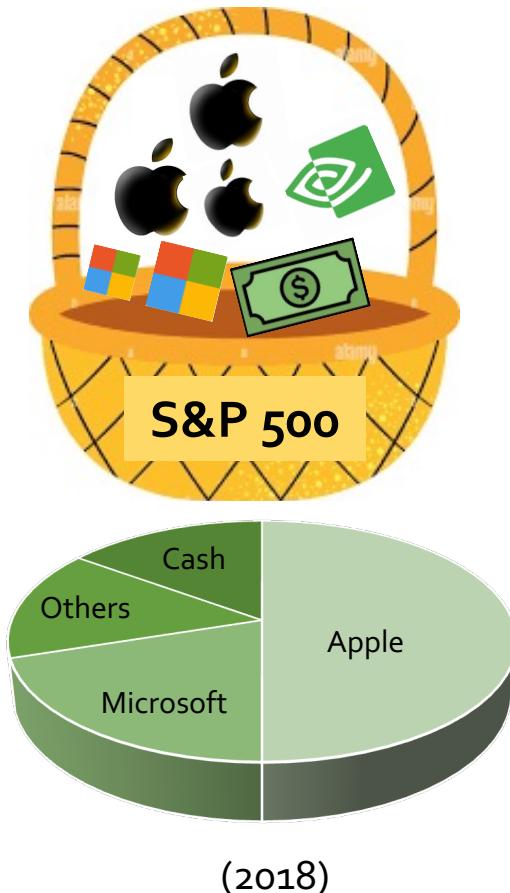
Speaker: Jingyi Gu (New Jersey Institute of Technology)

Authors: Jingyi Gu, Junyi Ye, Grace Wang, Wenpeng Yin

2024/11/17

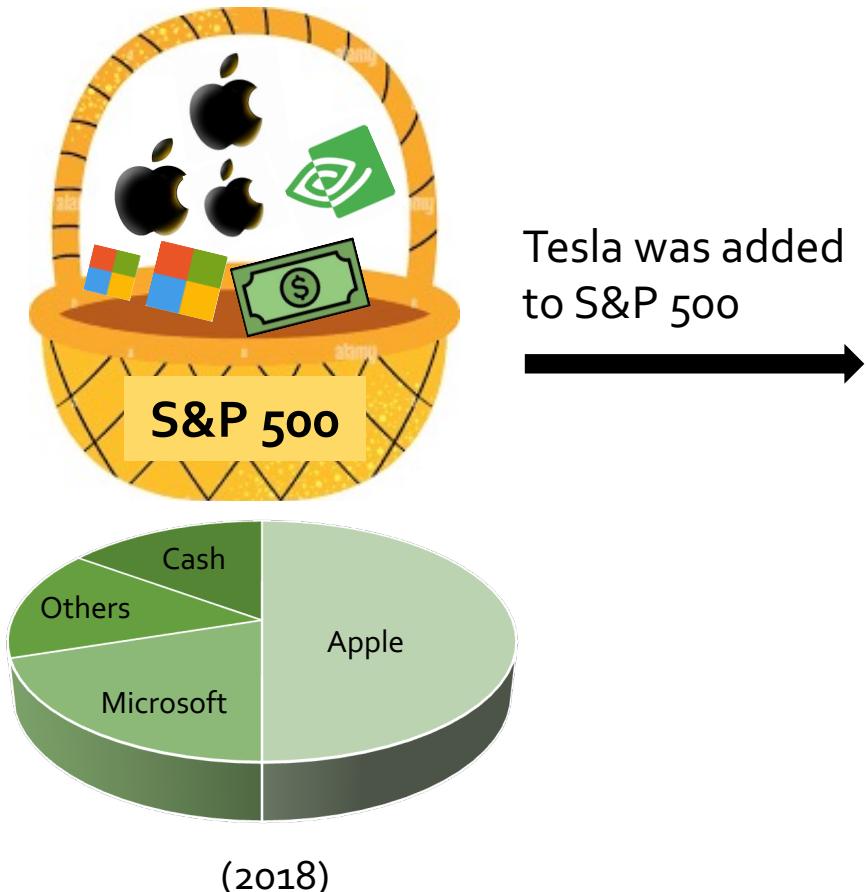
# Financial Portfolio Management

- Goal: maximize profit and minimize risk
- Action: dynamically adjust the portfolio



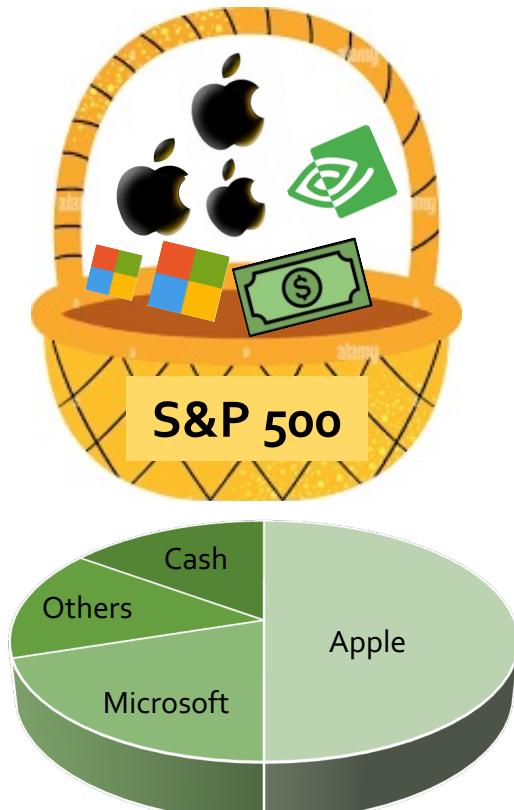
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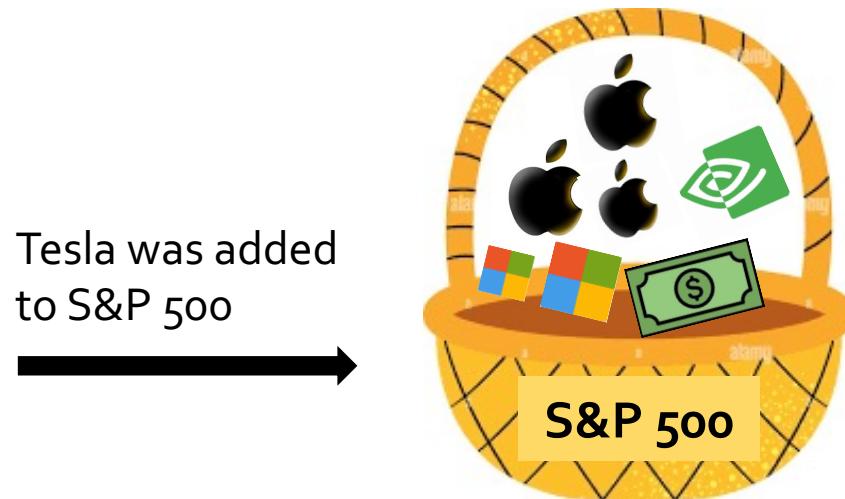


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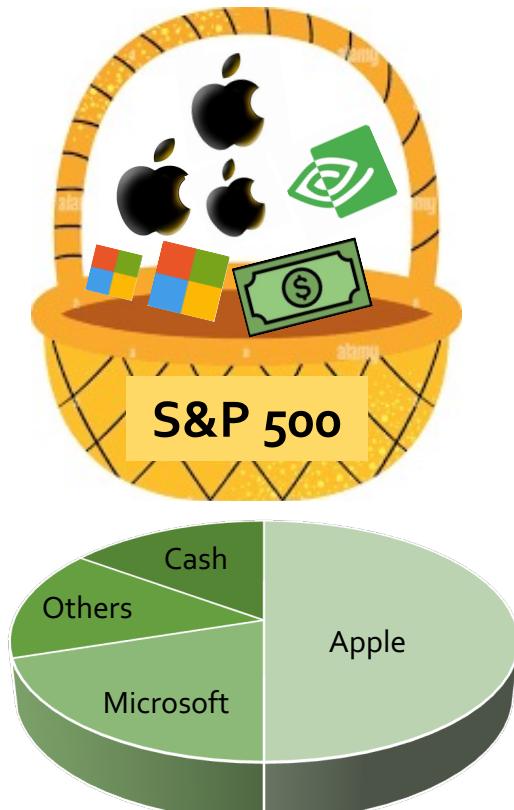


(2018)

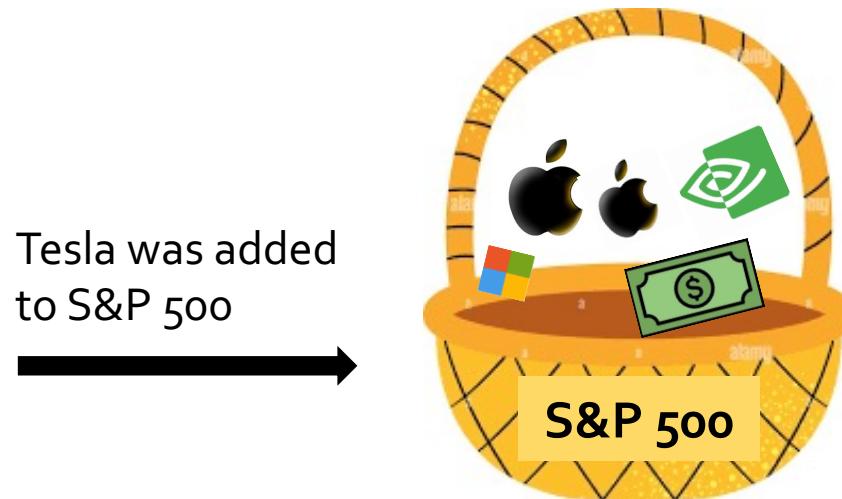


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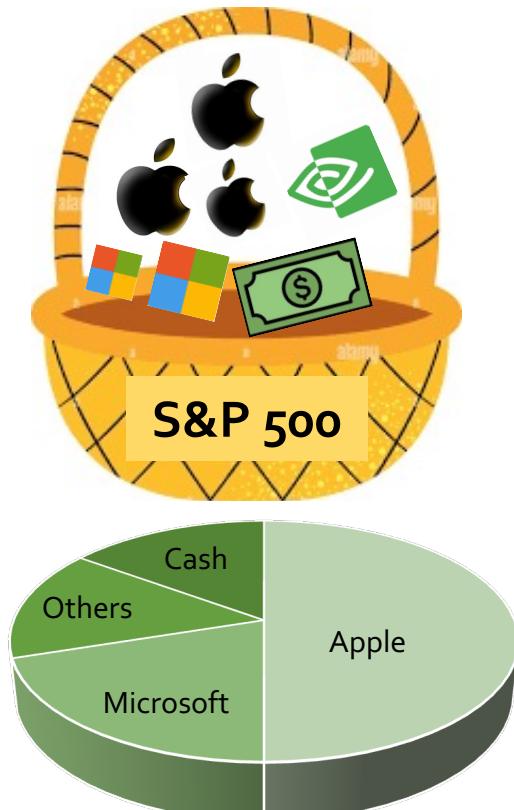


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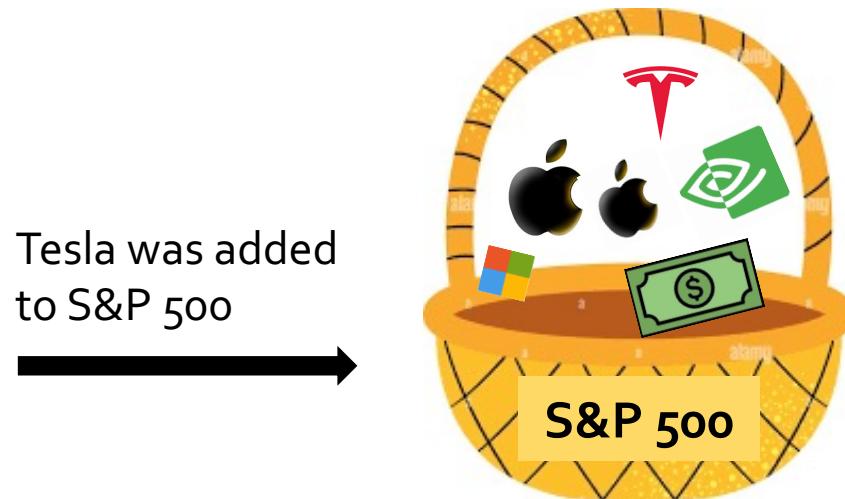


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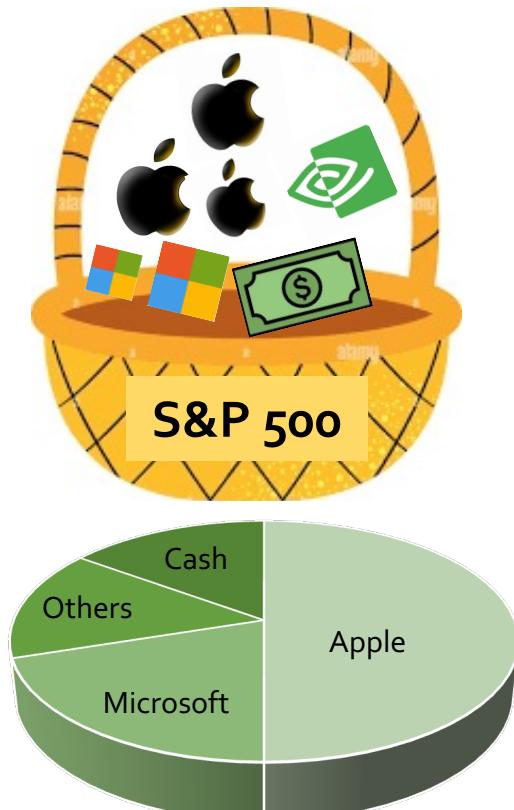


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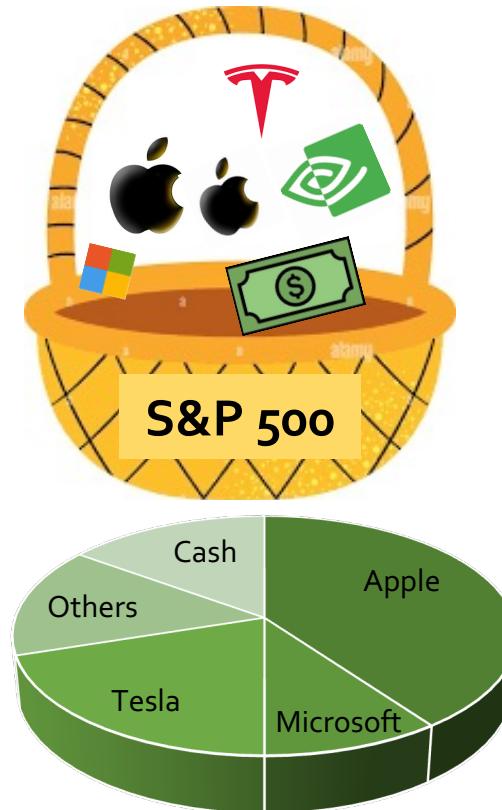
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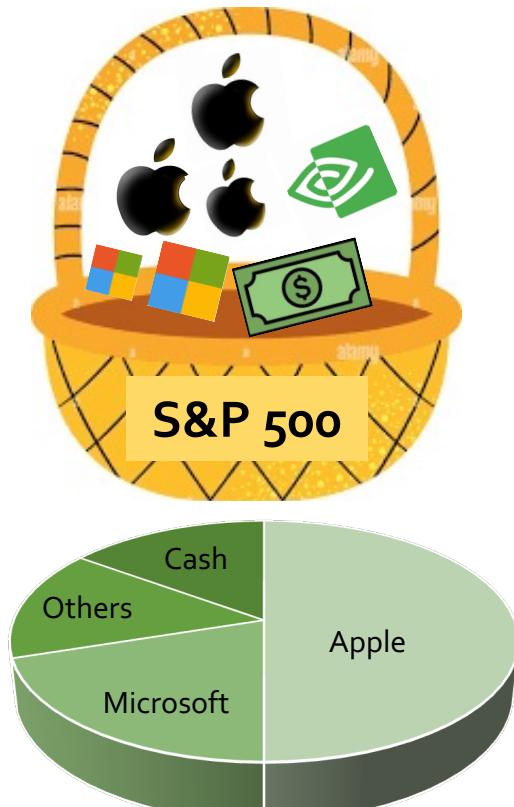
Tesla was added  
to S&P 500

A thick black arrow points from the 2018 S&P 500 basket to the 2020 S&P 500 basket.



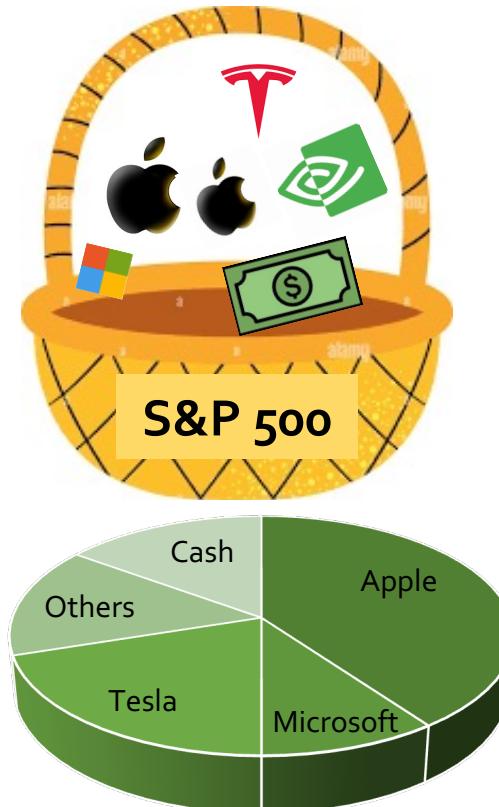
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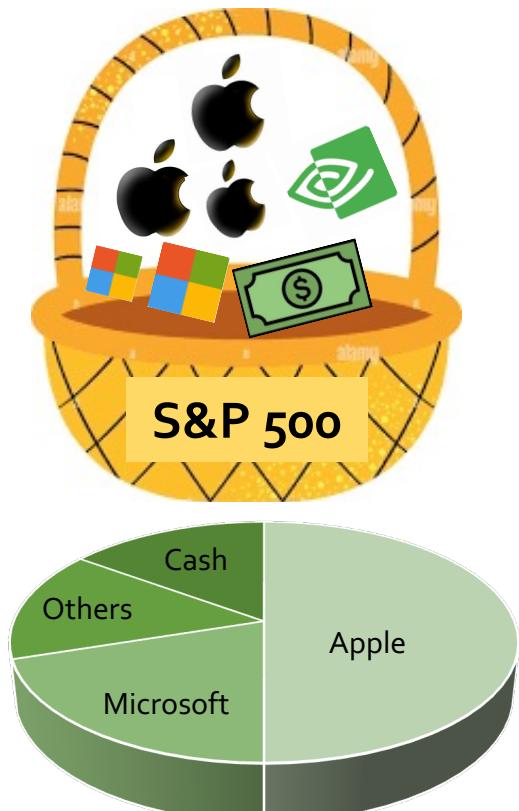


(2020)

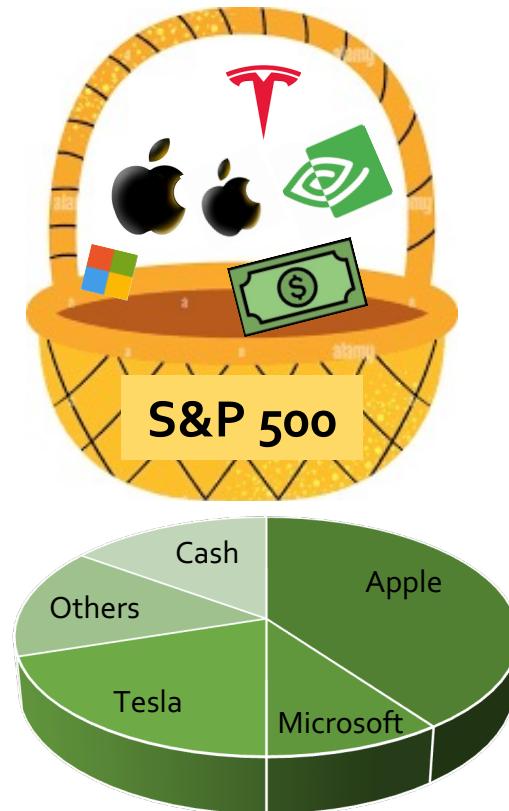
Increased demand  
for cloud service due  
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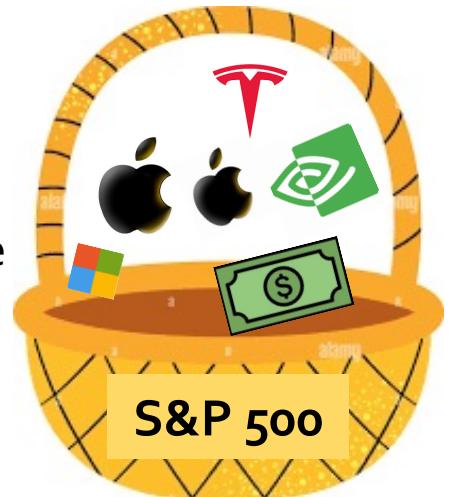
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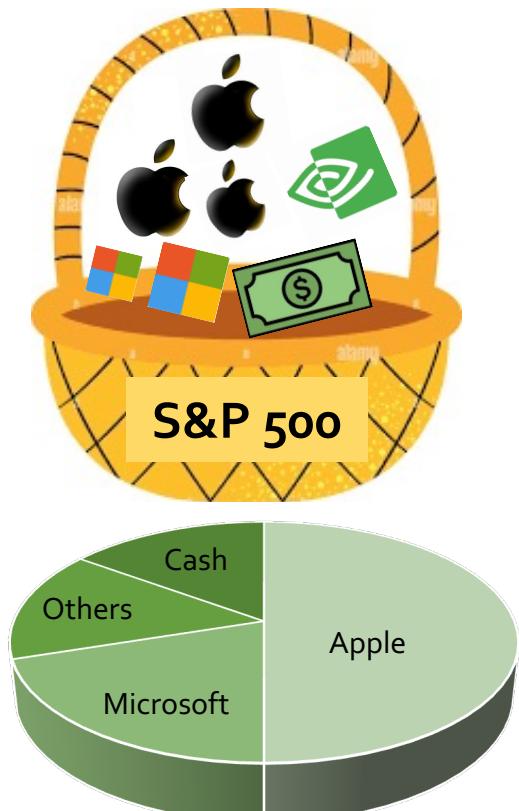


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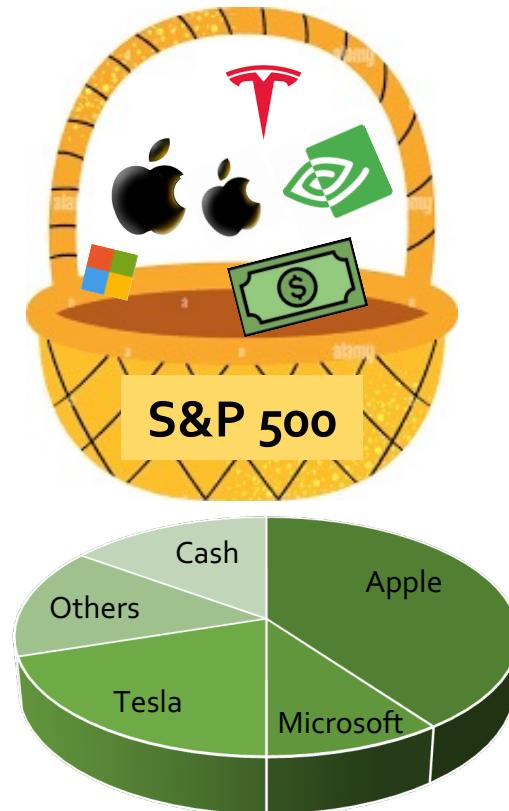


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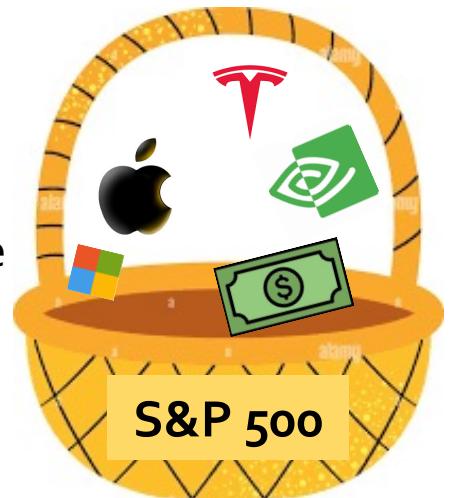
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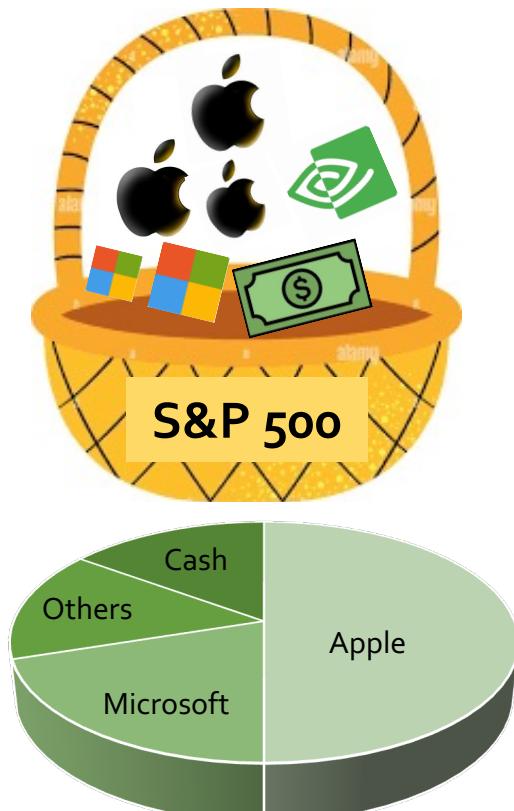


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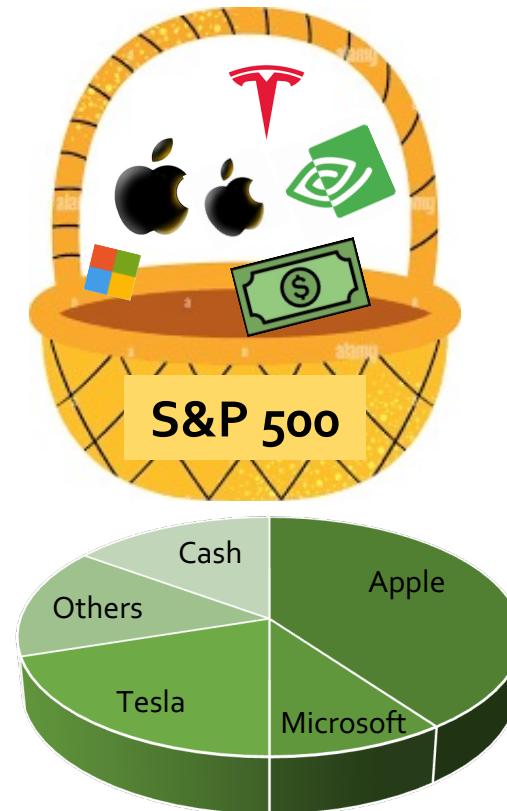


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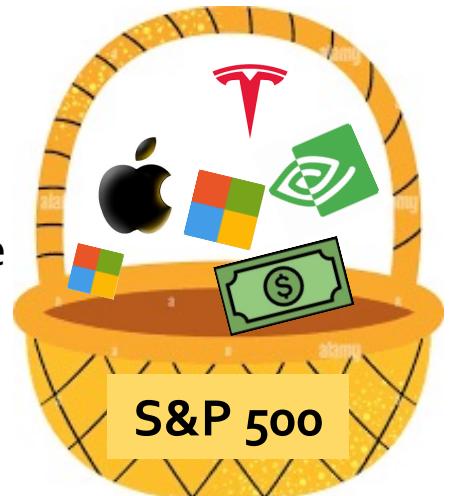
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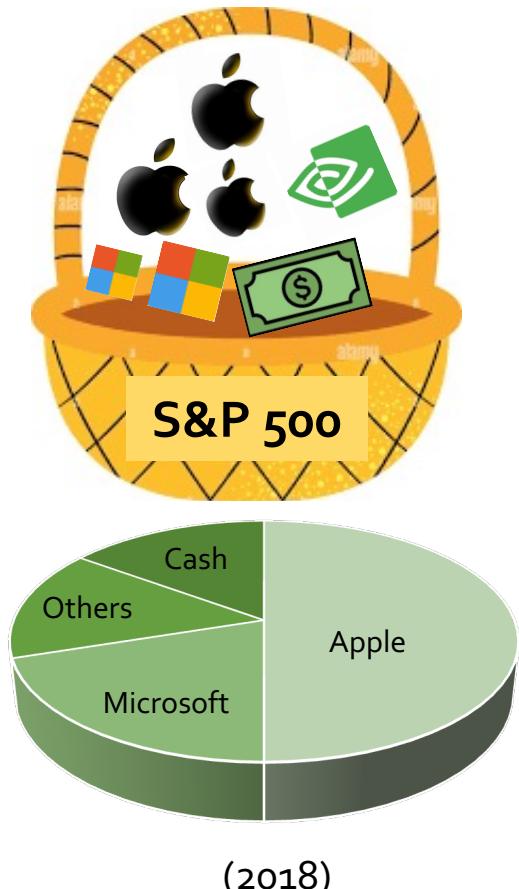


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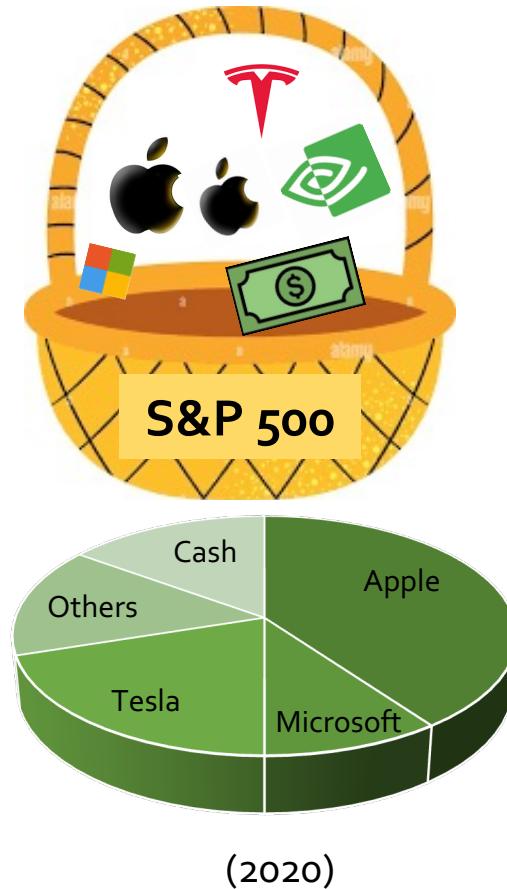


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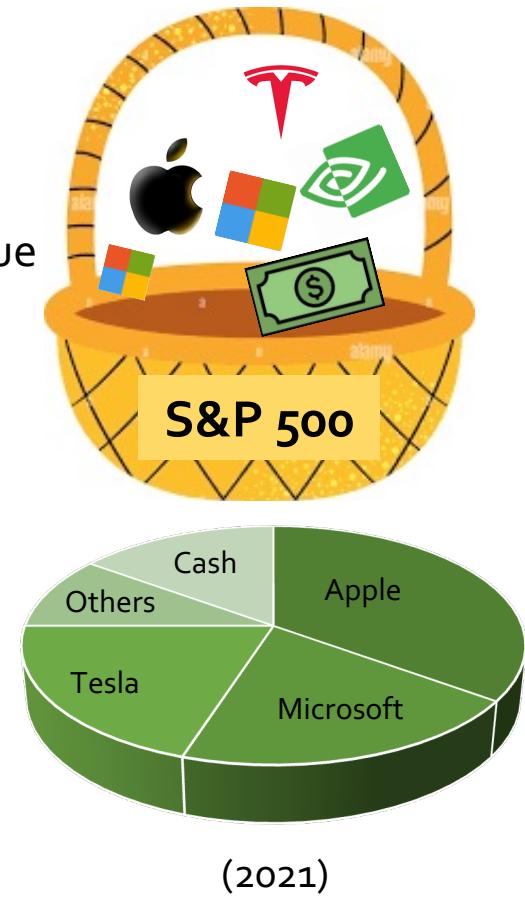
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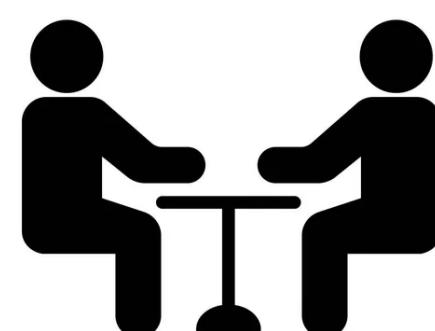


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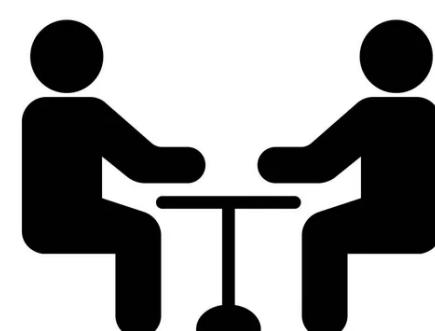


I bet a bullish market in the next month

I bet market will go down in the next month

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I bet a bullish market in the next month

+ 100 shares SPY @598.19  
(long)

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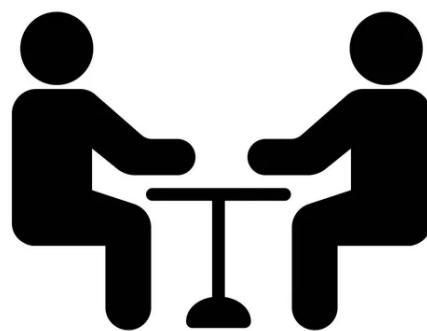
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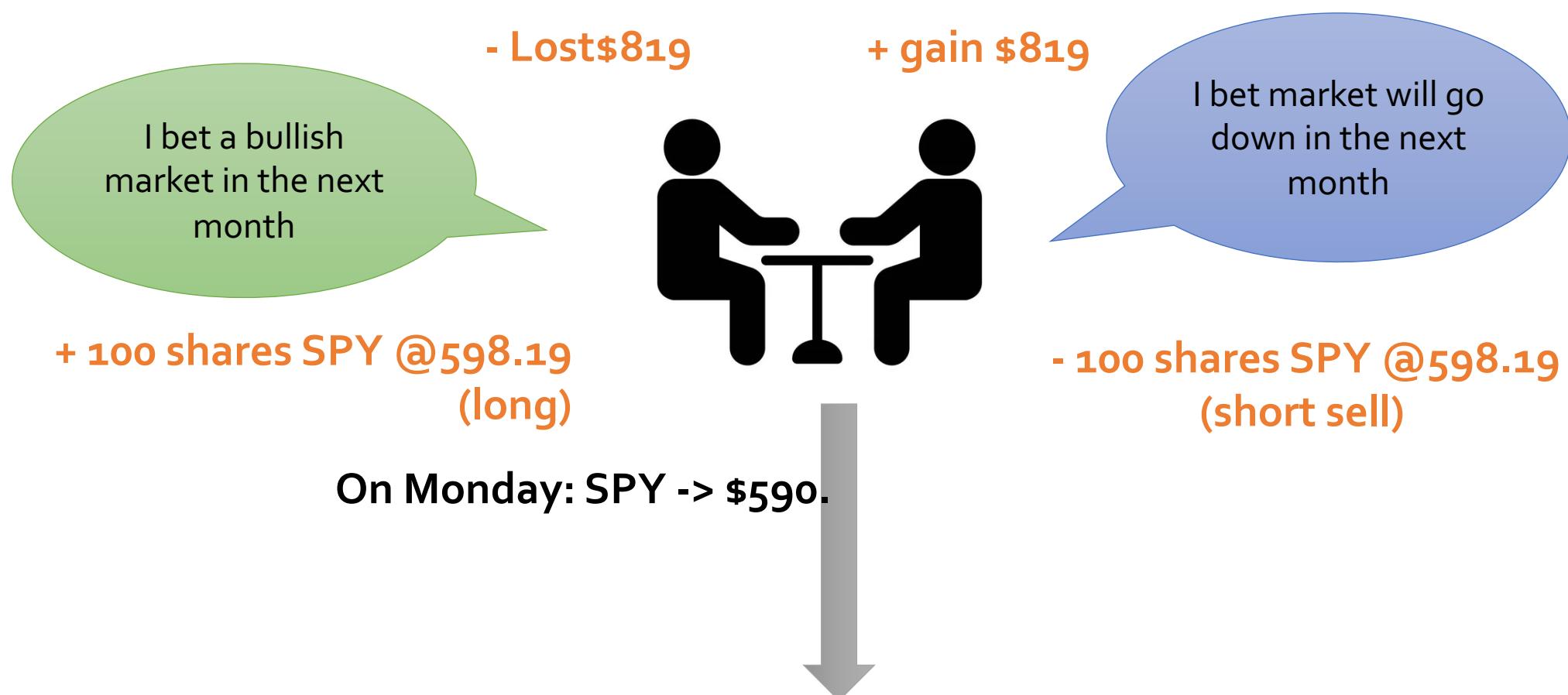
On Monday: SPY -> \$590.



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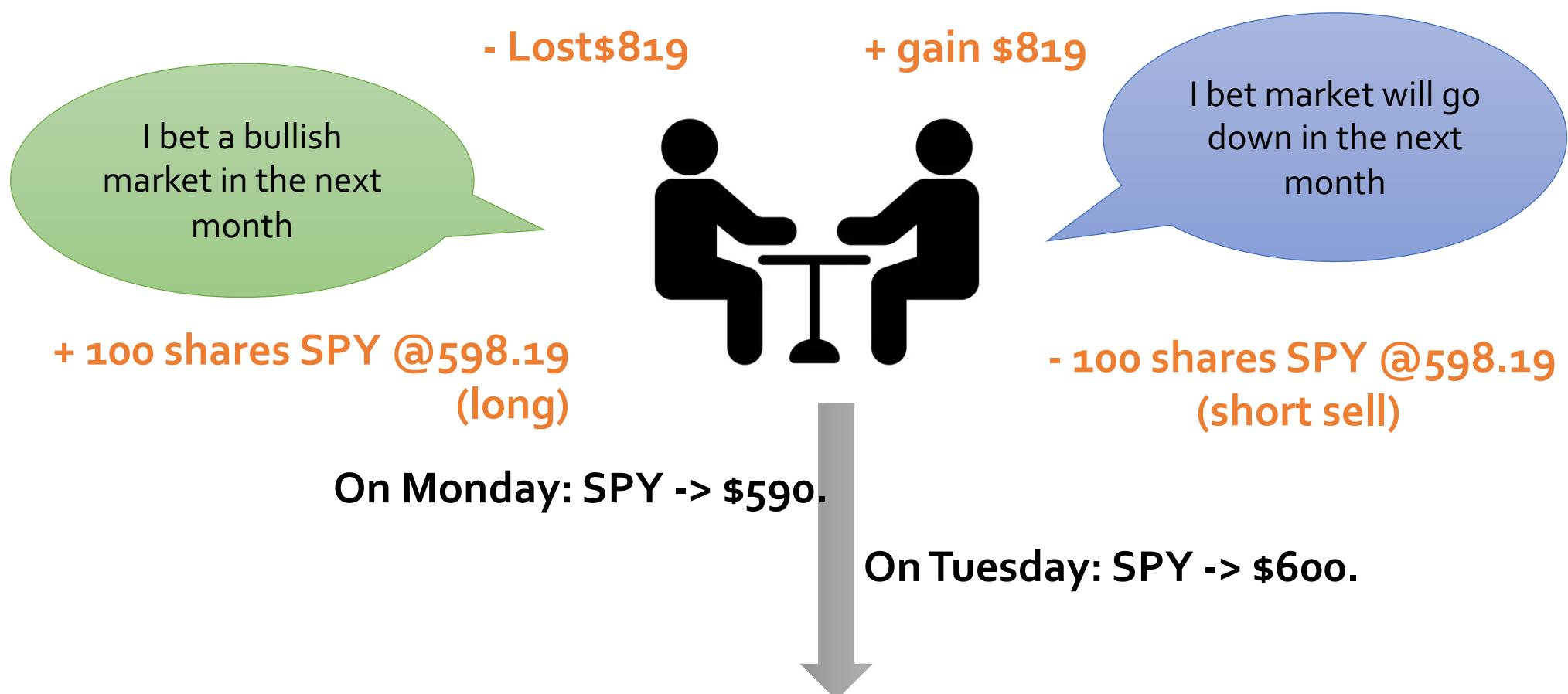
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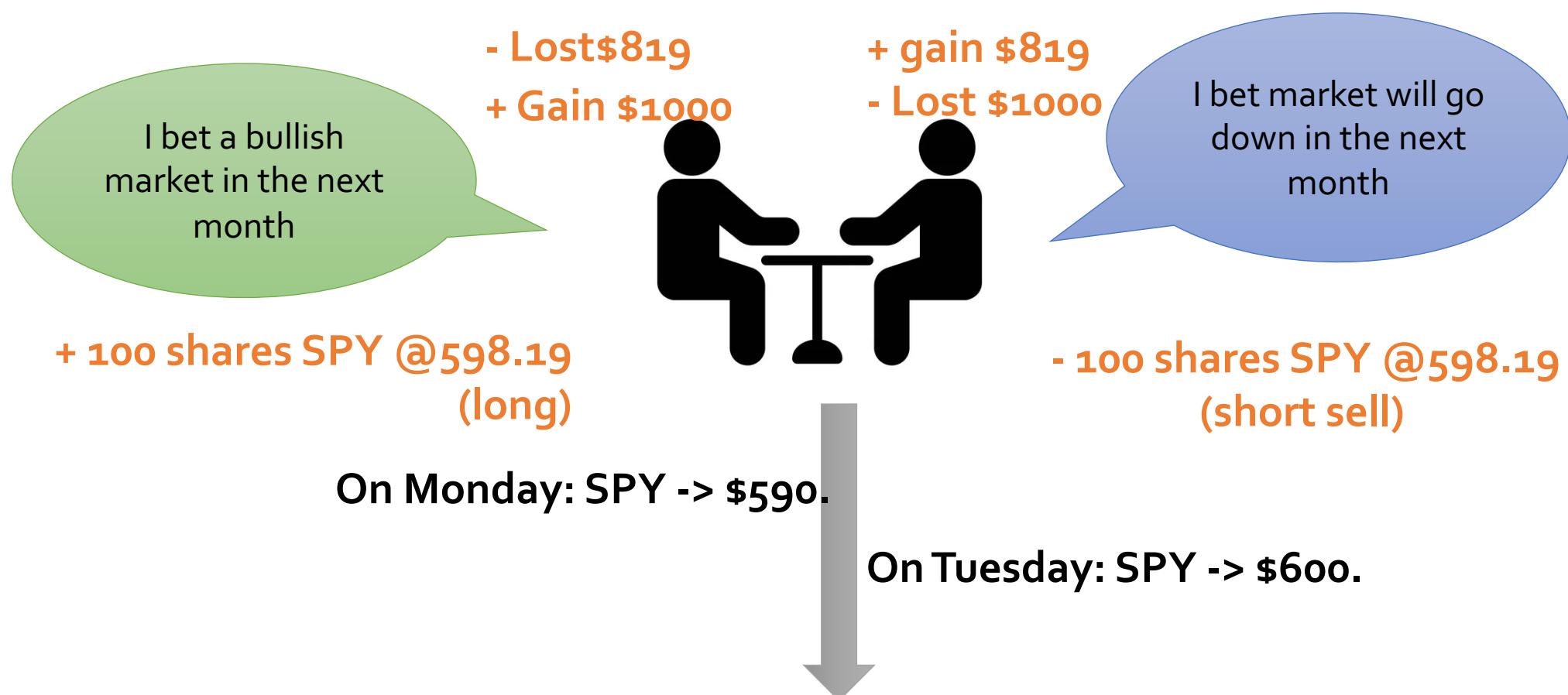
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Loan: \$80k



Buyer has \$20k

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Bought a house	\$100k	\$20k	0
Price up	\$120k (20%)	\$40k	\$20k (100%)
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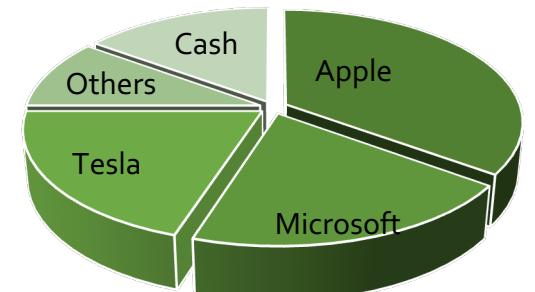
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- Margin Trading: Brokers act as banks and you can trade N times of your money
- What if go wrong? Margin Call ! Forced liquidation

# Portfolio Management

- To decide
  - Percentage of each assets
  - Long or Short
  - How to adjust and how frequent
  - Profit vs. risk
  - Handle margin



# Deep Reinforcement Learning For Portfolio Management

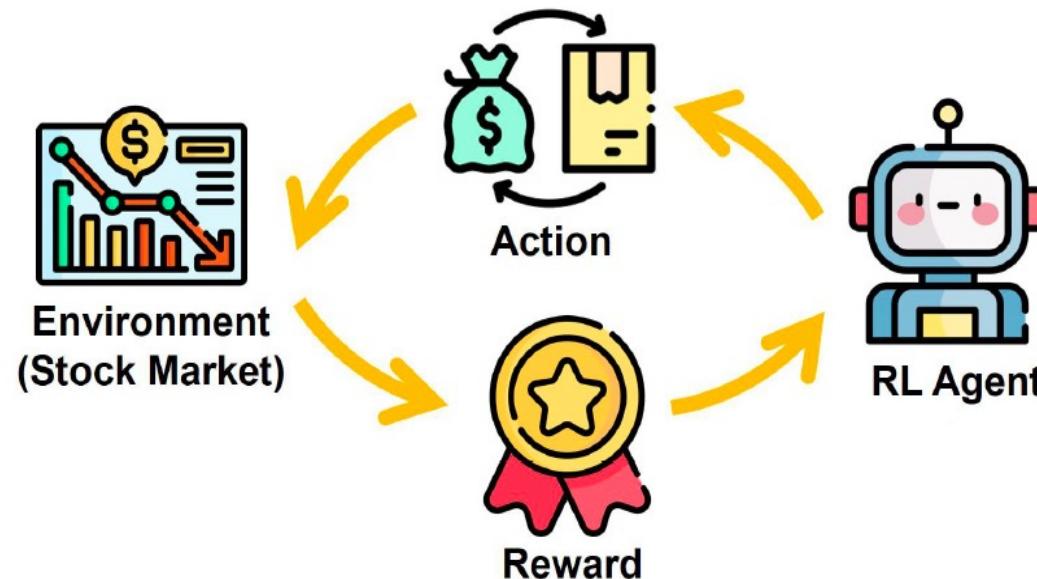
	#shares (before)	action	#shares (after)
AAPL	14	-3	9
MSFT	8	+2	10

## Market conditions

- prices of assets
- technical indicators

## Equity conditions:

- Long positions: available cash, loan, equity
- Short positions: available limit for short sale, credit balance, equity
- # holding shares



Actor-Critic algorithm

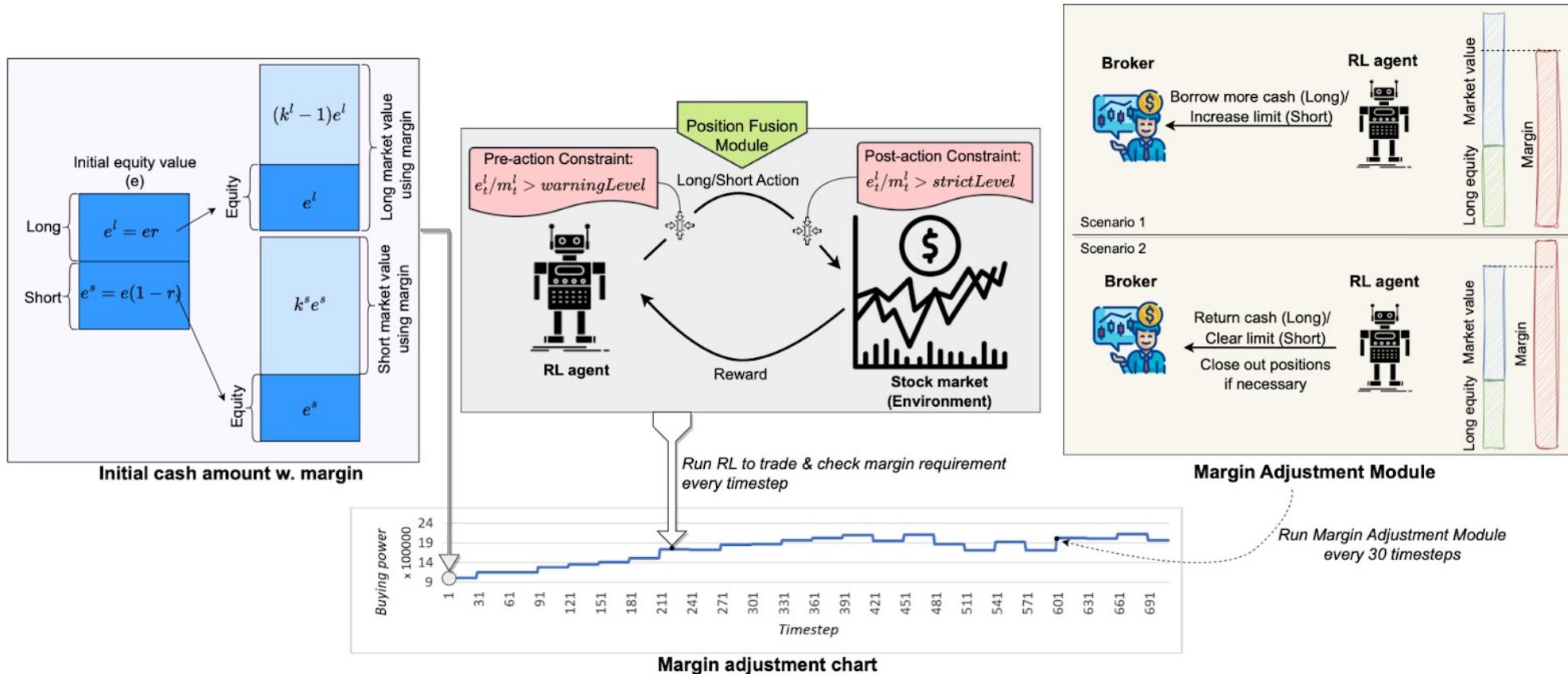
- A2C
- SAC
- PPO
- DDPG

## Profit and risk with shaping

- Profit: equity difference between two consecutive time steps
- Risk: Sharpe ratio, a risk-adjusted return metrics

# Margin Trader: a RL framework with margin accounts

A framework that incorporates margin with realistic constraints into portfolio management and build an RL framework for margin trading.



[1] Jingyi Gu, Wenlu Du, A M Muntasir Rahman, Guiling Wang. "Margin Trader: A Reinforcement Learning Framework for Portfolio Management with Margin and Constraints". 4<sup>th</sup> ACM International Conference on AI in Finance (ICAI-F23)

**Table 2: Numerical results of three agents (DJI, FinRL, and Margin Trader) and different position settings implemented by actor-critic algorithms. The best performance is marked in bold. The first four metrics are expressed as percentages.**

Agent	Model	Accumulated Return	Annual Return	Annual Volatility	Maximum Drawdown	Sharpe Ratio	Calmar Ratio
DJI		43.7%	12.9%	17.3%	-21.9%	0.790	0.587
FinRL (Long)	A2C	38.3%	11.5%	18.4%	-24.2%	0.684	0.474
	PPO	35.2%	10.6%	17.0%	<b>-13.9%</b>	0.680	0.764
	DDPG	60.6%	17.2%	18.4%	-23.4%	0.956	0.733
	SAC	54.4%	15.6%	18.2%	-19.5%	0.890	0.801
Margin Trader (Long & Short)	A2C	66.3%	18.5%	25.6%	-26.1%	0.793	0.710
	PPO	69.0%	19.2%	<b>16.3%</b>	18.2%	<b>1.160</b>	1.057
	DDPG	70.8%	20.9%	27.2%	-25.7%	0.835	0.812
	SAC	65.1%	18.3%	21.2%	-19.2%	0.901	0.950
Margin Trader (Long)	A2C	118.9%	30.0%	29.3%	-27.1%	1.044	1.106
	PPO	<b>123.4%</b>	<b>30.9%</b>	30.1%	-25.8%	1.046	<b>1.199</b>
	DDPG	110.0%	30.1%	30.7%	-32.9%	1.012	0.915
	SAC	113.4%	28.9%	29.4%	-31.5%	1.011	0.916

# The Allocation of Capital Value in Long/Short Matters

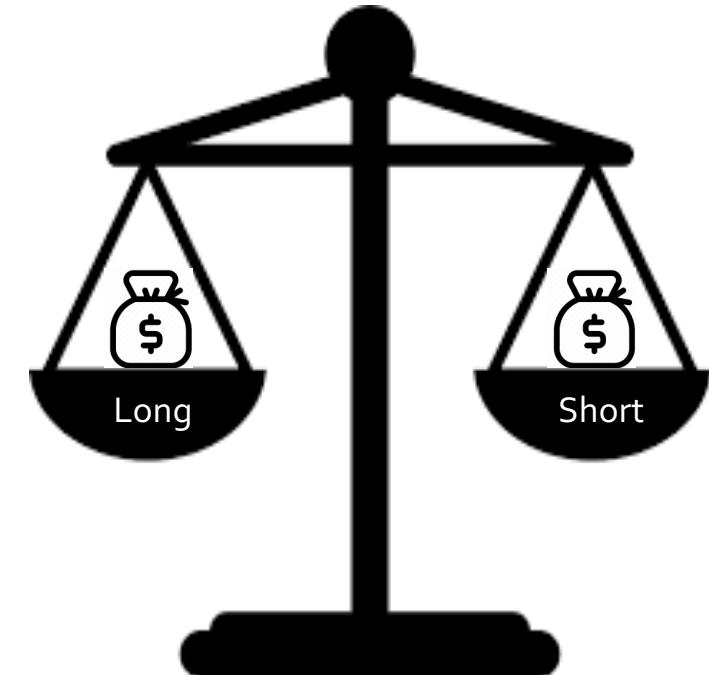
The allocation of capital value in long and short positions directly impacts both profit and risk under different market conditions

Existing works

- Assume short positions always maintain equal equity with long positions
- Simply allocate equity to both positions with fixed ratio at initialization, funds cannot be transferred between positions despite market changes
- Funds in long positions may not be fully invested on assets during volatile market, vice versa



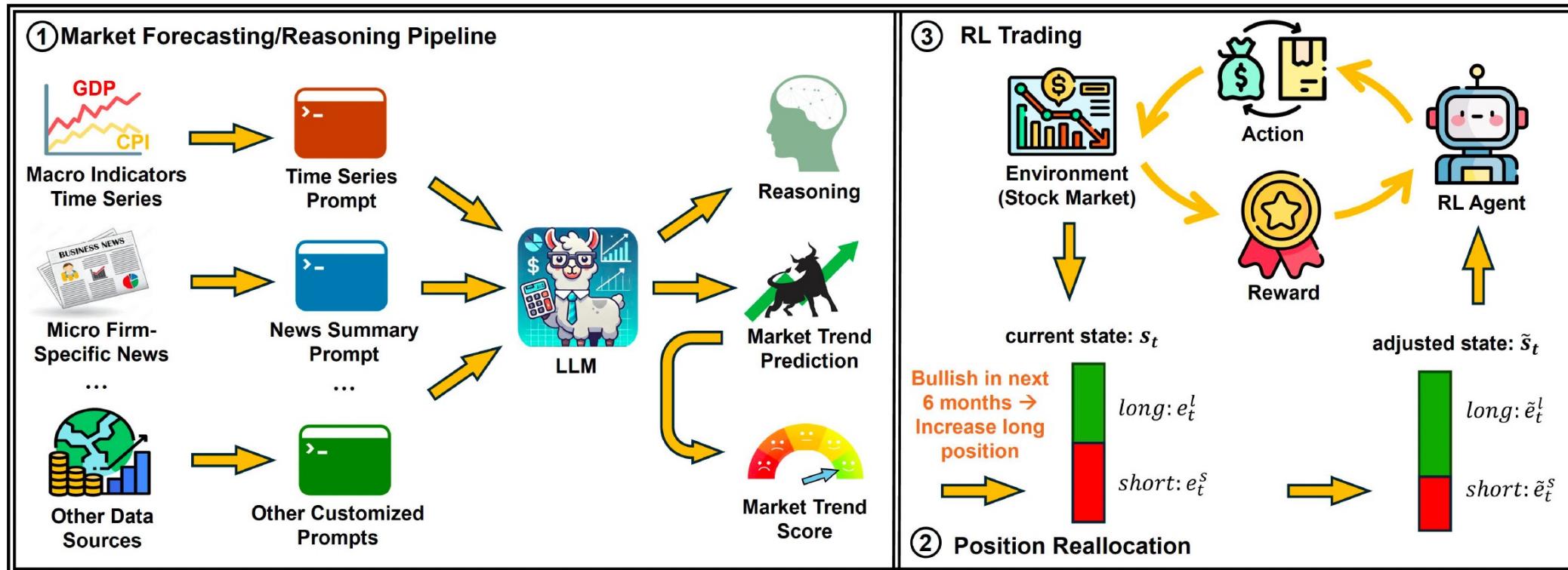
**Desired setting:** long-short position ratio *is adaptive to market conditions* and funds *can be transferred between positions* periodically.



# Solution: integrate LLM to decide long-short ratio

Design a **Plug-in LLM module** for **controlling the long-short ratio** in RL trading system.

1. **Market Trend Forecasting/Reasoning:** Use LLMs to analyze various data sources and forecast market trends with reasoning.
2. **Position Reallocation:** Adjust the long-short ratio based on the forecast and input it into the RL algorithm.
3. **RL Trading:** Regularly interact with the RL agent to execute trades. (**Fine-tuning is NOT required!**)



[1] Jingyi Gu, Junyi Ye, Guiling Wang, Wengpeng Yin. "Adaptive and Explainable Margin Trading via Large Language Models in Portfolio Management." Accepted by the 5<sup>th</sup> International Conference on AI in Finance (ICAIIF24)

# Explainable Market Forecasting/Reasoning Pipeline

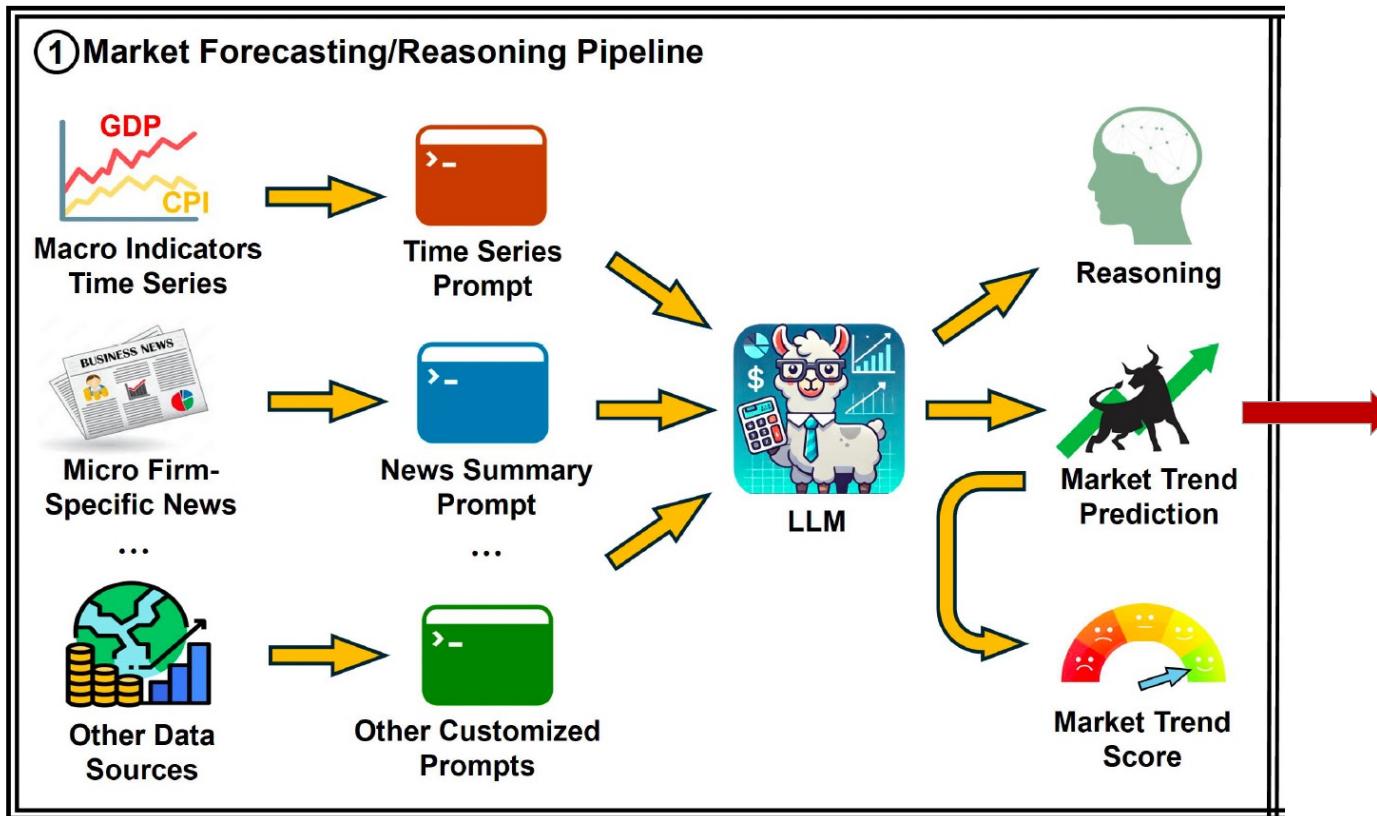


Table 1: The mapping between market sentiment and expected percentage change over the next 6 months. 6 out of 8 baseline LLMs agreed on this mapping. Phi-3 Medium and DeepSeek-V2 had more conservative ranges, e.g., Strongly Bullish was 10-20% and 15-20% respectively.

Market Sentiment	Expected Percentage Change
Strongly Bullish	Greater than +20%
Bullish	+10% to +20%
Slightly Bullish	+5% to +10%
Flat/Fluctuating	-5% to +5%
Slightly Bearish	-10% to -5%
Bearish	-20% to -10%
Strongly Bearish	Less than -20%

# 1. Explainable Pipeline on Firm-Specific News

Step 1: daily news aggregation on a monthly basis for each firm



Summarize the news for {American Express} ({AXP}) for the month of {April} {2020} in no more than 50 words. Focus on key events, announcements, or trends that could impact the future market performance of the company. Highlight any significant **financial results, product launches, management changes, regulatory news, and market sentiment**.

#### News Title, Content

"Here's Why **American Express** and Discover are Getting Hammered Today, , but Mastercard Isn't", "The difference in business models really comes into play when recessions arrive ..." "Here's Why Capital One, **Amex**, and Discover Were Falling on Friday", "The credit card stocks continue to take a beating in the coronavirus downturn ..." ...



In April 2020, American Express (AXP) faced **significant challenges** due to the **COVID-19 pandemic**, reporting a **76% drop** in Q1 profit and setting aside **\$2.6 billion for potential losses**. Despite **beating profit expectations, revenue fell short**. The company announced a **\$3 billion spending cut** to navigate the economic downturn.

#### Stocks



Apple

Daily  
News



July 1



July 2



July 31

...

Monthly  
News



Summary  
within 50 words

Step 2: summarization to fit LLM context limits (4k tokens)

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⋮  
⋮



TESLA



Microsoft

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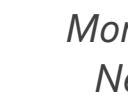


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Monthly  
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Monthly  
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Given the following stock news summaries for each company in the DJIA 30:

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...  
In April 2020, Apple Inc. (AAPL) acquired weather app Dark Sky, **launched a new budget iPhone SE**... The company also reported **Q2 earnings** with a **slight revenue increase** despite **COVID-19 impacts**...

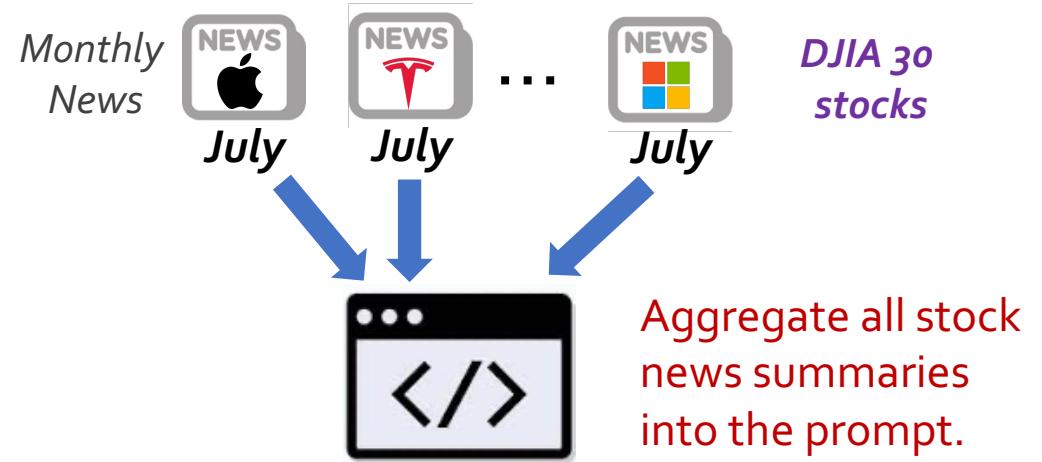
...  
Please predict the overall trend of the next half year's DJIA 30 index.  
Only output: **Strongly Bullish, Bullish, Slightly Bullish, Flat, Fluctuating, Slightly Bearish, Bearish, Strongly Bearish**

Simple explanation:



**Slightly Bearish**

Simple explanation: The DJIA 30 companies faced significant challenges due to the **COVID-19 pandemic**, including **profit drops, revenue shortfalls, and operational disruptions**. While some companies showed **resilience** and **growth potential**, the overall sentiment was cautious with many withdrawing guidance and implementing cost-cutting measures. The mixed performance and **uncertainties** suggest a **slightly bearish** trend for the next half year.



Step 3: fine-grained market trend prediction

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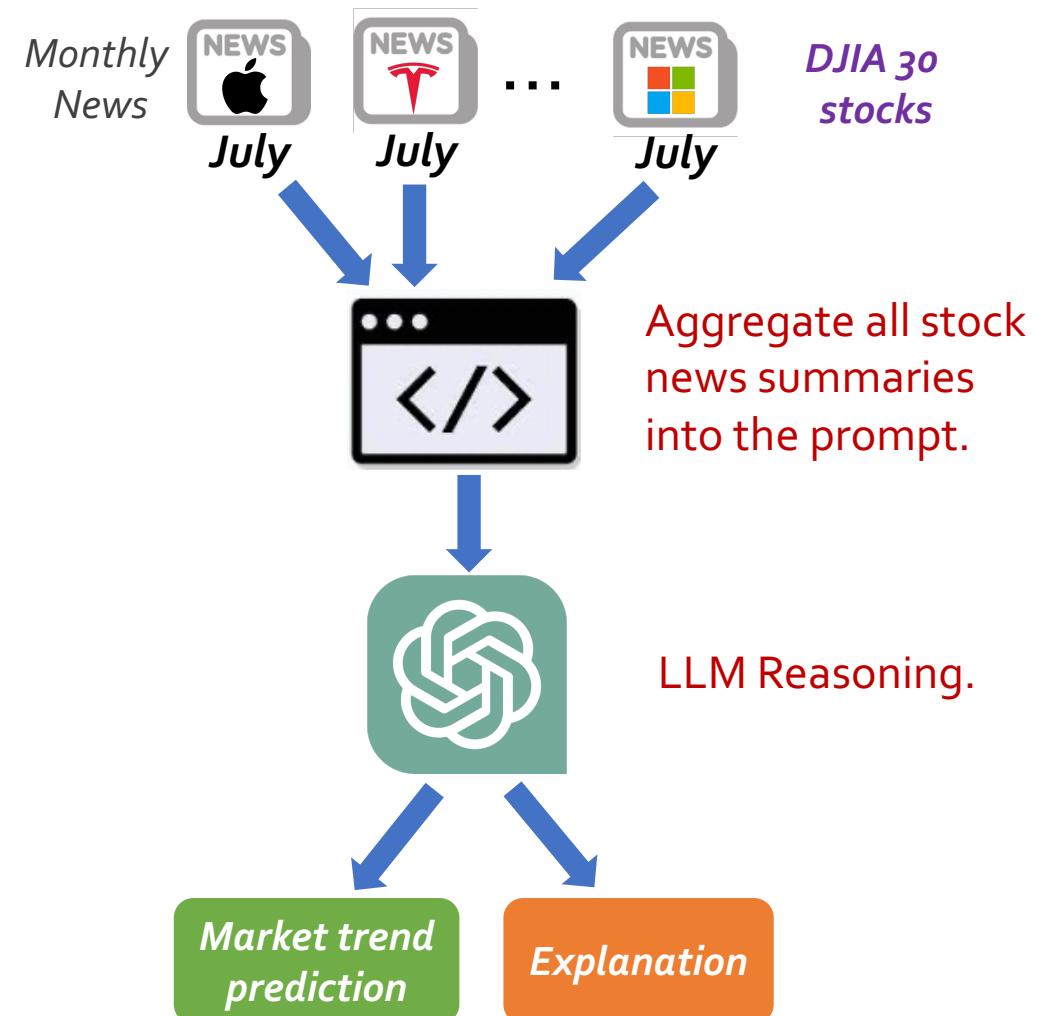
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## 2. Explainable Market Forecasting/Reasoning on Time Series



Given the following macroeconomics indicators' definitions:

1. Gross Domestic Product (GDP): ...
2. Unemployment Rate: ...
- ...

Given the macroeconomic indicators of the past six months below:

Date, GDP, Unemployment Rate, Inflation Rate, CPI,...

2019-11-01, 7300.8, 3.6, 2.1, 257.88...

2019-12-01, 7300.8, 3.6, 2.3, 258.63...

...

Please predict the overall trend of the next half year's DJIA 30 index.

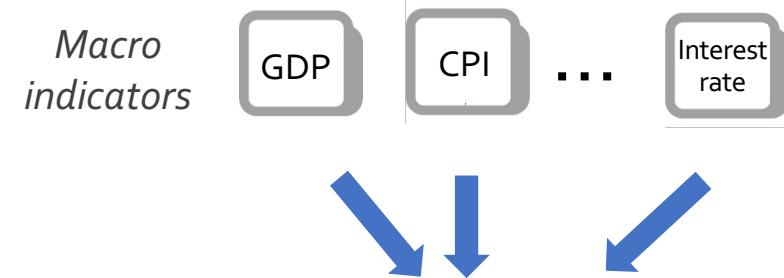
Only output: **Strongly Bullish, Bullish, Slightly Bullish, Flat, Fluctuating, Slightly Bearish, Bearish, Strongly Bearish**

Simple explanation:



**Strongly Bearish**

Simple explanation: The **significant drop in GDP**, a **sharp increase in the unemployment rate**, and a **dramatic decrease in the inflation rate and industrial production** indicate **severe economic distress**. Additionally, the **federal deficit has increased substantially**, and **retail sales have plummeted**, suggesting **reduced consumer spending**. These factors collectively point to a **strongly bearish** outlook for the DJIA 30 index in the next half year.



**Figure 2: Sample prompt during COVID-19 pandemic and GPT-4o response for predicting the overall trend of the DJIA 30 index based on macroeconomic indicator time series.**

## 2. Explainable Market Forecasting/Reasoning on Time Series



Given the following macroeconomics indicators' definitions:

1. Gross Domestic Product (GDP): ...
2. Unemployment Rate: ...
- ...

Given the macroeconomic indicators of the past six months below:

Date, GDP, Unemployment Rate, Inflation Rate, CPI,...

2019-11-01, 7300.8, 3.6, 2.1, 257.88...

2019-12-01, 7300.8, 3.6, 2.3, 258.63...

...

Please predict the overall trend of the next half year's DJIA 30 index.

Only output: **Strongly Bullish, Bullish, Slightly Bullish, Flat, Fluctuating, Slightly Bearish, Bearish, Strongly Bearish**

Simple explanation:



**Strongly Bearish**

Simple explanation: The **significant drop in GDP**, a **sharp increase in the unemployment rate**, and a **dramatic decrease in the inflation rate and industrial production** indicate **severe economic distress**. Additionally, the **federal deficit has increased substantially**, and **retail sales have plummeted**, suggesting **reduced consumer spending**. These factors collectively point to a **strongly bearish** outlook for the DJIA 30 index in the next half year.



LLM Reasoning.

Market trend prediction

Explanation

Figure 2: Sample prompt during COVID-19 pandemic and GPT-4o response for predicting the overall trend of the DJIA 30 index based on macroeconomic indicator time series.

# Interaction with RL agent

LLM interacts with RL process every k steps

## RL formulation (Margin Trader as backbone)

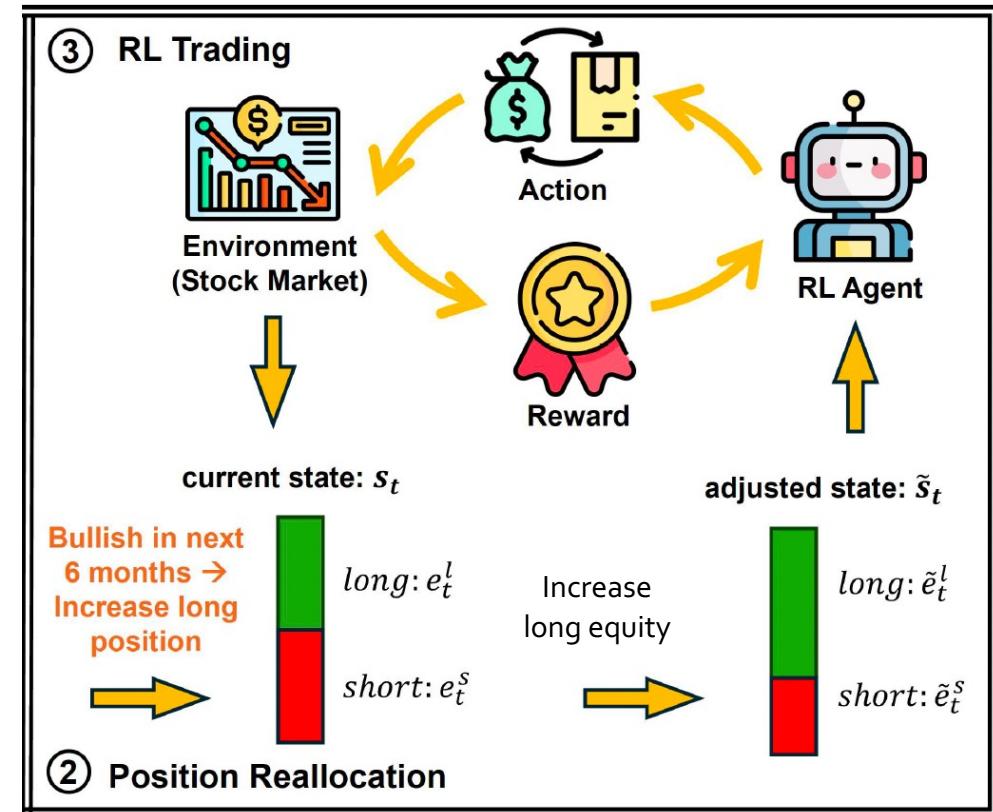
### State:

- Market conditions: close prices of assets, technical indicators
- Equity conditions on long and short positions separately: # holding shares

Action: # shares to trade for each stock

Reward: Sharpe ratio, a risk-adjusted return metrics

Position allocation: implemented through margin adjustment module of margin trader



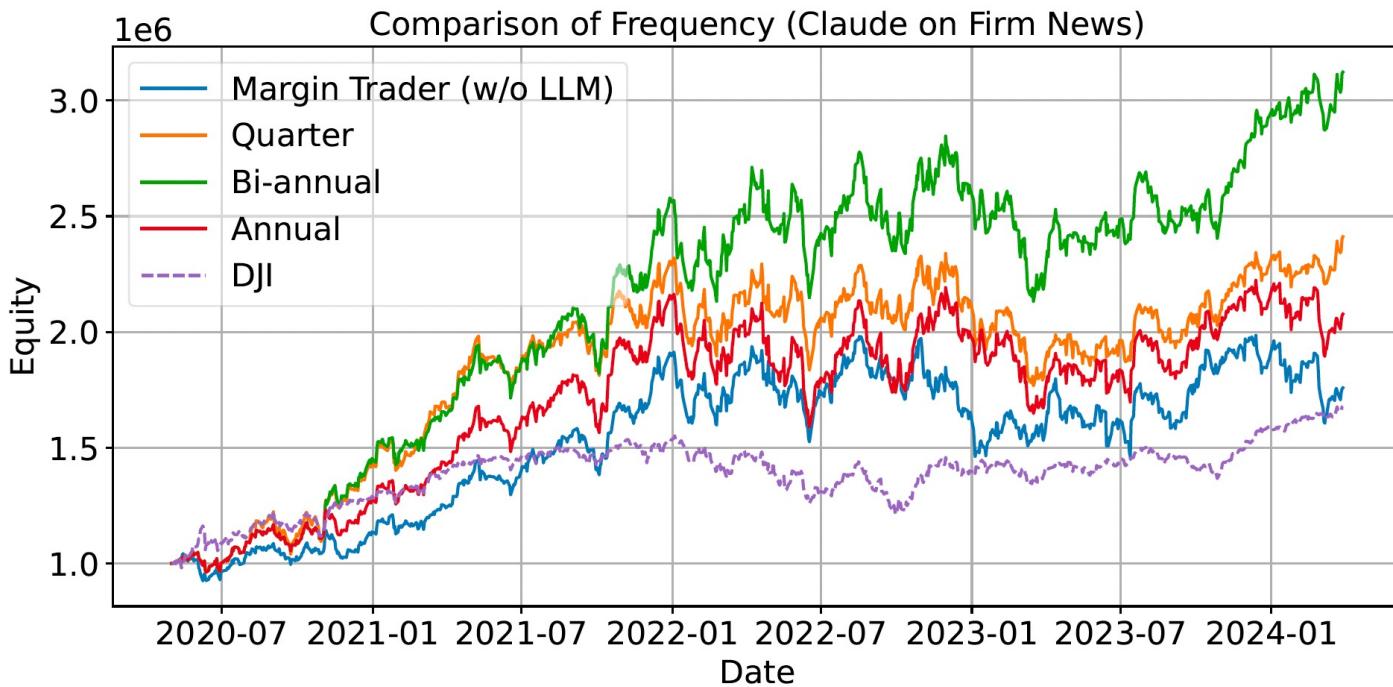
Proportional adjustment with ratio bound mitigate risks of overreacting to market fluctuation and facilitates smoother transitions between positions

# Portfolio Performance

**Table 2: Portfolio management results.** FinBERT and FinGPT, as sentiment analysis models, are unsuitable for macro time series data. FinGPT produces gibberish or multiple outputs with multiple news inputs, making it unsuitable for firm news data.

Model	Scaling factor=10%						Scaling factor=20%					
	Macro Indicator			Firm News			Macro Indicator			Firm News		
	AR(%)	SR	CR	AR(%)	SR	CR	AR(%)	SR	CR	AR(%)	SR	CR
DJI	67.795	0.917	0.646	-	-	-	-	-	-	-	-	-
Margin Trader	75.834	0.673	0.592	-	-	-	-	-	-	-	-	-
FinBERT	-	-	-	55.004	0.558	0.467	-	-	-	-15.561	-0.022	-0.112
FinGPT v3.3	-	-	-	-	-	-	-	-	-	-	-	-
GPT-4o	163.643	1.140	1.077	<b>205.197</b>	<b>1.199</b>	<b>1.353</b>	128.512	1.014	0.657	<b>243.852</b>	<b>1.314</b>	<b>1.508</b>
Claude-3.5 Sonnet	178.530	1.174	1.237	143.189	1.019	0.996	<b>198.117</b>	<b>1.252</b>	<b>1.604</b>	212.229	1.269	1.350
Qwen2 72B	<b>198.623</b>	<b>1.198</b>	<b>1.311</b>	175.395	1.140	1.266	194.996	1.170	1.270	193.232	1.173	1.377
Llama-3 70B	161.010	1.066	1.139	160.060	1.037	1.134	191.449	1.189	1.277	196.969	1.164	1.303
Mixtral 8x22B	160.060	1.037	1.134	160.060	1.037	1.134	196.969	1.164	1.303	196.969	1.164	1.303
DeepSeek-V2	170.553	1.111	1.187	112.173	0.894	0.812	163.889	1.111	1.143	123.893	0.969	0.639
Phi-3 Medium	164.705	1.139	1.192	106.022	0.900	0.920	182.110	1.224	1.494	106.022	0.900	0.920
Yi 34B	160.060	1.037	1.134	82.699	0.724	0.647	196.969	1.164	1.303	82.699	0.724	0.647

# Frequency Analysis.



- Frequent (quarterly) adjustment introduces higher volatility to portfolios
- Infrequent (annually) one misses out on opportunities to capitalize on timely market movements

**Important to find a reasonable frequency for optimal portfolio performance**