Predicting Volatility Regimes in Coinbase Stock

Chris Hathaway, Felipe Vianna,
Max Stracher, Ruyao (Anthony) Tian

Motivation

Bitcoin is considered a **safe-haven asset**, largely uncorrelated from stock markets

Could there be predictive power in Bitcoin price movements?

Goal

Create a model that uses **Bitcoin** price movements to predict near future **Coinbase volatility** spikes

Why Coinbase?

- We picked Coinbase because we'd traded it and kept seeing sharp reactions to market sentiment.
- Coinbase earns revenue from trading fees, so volatility should help them, yet the stock mainly moves with BTC's price level, making that disconnect worth studying.
- Coinbase stock behaves like a leveraged play on Bitcoin, making volatility the key thing to predict.

- Bitcoin often moves first, so we tested whether BTC signals can anticipate COIN's biggest swings.

Who is this for?

Quant firms **already** have models and low-latency infrastructure that we would never be able to come close to

Meanwhile, **non-quant investors** could easily benefit from a short-term volatility indicator for many types of trading strategies, such as a straddle options strategy

Modeling

Prediction Target

Predicting BINARY outcome: "Is the next period a volatile window?"

Definition: **volatile window** is determined true if next set of move is greater than the rolling median of the last 50 periods.

Feature Selection

Despite using Bitcoin as the main signal source, its **high volatility** prompted us to look for **secondary signals** that would **shield our model** from being too swayed by bigger swings in Bitcoin price

Features tested:

- Economic factors: HML, SMB, Beta, Momentum
- Mega-cap stocks (AAPL, MSFT, NVDA)
- Market benchmarks: S&P, Russell
- Volatility index: VIX

Dealing with look-ahead bias

- Used **time-ordered train, validation, and test splits**
  - Ensuring the model never trained on future information.
- Tuned **hyperparameters** only on validation window.
  - Final evaluation reserved for a fully out-of-sample test period.
- Mirrors **real world** deployment conditions.
  - Model is evaluated on data that comes after training.

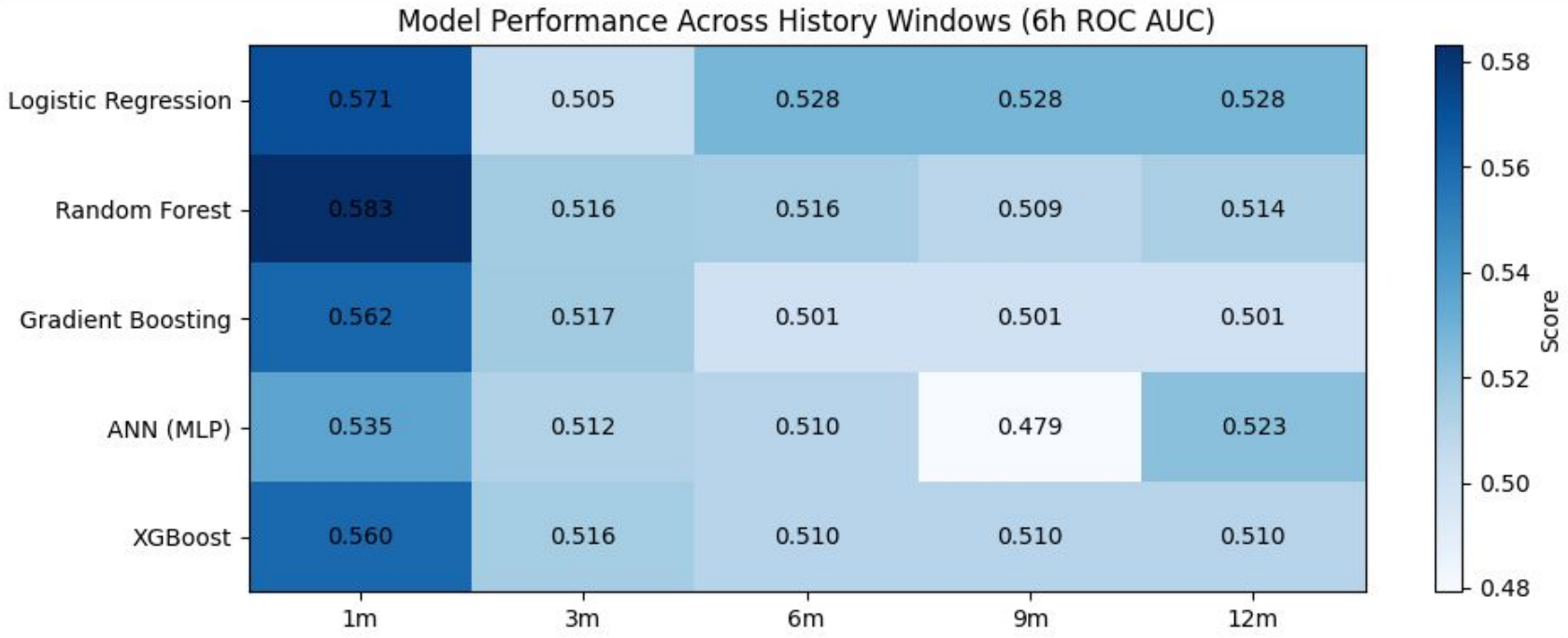
Training Time Frame

High volatility of BTC encourages a **shorter** training time frame

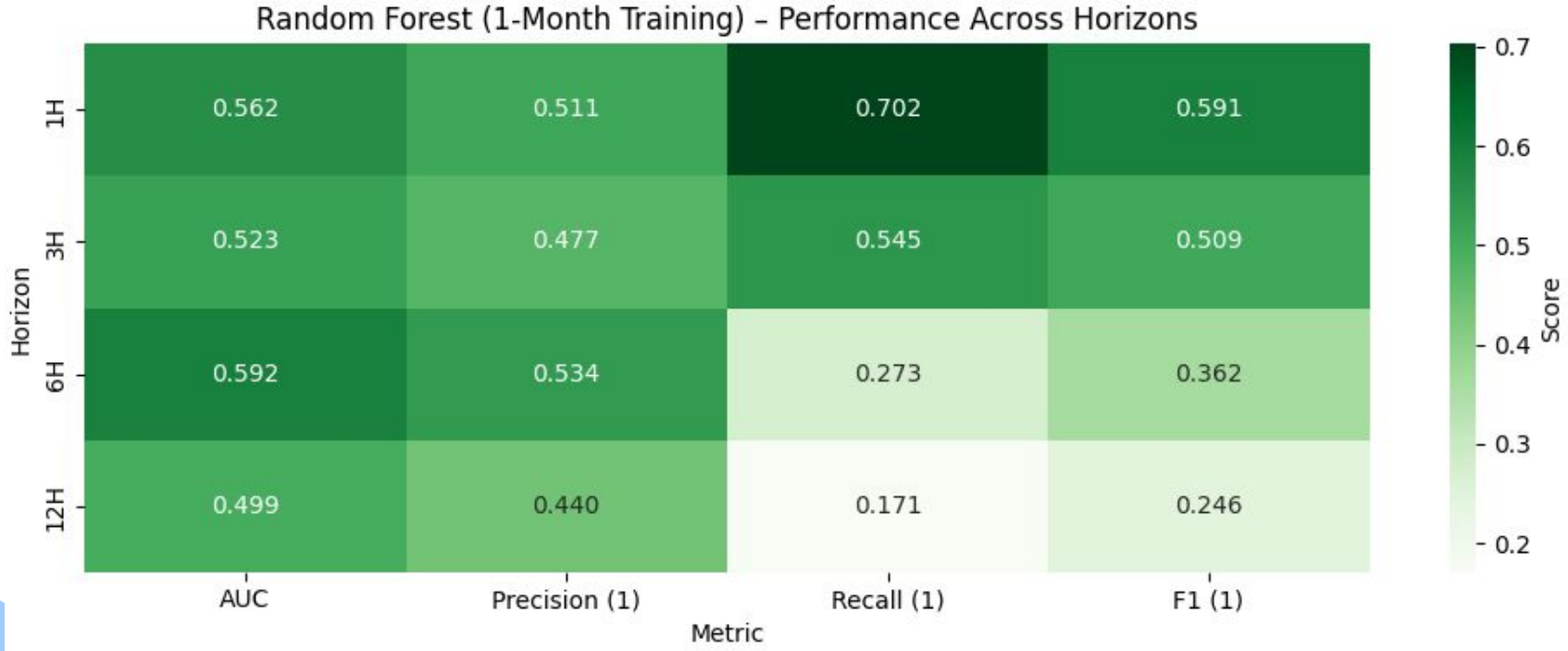
Outdated patterns won't affect predictability of current trends...

... but, too **narrow** windows will very easily lead to **overfitting**

Models Tested vs Training Windows



RF Model Results / Prediction Horizons



Model Interpretation

Prediction Target: ***Volatility***

Precision: Shows reliable signal **51%**

- Model says "large move" incoming => how true?
  => filters out half of the false alarms => less unnecessary losses.

Recall: Shows enough signal to be reliable **70%**

- Of ALL real "large moves", how often does the model identify them?
  => identifies half the volatile windows => potential "opportunity" windows; trade or not, is up to individual at this point.

F1: Both. **59%**

- F1 shows when price swings happen (Recall), and that it's reliable (Precision).

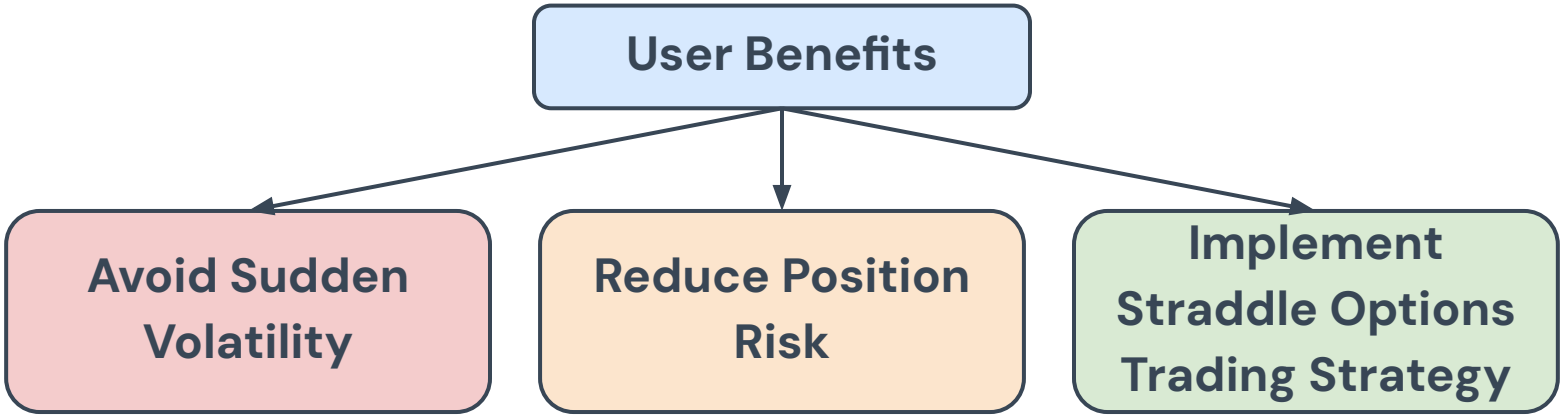
AUC-ROC: Model indeed has signal. **56%**

SET ASIDE: **Accuracy**

*more models in appendix

Business Takeaway

Our model predicts large price swings over a 1-hour window.



Implementation

Platform Integration

Independent Usage

- Mobile App
- Browser Extension
- TradingView Indicator

Thanks!

Any questions?

Appendix

```
Sample size: 1731
  Train: 969  | Val: 242  | Test: 520
Class balance in full sample (0=no large move, 1=large move):
  class 0: 911 (52.6%)
  class 1: 820 (47.4%)
```

1H Horizon

```
--------------------------------------------------------------------
XGBoost (Best tuned on val, refit on Train+Val)
--------------------------------------------------------------------
Accuracy: 54.038%
ROC AUC: 0.5362

Confusion Matrix:
[[142 127]
 [112 139]]

Classification Report:
              precision    recall  f1-score   support

           0      0.559     0.528     0.543       269
           1      0.523     0.554     0.538       251

    accuracy                          0.540       520
   macro avg      0.541     0.541     0.540       520
weighted avg      0.541     0.540     0.540       520


XGBoost Feature Importances:
coin_ret_1h       0.112594
coin_minus_btc    0.108686
btc_vol_6h        0.104581
btc_ret_lag_1     0.101507
coin_ret_lag_3    0.098962
coin_ret_lag_2    0.097359
coin_ret_lag_1    0.097044
coin_vol_6h       0.095198
btc_ret_lag_2     0.093845
btc_ret_1h        0.090223
```

3H Horizon

```
--------------------------------------------------------------------
XGBoost (Best tuned on val, refit on Train+Val)
--------------------------------------------------------------------
Accuracy: 52.115%
ROC AUC: 0.5458

Confusion Matrix:
[[137 114]
 [135 134]]

Classification Report:
              precision    recall  f1-score   support

           0      0.504     0.546     0.524       251
           1      0.540     0.498     0.518       269

    accuracy                          0.521       520
   macro avg      0.522     0.522     0.521       520
weighted avg      0.523     0.521     0.521       520


XGBoost Feature Importances:
coin_ret_1h       0.108898
coin_vol_6h       0.104527
btc_vol_6h        0.101893
coin_ret_lag_2    0.101026
btc_ret_lag_1     0.100867
btc_ret_lag_2     0.100061
coin_minus_btc    0.097254
coin_ret_lag_3    0.097031
btc_ret_1h        0.095638
coin_ret_lag_1    0.092805
```

6H Horizon

```
------------------------------------------------------------------
XGBoost (Best tuned on val, refit on Train+Val)
------------------------------------------------------------------
Accuracy: 53.077%
ROC AUC: 0.5490

Confusion Matrix:
[[149 108]
 [136 127]]

Classification Report:
              precision    recall  f1-score   support

           0      0.523     0.580     0.550       257
           1      0.540     0.483     0.510       263

    accuracy                          0.531       520
   macro avg      0.532     0.531     0.530       520
weighted avg      0.532     0.531     0.530       520


XGBoost Feature Importances:
btc_vol_6h        0.112538
btc_ret_1h        0.112536
coin_ret_lag_2    0.107217
coin_vol_6h       0.105637
coin_ret_1h       0.101768
btc_ret_lag_2     0.097017
btc_ret_lag_1     0.094319
coin_ret_lag_1    0.090958
coin_ret_lag_3    0.089689
coin_minus_btc    0.088322
```

12H Horizon

```
------------------------------------------------------------------
XGBoost (Best tuned on val, refit on Train+Val)
------------------------------------------------------------------
Accuracy: 52.692%
ROC AUC: 0.5410

Confusion Matrix:
[[157 105]
 [141 117]]

Classification Report:
              precision    recall  f1-score   support

           0      0.527     0.599     0.561       262
           1      0.527     0.453     0.487       258

    accuracy                          0.527       520
   macro avg      0.527     0.526     0.524       520
weighted avg      0.527     0.527     0.524       520


XGBoost Feature Importances:
coin_vol_6h       0.112660
btc_vol_6h        0.112189
coin_ret_lag_3    0.100470
btc_ret_1h        0.100392
coin_minus_btc    0.100156
btc_ret_lag_2     0.099230
coin_ret_lag_2    0.098082
btc_ret_lag_1     0.093292
coin_ret_lag_1    0.091793
coin_ret_1h       0.091737
```

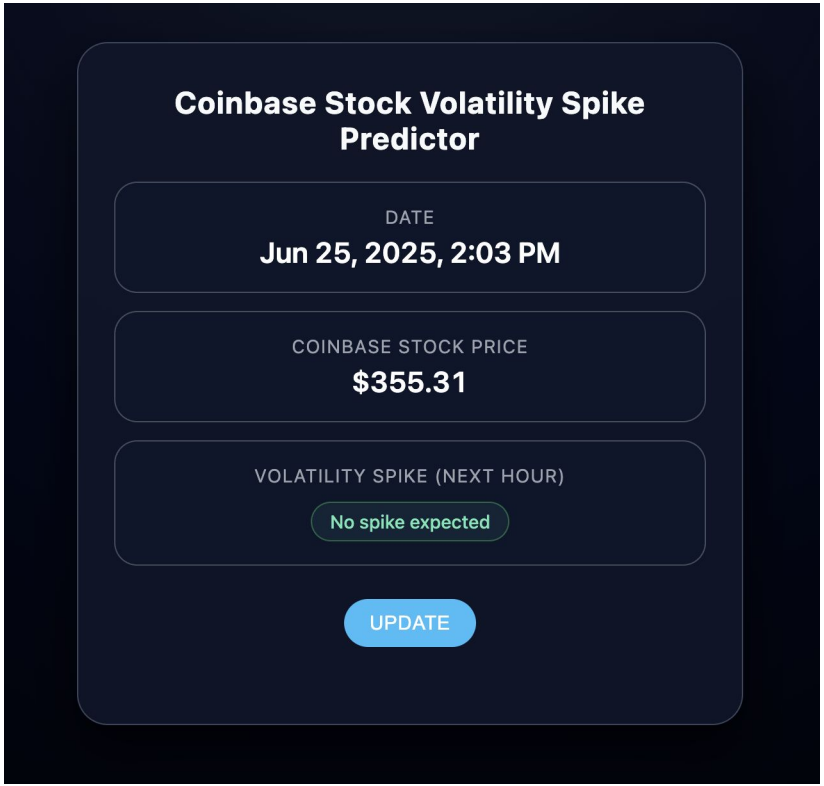
24H Horizon

```
----------------------------------------------------------------------
XGBoost (Best tuned on val, refit on Train+Val)
----------------------------------------------------------------------
Accuracy: 47.308%
ROC AUC: 0.4640

Confusion Matrix:
[[131 151]
 [123 115]]

Classification Report:
              precision    recall  f1-score   support

           0      0.516     0.465     0.489       282
           1      0.432     0.483     0.456       238

    accuracy                          0.473       520
   macro avg      0.474     0.474     0.473       520
weighted avg      0.478     0.473     0.474       520


XGBoost Feature Importances:
coin_vol_6h       0.113643
btc_vol_6h        0.110631
coin_minus_btc    0.101362
btc_ret_lag_1     0.098599
coin_ret_1h       0.097747
btc_ret_lag_2     0.097670
coin_ret_lag_2    0.097330
btc_ret_1h        0.096680
coin_ret_lag_1    0.095891
coin_ret_lag_3    0.090447
```

Model Results (RF 6H)

Horizon	AUC	Prec (1)	Recall (1)	F1 (1)
1H	0.563	0.521	0.628	0.570
3H	0.498	0.451	0.489	0.469
6H	0.579	0.547	0.489	0.516
12H	0.529	0.472	0.389	0.426

API Demo Screenshot



API Demo Repo

https://github.com/fe-vianna/ML-Final-Project