

# Forecasting stock or index prices with option volatility smirks and technical analysis

Group 6





# Agenda

- Introduction
- Dataset
- Skew Factors
- Technical Analysis
- Regression Analysis & Prediction
- Conclusion

# Introduction

- Use the Skew and Technical Analysis method for the data
- Regression and Hypothesis test
- Analysis results and compare different underlying
- Make decisions based on the result

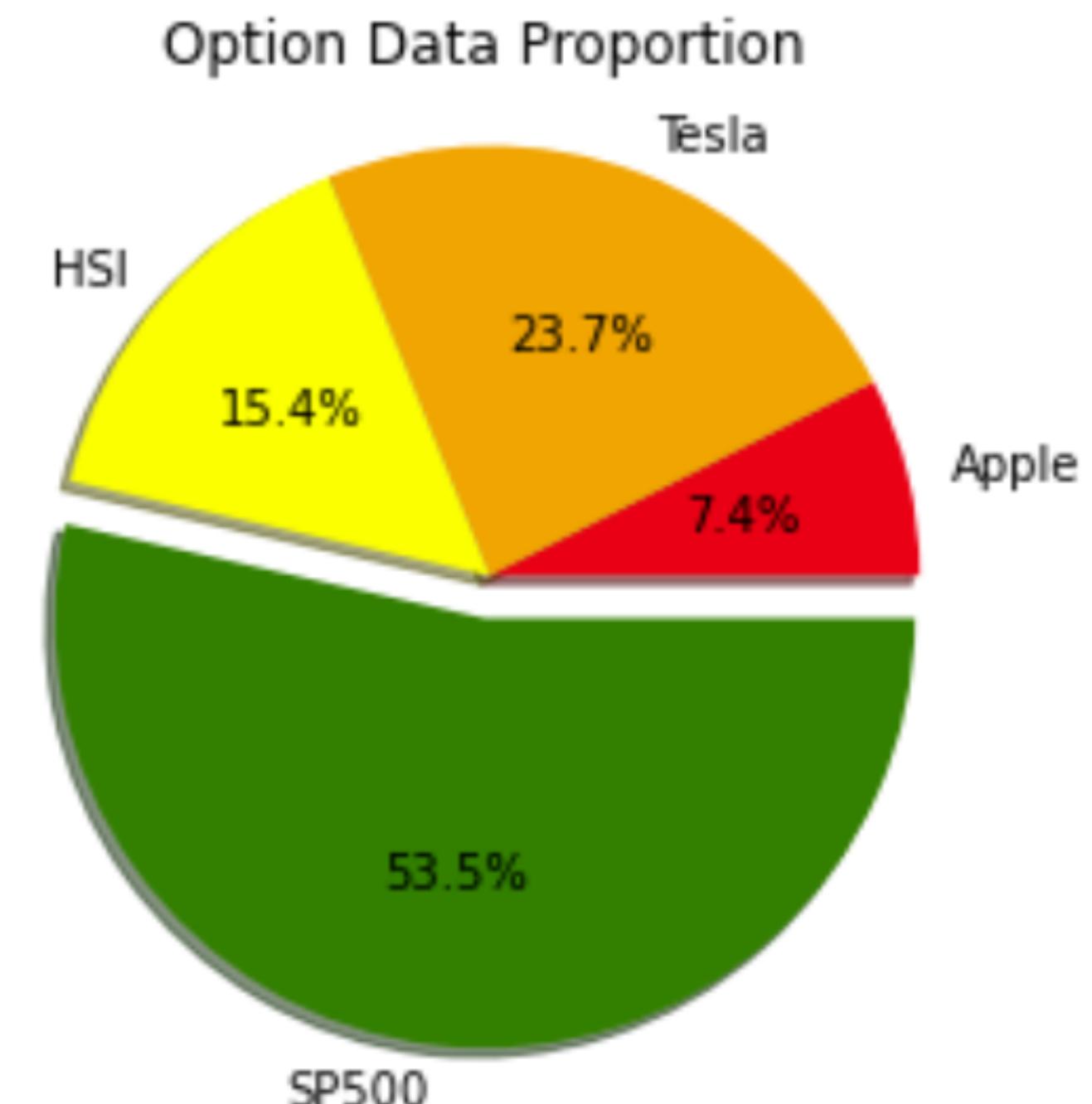
# Dataset

We choose the stock and options of the following companies and indexes

- Apple
- Tesla
- HSI
- SP500

Data Source

- Yahoo Finance
- Optionsdx
- Given HSI dataset



# Dataset

- Time period: From 2020.01 to 2021.12
- Size: Contain nearly 7 million data
- Maturity, Bid, Strike...

## Option

X.QUOTE_UNIXTIME. <int>	X.QUOTE_READTIME. <chr>	X.QUOTE_DATE. <chr>	X.QUOTE_TIME_HOURS. <dbl>	X.UNDERLYING_LAST. <dbl>	X.EXPIRE_DATE. <chr>
1577998800	2020-01-02 16:00	2020-01-02	16	300.35	2020-01-03
1577998800	2020-01-02 16:00	2020-01-02	16	300.35	2020-01-03
1577998800	2020-01-02 16:00	2020-01-02	16	300.35	2020-01-03
1577998800	2020-01-02 16:00	2020-01-02	16	300.35	2020-01-03
1577998800	2020-01-02 16:00	2020-01-02	16	300.35	2020-01-03
1577998800	2020-01-02 16:00	2020-01-02	16	300.35	2020-01-03
1577998800	2020-01-02 16:00	2020-01-02	16	300.35	2020-01-03
1577998800	2020-01-02 16:00	2020-01-02	16	300.35	2020-01-03
1577998800	2020-01-02 16:00	2020-01-02	16	300.35	2020-01-03
1577998800	2020-01-02 16:00	2020-01-02	16	300.35	2020-01-03
1577998800	2020-01-02 16:00	2020-01-02	16	300.35	2020-01-03
1577998800	2020-01-02 16:00	2020-01-02	16	300.35	2020-01-03
1577998800	2020-01-02 16:00	2020-01-02	16	300.35	2020-01-03

A tibble: 504 x 7

Date <chr>	Open <dbl>	High <dbl>	Low <dbl>	Close <dbl>	Adj.Close <dbl>	Volume <int>
2020-01-02	74.0600	75.1500	73.7975	75.0875	73.56155	135480400
2020-01-03	74.2875	75.1450	74.1250	74.3575	72.84636	146322800
2020-01-06	73.4475	74.9900	73.1875	74.9500	73.42683	118387200
2020-01-07	74.9600	75.2250	74.3700	74.5975	73.08150	108872000
2020-01-08	74.2900	76.1100	74.2900	75.7975	74.25710	132079200
2020-01-09	76.8100	77.6075	76.5500	77.4075	75.83439	170108400
2020-01-10	77.6500	78.1675	77.0625	77.5825	76.00582	140644800
2020-01-13	77.9100	79.2675	77.7875	79.2400	77.62965	121532000
2020-01-14	79.1750	79.3925	78.0425	78.1700	76.58139	161954400
2020-01-15	77.9625	78.8750	77.3875	77.8350	76.25319	121923600

## Stock

# HSI Options Data

A tibble: 1,098,101 × 11

Date	Series	Market	MarketName	Commodity	CommodityName	CurrencyCode	▶
<date>	<chr>	<chr>	<chr>	<chr>	<chr>	<chr>	
2020-01-02	HSIF0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	
2020-01-02	HSI20400A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	
2020-01-02	HSI20600A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	
2020-01-02	HSI20800A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	
2020-01-02	HSI21000A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	
2020-01-02	HSI21200A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	
2020-01-02	HSI21400A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	
2020-01-02	HSI21600A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	
2020-01-02	HSI21800A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	
2020-01-02	HSI22000A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	

1-10 of 1,098,101 rows | 1-7 of 11 columns

Previous [1](#) 2 3 4 5 6 ... 100 Next

Date	Series	Market	MarketName	Commodity	CommodityName	CurrencyCode	SettlementPrice	PreviousSettlementPrice	Difference	Impliedvolatility
<date>	<chr>	<chr>	<chr>	<chr>	<chr>	<chr>				
2020-01-02	HSIF0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	28606	28270	336	NA
2020-01-02	HSI21000A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	7611	7271	340	43.6811
2020-01-02	HSI22600A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	6007	5672	335	29.0455
2020-01-02	HSI22800A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	5807	5473	334	28.0442
2020-01-02	HSI23000A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	5607	5273	334	27.0494
2020-01-02	HSI29200A0W03	WK1	WEEKLY HANG SENG INDEX OPTIONS	HSI	HANG SENG INDEX	HKD	1	1	0	18.9963
2020-01-02	HSI29200A0W10	WK1	WEEKLY HANG SENG INDEX OPTIONS	HSI	HANG SENG INDEX	HKD	44	24	20	14.1587
2020-01-02	HSI29400A0W10	WK1	WEEKLY HANG SENG INDEX OPTIONS	HSI	HANG SENG INDEX	HKD	23	13	10	14.2431

# Series

- HANG SENG FURURES & OPTIONS

Description: df [891,507 × 7]

Date <date>	Series <chr>	MarketName <chr>
2020-01-23	HSIF0	HANG SENG FUTURES & OPTIONS
2020-01-23	HSI20400A0	HANG SENG FUTURES & OPTIONS
2020-01-23	HSI20600A0	HANG SENG FUTURES & OPTIONS
2020-01-23	HSI20800A0	HANG SENG FUTURES & OPTIONS
2020-01-23	HSI21000A0	HANG SENG FUTURES & OPTIONS
2020-01-23	HSI21200A0	HANG SENG FUTURES & OPTIONS
2020-01-23	HSI21400A0	HANG SENG FUTURES & OPTIONS
2020-01-23	HSI21600A0	HANG SENG FUTURES & OPTIONS
2020-01-23	HSI21800A0	HANG SENG FUTURES & OPTIONS
2020-01-23	HS 22000A0	HANG SENG FUTURES & OPTIONS

1-10 of 891,507 rows | 1-6 of 7 columns

strike price

期貨月份代碼	代表月份	認購 Call	認沽 Put	期權月份代碼
F	1	A	M	
G	2	B	N	
H	3	C	O	
J	4	D	P	
K	5	E	Q	
M	6	F	R	
N	7	G	S	
Q	8	H	T	
U	9	I	U	
V	10	J	V	
X	11	K	W	
Z	12	L	X	

# Series

- WEEKLY HANG SENG INDEX OPTIONS

Date <date>	Series <chr>	MarketName <chr>			
2020-01-23	HSIF0W24	WEEKLY HANG SENG INDEX OPTIONS			
2020-01-23	HSIF0W31	WEEKLY HANG SENG INDEX OPTIONS			
2020-01-23	HSI25200A0W24	WEEKLY HANG SENG INDEX OPTIONS			
2020-01-23	HSI25200A0W31	WEEKLY HANG SENG INDEX OPTIONS			
2020-01-23	HSI25400A0W24	WEEKLY HANG SENG INDEX OPTIONS			
2020-01-23	HSI25400A0W31	WEEKLY HANG SENG INDEX OPTIONS			
2020-01-23	HSI25600A0W24	WEEKLY HANG SENG INDEX OPTIONS			
2020-01-23	HSI25600A0W31	WEEKLY HANG SENG INDEX OPTIONS			
2020-01-23	HSI25800A0W24	WEEKLY HANG SENG INDEX OPTIONS			
2020-01-23	HSI25800A0W31	WEEKLY HANG SENG INDEX OPTIONS			

1-10 of 123,932 rows | 1-5 of 6 columns

maturity date

# OTM Put & ATM Call

$$\boxed{\phantom{0}} \leq \text{Ratio} = \frac{\text{Strike Price}}{\text{Stock Price}} \leq \boxed{\phantom{0}}$$

Date	Series
<date>	<chr>
2020-01-23	HSI26000A0W24
2020-01-23	HSI26000A0W31
2020-01-23	HS <span style="border: 2px solid red;">26200A0W24</span>

→ strike price

Date	Open	High	Low	Close	Adj.Close
2020-01-23	27909.1	27909.1	27909.1	27909.1	27909.1
2020-01-24	27949.6	27949.6	27949.6	27949.6	27949.6
2020-01-29	27160.6	27160.6	27160.6	27160.6	27160.6

→ stock price

```
cat(sigma_TSLA)
```

```
## 0.04675678
```

OTM Put: (0.6, 0.8)  
ATM Call: (0.8, 1.2)

```
cat(sigma_AAPL)
```

```
## 0.02362969
```

OTM Put: (0.8, 0.9)  
ATM Call: (0.9, 1.1)

```
cat(sigma_SPX)
```

```
## 0.01652697
```

OTM Put: (0.8, 0.95)  
ATM Call: (0.95, 1.05)

```
cat(sigma_HSI)
```

```
## 0.01375497
```

OTM Put: (0.8, 0.95)  
ATM Call: (0.95, 1.05)

# Skew

JOURNAL OF FINANCIAL AND QUANTITATIVE ANALYSIS Vol. 45, No. 3, June 2010, pp. 641–662  
COPYRIGHT 2010, MICHAEL G. FOSTER SCHOOL OF BUSINESS, UNIVERSITY OF WASHINGTON, SEATTLE, WA 98195  
doi:10.1017/S0022109010000220

## What Does the Individual Option Volatility Smirk Tell Us About Future Equity Returns?

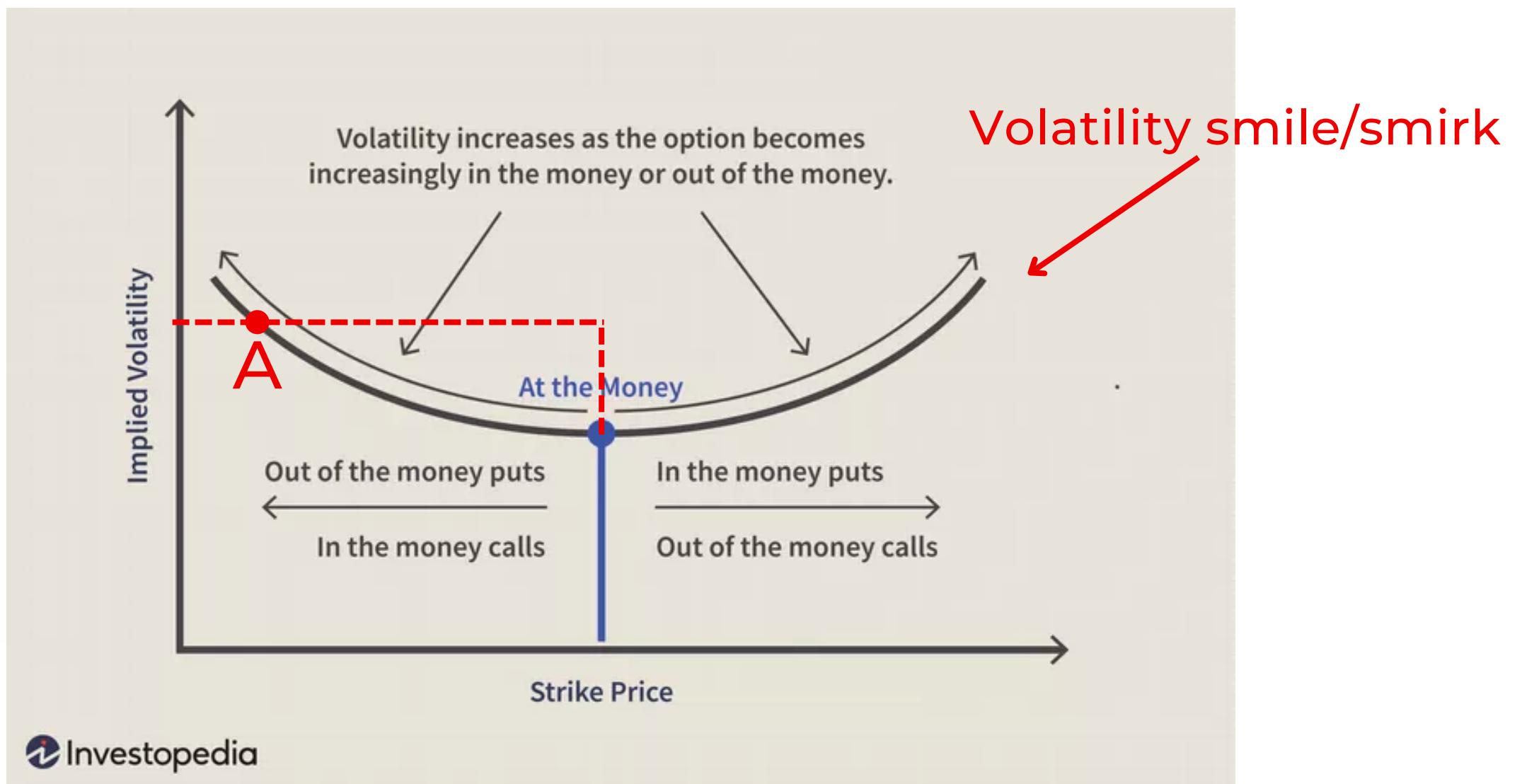
Yuhang Xing, Xiaoyan Zhang, and Rui Zhao\*

### Abstract

The shape of the volatility smirk has significant cross-sectional predictive power for future equity returns. Stocks exhibiting the steepest smirks in their traded options underperform stocks with the least pronounced volatility smirks in their options by 10.9% per year on a risk-adjusted basis. This predictability persists for at least 6 months, and firms with the steepest volatility smirks are those experiencing the worst earnings shocks in the following quarter. The results are consistent with the notion that informed traders with negative news prefer to trade out-of-the-money put options, and that the equity market is slow in incorporating the information embedded in volatility smirks.

We calculate our implied volatility smirk measure for firm  $i$  at week  $t$ ,  $\text{SKEW}_{i,t}$ , as the difference between the implied volatilities of OTM puts and ATM calls, denoted by  $\text{VOL}_{i,t}^{\text{OTMP}}$  and  $\text{VOL}_{i,t}^{\text{ATMC}}$ , respectively. That is,

$$(1) \quad \text{SKEW}_{i,t} = \text{VOL}_{i,t}^{\text{OTMP}} - \text{VOL}_{i,t}^{\text{ATMC}}.$$



# Skew

$$\text{SKEW}_{i,t} = \text{VOL}_{i,t}^{\text{OTMP}} - \text{VOL}_{i,t}^{\text{ATMC}}$$

Date	Series	Market	MarketName	Commodity	CommodityName	CurrencyCode	SettlementPrice	PreviousSettlementPrice	Difference	Impliedvolatility
2020-01-02	HSIF0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	28606	28270	336	NA
2020-01-02	HSI21000A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	7611	7271	340	43.6811
2020-01-02	HSI22600A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	6007	5672	335	29.0455
2020-01-02	HSI22800A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	5807	5473	334	28.0442
2020-01-02	HSI23000A0	HSI	HANG SENG FUTURES & OPTIONS	HSI	HANG SENG INDEX	HKD	5607	5273	334	27.0494
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2020-01-02	HSI29200A0W10	WK1	WEEKLY HANG SENG INDEX OPTIONS	HSI	HANG SENG INDEX	HKD	44	24	20	14.1587
2020-01-02	HSI29400A0W10	WK1	WEEKLY HANG SENG INDEX OPTIONS	HSI	HANG SENG INDEX	HKD	23	13	10	14.2431

Date	SKEW_1M	SKEW_2M
2020-01-02	7.7997595	5.1513964
2020-01-03	8.5299455	5.8144214
2020-01-04	7.6436864	5.3623899
2020-01-05	9.0896667	5.8221643
2020-01-06	9.4672524	5.8933262
2020-01-07	8.7721976	5.1683
2020-01-08	9.3230721	5.1767088
2020-01-09	7.8886829	4.9195191
2020-01-10	7.9982429	4.5778786
2020-01-11	8.2158805	4.7875505
2020-01-12	5.7675377	4.9092006
2020-01-13	5.5788214	4.7956929

Date	SKEW_1W	SKEW_2W
2020-01-02	46.3518673	9.4637961
2020-01-03	9.05782662	1.79007321
2020-01-04	11.6127143	6.42157143
2020-01-05	19.4631814	8.64929762
2020-01-06	20.2490881	8.05795
2020-01-07	47.6076091	10.3109883
2020-01-08	11.4477762	2.29616429
2020-01-09	17.6196133	5.48431333
2020-01-10	18.5636989	5.02696286
2020-01-11	29.146175	6.37653778
2020-01-12	47.2939559	9.24844571
2020-01-13	10.3484779	4.90220286

Results:

# Technical Analysis

- **Simple Moving Average**  
the average price over the period of 5, 20, 50 days.
- **Momentum**  
measures the rate of the rise or fall of stock prices.
- **Relative Strength Index**  
measures the speed and magnitude of stock price
- **Average True Range**  
measures market volatility

# Technical Analysis

$$\text{SMA} = \frac{A_1 + A_2 + \dots + A_n}{n}$$

**where:**

$A_n$  = the price of an asset at period  $n$

$n$  = the number of total periods

$$\text{RSI} = 100 - \left( \frac{100}{1 + RS} \right)$$

$$RS = \frac{\text{Average of } x \text{ days' up closes}}{\text{Average of } x \text{ days' down closes}}$$

**where:**

$RSI$  = relative strength index

$$\text{momentum} = \text{close}_{\text{today}} - \text{close}_{N \text{ days ago}}$$

$$TR = \text{Max}[(H - L), \text{Abs}(H - C_P), \text{Abs}(L - C_P)]$$

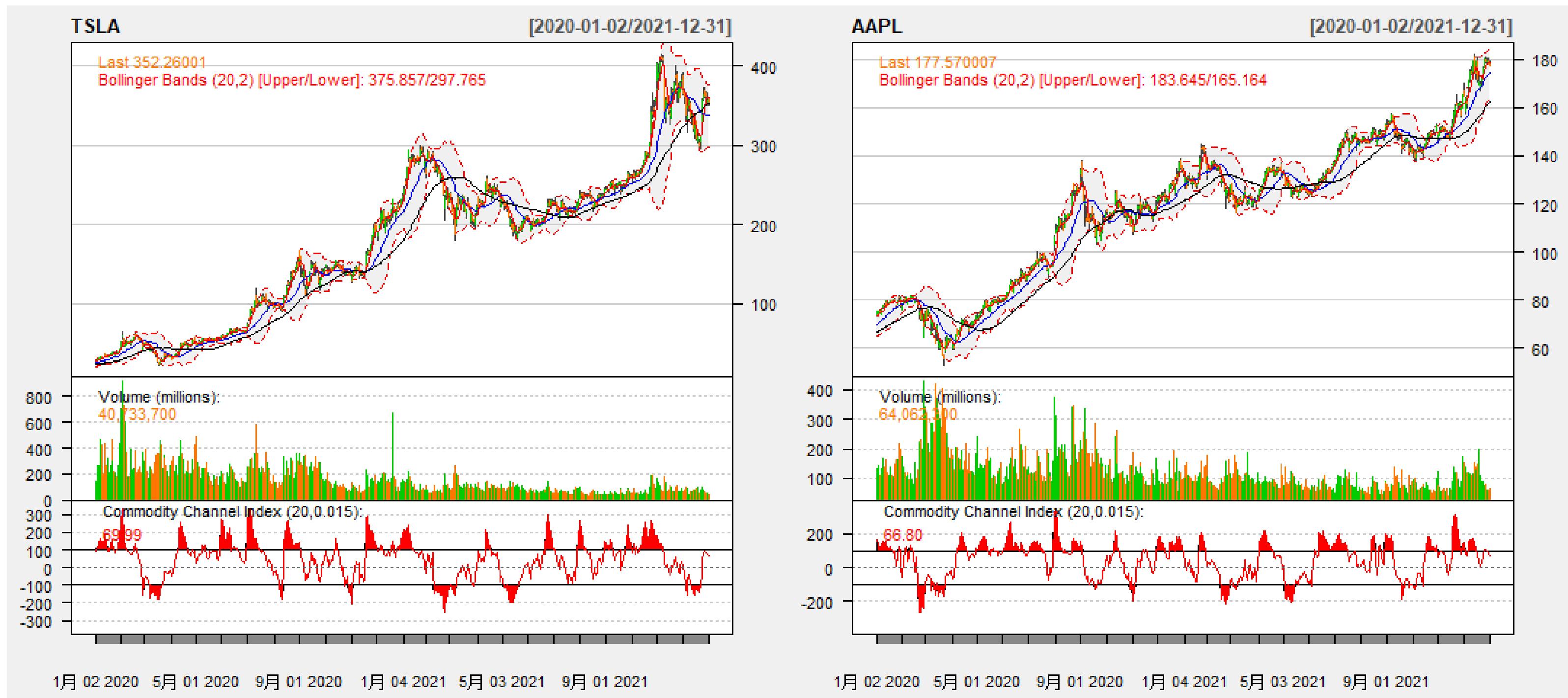
$$ATR = \left( \frac{1}{n} \right) \sum_{(i=1)}^{(n)} TR_i$$

**where:**

$TR_i$  = A particular true range

$n$  = The time period employed

# Technical Analysis



# Regression and Prediction Steps

- Regress tomorrow's close price on today's adjusted close price, TA factors, and skew factors
  - Use data of 2020.1-2021.12
- Do the regression on sample data and predict the close prices in the last month
  - Use data of 2021-2021.11 to regress and predict 2021.12
  - Calculate returns based on the model

# Regression with all data (2020.1-2021.12)

	1	2	3	4	5	6	7	8	9	10	11	12
Variables	(Intercept)	Adjusted Close	SMA5	SMA20	SMA50	RSI	MOMEN	ATR	SKEW 1W	SKEW 2W	SKEW 1M	SKEW 2M
APPL	2.219864*** (0.514877)	0.994336*** (0.004146)										
TSLA		0.993288*** (0.003181)							3.182447*** (0.932229)			
HSI		0.83815*** (0.05438)		0.14240** (0.04776)		10.0221** (3.82138)						
SP500			3.65709*** (0.09454564)				2.603851*** (0.5939866)		8.37919*** (6.78755)			

Standard errors of coefficients in parentheses.

\* p < 0.05

\*\* p < 0.01

\*\*\* p < 0.001

- Short-term data are more significant. (SMA5, SKEW 1W)
- The model accounts for a large proportion (R-squared) of the prices.

# Regression with partial data

(2020.1-2021.11, predict 2021.12)

	1	2	3	4	5	6	7	8	9	10	11	12
Variables	(Intercept)	Adjusted Close	SMA5	SMA20	SMA50	RSI	MOMEN	ATR	SKEW 1W	SKEW 2W	SKEW 1M	SKEW 2M
APPL	1.41419*** (0.15523)	0.92846*** (0.03008)	0.07233* (0.03015)				0.05888* (0.02302)		-4.23511*** (1.00773)			
TSLA		0.9999617*** (0.0002609)										
HSI		0.9999617*** (0.0002609)										
SP500			1.03487*** (0.02382)	-0.16256*** (0.03277)	0.12409*** (0.01974)		0.64324*** (0.03671)				467.12450*** (75.12749)	

Standard errors of coefficients in parentheses.

\* p < 0.05

\*\* p < 0.01

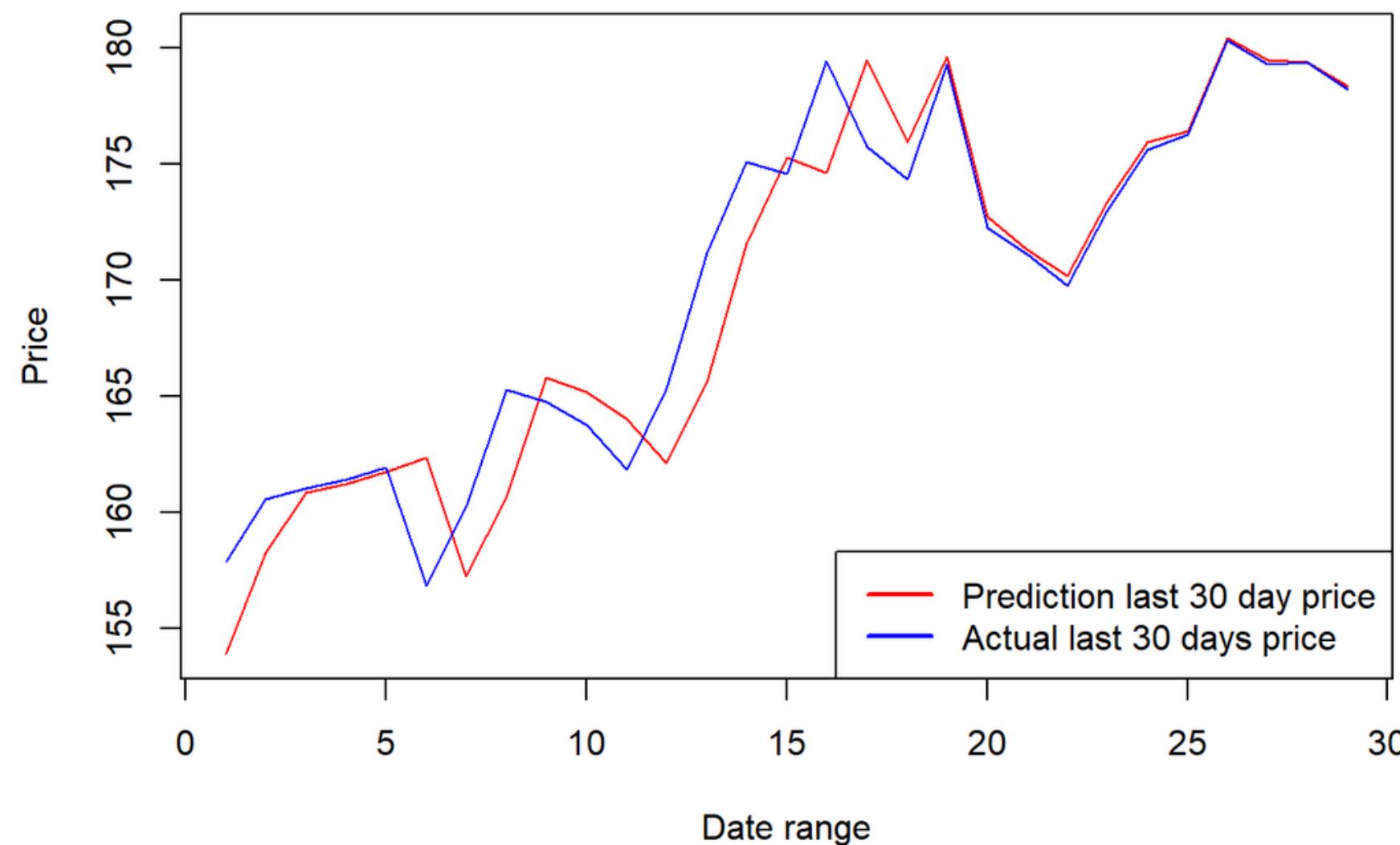
\*\*\* p < 0.001

- The model of the same stock changes greatly when we change the data input.

# Apple Stock

- Average daily return: 1.03%

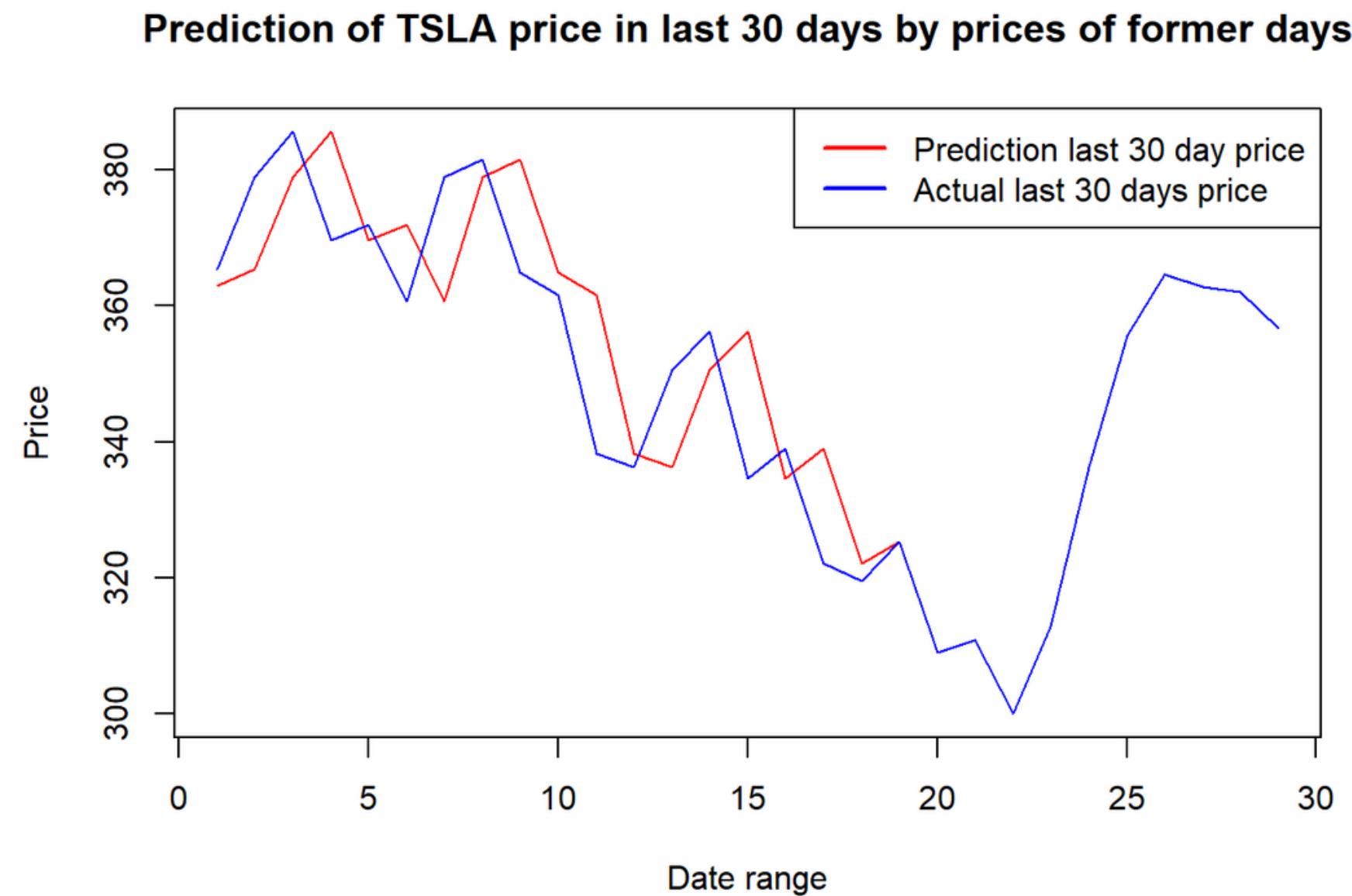
**Prediction of Apple price in last 30 days by prices of former days**



Date	Actual	Prediction	Return
2021/11/17	153.49		
2021/11/18	157.87	153.90	2.85%
2021/11/19	160.55	158.24	1.70%
2021/11/22	161.02	160.83	0.29%
2021/11/23	161.41	161.24	0.24%
2021/11/24	161.94	161.74	0.33%
2021/11/26	156.81	162.37	-3.17%
2021/11/29	160.24	157.26	
2021/11/30	165.30	160.68	3.16%
2021/12/1	164.77	165.82	-0.32%
2021/12/2	163.76	165.17	
2021/12/3	161.84	163.99	
2021/12/6	165.32	162.11	
2021/12/7	171.18	165.62	3.54%
2021/12/8	175.08	171.56	2.28%
2021/12/9	174.56	175.29	-0.30%
2021/12/10	179.45	174.64	
2021/12/13	175.74	179.48	-2.07%
2021/12/14	174.33	175.97	
2021/12/15	179.30	179.64	2.85%
2021/12/16	172.26	172.75	
2021/12/17	171.14	171.34	
2021/12/20	169.75	170.17	
2021/12/21	172.99	173.38	1.91%
2021/12/22	175.64	175.97	1.53%
2021/12/23	176.28	176.43	0.36%
2021/12/27	180.33	180.42	2.30%
2021/12/28	179.29	179.50	
2021/12/29	179.38	179.42	
2021/12/30	178.20	178.35	

# Tesla Stock

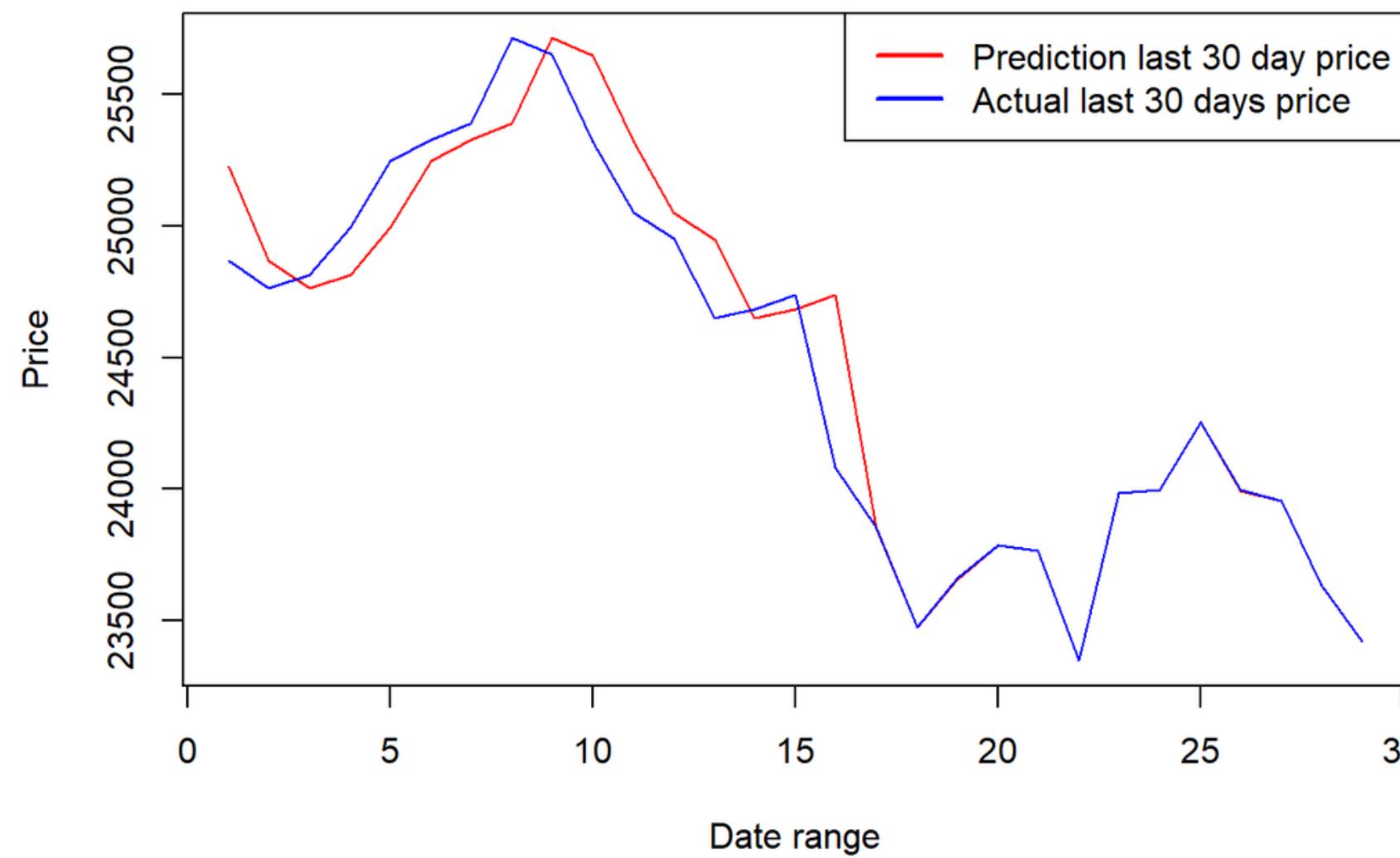
- Average daily return: 0.52%



# HSI Index

- Average daily return: 0.47%

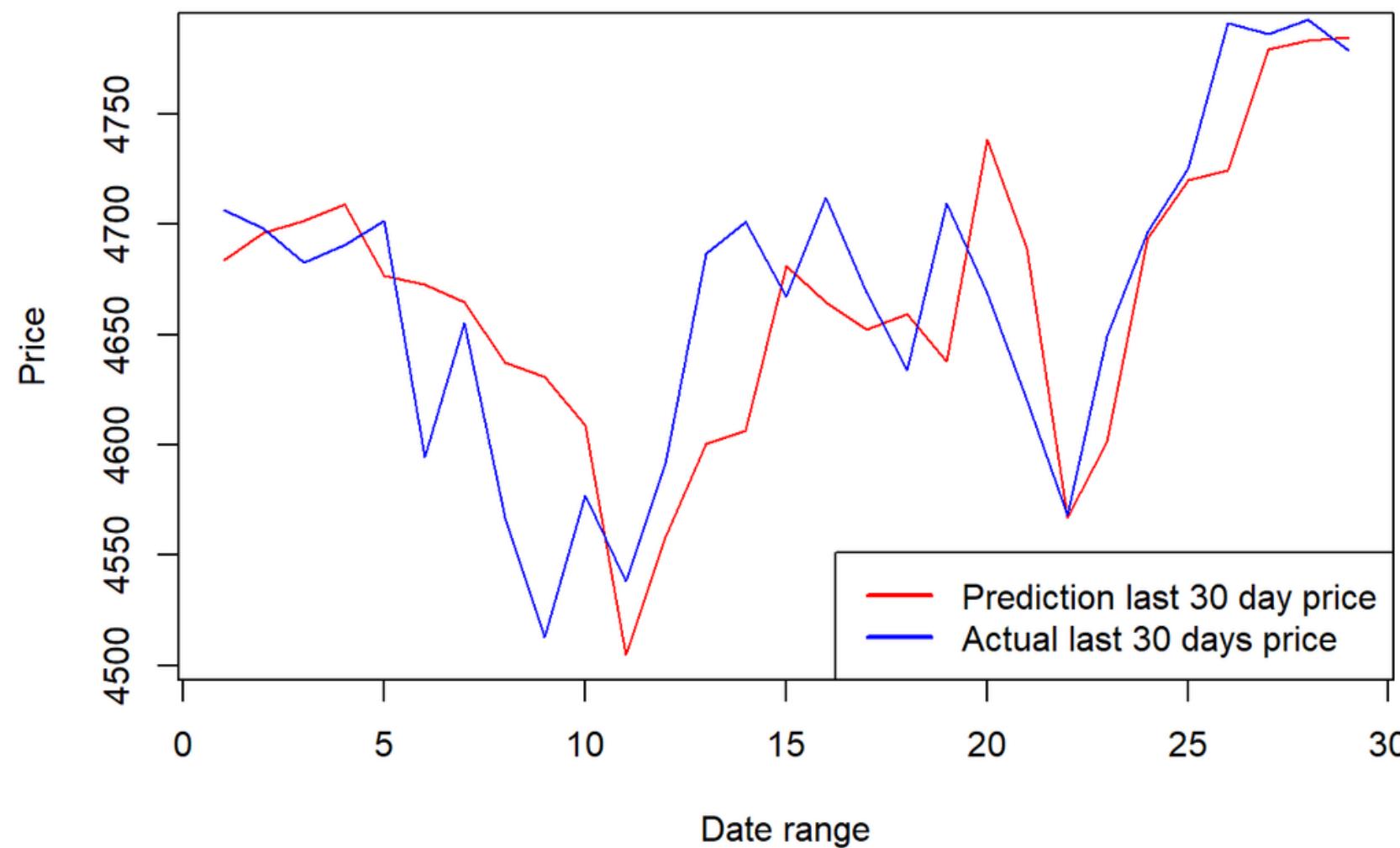
**Prediction of HSI price in last 30 days by prices of former days**



# S&P500 Index

- Average daily return: 0.34%

**Prediction of SP500 price in last 30 days by prices of former days**



Date	Actual	Prediction	Return
2021/11/17	4688.67	4683.87	
2021/11/18	4706.64	4683.87	
2021/11/19	4697.96	4696.28	-0.18%
2021/11/22	4682.95	4701.52	-0.32%
2021/11/23	4690.70	4709.30	0.17%
2021/11/24	4701.46	4676.83	
2021/11/26	4594.62	4673.00	
2021/11/29	4655.27	4664.90	
2021/11/30	4567.00	4637.49	
2021/12/1	4513.04	4630.99	
2021/12/2	4577.10	4609.05	
2021/12/3	4538.43	4504.83	
2021/12/6	4591.67	4558.24	1.17%
2021/12/7	4686.75	4600.54	2.07%
2021/12/8	4701.21	4606.46	0.31%
2021/12/9	4667.45	4681.27	-0.72%
2021/12/10	4712.02	4664.68	
2021/12/13	4669.15	4652.30	
2021/12/14	4634.09	4659.09	-0.75%
2021/12/15	4709.84	4637.80	
2021/12/16	4668.67	4738.69	-0.87%
2021/12/17	4620.64	4689.29	
2021/12/20	4568.02	4567.03	
2021/12/21	4649.23	4601.35	1.78%
2021/12/22	4696.56	4693.53	1.02%
2021/12/23	4725.78	4719.98	0.62%
2021/12/27	4791.19	4724.39	1.38%
2021/12/28	4786.36	4779.59	-0.10%
2021/12/29	4793.06	4783.60	0.14%
2021/12/30	4778.73	4784.65	-0.30%

# Limitations and Implications

- Technical analysis:
  - Relies on historical data, not sufficient to discover and explain new trends
  - May be too late in identifying trends
  - Existence of multicollinearity makes the model less dependable
- Limitations of research:
  - Data: limited underlying assets, options, and time span
  - Ignore fundamental factors (corporate reports, external impacts, etc.)

# Discussion and Conclusion

- The relationship between the future stock price and the factors varies with the progression of time
- In practice, we can use shorter samples (e.g., a few months) to estimate the model, and renew the model frequently
- We can use the method for decision-making: observe the stock price near closing, if the predicted price is higher, make an order near close price, and sell the stock tomorrow at close price

# Thank you!

