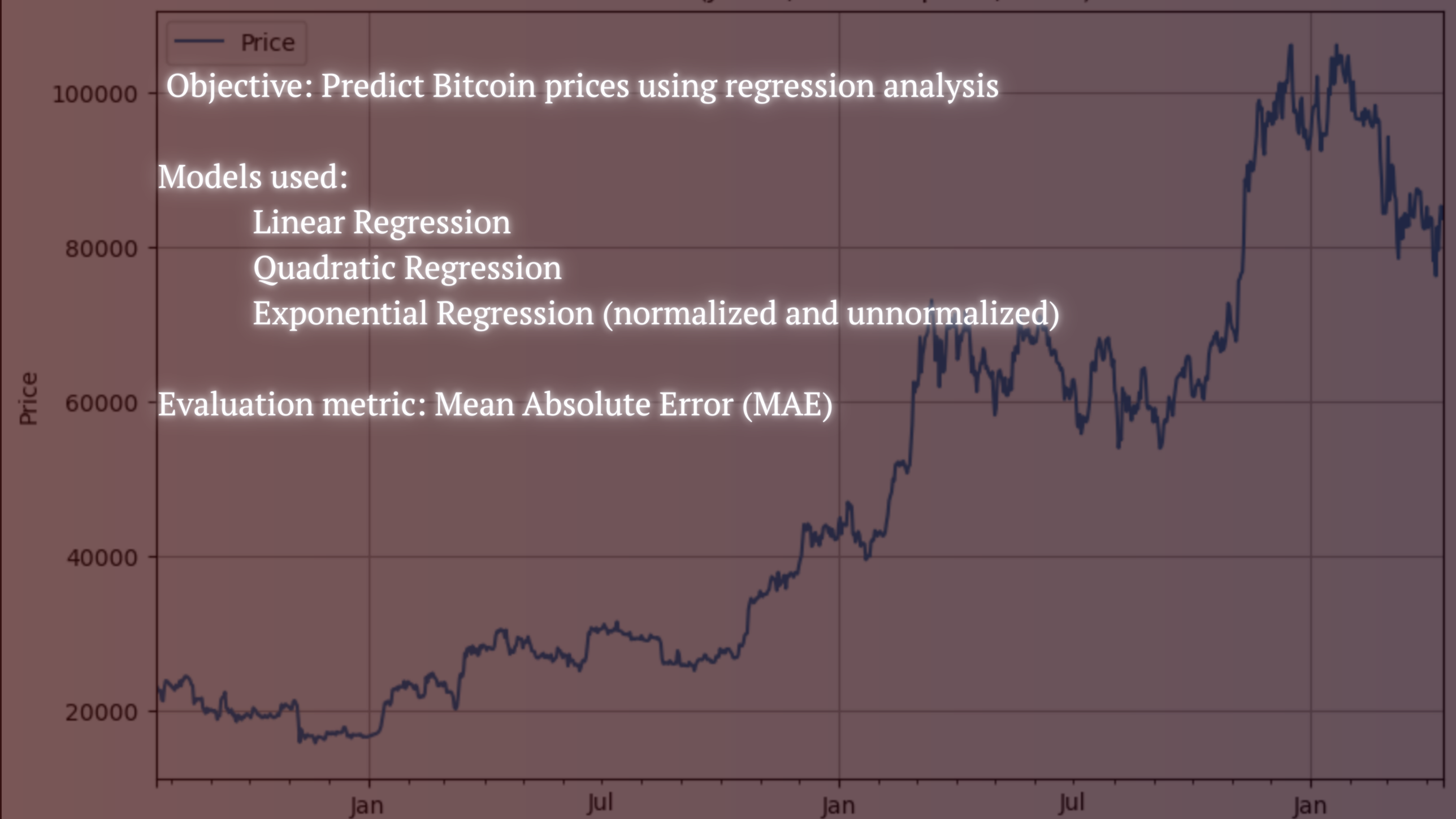
Modeling Bitcoin Price Trends Using Regression and Gradient Descent

CSCI 240 Final Project

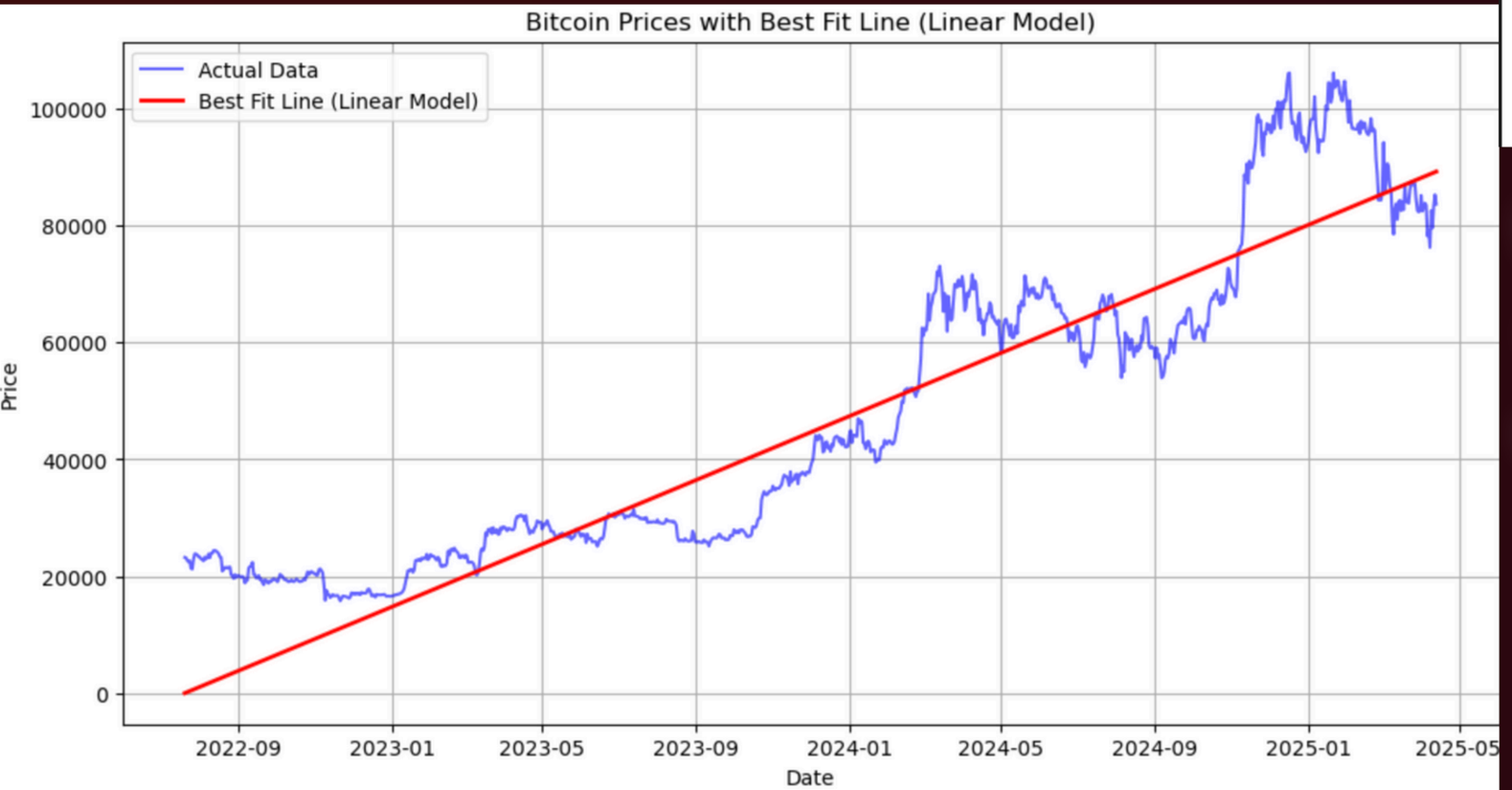
Adam Kaderbhai

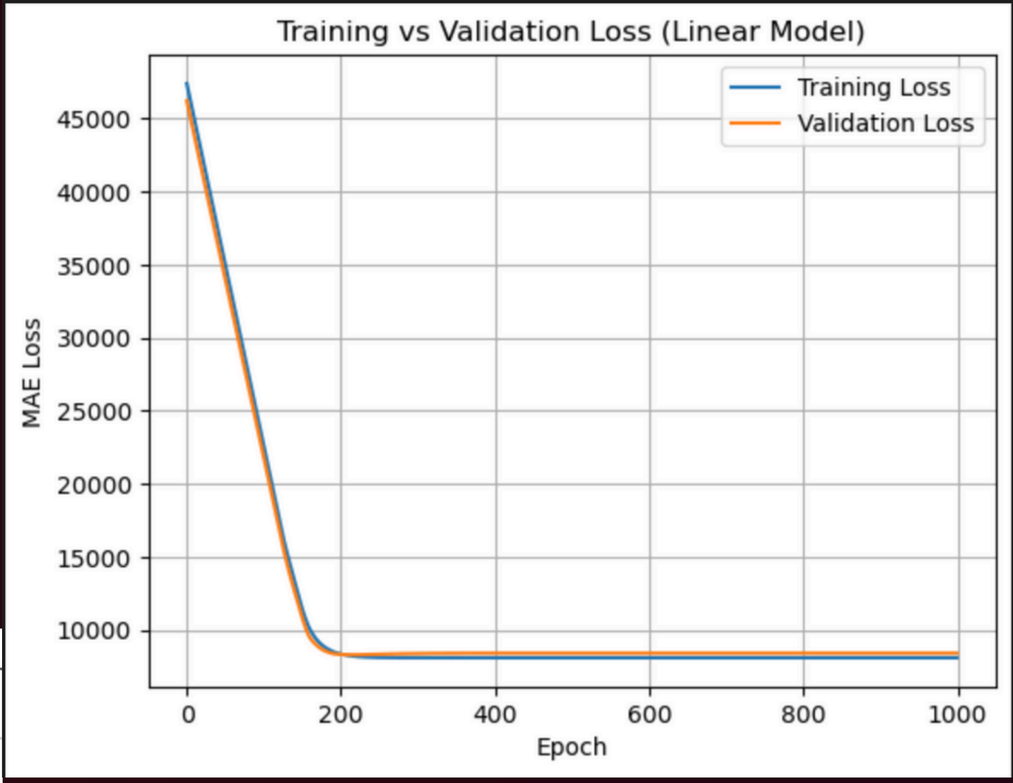
Spring 2025


Price
Objective: Predict Bitcoin prices using regression analysis
Models used:
Linear Regression
Quadratic Regression
Exponential Regression (normalized and unnormalized)
Evaluation metric: Mean Absolute Error (MAE)
100000
80000
60000
40000
20000
Price
Jan
Jul
Jan
Jul
Jan

- Linear – models a straight-line relationship $$y = mx + b$$
- Quadratic – captures curvature in the trend $$\hat{y} = ax^2 + bx + c$$
-
- Exponential – captures compounding growth (sensitive to input scale) $$\hat{y} = a \cdot e^{bx} + c$$

Linear Model Results



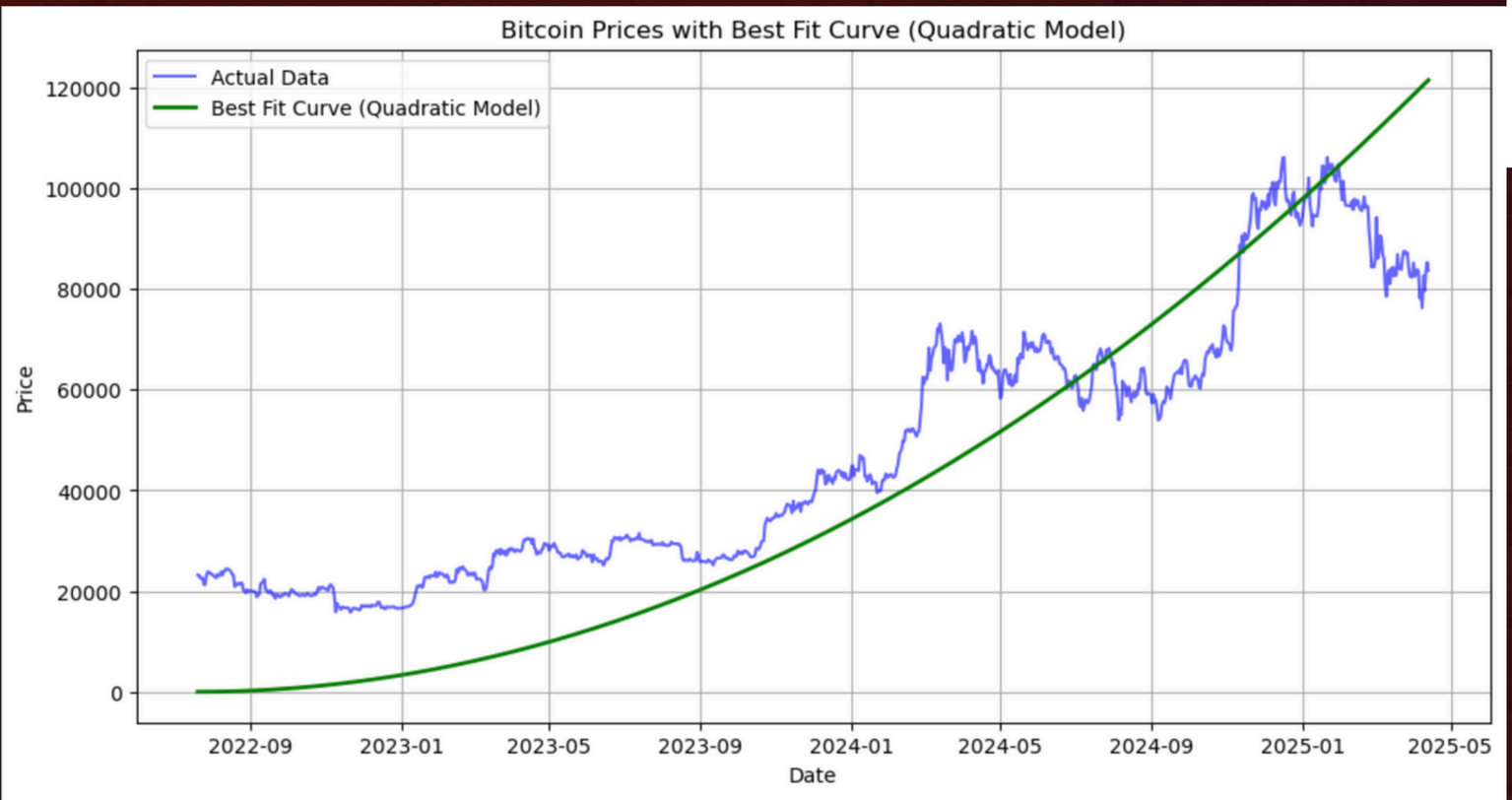


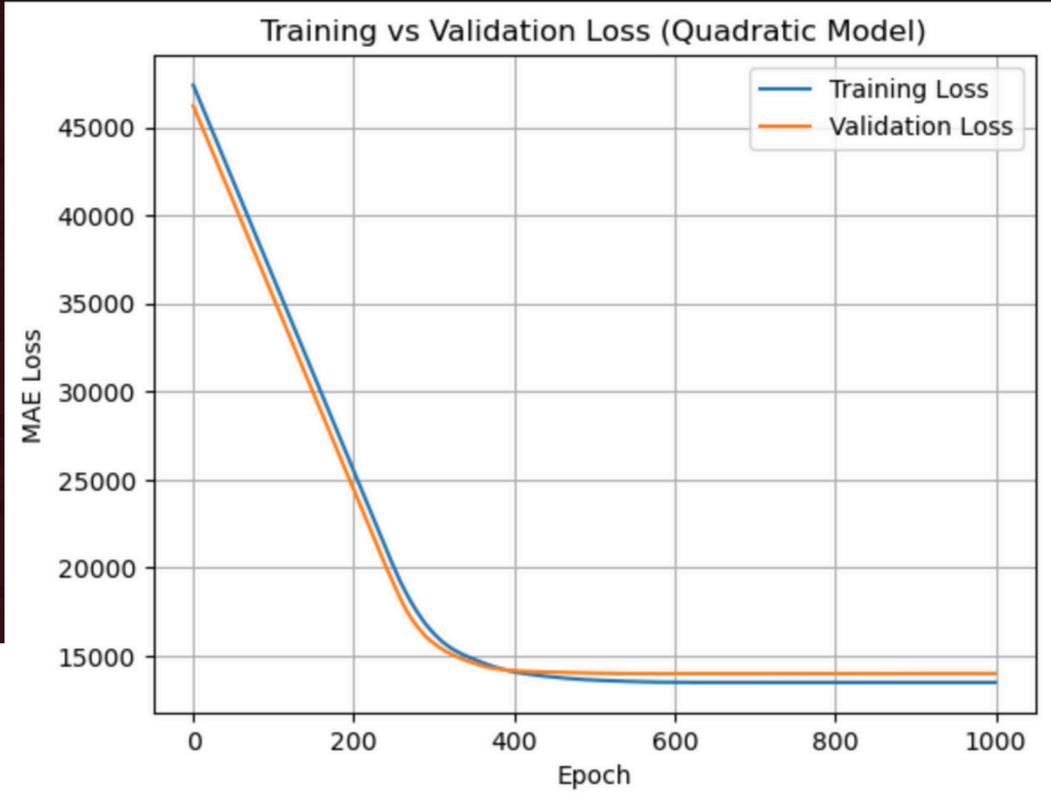
Test MAE: 8,025.69

Captures general trend but underfits volatility

Train & validation losses closely aligned

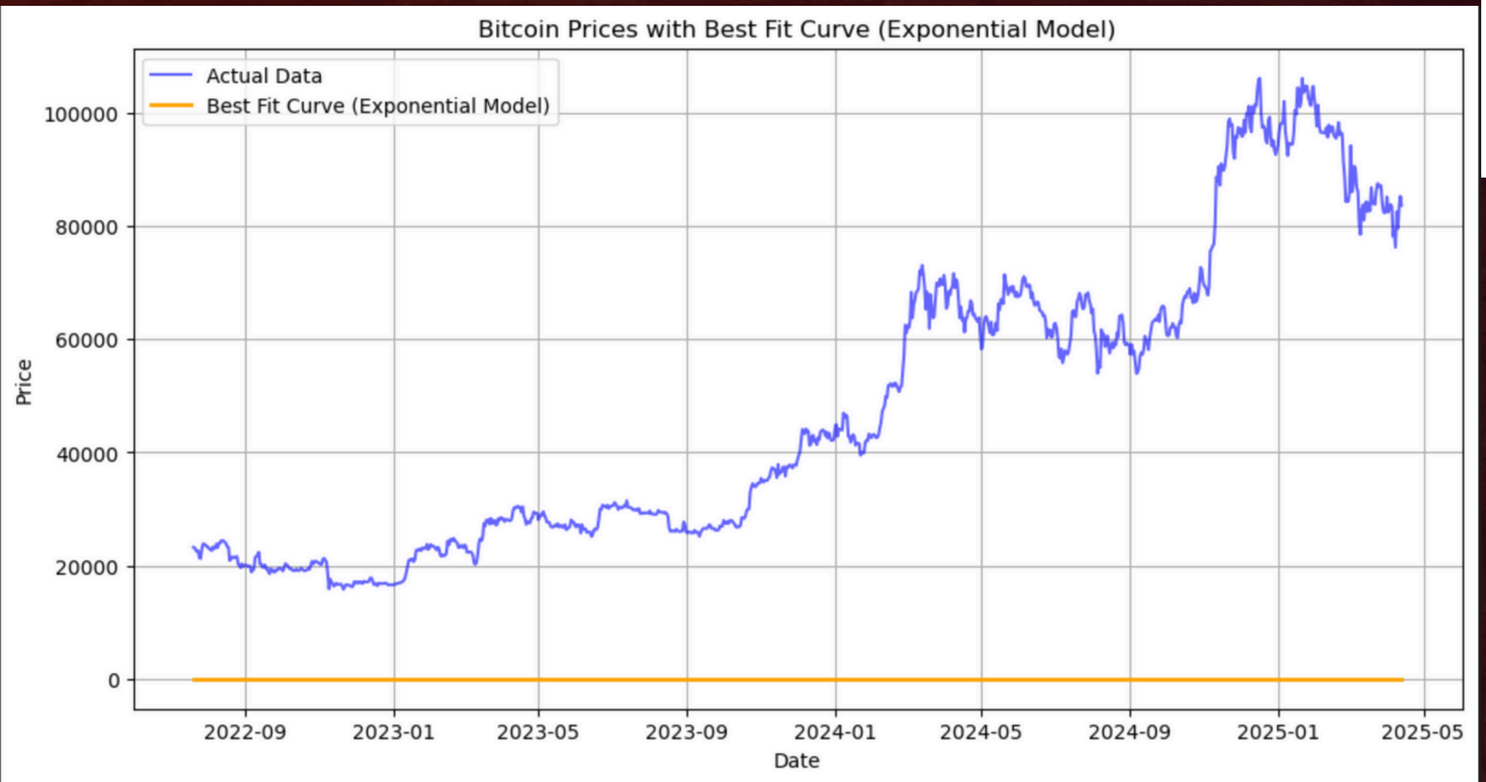
QUADRATIC MODEL

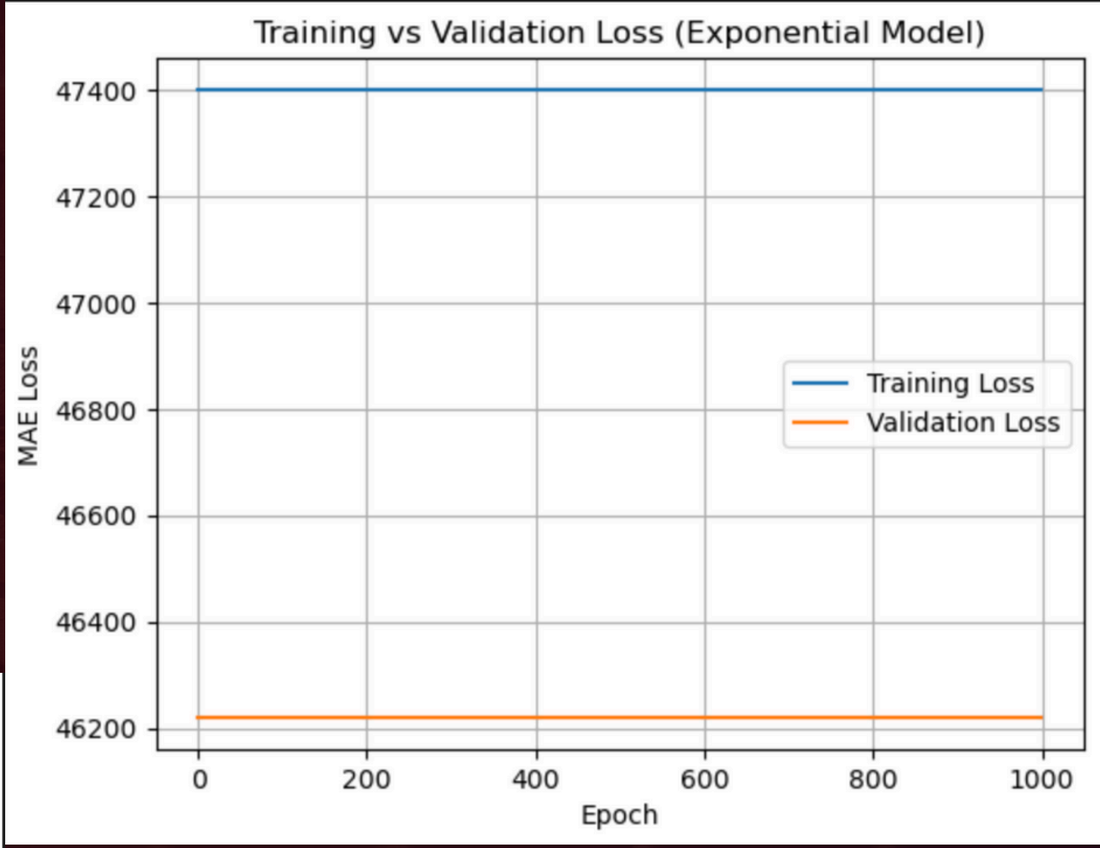




- Test MAE: 13,596.98
- Models curvature better than linear
- Overshoots prices in later stages (late 2024)

Exponential Model (Unnormalized)



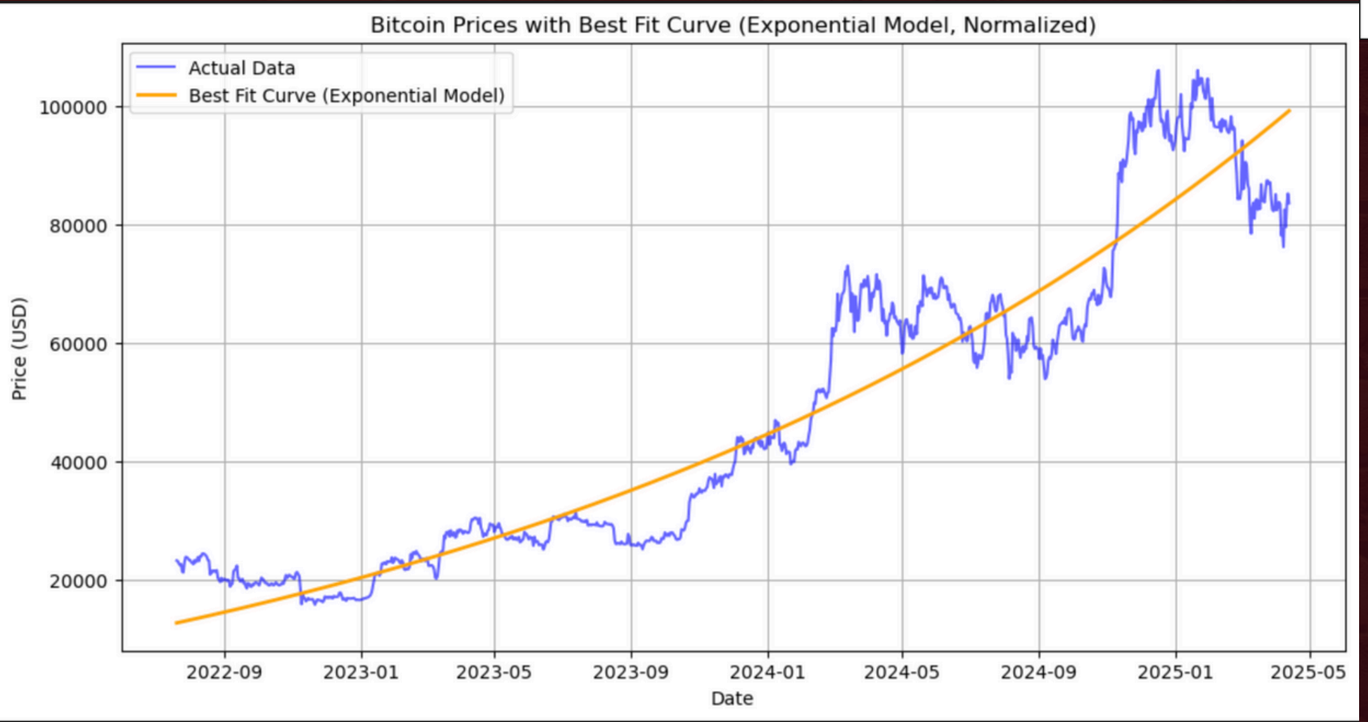


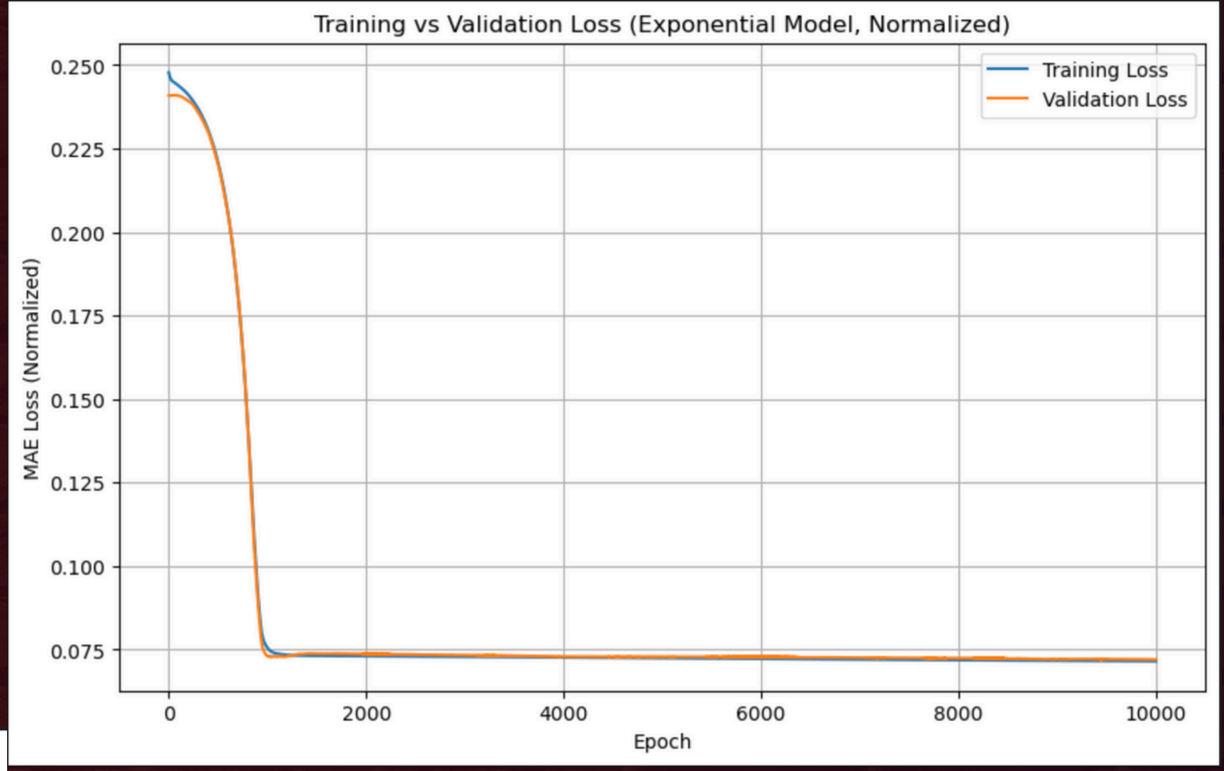
Test MAE: 48,540.17

Failed due to gradient explosion (large input magnitudes)

Predictions were flat or unstable

Exponential Model (Normalized)





Test MAE: 6,234.13 (Best)

After normalization, model converged well

Accurately modeled compounding growth and plateau

Model Comparison

Model	Train MAE	Val MAE	Test MAE	Notes
Linear	8109.81	8419.15	8025.69	Underfit, stable
Quadratic	13485.80	13993.05	13596.98	Overshoots late prices
Exponential (Unnormalized)	47400.18	46220.12	48540.17	Failed to learn
Exponential (Normalized)	~0.07 (scaled)	~0.07 (scaled)	6234.13	Best model

CONCLUSION

This project provided a valuable opportunity to apply regression models to a real-world dataset and evaluate their effectiveness in capturing Bitcoin price trends. I implemented linear, quadratic, and exponential models from scratch using custom gradient descent, gaining a deeper understanding of training dynamics and model behavior. The results showed that while the linear model provided a stable baseline and the quadratic model offered flexibility, both struggled to generalize accurately. The unnormalized exponential model failed due to instability, but after applying normalization, the exponential model achieved the lowest test MAE (6234.13) and best overall fit capturing both the early stability and late-stage growth in prices.