In [ ]:
```
import pandas as pd # type: ignore
import numpy as np # type: ignore
import matplotlib.pyplot as plt # type: ignore
import seaborn as sns # type: ignore
from transformers import AutoTokenizer, AutoModelForSequenceClassification
# type: ignore
from torch.nn.functional import softmax # type: ignore
from tqdm import tqdm # type: ignore
import pandas_market_calendars as mcal # type: ignore
from collections import Counter
import torch
import nltk
from nltk.sentiment import SentimentIntensityAnalyzer # type: ignore
from nltk.corpus import stopwords
from nltk.stem import WordNetLemmatizer
import re
```

In [2]:
```
# drive.mount('/content/drive')
```

In [3]:
```
# file_path = '/content/drive/My Drive/DJIA Dataset/upload_DJIA_table.csv'
file_path = 'B:/Dublin City University/Practicum/Proj/Dataset/main/raw/upload_DJIA_table.csv'
stock_data = pd.read_csv(file_path)
stock_data.head()
```

Out[3]:

	Date	Open	High	Low	Close	Volume	Adj Close
0	2016-07-01	17924.240234	18002.380859	17916.910156	17949.369141	82160000	17949.369141
1	2016-06-30	17712.759766	17930.609375	17711.800781	17929.990234	133030000	17929.990234
2	2016-06-29	17456.019531	17704.509766	17456.019531	17694.679688	106380000	17694.679688
3	2016-06-28	17190.509766	17409.720703	17190.509766	17409.720703	112190000	17409.720703
4	2016-06-27	17355.210938	17355.210938	17063.080078	17140.240234	138740000	17140.240234

In [4]:
```
file_path1 = 'B:/Dublin City University/Practicum/Proj/Dataset/main/raw/RedditNews.csv'
reddit_data = pd.read_csv(file_path1)
reddit_data.head()
```

Out[4]:

	Date	News
0	2016-07-01	A 117-year-old woman in Mexico City finally re...
1	2016-07-01	IMF chief backs Athens as permanent Olympic host
2	2016-07-01	The president of France says if Brexit won, so...
3	2016-07-01	British Man Who Must Give Police 24 Hours' Not...
4	2016-07-01	100+ Nobel laureates urge Greenpeace to stop o...

In [5]:
```
file_path2 = 'B:/Dublin City University/Practicum/Proj/Dataset/main/raw/Combined_News_DJIA.csv'
news_data = pd.read_csv(file_path2)
news_data.head()
```

Out[5]:

	Date	Label	Top1	Top2	Top3	Top4	Top5	Top6
0	2008-08-08	0	b"Georgia 'downs two Russian warplanes' as cou...	b'BREAKING: Musharraf to be impeached.'	b'Russia Today: Columns of troops roll into So...	b'Russian tanks are moving towards the capital...	b"Afghan children raped with 'impunity,' U.N. ...	b'150 Russian tanks have entered South Ossetia...
1	2008-08-11	1	b'Why wont America and Nato help us? If they w...	b'Bush puts foot down on Georgian conflict'	b"Jewish Georgian minister: Thanks to Israeli ...	b'Georgian army flees in disarray as Russians ...	b"Olympic opening ceremony fireworks 'faked'"	b'What were the Mossad with fraudulent New Zea...
2	2008-08-12	0	b'Remember that adorable 9-year-old who sang a...	b"Russia 'ends Georgia operation'"	b'"If we had no sexual harassment we would hav...	b"Al-Qa'eda is losing support in Iraq because ...	b'Ceasefire in Georgia: Putin Outmaneuvers the...	b'Why Microsoft and Intel tried to kill the XO...
3	2008-08-13	0	b' U.S. refuses Israel weapons to attack Iran:...	b"When the president ordered to attack Tskhinv...	b' Israel clears troops who killed Reuters cam...	b'Britain\'s policy of being tough on drugs is...	b'Body of 14 year old found in trunk; Latest (...	b'China has moved 10 *million* quake survivors...
4	2008-08-14	1	b'All the experts admit that we should legalis...	b'War in South Osetia - 89 pictures made by a ...	b'Swedish wrestler Ara Abrahamian throws away ...	b'Russia exaggerated the death toll in South O...	b'Missile That Killed 9 Inside Pakistan May Ha...	b"Rushdie Condemns Random House's Refusal to P...

5 rows × 27 columns

In [6]:
```
stock_data.isnull().sum()
reddit_data.isnull().sum()
news_data.isnull().sum()
```

Out[6]:
```
Date     0
Label    0
Top1     0
Top2     0
Top3     0
Top4     0
Top5     0
Top6     0
Top7     0
Top8     0
Top9     0
Top10    0
Top11    0
Top12    0
Top13    0
Top14    0
Top15    0
Top16    0
Top17    0
Top18    0
Top19    0
Top20    0
Top21    0
Top22    0
Top23    1
Top24    3
Top25    3
dtype: int64
```

In [7]:
```
stock_data.info()
reddit_data.info()
news_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1989 entries, 0 to 1988
Data columns (total 7 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   Date       1989 non-null   object 
 1   Open       1989 non-null   float64
 2   High       1989 non-null   float64
 3   Low        1989 non-null   float64
 4   Close      1989 non-null   float64
 5   Volume     1989 non-null   int64  
 6   Adj Close  1989 non-null   float64
dtypes: float64(5), int64(1), object(1)
memory usage: 108.9+ KB
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 73608 entries, 0 to 73607
Data columns (total 2 columns):
 #   Column  Non-Null Count  Dtype 
---  ------  --------------  ----- 
 0   Date    73608 non-null  object
 1   News    73608 non-null  object
dtypes: object(2)
memory usage: 1.1+ MB
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1989 entries, 0 to 1988
Data columns (total 27 columns):
 #   Column  Non-Null Count  Dtype 
---  ------  --------------  ----- 
 0   Date    1989 non-null   object
 1   Label   1989 non-null   int64 
 2   Top1    1989 non-null   object
 3   Top2    1989 non-null   object
 4   Top3    1989 non-null   object
 5   Top4    1989 non-null   object
 6   Top5    1989 non-null   object
 7   Top6    1989 non-null   object
 8   Top7    1989 non-null   object
 9   Top8    1989 non-null   object
 10  Top9    1989 non-null   object
 11  Top10   1989 non-null   object
 12  Top11   1989 non-null   object
 13  Top12   1989 non-null   object
 14  Top13   1989 non-null   object
 15  Top14   1989 non-null   object
 16  Top15   1989 non-null   object
 17  Top16   1989 non-null   object
 18  Top17   1989 non-null   object
 19  Top18   1989 non-null   object
 20  Top19   1989 non-null   object
 21  Top20   1989 non-null   object
 22  Top21   1989 non-null   object
 23  Top22   1989 non-null   object
 24  Top23   1988 non-null   object
 25  Top24   1986 non-null   object
 26  Top25   1986 non-null   object
dtypes: int64(1), object(26)
memory usage: 419.7+ KB
```

In [8]:
```
# filled missing values by a blank space for text pre-processing
news_data.fillna('', inplace=True)
reddit_data.fillna('', inplace=True)
```

In [9]:
```
news_data.isnull().sum()
reddit_data.isnull().sum()
```

Out[9]:
```
Date    0
News    0
dtype: int64
```

In [10]:
```
print(stock_data['Date'].dtype)
print(reddit_data['Date'].dtype)
print(news_data['Date'].dtype)
```

```
object
object
object
```

In [11]:
```
# changing to datetime format
stock_data['Date'] = pd.to_datetime(stock_data['Date'])
reddit_data['Date'] = pd.to_datetime(reddit_data['Date'])
news_data['Date'] = pd.to_datetime(news_data['Date'])

print(stock_data['Date'].dtype)
print(reddit_data['Date'].dtype)
print(news_data['Date'].dtype)
```

```
datetime64[ns]
datetime64[ns]
datetime64[ns]
```

In [12]:
```
# sorted data to follow ascending order as the other dataframes do
news_data = news_data.sort_values(by='Date', ascending=True).reset_index(dr
op=True)
reddit_data = reddit_data.sort_values(by='Date', ascending=True).reset_inde
x(drop=True)
```

In [13]:
```
news_data.head()
```

Out[13]:

	Date	Label	Top1	Top2	Top3	Top4	Top5	Top6
0	2008-08-08	0	b"Georgia 'downs two Russian warplanes' as cou...	b'BREAKING: Musharraf to be impeached.'	b'Russia Today: Columns of troops roll into So...	b'Russian tanks are moving towards the capital...	b"Afghan children raped with 'impunity,' U.N. ...	b'150 Russian tanks have entered South Ossetia...
1	2008-08-11	1	b'Why wont America and Nato help us? If they w...	b'Bush puts foot down on Georgian conflict'	b"Jewish Georgian minister: Thanks to Israeli ...	b'Georgian army flees in disarray as Russians ...	b"Olympic opening ceremony fireworks 'faked'"	b'What were the Mossad with fraudulent New Zea...
2	2008-08-12	0	b'Remember that adorable 9-year-old who sang a...	b"Russia 'ends Georgia operation'"	b"'If we had no sexual harassment we would hav...	b"Al-Qa'eda is losing support in Iraq because ...	b'Ceasefire in Georgia: Putin Outmaneuvers the...	b'Why Microsoft and Intel tried to kill the XO...
3	2008-08-13	0	b' U.S. refuses Israel weapons to attack Iran:...	b"When the president ordered to attack Tskhinv...	b' Israel clears troops who killed Reuters cam...	b'Britain\'s policy of being tough on drugs is...	b'Body of 14 year old found in trunk; Latest (...	b'China has moved 10 *million* quake survivors...
4	2008-08-14	1	b'All the experts admit that we should legalis...	b'War in South Osetia - 89 pictures made by a ...	b'Swedish wrestler Ara Abrahamian throws away ...	b'Russia exaggerated the death toll in South O...	b'Missile That Killed 9 Inside Pakistan May Ha...	b"Rushdie Condemns Random House's Refusal to P...

5 rows × 27 columns

In [14]:
```
reddit_data.head()
```

Out[14]:

	Date	News
0	2008-06-08	b'Marriage, they said, was reduced to the stat...
1	2008-06-08	b'Nim Chimpsky: The tragedy of the chimp who t...
2	2008-06-08	b"Canada: Beware slippery slope' to censorship...
3	2008-06-08	b'EU Vice-President Luisa Morgantini and the I...
4	2008-06-08	b"Israeli minister: Israel will attack Iran if...

In [15]:
```
print(stock_data['Date'].min(), stock_data['Date'].max())
print(reddit_data['Date'].min(), reddit_data['Date'].max())
print(news_data['Date'].min(), news_data['Date'].max())
```

```
2008-08-08 00:00:00 2016-07-01 00:00:00
2008-06-08 00:00:00 2016-07-01 00:00:00
2008-08-08 00:00:00 2016-07-01 00:00:00
```

In [16]:
```
# removed every sentence starting with letter 'b'
for i in range(1, 26):
    news_data[f'Top{i}'] = news_data[f'Top{i}'].apply(lambda x: x.replace
("b'", "").replace("'", "").replace('b"','').replace('"', '') if isinstance
(x, str) else x)


reddit_data[f'News'] = reddit_data[f'News'].apply(lambda x: x.replace("b'",
"").replace("'", "").replace('b"','').replace('"', '') if isinstance(x, st
r) else x)
```

In [17]:
```
news_data.head()
```

Out[17]:

	Date	Label	Top1	Top2	Top3	Top4	Top5	Top6
0	2008-08-08	0	Georgia downs two Russian warplanes as countri...	BREAKING: Musharraf to be impeached.	Russia Today: Columns of troops roll into Sout...	Russian tanks are moving towards the capital o...	Afghan children raped with impunity, U.N. offi...	150 Russian tanks have entered South Ossetia w...
1	2008-08-11	1	Why wont America and Nato help us? If they won...	Bush puts foot down on Georgian conflict	Jewish Georgian minister: Thanks to Israeli tr...	Georgian army flees in disarray as Russians ad...	Olympic opening ceremony fireworks faked	What were the Mossad with fraudulent New Zeala...
2	2008-08-12	0	Remember that adorable 9-year-old who sang at ...	Russia ends Georgia operation	If we had no sexual harassment we would have n...	Al-Qaeda is losing support in Iraq because of ...	Ceasefire in Georgia: Putin Outmaneuvers the West	Why Microsoft and Intel tried to kill the XO $...
3	2008-08-13	0	U.S. refuses Israel weapons to attack Iran: r...	When the president ordered to attack Tskhinval...	Israel clears troops who killed Reuters camer...	Britain\s policy of being tough on drugs is po...	Body of 14 year old found in trunk; Latest (ra...	China has moved 10 *million* quake survivors i...
4	2008-08-14	1	All the experts admit that we should legalise ...	War in South Osetia - 89 pictures made by a Ru...	Swedish wrestler Ara Abrahamian throws away me...	Russia exaggerated the death toll in South Oss...	Missile That Killed 9 Inside Pakistan May Have...	Rushdie Condemns Random Houses Refusal to Publ...

5 rows × 27 columns

In [18]:
```
reddit_data.head()
```

Out[18]:

	Date	News
0	2008-06-08	Marriage, they said, was reduced to the status...
1	2008-06-08	Nim Chimpsky: The tragedy of the chimp who tho...
2	2008-06-08	Canada: Beware slippery slope to censorship, h...
3	2008-06-08	EU Vice-President Luisa Morgantini and the Iri...
4	2008-06-08	Israeli minister: Israel will attack Iran if i...

In [19]:
```
# removed spaces
news_data = news_data.map(lambda x: x.strip() if isinstance(x, str) else x)
reddit_data = reddit_data.map(lambda x: x.strip() if isinstance(x, str) els
e x)
```

In [20]:
```
reddit_data['News'] = reddit_data['News'].str.strip()

for i in range(1, 26):
    news_data[f'Top{i}'] = news_data[f'Top{i}'].str.strip()
```

In [21]:
```
# lowercasing text data
for i in range(1, 26):
    news_data[f'Top{i}'] = news_data[f'Top{i}'].str.lower()

for i in range(1, 26):
    reddit_data[f'News'] = reddit_data[f'News'].str.lower()
```

In [22]:
```
# combining all the Top1 to Top25 news headlines of each day into one singl
e string as FinBERT works best on one single large text/sentece
news_data['combined_news'] = news_data[[f'Top{i}' for i in range(1,26)]].ap
ply(lambda row: ' '.join(row.values.astype(str)), axis=1)
```

In [23]:
```
reddit_grouped = reddit_data.groupby('Date')['News'].apply(lambda x: ' '.jo
in(x)).reset_index()

reddit_grouped.rename(columns={'News': 'Combined_Reddit_News'}, inplace=Tru
e)
```

In [24]:
```
reddit_grouped.tail()
```

Out[24]:

	Date	Combined_Reddit_News
2938	2016-06-27	angela merkel said the u.k. must file exit pap...
2939	2016-06-28	hong kong democracy activists call for return ...
2940	2016-06-29	a chatbot programmed by a british teenager has...
2941	2016-06-30	us airstrikes kill at least 250 isis fighters ...
2942	2016-07-01	china kills millions of innocent meditators fo...

In [25]:
```
news_data.tail()
```

Out[25]:

	Date	Label	Top1	Top2	Top3	Top4	Top5	Top6	
1984	2016-06-27	0	barclays and rbs shares suspended from trading...	pope says church should ask forgiveness from g...	poland shocked by xenophobic abuse of poles in uk	there will be no second referendum, cabinet ag...	scotland welcome to join eu, merkel ally says	sterling dips below fridays 31-year low amid b...	ne pr
1985	2016-06-28	1	2,500 scientists to australia: if you want to ...	the personal details of 112,000 french police ...	s&p cuts united kingdom sovereign credit r...	huge helium deposit found in africa	ceo of the south african state broadcaster qui...	brexit cost investors $2 trillion, the worst o...	h d
1986	2016-06-29	1	explosion at airport in istanbul	yemeni former president: terrorism is the offs...	uk must accept freedom of movement to access e...	devastated: scientists too late to captive bre...	british labor party leader jeremy corbyn loses...	a muslim shop in the uk was just firebombed wh...	a
1987	2016-06-30	1	jamaica proposes marijuana dispensers for tour...	stephen hawking says pollution and stupidity s...	boris johnson says he will not run for tory pa...	six gay men in ivory coast were abused and for...	switzerland denies citizenship to muslim immig...	palestinian terrorist stabs israeli teen girl ...	p w
1988	2016-07-01	1	a 117-year-old woman in mexico city finally re...	imf chief backs athens as permanent olympic host	the president of france says if brexit won, so...	british man who must give police 24 hours noti...	100+ nobel laureates urge greenpeace to stop o...	brazil: huge spike in number of police killing...	pr

5 rows × 28 columns

In [26]:
```
# # Combine all news headlines into one string
# all_news_text = ' '.join(news_data['combined_news'].astype(str).tolist())
# all_reddit_text = ' '.join(reddit_grouped['Combined_Reddit_News'].astype
(str).tolist())

# # Tokenize by splitting on spaces
# news_words = all_news_text.lower().split()
# reddit_words = all_reddit_text.lower().split()

# # Count word frequencies
# news_word_freq = Counter(news_words)
# reddit_word_freq = Counter(reddit_words)

# # Top 20 most common words
# print("Top News Words:", news_word_freq.most_common(20))
# print("Top Reddit Words:", reddit_word_freq.most_common(20))
```

In [27]:
```
# nltk.download('stopwords')
# nltk.download('wordnet')

# stop_words = set(stopwords.words('english'))
# lemmatizer = WordNetLemmatizer()

# def preprocess(text):
#     words = re.findall(r'\b[a-zA-Z]{2,}\b', text.lower())  # remove punct
uation/numbers
#     words = [lemmatizer.lemmatize(word) for word in words if word not in
stop_words]
#     return words

# # Apply to news and reddit
# news_clean_words = preprocess(all_news_text)
# reddit_clean_words = preprocess(all_reddit_text)

# # Count frequencies
# news_clean_freq = Counter(news_clean_words)
# reddit_clean_freq = Counter(reddit_clean_words)

# print("Top Clean News Words:", news_clean_freq.most_common(20))
# print("Top Clean Reddit Words:", reddit_clean_freq.most_common(20))
```

In [28]:
```
# Get NYSE trading calendar
nyse = mcal.get_calendar('NYSE')

# Get all trading days between min and max date
trading_days = nyse.valid_days(
    start_date=min(reddit_grouped['Date'].min(), news_data['Date'].min()),
    end_date=max(reddit_grouped['Date'].max(), news_data['Date'].max())
).to_pydatetime()
```

In [29]:
```
print(news_data.loc[0, 'combined_news'])
```

```
georgia downs two russian warplanes as countries move to brink of war brea
king: musharraf to be impeached. russia today: columns of troops roll into
south ossetia; footage from fighting (youtube) russian tanks are moving to
wards the capital of south ossetia, which has reportedly been completely d
estroyed by georgian artillery fire afghan children raped with impunity,
u.n. official says - this is sick, a three year old was raped and they do
nothing 150 russian tanks have entered south ossetia whilst georgia shoots
down two russian jets. breaking: georgia invades south ossetia, russia war
ned it would intervene on sos side the enemy combatent trials are nothing
but a sham: salim haman has been sentenced to 5 1/2 years, but will be kep
t longer anyway just because they feel like it. georgian troops retreat fr
om s. osettain capital, presumably leaving several hundred people killed.
[video] did the u.s. prep georgia for war with russia? rice gives green li
ght for israel to attack iran: says u.s. has no veto over israeli military
ops announcing:class action lawsuit on behalf of american public against t
he fbi so---russia and georgia are at war and the nyts top story is openin
g ceremonies of the olympics?  what a fucking disgrace and yet further pro
of of the decline of journalism. china tells bush to stay out of other cou
ntries affairs did world war iii start today? georgia invades south osseti
a - if russia gets involved, will nato absorb georgia and unleash a full s
cale war? al-qaeda faces islamist backlash condoleezza rice: the us would
not act to prevent an israeli strike on iran. israeli defense minister ehu
d barak: israel is prepared for uncompromising victory in the case of mili
tary hostilities. this is a busy day:  the european union has approved new
sanctions against iran in protest at its nuclear programme. georgia will w
ithdraw 1,000 soldiers from iraq to help fight off russian forces in georg
ias breakaway region of south ossetia why the pentagon thinks attacking ir
an is a bad idea - us news &amp;amp; world report caucasus in crisis: georgia
invades south ossetia indian shoe manufactory  - and again in a series of
you do not like your work? visitors suffering from mental illnesses banned
from olympics no help for mexicos kidnapping surge
```

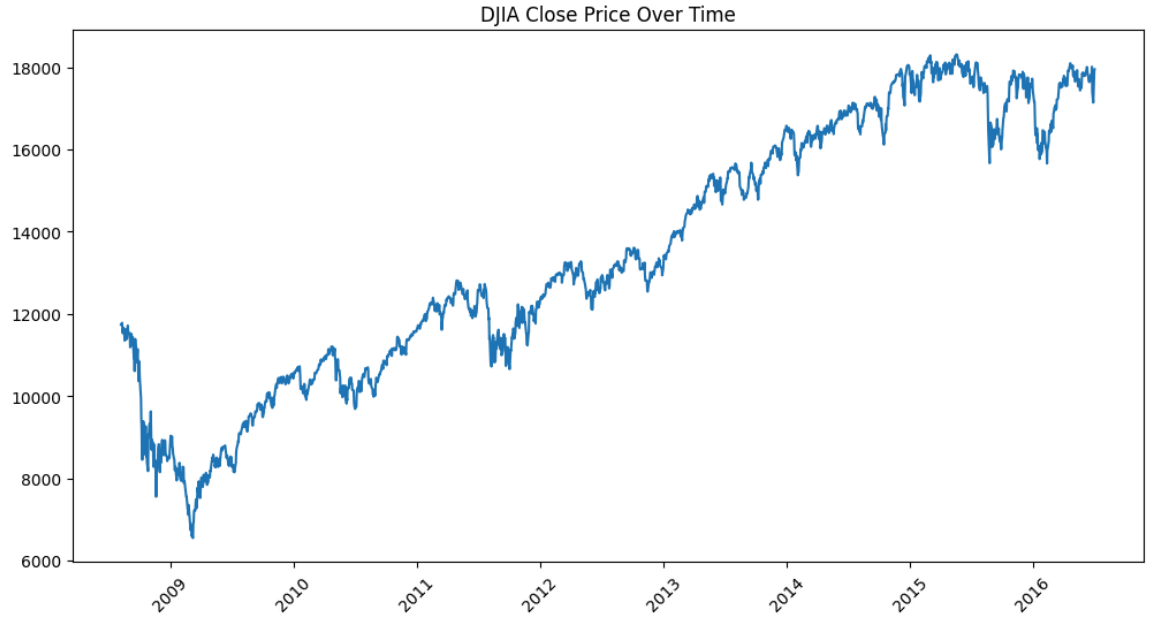
In [30]:
```
print(reddit_data.loc[3, 'News'])
```

```
eu vice-president luisa morgantini and the irish nobel laureate, mairead c
orrigan, have been tear gased and injured by the idf while attending the i
nternational conference on non-violent resistance
```

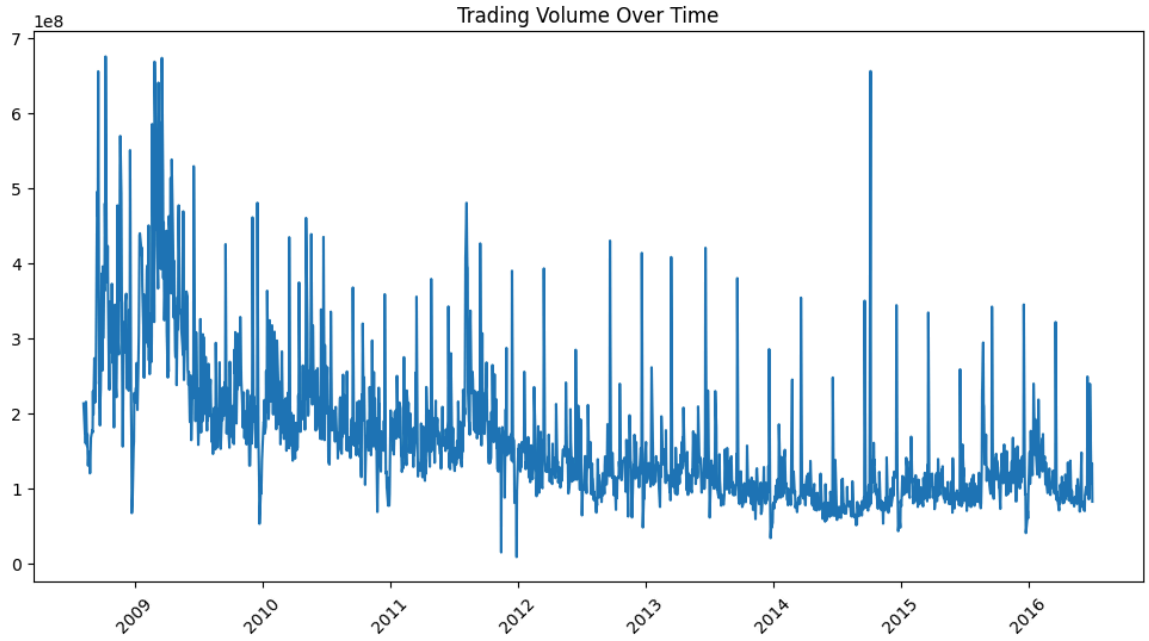
In [31]:
```
news_data.duplicated().sum()
reddit_data.duplicated().sum()
stock_data.duplicated().sum()
news_data['Date'].duplicated().sum()
```

Out[31]:
```
np.int64(0)
```

In [32]:
```
# Closing Price over time
plt.figure(figsize=(12,6))
plt.plot(stock_data['Date'], stock_data['Close'])
plt.title('DJIA Close Price Over Time')
plt.xticks(rotation=45)
plt.show()
```

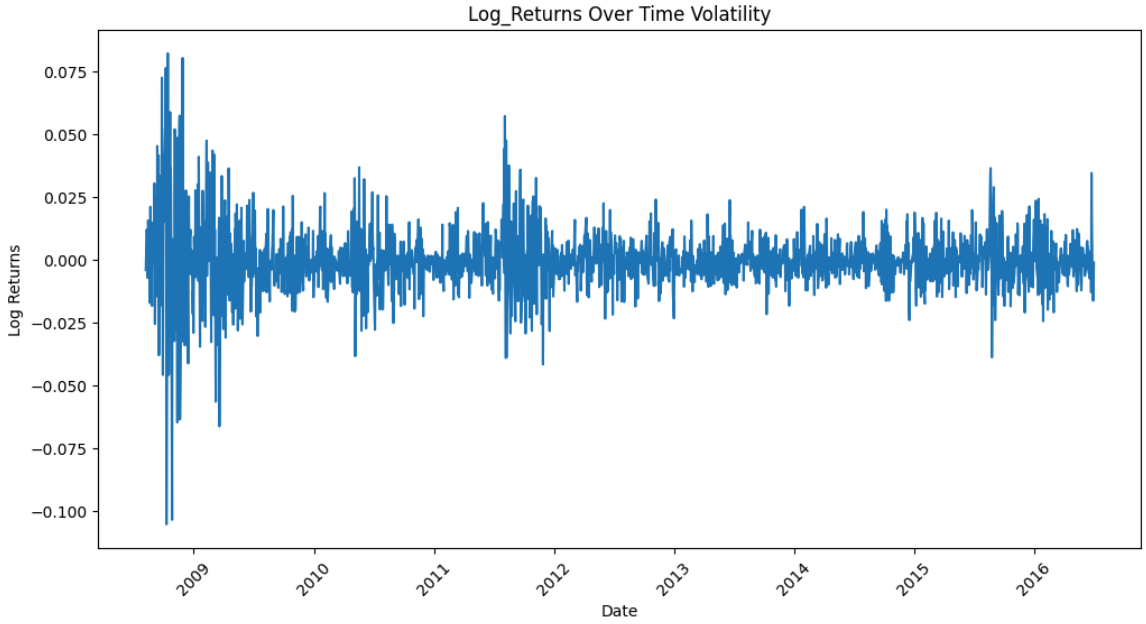


In [33]:
```
plt.figure(figsize=(12,6))
plt.plot(stock_data['Date'], stock_data['Volume'])
plt.title('Trading Volume Over Time')
plt.xticks(rotation=45)
plt.show()
```

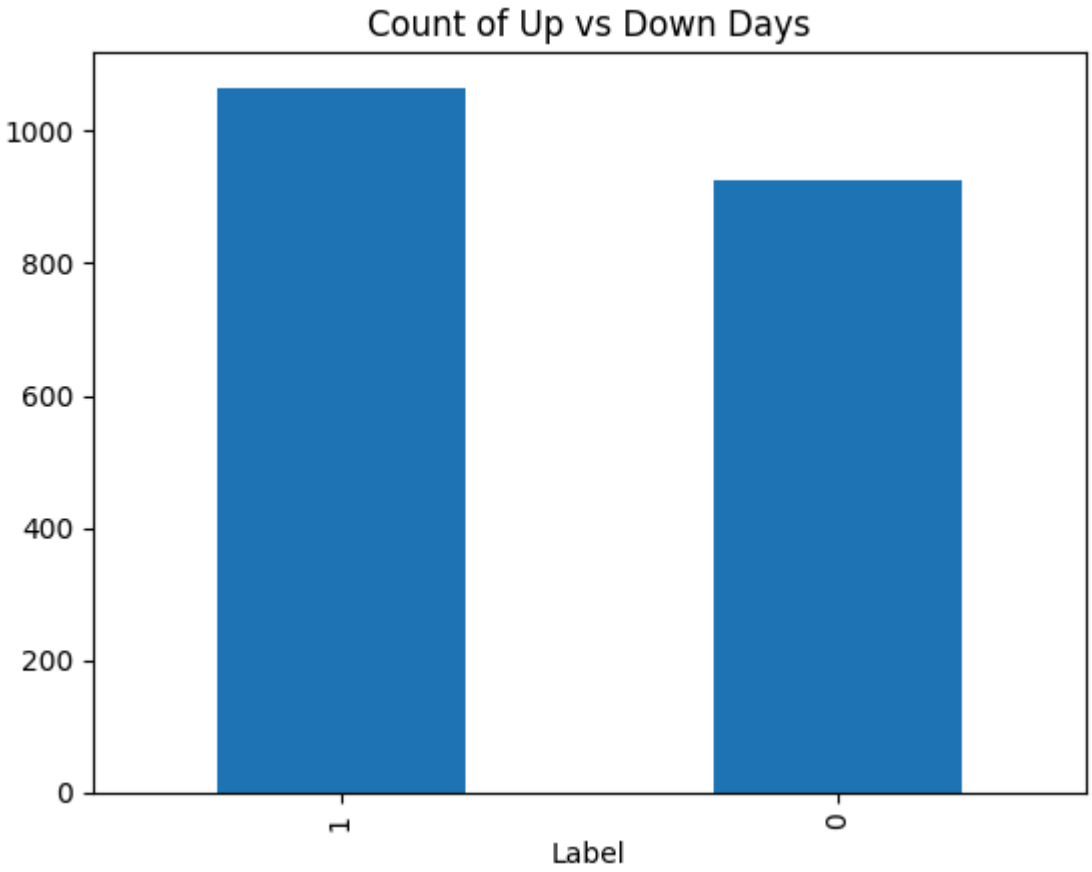


In [34]:
```
# stock_data['Volatility'] = stock_data['Close'].rolling(window=10).std()
stock_data['Log_Returns'] = np.log(stock_data['Close'] / stock_data['Clos
e'].shift(1))
stock_data['Volatility_Log_10'] = stock_data['Log_Returns'].rolling(window=
10).std() * np.sqrt(252)
stock_data['cl-op'] = stock_data['Close'] - stock_data['Open']
stock_data['hi-lo'] = stock_data['High'] - stock_data['Low']

plt.figure(figsize=(12,6))
plt.plot(stock_data['Date'], stock_data['Log_Returns'], label='Log Return
s')
plt.title('Log_Returns Over Time Volatility')
plt.xlabel('Date')
plt.ylabel('Log Returns')
plt.xticks(rotation=45)
plt.show()
```



In [35]:
```
news_data['Label'].value_counts().plot(kind='bar')
plt.title('Count of Up vs Down Days')
plt.show()
```



In [36]:
```
stock_features = stock_data[['Open', 'High', 'Low', 'Close', 'Volume']]

correlation_matrix = stock_features.corr() # type: ignore

print(correlation_matrix)
```

```
             Open      High       Low     Close    Volume
Open     1.000000  0.999592  0.999436  0.998991 -0.691621
High     0.999592  1.000000  0.999373  0.999546 -0.686997
Low      0.999436  0.999373  1.000000  0.999595 -0.699572
Close    0.998991  0.999546  0.999595  1.000000 -0.694281
Volume -0.691621 -0.686997 -0.699572 -0.694281  1.000000
```

In [37]:
```
stock_features = stock_data[['Open', 'High', 'Low', 'Close', 'Volume']]

covariance_matrix = stock_features.cov() # type: ignore

print(covariance_matrix)
```

```
                Open          High           Low         Close        Volu
me
Open    9.880219e+06  9.854163e+06  9.897074e+06  9.872527e+06 -2.041858e+
11
High    9.854163e+06  9.836200e+06  9.874379e+06  9.855979e+06 -2.023682e+
11
Low     9.897074e+06  9.874379e+06  9.925152e+06  9.900935e+06 -2.070022e+
11
Close   9.872527e+06  9.855979e+06  9.900935e+06  9.884780e+06 -2.050184e+
11
Volume -2.041858e+11 -2.023682e+11 -2.070022e+11 -2.050184e+11  8.821610e+
15
```

In [38]:
```
# !pip install transformers
# !pip install torch
```

In [39]:
```
nltk.download('vader_lexicon', quiet=True)

# Initialize VADER sentiment analyzer
sia = SentimentIntensityAnalyzer()
```

In [40]:
```
def get_vader_sentiment(text):
    if pd.isna(text) or text == '' or text == 'nan':
        return 0.0

    try:
        scores = sia.polarity_scores(str(text))
        return scores['compound']
    except:
        return 0.0
```

In [41]:
```
# VADER to news data
print("Computing VADER sentiment for news data...")
print(f"Processing {len(news_data)} rows...")

tqdm.pandas(desc="News VADER Sentiment")

news_data['vader_news_sentiment'] = news_data['combined_news'].progress_app
ly(get_vader_sentiment)

print(f"Sentiment range: {news_data['vader_news_sentiment'].min():.4f} to
{news_data['vader_news_sentiment'].max():.4f}")
print(f"Mean sentiment: {news_data['vader_news_sentiment'].mean():.4f}")
```

```
Computing VADER sentiment for news data...
Processing 1989 rows...

News VADER Sentiment: 100%|██████████| 1989/1989 [00:06<00:00, 300.53it/s]

Sentiment range: -0.9996 to 0.9910
Mean sentiment: -0.9602
```

In [42]:
```
reddit_grouped.columns
```

Out[42]:
```
Index(['Date', 'Combined_Reddit_News'], dtype='object')
```

In [43]:
```
# VADER to reddit_data
print("Computing VADER sentiment for reddit data...")
print(f"Processing {len(reddit_grouped)} rows...")

tqdm.pandas(desc="Reddit VADER Sentiment")

reddit_grouped['vader_reddit_sentiment'] = reddit_grouped['Combined_Reddit_
News'].progress_apply(get_vader_sentiment)

print(f"Sentiment range: {reddit_grouped['vader_reddit_sentiment'].min():.4
f} to {reddit_grouped['vader_reddit_sentiment'].max():.4f}")
print(f"Mean sentiment: {reddit_grouped['vader_reddit_sentiment'].mean():.4
f}")
```

```
Computing VADER sentiment for reddit data...
Processing 2943 rows...

Reddit VADER Sentiment: 100%|██████████| 2943/2943 [00:09<00:00, 304.85it/
s]

Sentiment range: -0.9996 to 0.9736
Mean sentiment: -0.9583
```

In [44]:
```
# Verify the results
print("\nNews Data - First 5 sentiment scores:")
print(news_data[['Date', 'vader_news_sentiment']].head())

print("\nReddit Data - First 5 sentiment scores:")
print(reddit_grouped[['Date', 'vader_reddit_sentiment']].head())

print(f"\nMissing values in vader_news_sentiment: {news_data['vader_news_se
ntiment'].isnull().sum()}")
print(f"Missing values in vader_reddit_sentiment: {reddit_grouped['vader_re
ddit_sentiment'].isnull().sum()}")
```

```
News Data - First 5 sentiment scores:
        Date  vader_news_sentiment
0 2008-08-08               -0.9978
1 2008-08-11               -0.9814
2 2008-08-12               -0.9778
3 2008-08-13               -0.9809
4 2008-08-14               -0.9899

Reddit Data - First 5 sentiment scores:
        Date  vader_reddit_sentiment
0 2008-06-08                 -0.9975
1 2008-06-09                 -0.9968
2 2008-06-10                 -0.9962
3 2008-06-11                 -0.9901
4 2008-06-12                 -0.8840

Missing values in vader_news_sentiment: 0
Missing values in vader_reddit_sentiment: 0
```

In [45]:
```
# Check the date distribution in reddit_data
print("Reddit data date distribution:")
print(f"Unique dates in reddit_data: {reddit_grouped['Date'].nunique()}")
print(f"Total rows in reddit_data: {len(reddit_grouped)}")
print(f"Average posts per date: {len(reddit_grouped) / reddit_grouped['Dat
e'].nunique():.1f}")
```

```
Reddit data date distribution:
Unique dates in reddit_data: 2943
Total rows in reddit_data: 2943
Average posts per date: 1.0
```

In [46]:
```
# Check the date distribution in news_data
print("Reddit data date distribution:")
print(f"Unique dates in vader_news_data: {news_data['Date'].nunique()}")
print(f"Total rows in vader_news_data: {len(news_data)}")
print(f"Average posts per date: {len(news_data) / news_data['Date'].nunique
():.1f}")
```

```
Reddit data date distribution:
Unique dates in vader_news_data: 1989
Total rows in vader_news_data: 1989
Average posts per date: 1.0
```

FinBERT

In [47]:
```
tokenizer = AutoTokenizer.from_pretrained("ProsusAI/finbert")
model = AutoModelForSequenceClassification.from_pretrained("ProsusAI/finber
t")
```

In [49]:
```
def get_finbert_sentiment_with_label(text):
    inputs = tokenizer(text, return_tensors="pt", truncation=True, max_leng
th=512)
    with torch.no_grad():
        outputs = model(**inputs)
        probs = softmax(outputs.logits, dim=1)

        negative = probs[0][0].item()
        neutral = probs[0][1].item()
        positive = probs[0][2].item()

        # Improved Neutral Handling
        if 0.2 < neutral < 0.6:
          sentiment_score = 0.0
          label = 'Neutral'
        else:
          sentiment_score = positive - negative
          # Avoid extreme +1.0 or -0.5 scores
          sentiment_score = max(min(sentiment_score, 0.9), -0.4)
          # Basic label assignment
          label = 'Positive' if sentiment_score > 0 else 'Negative'


    return sentiment_score, label
```

In [50]:
```
news_data.columns
```

Out[50]:
```
Index(['Date', 'Label', 'Top1', 'Top2', 'Top3', 'Top4', 'Top5', 'Top6', 'T
op7',
       'Top8', 'Top9', 'Top10', 'Top11', 'Top12', 'Top13', 'Top14', 'Top1
5',
       'Top16', 'Top17', 'Top18', 'Top19', 'Top20', 'Top21', 'Top22', 'Top
23',
       'Top24', 'Top25', 'combined_news', 'vader_news_sentiment'],
      dtype='object')
```

In [51]:
```
tqdm.pandas()

news_data[['FinBERT_news_sentiment', 'FinBERT_news_label']] = news_data['co
mbined_news'].progress_apply(
    lambda x: pd.Series(get_finbert_sentiment_with_label(x))
)
print(news_data[['Date', 'combined_news', 'FinBERT_news_sentiment', 'FinBER
T_news_label']].head())
```

```
100%|██████████| 1989/1989 [13:57<00:00,  2.37it/s]

        Date                                      combined_news  \
0 2008-08-08  georgia downs two russian warplanes as countri...
1 2008-08-11  why wont america and nato help us? if they won...
2 2008-08-12  remember that adorable 9-year-old who sang at ...
3 2008-08-13  u.s. refuses israel weapons to attack iran: re...
4 2008-08-14  all the experts admit that we should legalise ...

   FinBERT_news_sentiment FinBERT_news_label
0                0.190408           Positive
1                0.255340           Positive
2                0.000000            Neutral
3                0.000000            Neutral
4                0.142573           Positive
```

In [52]:
```
tqdm.pandas()

reddit_grouped[['FinBERT_reddit_sentiment', 'FinBERT_reddit_label']] = redd
it_grouped['Combined_Reddit_News'].progress_apply(
    lambda x: pd.Series(get_finbert_sentiment_with_label(x))
)
print(reddit_grouped[['Date', 'Combined_Reddit_News', 'FinBERT_reddit_senti
ment', 'FinBERT_reddit_label']].head())
```

```
100%|██████████| 2943/2943 [22:07<00:00,  2.22it/s]

        Date                                  Combined_Reddit_News  \
0 2008-06-08  marriage, they said, was reduced to the status...
1 2008-06-09  chew qat: in yemen, 72 per cent of men and 32 ...
2 2008-06-10  31 year old beats 3 year old to death: worst c...
3 2008-06-11  pakistan blames u.s. coalition for troops deat...
4 2008-06-12  marine mean motari gets expelled, another puni...

   FinBERT_reddit_sentiment FinBERT_reddit_label
0                  0.305556             Positive
1                  0.268858             Positive
2                  0.312289             Positive
3                  0.000000              Neutral
4                  0.000000              Neutral
```

In [53]:
```
# Verify the results
print("\nNews Data - First 5 sentiment scores:")
print(news_data[['Date', 'FinBERT_news_sentiment']].head())

print("\nReddit Data - First 5 sentiment scores:")
print(reddit_grouped[['Date', 'FinBERT_reddit_sentiment']].head())

print(f"\nMissing values in FinBERT_news_sentiment: {news_data['FinBERT_new
s_sentiment'].isnull().sum()}")
print(f"Missing values in FinBERT_reddit_sentiment: {reddit_grouped['FinBER
T_reddit_sentiment'].isnull().sum()}")

print(f"Sentiment range: {news_data['FinBERT_news_sentiment'].min():.4f} to
{news_data['FinBERT_news_sentiment'].max():.4f}")
print(f"Mean sentiment: {news_data['FinBERT_news_sentiment'].mean():.4f}")

print(f"Sentiment range: {reddit_grouped['FinBERT_reddit_sentiment'].min
():.4f} to {reddit_grouped['FinBERT_reddit_sentiment'].max():.4f}")
print(f"Mean sentiment: {reddit_grouped['FinBERT_reddit_sentiment'].mean
():.4f}")
```

```
News Data - First 5 sentiment scores:
        Date  FinBERT_news_sentiment
0 2008-08-08                0.190408
1 2008-08-11                0.255340
2 2008-08-12                0.000000
3 2008-08-13                0.000000
4 2008-08-14                0.142573

Reddit Data - First 5 sentiment scores:
        Date  FinBERT_reddit_sentiment
0 2008-06-08                  0.305556
1 2008-06-09                  0.268858
2 2008-06-10                  0.312289
3 2008-06-11                  0.000000
4 2008-06-12                  0.000000

Missing values in FinBERT_news_sentiment: 0
Missing values in FinBERT_reddit_sentiment: 0
Sentiment range: -0.0197 to 0.8869
Mean sentiment: 0.1401
Sentiment range: -0.4000 to 0.8561
Mean sentiment: 0.1364
```

Smart Sentiment

In [54]:
```
def smart_sentiment(text):
    score, label = get_finbert_sentiment_with_label(text)

    # Keyword lists
    extreme_negative_words = ['crash', 'collapse', 'plummet', 'wipeout', 'b
ankruptcy', 'liquidation', 'massive loss', 'wipe out']
    negative_words = ['fall', 'down', 'drop', 'loss', 'bearish', 'sell', 'b
reakdown', 'decline']
    positive_words = ['rise', 'gain', 'soar', 'up', 'surge', 'bullish', 'pr
ofit', 'growth', 'buy', 'record high']
    neutral_words = ['neutral', 'flat', 'no change', 'unchanged', 'stable',
'steady']

    text_lower = text.lower()

    # Apply Extreme Negative Penalty (Higher)
    if any(word in text_lower for word in extreme_negative_words):
        score -= 0.7
        label = 'Negative'

    # Apply Regular Negative Penalty
    elif any(word in text_lower for word in negative_words):
        score -= 0.4
        label = 'Negative'

    # Apply Positive Boost
    elif any(word in text_lower for word in positive_words):
        score += 0.4
        label = 'Positive'

    # Set Explicit Neutral Handling
    elif any(word in text_lower for word in neutral_words):
        score = 0.0
        label = 'Neutral'

    # Clip score between -1 and 1
    score = max(min(score, 0.9), -0.7)

    # Final Label Assignment (Refined Thresholds)
    if score > 0.3:
        label = 'Positive'
    elif score < -0.3:
        label = 'Negative'
    else:
        label = 'Neutral'

    return score, label
```

In [55]:
```
tqdm.pandas()

news_data[['Smart_news_sentiment', 'Smart_news_label']] = news_data['combin
ed_news'].progress_apply(
    lambda x: pd.Series(smart_sentiment(x))
)
print(news_data[['Date', 'combined_news', 'Smart_news_sentiment', 'Smart_ne
ws_label']].head())
```

```
100%|██████████| 1989/1989 [14:31<00:00,  2.28it/s]

        Date                                      combined_news  \
0 2008-08-08  georgia downs two russian warplanes as countri...
1 2008-08-11  why wont america and nato help us? if they won...
2 2008-08-12  remember that adorable 9-year-old who sang at ...
3 2008-08-13  u.s. refuses israel weapons to attack iran: re...
4 2008-08-14  all the experts admit that we should legalise ...

   Smart_news_sentiment Smart_news_label
0             -0.209592          Neutral
1             -0.144660          Neutral
2             -0.400000         Negative
3              0.400000         Positive
4              0.542573         Positive
```

In [56]:
```
tqdm.pandas()

reddit_grouped[['Smart_reddit_sentiment', 'Smart_reddit_label']] = reddit_g
rouped['Combined_Reddit_News'].progress_apply(
    lambda x: pd.Series(smart_sentiment(x))
)
print(reddit_grouped[['Date', 'Combined_Reddit_News', 'Smart_reddit_sentime
nt', 'Smart_reddit_label']].head())
```

```
100%|██████████| 2943/2943 [20:49<00:00,  2.35it/s]

        Date                                Combined_Reddit_News  \
0 2008-06-08  marriage, they said, was reduced to the status...
1 2008-06-09  chew qat: in yemen, 72 per cent of men and 32 ...
2 2008-06-10  31 year old beats 3 year old to death: worst c...
3 2008-06-11  pakistan blames u.s. coalition for troops deat...
4 2008-06-12  marine mean motari gets expelled, another puni...

   Smart_reddit_sentiment Smart_reddit_label
0                0.705556          Positive
1               -0.131142           Neutral
2               -0.087711           Neutral
3               -0.400000          Negative
4               -0.400000          Negative
```

In [57]:
```
# Verify the results
print("\nNews Data - First 5 sentiment scores:")
print(news_data[['Date', 'Smart_news_sentiment']].head())

print("\nReddit Data - First 5 sentiment scores:")
print(reddit_grouped[['Date', 'Smart_reddit_sentiment']].head())

print(f"\nMissing values in Smart_news_sentiment: {news_data['Smart_news_se
ntiment'].isnull().sum()}")
print(f"Missing values in Smart_reddit_sentiment: {reddit_grouped['Smart_re
ddit_sentiment'].isnull().sum()}")

print(f"Sentiment range: {news_data['Smart_news_sentiment'].min():.4f} to
{news_data['Smart_news_sentiment'].max():.4f}")
print(f"Mean sentiment: {news_data['Smart_news_sentiment'].mean():.4f}")

print(f"Sentiment range: {reddit_grouped['Smart_reddit_sentiment'].min():.4
f} to {reddit_grouped['Smart_reddit_sentiment'].max():.4f}")
print(f"Mean sentiment: {reddit_grouped['Smart_reddit_sentiment'].mean():.4
f}")
```

```
News Data - First 5 sentiment scores:
        Date  Smart_news_sentiment
0 2008-08-08             -0.209592
1 2008-08-11             -0.144660
2 2008-08-12             -0.400000
3 2008-08-13              0.400000
4 2008-08-14              0.542573

Reddit Data - First 5 sentiment scores:
        Date  Smart_reddit_sentiment
0 2008-06-08                0.705556
1 2008-06-09               -0.131142
2 2008-06-10               -0.087711
3 2008-06-11               -0.400000
4 2008-06-12               -0.400000

Missing values in Smart_news_sentiment: 0
Missing values in Smart_reddit_sentiment: 0
Sentiment range: -0.7000 to 0.9000
Mean sentiment: -0.1374
Sentiment range: -0.7000 to 0.9000
Mean sentiment: -0.1291
```

In [58]:
```
# Intent
def extract_intent_features(text):
    if pd.isna(text) or text == '' or text == 'nan':
        return {
            'buying_intent': 0, 'selling_intent': 0, 'uncertainty_intent':
0,
            'urgency_intent': 0, 'prediction_intent': 0, 'fear_intent': 0,
            'greed_intent': 0, 'question_intent': 0, 'action_intent': 0
        }

    text = str(text).lower()

    # intent keywords
    buying_keywords = ['buy', 'purchase', 'invest', 'bull', 'bullish', 'lon
g', 'growth', 'rise', 'gain', 'up', 'increase', 'rally', 'boom', 'positiv
e', 'optimistic']
    selling_keywords = ['sell', 'short', 'bear', 'bearish', 'dump', 'cras
h', 'fall', 'decline', 'drop', 'down', 'decrease', 'plunge', 'collapse', 'n
egative', 'pessimistic']
    uncertainty_keywords = ['maybe', 'might', 'could', 'uncertain', 'unclea
r', 'confused', 'doubt', 'unsure', 'possibly', 'perhaps', 'volatility', 'un
predictable']
    urgency_keywords = ['urgent', 'immediately', 'asap', 'quick', 'fast',
'now', 'breaking', 'alert', 'rush', 'emergency', 'critical', 'instant']
    prediction_keywords = ['predict', 'forecast', 'expect', 'anticipate',
'will', 'going to', 'likely', 'estimate', 'project', 'outlook', 'future',
'target']
    fear_keywords = ['fear', 'panic', 'worry', 'scared', 'anxious', 'concer
n', 'risk', 'danger', 'threat', 'crisis', 'disaster', 'trouble']
    greed_keywords = ['profit', 'money', 'rich', 'wealth', 'fortune', 'jack
pot', 'windfall', 'earnings', 'revenue', 'income', 'gains', 'returns']
    question_keywords = ['?', 'what', 'how', 'when', 'where', 'why', 'shoul
d', 'would', 'could', 'can', 'who', 'which']
    action_keywords = ['action', 'move', 'decision', 'strategy', 'plan', 'e
xecute', 'implement', 'act', 'do', 'trade', 'invest', 'position']

    # Count occurrences
    buying_count = sum(1 for word in buying_keywords if word in text)
    selling_count = sum(1 for word in selling_keywords if word in text)
    uncertainty_count = sum(1 for word in uncertainty_keywords if word in t
ext)
    urgency_count = sum(1 for word in urgency_keywords if word in text)
    prediction_count = sum(1 for word in prediction_keywords if word in tex
t)
    fear_count = sum(1 for word in fear_keywords if word in text)
    greed_count = sum(1 for word in greed_keywords if word in text)
    question_count = sum(1 for word in question_keywords if word in text)
    action_count = sum(1 for word in action_keywords if word in text)

    return {
        'buying_intent': buying_count,
        'selling_intent': selling_count,
        'uncertainty_intent': uncertainty_count,
        'urgency_intent': urgency_count,
        'prediction_intent': prediction_count,
        'fear_intent': fear_count,
        'greed_intent': greed_count,
        'question_intent': question_count,
        'action_intent': action_count
    }
```

In [59]:
```
# Apply intent analysis to news_data
print("Computing intent features for news data...")
print(f"Processing {len(news_data)} rows...")

tqdm.pandas(desc="News Intent Analysis")
news_intent_features = news_data['combined_news'].progress_apply(extract_in
tent_features)

# Convert to DataFrame and add to news_data
news_intent_df = pd.DataFrame(news_intent_features.tolist())
news_data = pd.concat([news_data, news_intent_df], axis=1)

print("News intent analysis completed!")
print("Intent features added:", list(news_intent_df.columns))
```

```
Computing intent features for news data...
Processing 1989 rows...

News Intent Analysis: 100%|██████████| 1989/1989 [00:00<00:00, 4810.68it/
s]

News intent analysis completed!
Intent features added: ['buying_intent', 'selling_intent', 'uncertainty_in
tent', 'urgency_intent', 'prediction_intent', 'fear_intent', 'greed_inten
t', 'question_intent', 'action_intent']
```

In [60]:
```
# Apply intent analysis to reddit_data
print("Computing intent features for reddit data...")
print(f"Processing {len(reddit_grouped)} rows...")

tqdm.pandas(desc="Reddit Intent Analysis")
reddit_intent_features = reddit_grouped['Combined_Reddit_News'].progress_ap
ply(extract_intent_features)

# Convert to DataFrame and add to reddit_data
reddit_intent_df = pd.DataFrame(reddit_intent_features.tolist())
reddit_grouped = pd.concat([reddit_grouped, reddit_intent_df], axis=1)

print("Reddit intent analysis completed!")
print("Intent features added:", list(reddit_intent_df.columns))
```

```
Computing intent features for reddit data...
Processing 2943 rows...

Reddit Intent Analysis: 100%|██████████| 2943/2943 [00:00<00:00, 4818.56i
t/s]

Reddit intent analysis completed!
Intent features added: ['buying_intent', 'selling_intent', 'uncertainty_in
tent', 'urgency_intent', 'prediction_intent', 'fear_intent', 'greed_inten
t', 'question_intent', 'action_intent']
```

In [61]:
```
# Display intent statistics for news_data
print("\nNews Data Intent")
intent_cols = ['buying_intent', 'selling_intent', 'uncertainty_intent', 'urgency_intent',
               'prediction_intent', 'fear_intent', 'greed_intent', 'question_intent', 'action_intent']

for col in intent_cols:
    print(f"{col}: Mean={news_data[col].mean():.2f}, Max={news_data[col].max()}, Sum={news_data[col].sum()}")
```

```
News Data Intent
buying_intent: Mean=2.86, Max=7, Sum=5698
selling_intent: Mean=1.38, Max=6, Sum=2748
uncertainty_intent: Mean=0.56, Max=3, Sum=1106
urgency_intent: Mean=1.08, Max=4, Sum=2151
prediction_intent: Mean=1.43, Max=6, Sum=2850
fear_intent: Mean=1.28, Max=6, Sum=2546
greed_intent: Mean=1.11, Max=4, Sum=2201
question_intent: Mean=4.84, Max=11, Sum=9623
action_intent: Mean=3.60, Max=8, Sum=7163
```

In [62]:
```
# Display intent statistics for reddit_data
print("\nReddit Data Intent")
for col in intent_cols:
    print(f"{col}: Mean={reddit_grouped[col].mean():.2f}, Max={reddit_grouped[col].max()}, Sum={reddit_grouped[col].sum()}")
```

```
Reddit Data Intent
buying_intent: Mean=2.87, Max=7, Sum=8457
selling_intent: Mean=1.36, Max=6, Sum=4002
uncertainty_intent: Mean=0.56, Max=3, Sum=1636
urgency_intent: Mean=1.07, Max=4, Sum=3138
prediction_intent: Mean=1.42, Max=6, Sum=4193
fear_intent: Mean=1.29, Max=6, Sum=3801
greed_intent: Mean=1.11, Max=4, Sum=3277
question_intent: Mean=4.81, Max=11, Sum=14154
action_intent: Mean=3.60, Max=9, Sum=10592
```

In [63]:
```
news_data.columns
```

Out[63]:
```
Index(['Date', 'Label', 'Top1', 'Top2', 'Top3', 'Top4', 'Top5', 'Top6', 'Top7',
       'Top8', 'Top9', 'Top10', 'Top11', 'Top12', 'Top13', 'Top14', 'Top15',
       'Top16', 'Top17', 'Top18', 'Top19', 'Top20', 'Top21', 'Top22', 'Top23',
       'Top24', 'Top25', 'combined_news', 'vader_news_sentiment',
       'FinBERT_news_sentiment', 'FinBERT_news_label', 'Smart_news_sentiment',
       'Smart_news_label', 'buying_intent', 'selling_intent',
       'uncertainty_intent', 'urgency_intent', 'prediction_intent',
       'fear_intent', 'greed_intent', 'question_intent', 'action_intent'],
      dtype='object')
```

In [64]:
```
reddit_grouped.columns
```

Out[64]:
```
Index(['Date', 'Combined_Reddit_News', 'vader_reddit_sentiment',
       'FinBERT_reddit_sentiment', 'FinBERT_reddit_label',
       'Smart_reddit_sentiment', 'Smart_reddit_label', 'buying_intent',
       'selling_intent', 'uncertainty_intent', 'urgency_intent',
       'prediction_intent', 'fear_intent', 'greed_intent', 'question_inten
t',
       'action_intent'],
      dtype='object')
```

In [65]:
```
print("\nNews data with sentiment and intent:")
sample_cols = ['Date', 'vader_news_sentiment',
       'FinBERT_news_sentiment', 'Smart_news_sentiment'] + intent_cols
print(news_data[sample_cols].head())

print("\nReddit data with sentiment and intent:")
sample_cols = ['Date', 'vader_reddit_sentiment',
       'FinBERT_reddit_sentiment',
       'Smart_reddit_sentiment'] + intent_cols
print(reddit_grouped[sample_cols].head())
```

```
News data with sentiment and intent:
        Date  vader_news_sentiment  FinBERT_news_sentiment  \
0 2008-08-08               -0.9978                0.190408
1 2008-08-11               -0.9814                0.255340
2 2008-08-12               -0.9778                0.000000
3 2008-08-13               -0.9809                0.000000
4 2008-08-14               -0.9899                0.142573

   Smart_news_sentiment  buying_intent  selling_intent  uncertainty_intent
\
0             -0.209592              2               2                   0
1             -0.144660              1               1                   1
2             -0.400000              3               2                   1
3              0.400000              2               0                   0
4              0.542573              1               0                   1

   urgency_intent  prediction_intent  fear_intent  greed_intent  \
0               1                  1            1             1
1               1                  0            1             0
2               1                  0            0             0
3               0                  1            0             1
4               2                  3            2             1

   question_intent  action_intent
0                6              5
1                4              3
2                6              3
3                5              5
4                5              3

Reddit data with sentiment and intent:
        Date  vader_reddit_sentiment  FinBERT_reddit_sentiment  \
0 2008-06-08                 -0.9975                  0.305556
1 2008-06-09                 -0.9968                  0.268858
2 2008-06-10                 -0.9962                  0.312289
3 2008-06-11                 -0.9901                  0.000000
4 2008-06-12                 -0.8840                  0.000000

   Smart_reddit_sentiment  buying_intent  selling_intent  uncertainty_inte
nt  \
0                0.705556              3               1
1
1               -0.131142              2               1
0
2               -0.087711              2               2
0
3               -0.400000              2               1
0
4               -0.400000              2               2
0

   urgency_intent  prediction_intent  fear_intent  greed_intent  \
0               1                  3            3             1
1               1                  2            4             1
2               0                  0            3             1
3               0                  1            2             1
4               1                  2            1             0

   question_intent  action_intent
0                6              5
1                6              1
```

```
2               4               3
3               3               3
4               5               3
```

In [66]:
```
news_data.rename(
    columns={col: f'news_{col}' for col in news_data.columns if 'intent' in col and not col.startswith('news_')},
    inplace=True
)
```

In [67]:
```
reddit_grouped.rename(
    columns={col: f'reddit_{col}' for col in reddit_grouped.columns if 'intent' in col and not col.startswith('reddit_')},
    inplace=True
)
```

In [68]:
```
reddit_grouped.columns
```

Out[68]:
```
Index(['Date', 'Combined_Reddit_News', 'vader_reddit_sentiment',
       'FinBERT_reddit_sentiment', 'FinBERT_reddit_label',
       'Smart_reddit_sentiment', 'Smart_reddit_label', 'reddit_buying_intent',
       'reddit_selling_intent', 'reddit_uncertainty_intent',
       'reddit_urgency_intent', 'reddit_prediction_intent',
       'reddit_fear_intent', 'reddit_greed_intent', 'reddit_question_intent',
       'reddit_action_intent'],
      dtype='object')
```

In [69]:
```
news_data.columns
```

Out[69]:
```
Index(['Date', 'Label', 'Top1', 'Top2', 'Top3', 'Top4', 'Top5', 'Top6', 'Top7',
       'Top8', 'Top9', 'Top10', 'Top11', 'Top12', 'Top13', 'Top14', 'Top15',
       'Top16', 'Top17', 'Top18', 'Top19', 'Top20', 'Top21', 'Top22', 'Top23',
       'Top24', 'Top25', 'combined_news', 'vader_news_sentiment',
       'FinBERT_news_sentiment', 'FinBERT_news_label', 'Smart_news_sentiment',
       'Smart_news_label', 'news_buying_intent', 'news_selling_intent',
       'news_uncertainty_intent', 'news_urgency_intent',
       'news_prediction_intent', 'news_fear_intent', 'news_greed_intent',
       'news_question_intent', 'news_action_intent'],
      dtype='object')
```

In [70]:
```
# Display intent statistics for news_data
print("\nNews Data Intent")
intent_cols_news = ['news_buying_intent', 'news_selling_intent',
       'news_uncertainty_intent', 'news_urgency_intent',
       'news_prediction_intent', 'news_fear_intent', 'news_greed_intent',
       'news_question_intent', 'news_action_intent']

for col in intent_cols_news:
    print(f"{col}: Mean={news_data[col].mean():.2f}, Max={news_data[col].ma
x()}, Sum={news_data[col].sum()}")
```

```
News Data Intent
news_buying_intent: Mean=2.86, Max=7, Sum=5698
news_selling_intent: Mean=1.38, Max=6, Sum=2748
news_uncertainty_intent: Mean=0.56, Max=3, Sum=1106
news_urgency_intent: Mean=1.08, Max=4, Sum=2151
news_prediction_intent: Mean=1.43, Max=6, Sum=2850
news_fear_intent: Mean=1.28, Max=6, Sum=2546
news_greed_intent: Mean=1.11, Max=4, Sum=2201
news_question_intent: Mean=4.84, Max=11, Sum=9623
news_action_intent: Mean=3.60, Max=8, Sum=7163
```

In [71]:
```
# Display intent statistics for reddit_data
print("\nReddit Data Intent")
intent_cols_reddit = ['reddit_buying_intent',
       'reddit_selling_intent', 'reddit_uncertainty_intent',
       'reddit_urgency_intent', 'reddit_prediction_intent',
       'reddit_fear_intent', 'reddit_greed_intent', 'reddit_question_inten
t',
       'reddit_action_intent']

for col in intent_cols_reddit:
    print(f"{col}: Mean={reddit_grouped[col].mean():.2f}, Max={reddit_group
ed[col].max()}, Sum={reddit_grouped[col].sum()}")
```

```
Reddit Data Intent
reddit_buying_intent: Mean=2.87, Max=7, Sum=8457
reddit_selling_intent: Mean=1.36, Max=6, Sum=4002
reddit_uncertainty_intent: Mean=0.56, Max=3, Sum=1636
reddit_urgency_intent: Mean=1.07, Max=4, Sum=3138
reddit_prediction_intent: Mean=1.42, Max=6, Sum=4193
reddit_fear_intent: Mean=1.29, Max=6, Sum=3801
reddit_greed_intent: Mean=1.11, Max=4, Sum=3277
reddit_question_intent: Mean=4.81, Max=11, Sum=14154
reddit_action_intent: Mean=3.60, Max=9, Sum=10592
```

In [72]:
```
print(f"\nNews data shape: {news_data.shape}")
print(f"Reddit data shape: {reddit_grouped.shape}")

print(f"\nMissing values in news intent features:")
for col in intent_cols_news:
    missing = news_data[col].isnull().sum()
    print(f"{col}: {missing}")

print(f"\nMissing values in reddit intent features:")
for col in intent_cols_reddit:
    missing = reddit_grouped[col].isnull().sum()
    print(f"{col}: {missing}")
```

```
News data shape: (1989, 42)
Reddit data shape: (2943, 16)

Missing values in news intent features:
news_buying_intent: 0
news_selling_intent: 0
news_uncertainty_intent: 0
news_urgency_intent: 0
news_prediction_intent: 0
news_fear_intent: 0
news_greed_intent: 0
news_question_intent: 0
news_action_intent: 0

Missing values in reddit intent features:
reddit_buying_intent: 0
reddit_selling_intent: 0
reddit_uncertainty_intent: 0
reddit_urgency_intent: 0
reddit_prediction_intent: 0
reddit_fear_intent: 0
reddit_greed_intent: 0
reddit_question_intent: 0
reddit_action_intent: 0
```

In [73]:
```
merged_data = stock_data.merge(
    news_data[['Date', 'Label', 'combined_news', 'vader_news_sentiment',
       'FinBERT_news_sentiment', 'FinBERT_news_label', 'Smart_news_sentimen
t',
       'Smart_news_label', 'news_buying_intent', 'news_selling_intent',
       'news_uncertainty_intent', 'news_urgency_intent',
       'news_prediction_intent', 'news_fear_intent', 'news_greed_intent',
       'news_question_intent', 'news_action_intent']],
    on='Date',
    how='inner'
)

merged_data = merged_data.merge(
    reddit_grouped[['Date','Combined_Reddit_News', 'vader_reddit_sentimen
t',
       'FinBERT_reddit_sentiment', 'FinBERT_reddit_label',
       'Smart_reddit_sentiment', 'Smart_reddit_label', 'reddit_buying_inten
t',
       'reddit_selling_intent', 'reddit_uncertainty_intent',
       'reddit_urgency_intent', 'reddit_prediction_intent',
       'reddit_fear_intent', 'reddit_greed_intent', 'reddit_question_inten
t',
       'reddit_action_intent']],
    on='Date',
    how='inner'
)
```

In [74]:
```
merged_data['Target'] = (merged_data['Close'].shift(-1) > merged_data['Clos
e']).astype(int)
```

In [75]:
```
merged_data['pct_change'] = merged_data['Close'].pct_change()
```

In [76]:
```
news_data.columns
```

Out[76]:
```
Index(['Date', 'Label', 'Top1', 'Top2', 'Top3', 'Top4', 'Top5', 'Top6', 'T
op7',
       'Top8', 'Top9', 'Top10', 'Top11', 'Top12', 'Top13', 'Top14', 'Top1
5',
       'Top16', 'Top17', 'Top18', 'Top19', 'Top20', 'Top21', 'Top22', 'Top
23',
       'Top24', 'Top25', 'combined_news', 'vader_news_sentiment',
       'FinBERT_news_sentiment', 'FinBERT_news_label', 'Smart_news_sentime
nt',
       'Smart_news_label', 'news_buying_intent', 'news_selling_intent',
       'news_uncertainty_intent', 'news_urgency_intent',
       'news_prediction_intent', 'news_fear_intent', 'news_greed_intent',
       'news_question_intent', 'news_action_intent'],
      dtype='object')
```

In [77]:
```
reddit_grouped.columns
```

Out[77]:
```
Index(['Date', 'Combined_Reddit_News', 'vader_reddit_sentiment',
       'FinBERT_reddit_sentiment', 'FinBERT_reddit_label',
       'Smart_reddit_sentiment', 'Smart_reddit_label', 'reddit_buying_inte
nt',
       'reddit_selling_intent', 'reddit_uncertainty_intent',
       'reddit_urgency_intent', 'reddit_prediction_intent',
       'reddit_fear_intent', 'reddit_greed_intent', 'reddit_question_inten
t',
       'reddit_action_intent'],
      dtype='object')
```

In [78]:
```
merged_data.columns
```

Out[78]:
```
Index(['Date', 'Open', 'High', 'Low', 'Close', 'Volume', 'Adj Close',
       'Log_Returns', 'Volatility_Log_10', 'cl-op', 'hi-lo', 'Label',
       'combined_news', 'vader_news_sentiment', 'FinBERT_news_sentiment',
       'FinBERT_news_label', 'Smart_news_sentiment', 'Smart_news_label',
       'news_buying_intent', 'news_selling_intent', 'news_uncertainty_inte
nt',
       'news_urgency_intent', 'news_prediction_intent', 'news_fear_inten
t',
       'news_greed_intent', 'news_question_intent', 'news_action_intent',
       'Combined_Reddit_News', 'vader_reddit_sentiment',
       'FinBERT_reddit_sentiment', 'FinBERT_reddit_label',
       'Smart_reddit_sentiment', 'Smart_reddit_label', 'reddit_buying_inte
nt',
       'reddit_selling_intent', 'reddit_uncertainty_intent',
       'reddit_urgency_intent', 'reddit_prediction_intent',
       'reddit_fear_intent', 'reddit_greed_intent', 'reddit_question_inten
t',
       'reddit_action_intent', 'Target', 'pct_change'],
      dtype='object')
```

In [79]:
```
merged_data['finbert_final_sentiment'] = (
    0.6 * merged_data['FinBERT_news_sentiment'] +
    0.4 * merged_data['FinBERT_reddit_sentiment']
)
```

In [80]:
```
# List of base intent types
intent_types = [
    'buying', 'selling', 'uncertainty', 'urgency',
    'prediction', 'fear', 'greed', 'question', 'action'
]

# 1. Total intent score per type (news + reddit)
for intent in intent_types:
    merged_data[f'total_{intent}_intent'] = (
        merged_data[f'news_{intent}_intent'] + merged_data[f'reddit_{inten
t}_intent']
    )

# 2. Sentiment-adjusted intent interaction (FinBERT sentiment minus intent
s)
for intent in ['uncertainty', 'fear', 'action', 'urgency', 'prediction']:
    merged_data[f'sentiment_minus_{intent}'] = (
        merged_data['finbert_final_sentiment'] -
        merged_data[f'news_{intent}_intent'] -
        merged_data[f'reddit_{intent}_intent']
    )
```

In [81]:
```
merged_data.columns
```

Out[81]:
```
Index(['Date', 'Open', 'High', 'Low', 'Close', 'Volume', 'Adj Close',
       'Log_Returns', 'Volatility_Log_10', 'cl-op', 'hi-lo', 'Label',
       'combined_news', 'vader_news_sentiment', 'FinBERT_news_sentiment',
       'FinBERT_news_label', 'Smart_news_sentiment', 'Smart_news_label',
       'news_buying_intent', 'news_selling_intent', 'news_uncertainty_inte
nt',
       'news_urgency_intent', 'news_prediction_intent', 'news_fear_inten
t',
       'news_greed_intent', 'news_question_intent', 'news_action_intent',
       'Combined_Reddit_News', 'vader_reddit_sentiment',
       'FinBERT_reddit_sentiment', 'FinBERT_reddit_label',
       'Smart_reddit_sentiment', 'Smart_reddit_label', 'reddit_buying_inte
nt',
       'reddit_selling_intent', 'reddit_uncertainty_intent',
       'reddit_urgency_intent', 'reddit_prediction_intent',
       'reddit_fear_intent', 'reddit_greed_intent', 'reddit_question_inten
t',
       'reddit_action_intent', 'Target', 'pct_change',
       'finbert_final_sentiment', 'total_buying_intent',
       'total_selling_intent', 'total_uncertainty_intent',
       'total_urgency_intent', 'total_prediction_intent', 'total_fear_inte
nt',
       'total_greed_intent', 'total_question_intent', 'total_action_inten
t',
       'sentiment_minus_uncertainty', 'sentiment_minus_fear',
       'sentiment_minus_action', 'sentiment_minus_urgency',
       'sentiment_minus_prediction'],
      dtype='object')
```

In [82]:
```
merged_data.shape
```

Out[82]:
```
(1989, 59)
```

`sentiment_minus_fear = finbert_final_sentiment - news_fear_intent - reddit_fear_intent`

This tells us:
Even if sentiment seems positive, is it being dragged down by fear-driven context?
Or: If sentiment is already negative and there's also high fear, this difference gets more negative — stronger bearish signal.

Feature	Interpretation
sentiment_minus_fear	Net market tone after accounting for fear-driven language
sentiment_minus_uncertainty	Is the sentiment confident, or overshadowed by uncertainty?
sentiment_minus_action	Is sentiment just talk, or accompanied by strong “action” language?
sentiment_minus_urgency	Is market tone rushed or calm despite the sentiment?
sentiment_minus_prediction	Is there a concrete outlook or just speculative mood?

`sentiment_minus_<intent>` features help measure how pure sentiment is affected by deeper psychological tones like fear, uncertainty, urgency, etc.
They're designed to make your model more aware of contextual market signals that drive price moves.

In [83]:
```
(merged_data['Target'] == merged_data['Label']).mean()
```

Out[83]:
```
np.float64(0.0015082956259426848)
```

In [84]:
```
merged_data.to_csv('multimodal_dataset_final2.csv', index=False)
```

In [86]:
```
merged_data.to_csv('B:/Dublin City University/Practicum/Proj/Dataset/main/processed/multimodal_dataset_final3.csv', index=False)
```

In [87]:
```
merged_data.shape
```

Out[87]:
```
(1989, 59)
```