Supplementary Material

**Decoding Stock Trends: A Comparative Study of GRU, LSTM, and Transformer Models in Tech Sector Prediction**
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ORCID IDs: 0000-0003-3656-365X, 0009-0009-5132-6477, 0000-0002-0110-2194
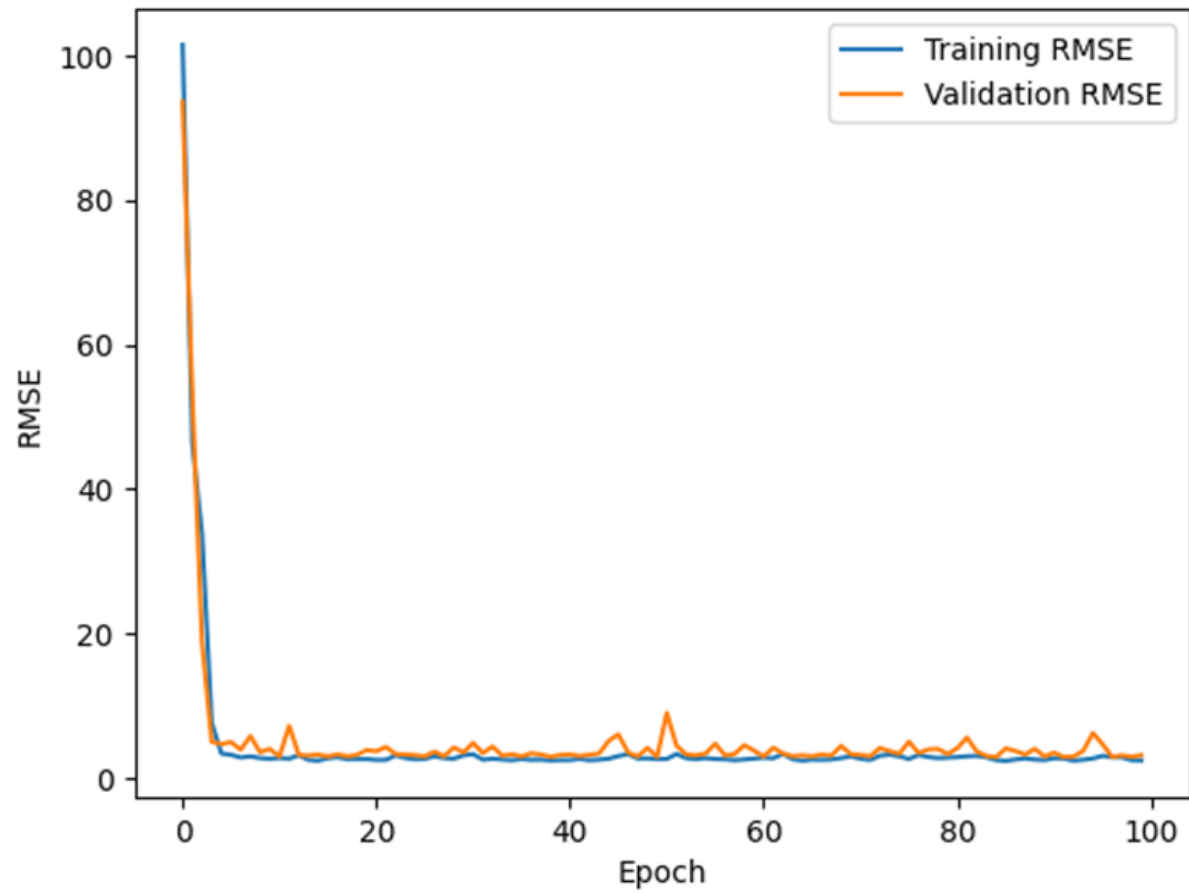
AAPL Loss Function:
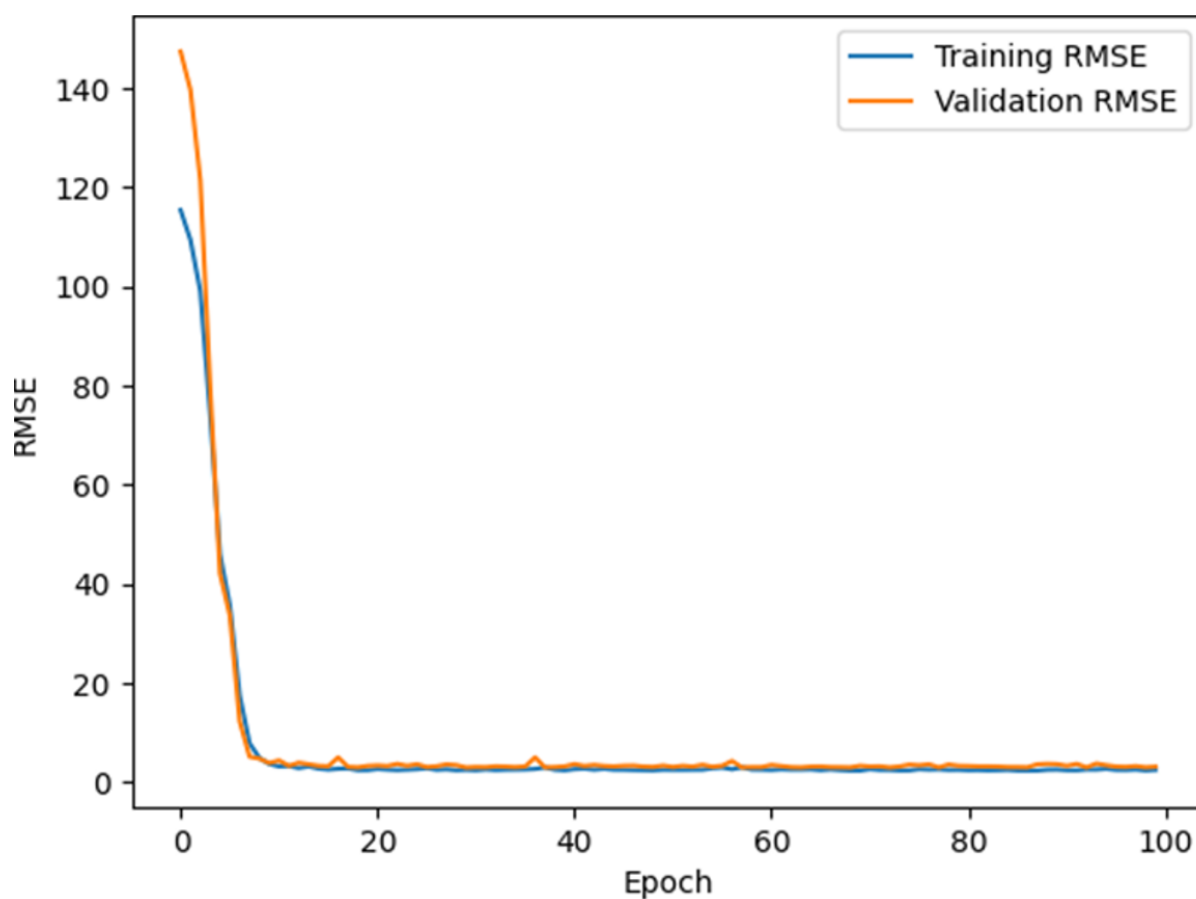
Figure S1: The GRU model exhibits a low minimum RMSE of 2.97128, indicating strong predictive capability, despite a significantly higher maximum RMSE of 104.707, suggesting initial poor performance that improves with training epochs.

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Figure S2: The LSTM model shows a slightly higher minimum RMSE (2.95009) compared to GRU, with a substantially higher maximum RMSE of 150.436, implying poorer initial predictions that improve over time to a similar level of accuracy.
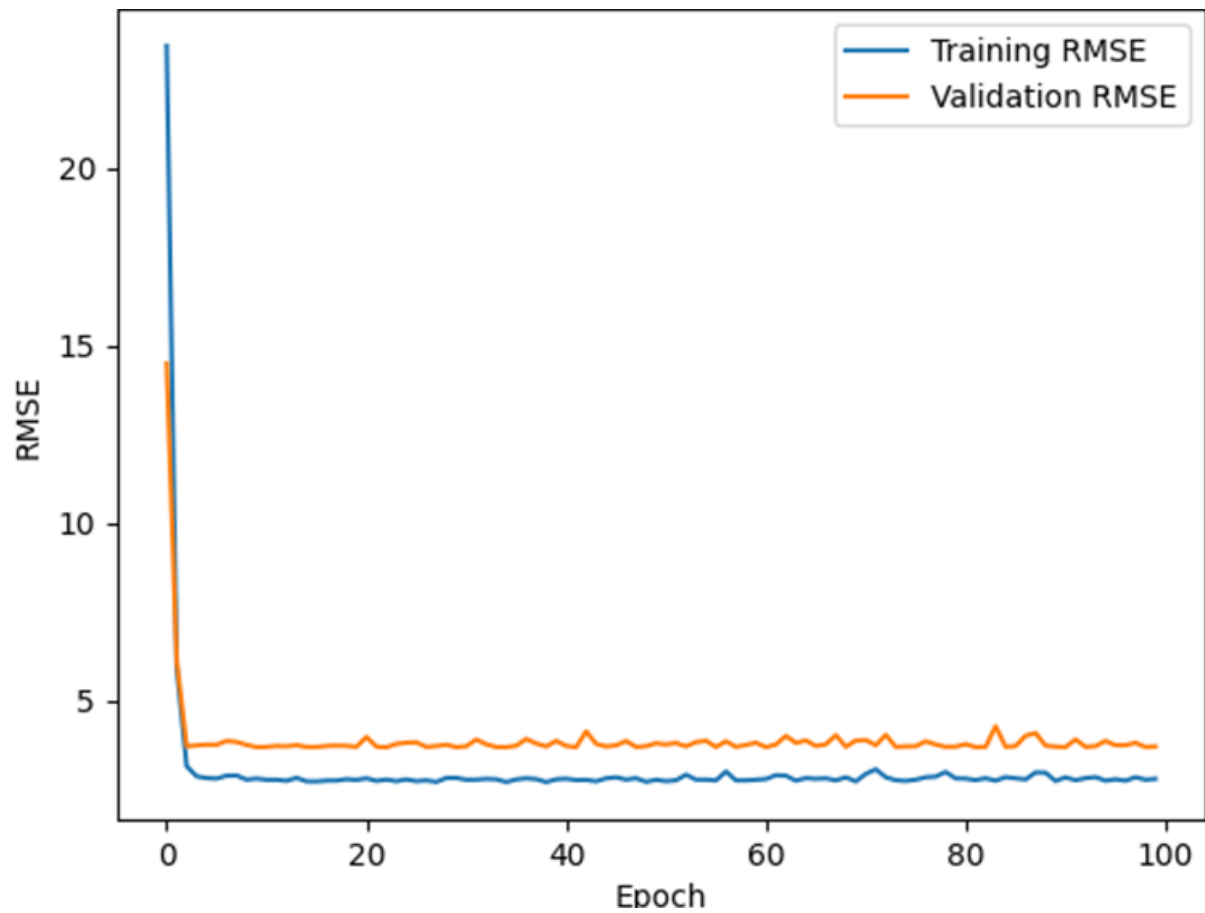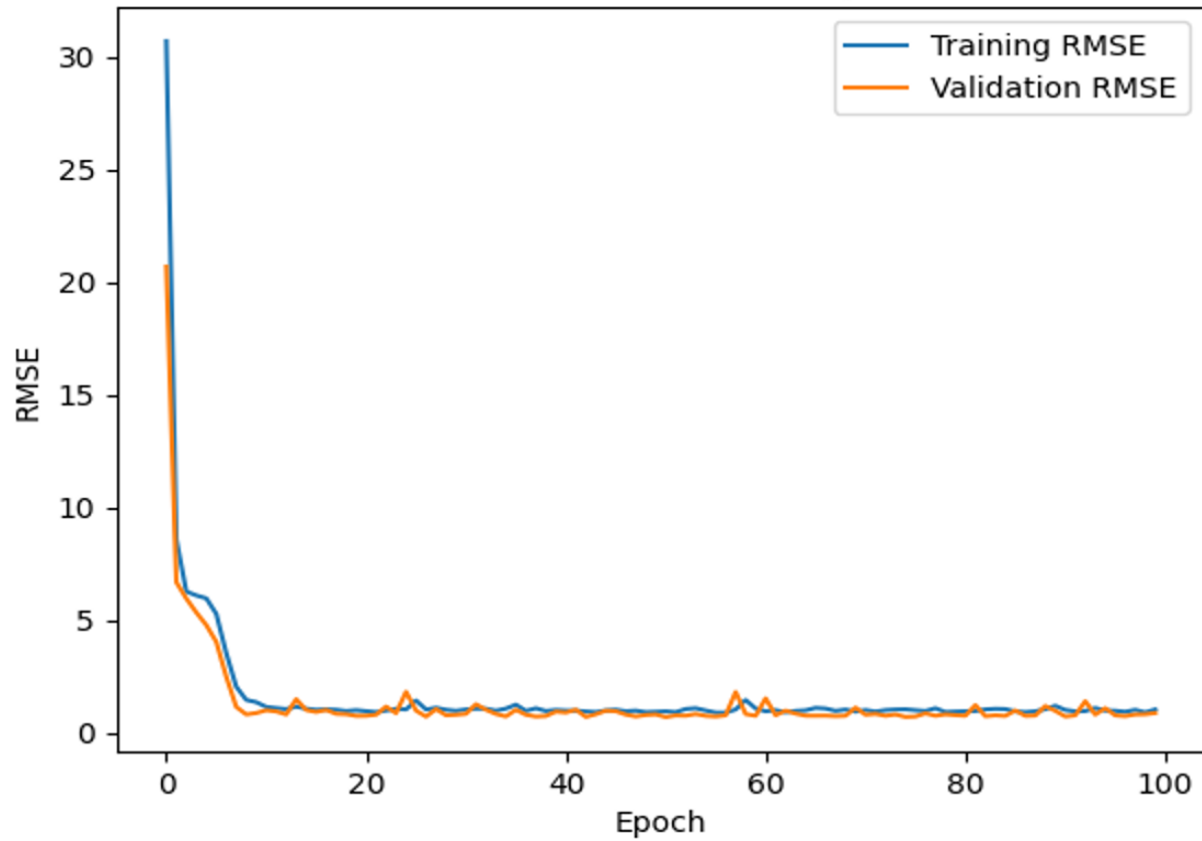
Figure S3: The Transformer model displays a broader range of RMSE, with a higher minimum RMSE (3.67839) compared to GRU but a slightly lower maximum RMSE than LSTM, suggesting better initial predictions. Despite this, the GRU model provides the best predictions at its peak performance.
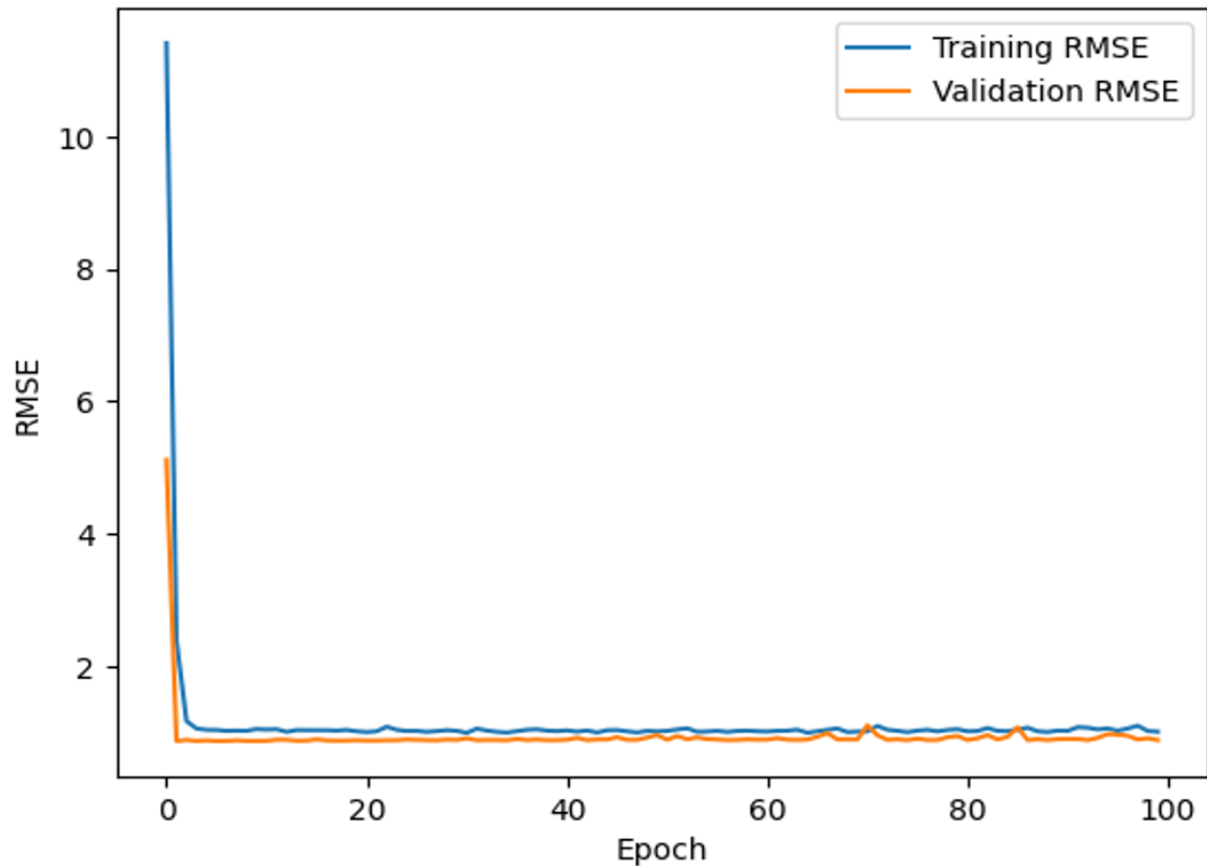
CSCO Loss Function:
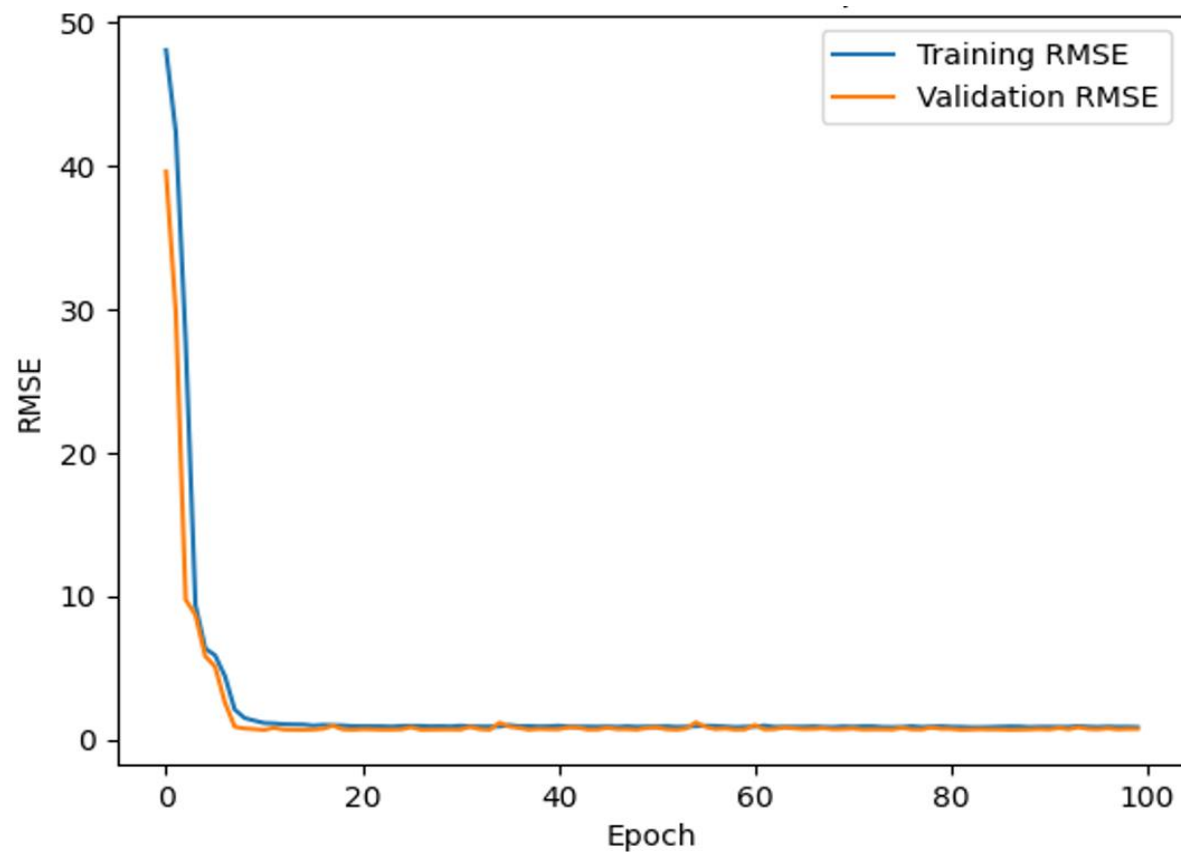
Figure S4: The GRU model exhibits a significant reduction in validation RMSE from 12.49 to 145.81, suggesting an initial high error that improves during training.

Figure S5: The LSTM model displays a broader range of validation RMSE (5.68 to 150.69) compared to GRU, potentially indicating better performance at its best.
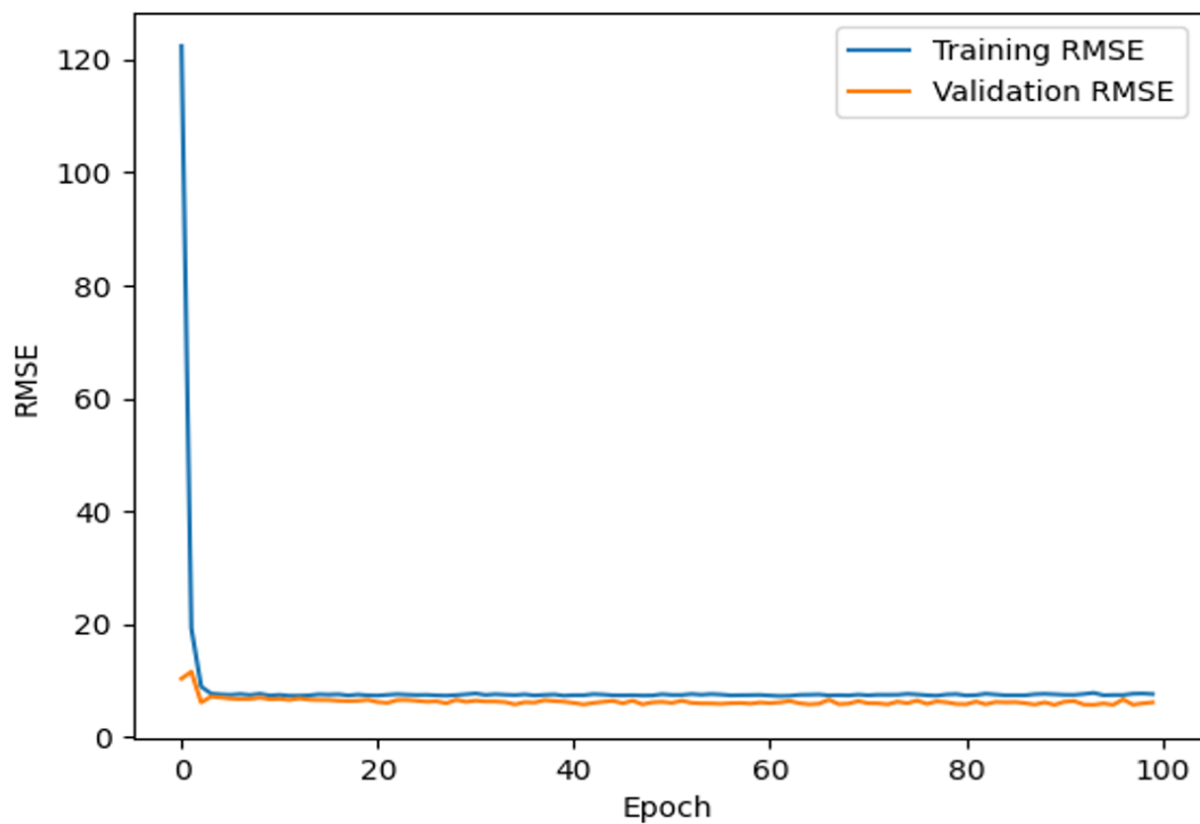
Figure S6: The Transformer model shows a minimum validation RMSE of 9.95 and a maximum of 150.69, with performance comparable to LSTM's worst but not best. Model selection depends on application specifics, with LSTM potentially offering the most accurate predictions, though other factors like training time and complexity also play a role.

META Loss Function:
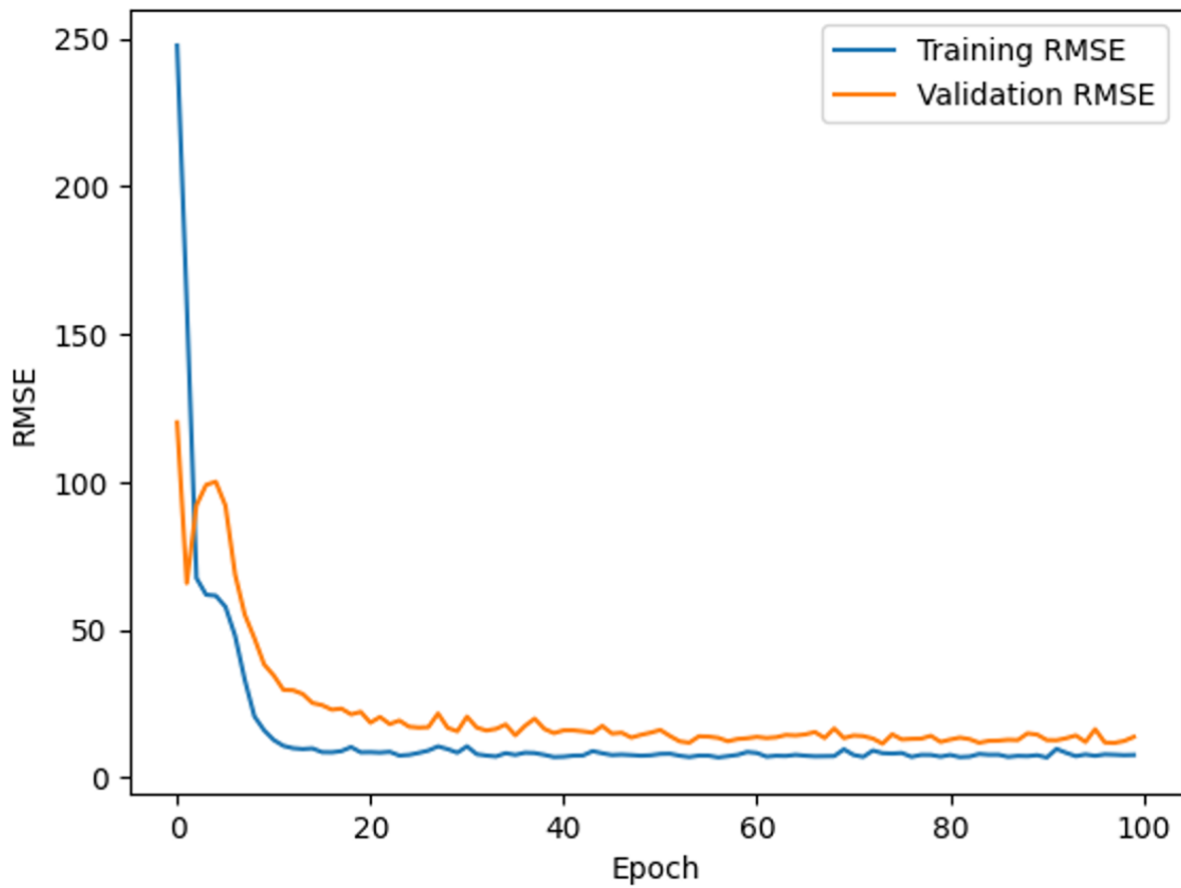
Figure S7: The LSTM model displays the lowest minimum RMSE (5.67821) and maximum RMSE (27.6134), suggesting the most accurate predictions and overall best performance among the three models for this dataset and task.
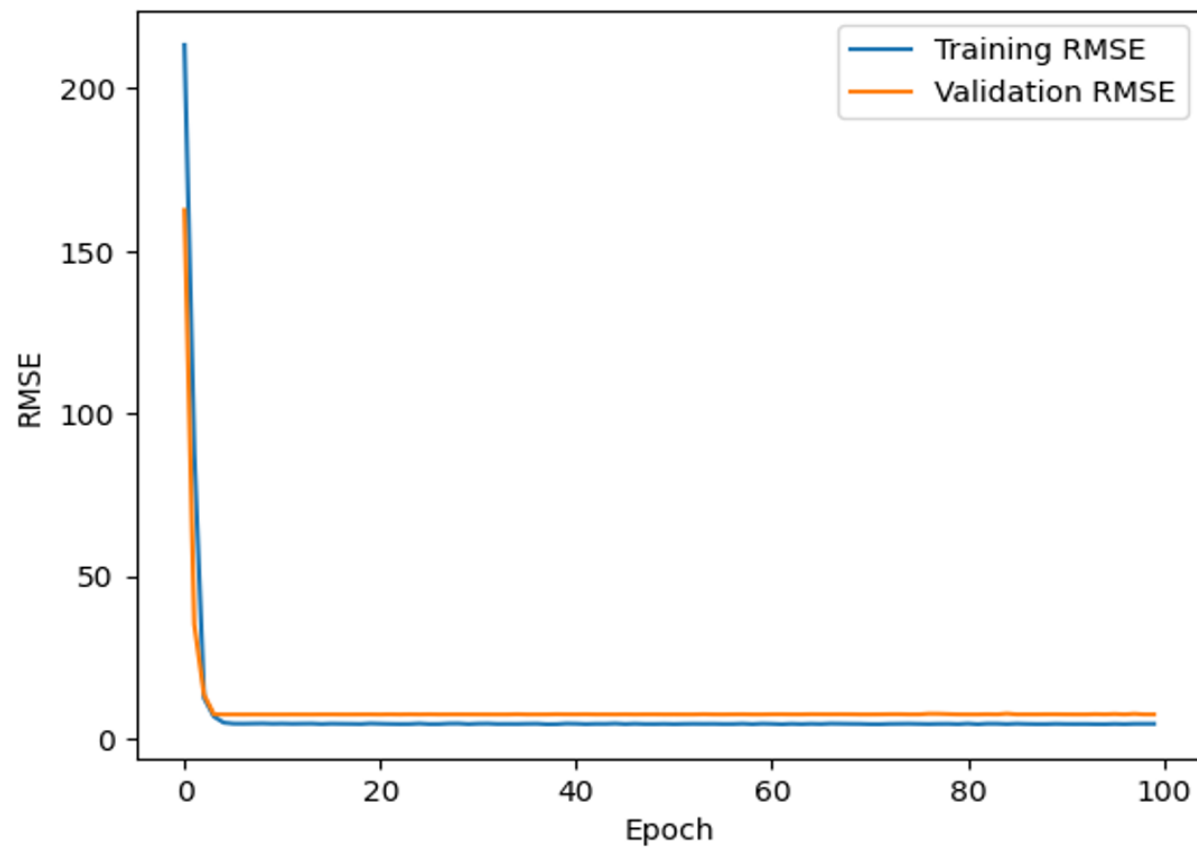
Figure S8: The GRU model exhibits higher RMSE values, with a minimum of 11.4971 and maximum of 120.165, indicating lower accuracy compared to LSTM for this prediction task.
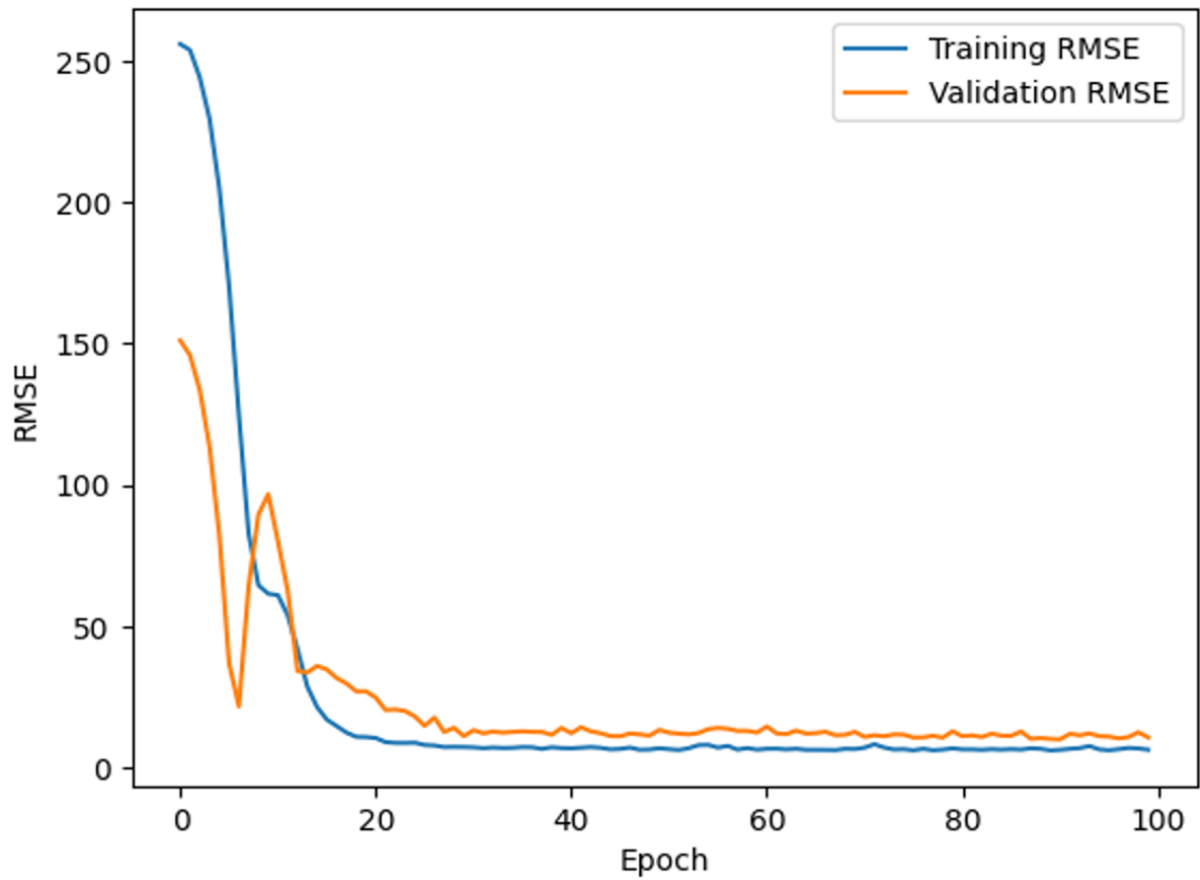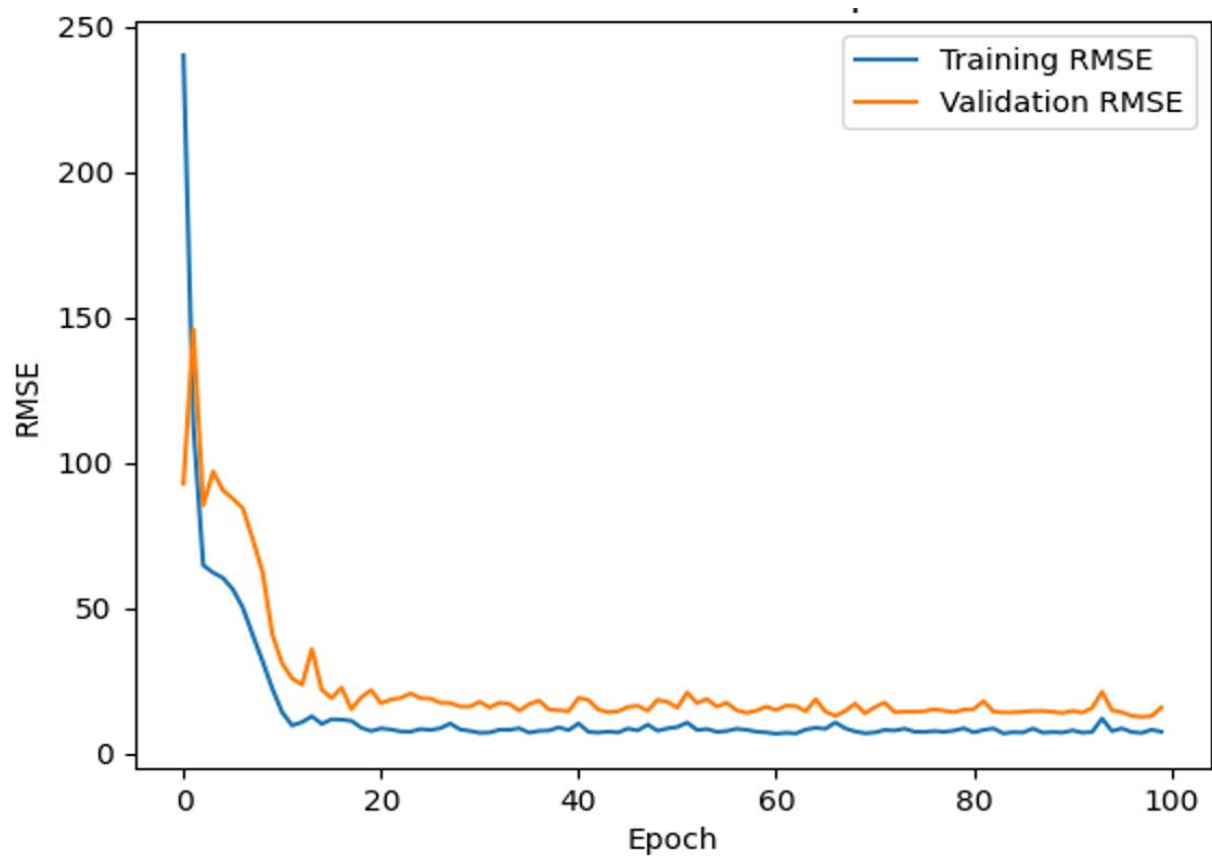
Figure S9: The Transformer model shows a lower minimum RMSE (10.1143) but a higher maximum RMSE (151.109) than GRU, suggesting initial issues but eventual improvement. Generally, LSTM demonstrates the best performance based on RMSE values for this task.
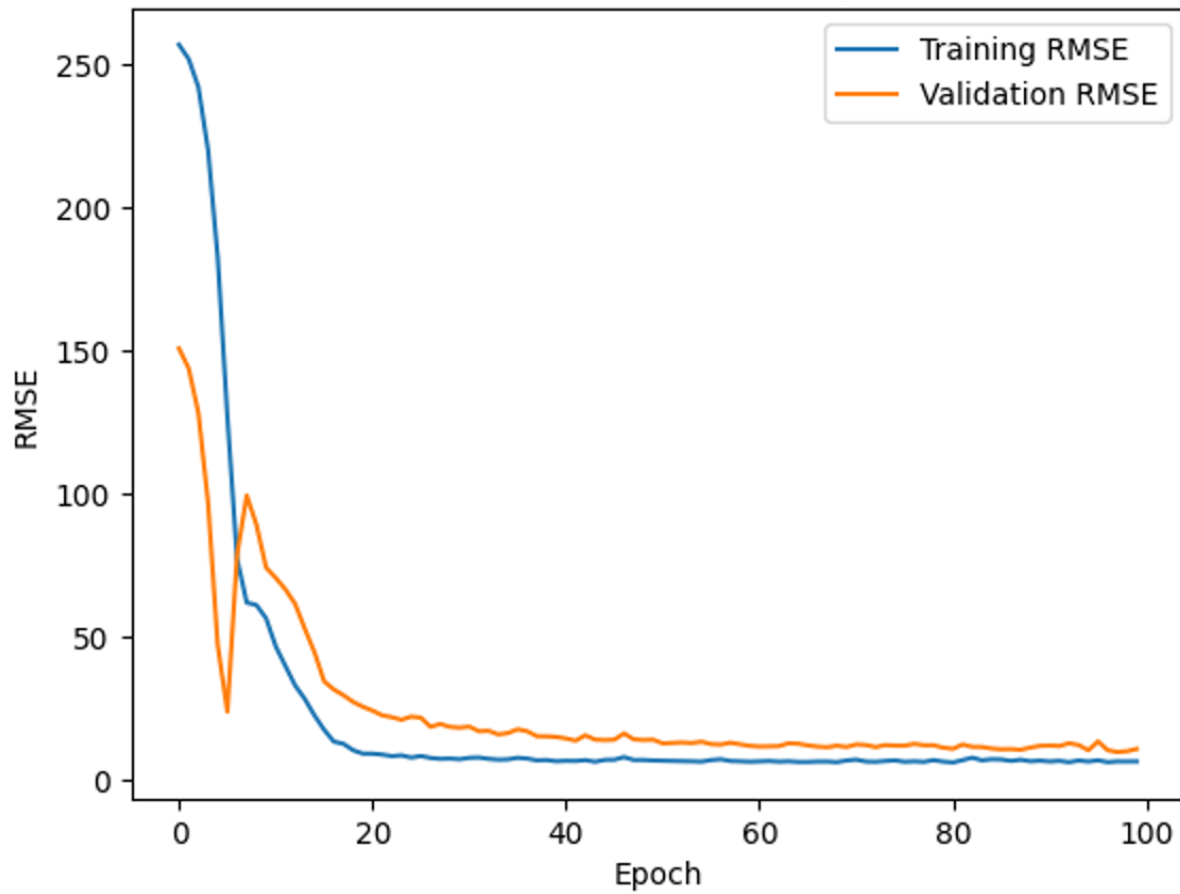
MSFT Loss Function:

Figure S10: The GRU model achieved its best (minimum) validation RMSE of 5.67906, with the largest average error during the validation phase at 22.2298.

Figure S11: The LSTM model exhibited a higher minimum validation RMSE (12.4912) than GRU but a lower maximum validation RMSE (145.810) compared to Transformer, suggesting varying levels of accuracy.

Figure S12: The Transformer model recorded a minimum validation RMSE of 9.94773, worse than GRU's but better than LSTM's minimum, with the highest maximum validation RMSE (150.690) among the three models. GRU demonstrates the best performance on the MSFT dataset based on the lowest minimum RMSE.

**TSLA Loss Function:**
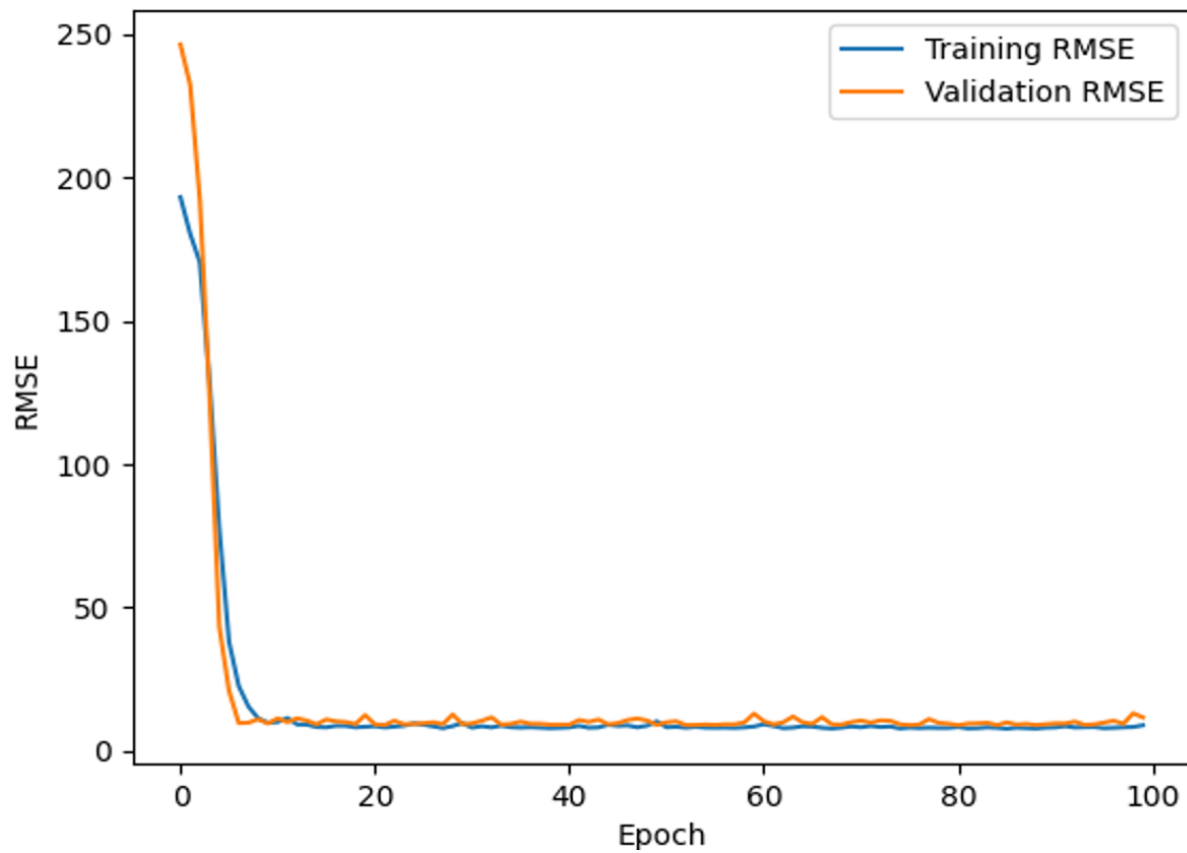
Figure S13: The GRU model displays a range of RMSE values, with a minimum of 8.76743 and a maximum of 93.7775, indicating varying levels of accuracy and potential for significant errors.
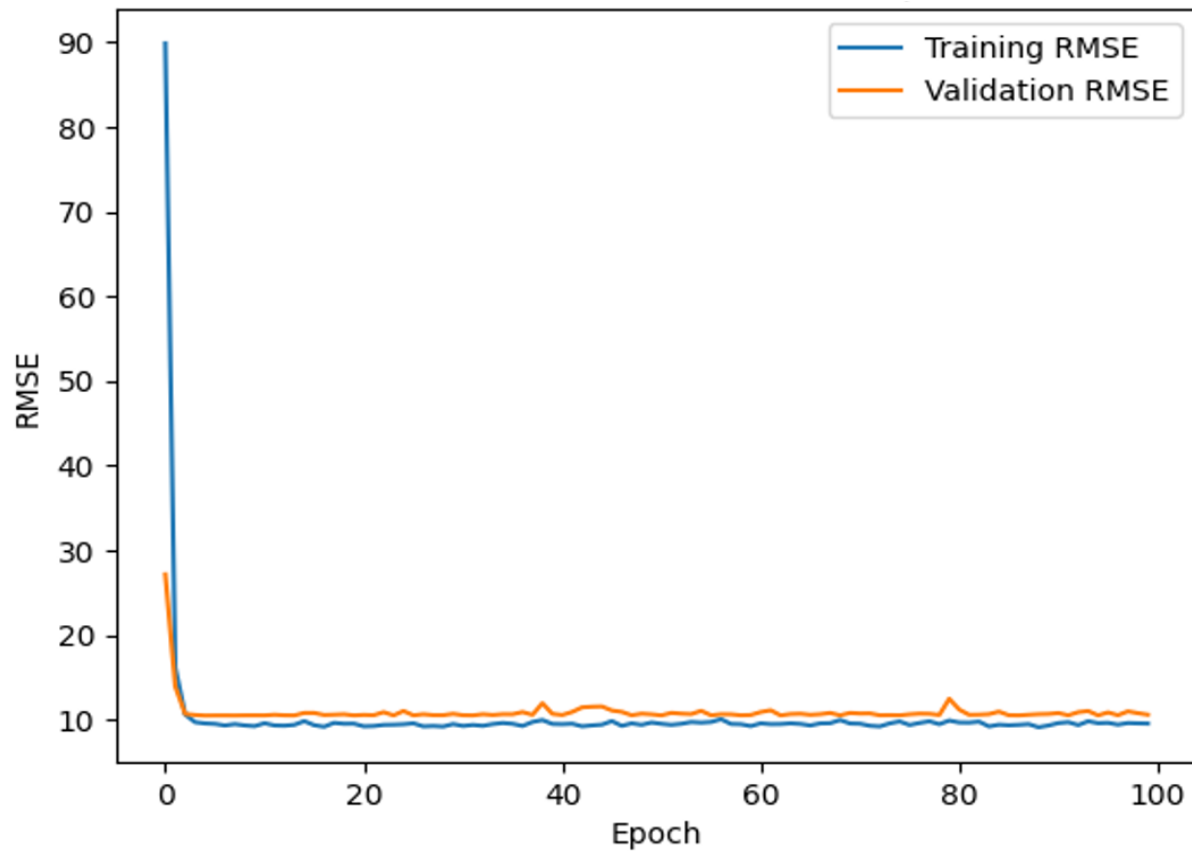
Figure S14: The LSTM model exhibits a minimum RMSE of 10.4482 and a higher maximum RMSE of 249.601 compared to GRU, suggesting potential overfitting or instability in model training.
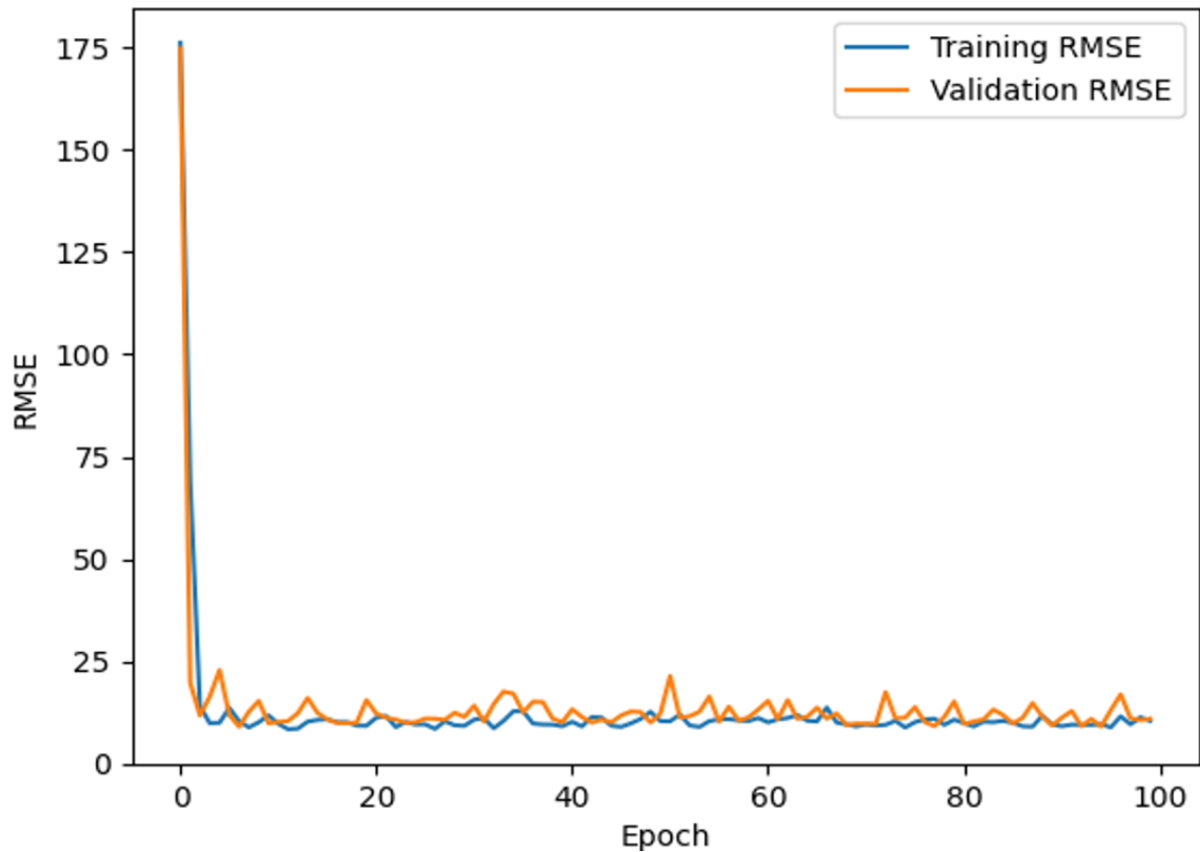
Figure S15: The Transformer model demonstrates a range of RMSE values, with a minimum of 8.96747 and a maximum of 175.762, suggesting potential volatility in performance.
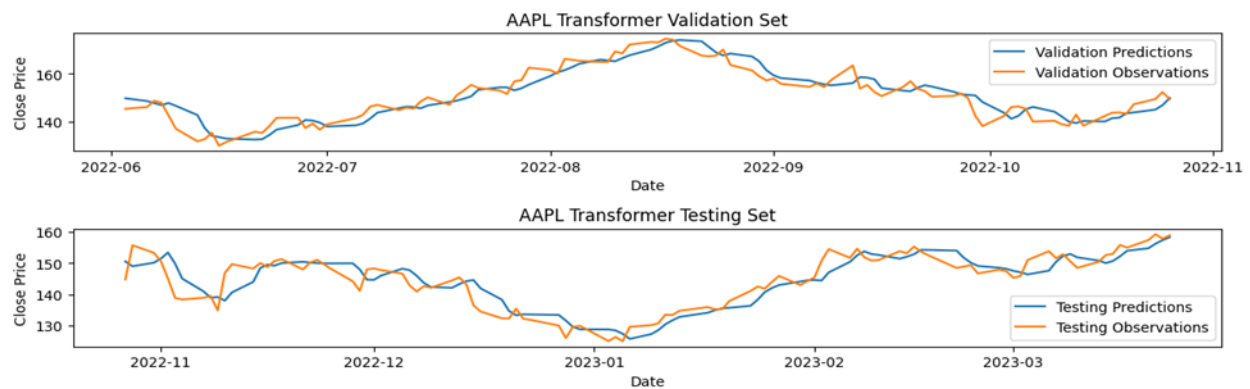
AAPL Validation and Testing Set:
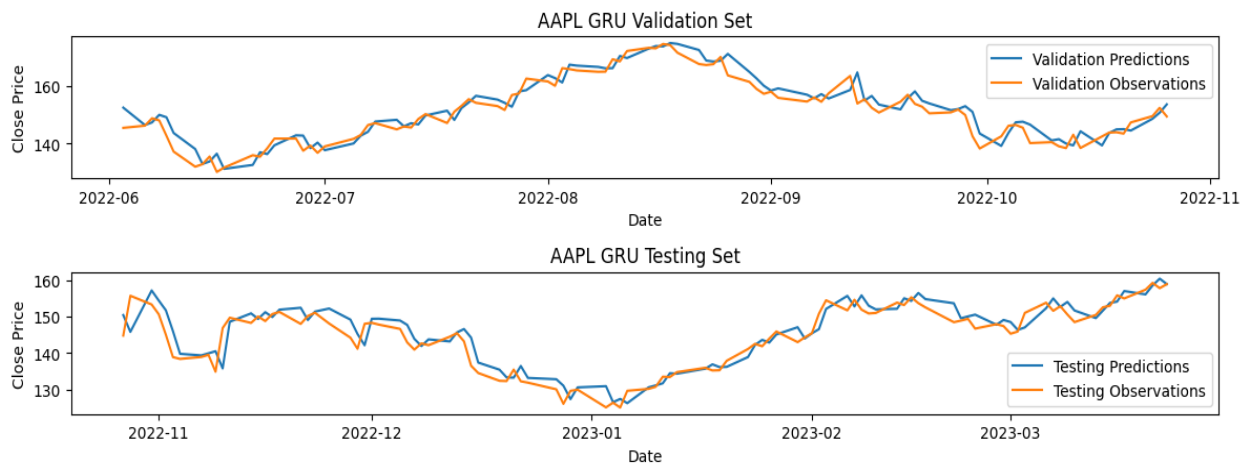
Figure S16: GRU Validation and Testing AAPL exhibits a modest Mean Absolute Error (MAE) of $2.53, indicating reliable predictions with potential economic implications, highlighted by its R-squared (R^2) value of 0.92. Its Root

Mean Absolute Error (RMAE) of 1.59 underscores precision, offering insights into financial strategies and market behavior.
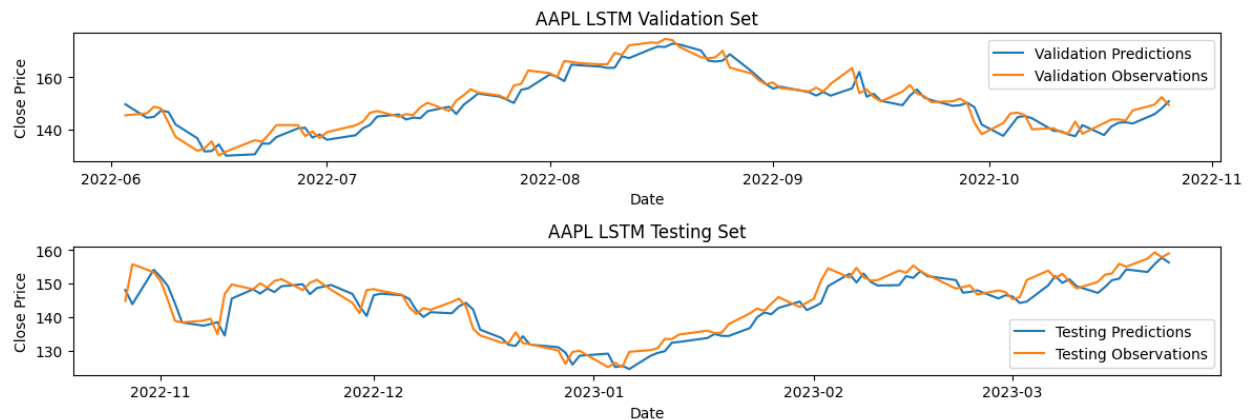

Figure S17: LSTM Validation and Testing AAPL, with a Mean Absolute Error (MAE) of $2.44, demonstrates reliable predictions crucial for financial practitioners, highlighted by its high R-squared (R^2) value of over 92%, indicating strong explanatory power and potential economic implications for stock price prediction. The Root Mean Absolute Error (RMAE) of 1.56 underscores precision, offering insights for managing financial risks and making informed investment decisions, though limitations in anticipating unforeseen market events should be considered.



Figure S18: Transformer Validation and Testing AAPL present the Transformer model's predictions with an MAE of $3.10, indicating less precision than GRU and LSTM models. The R-squared value of approximately 88.34% suggests its explanatory power lags, potentially affecting its reliability in capturing stock price dynamics.
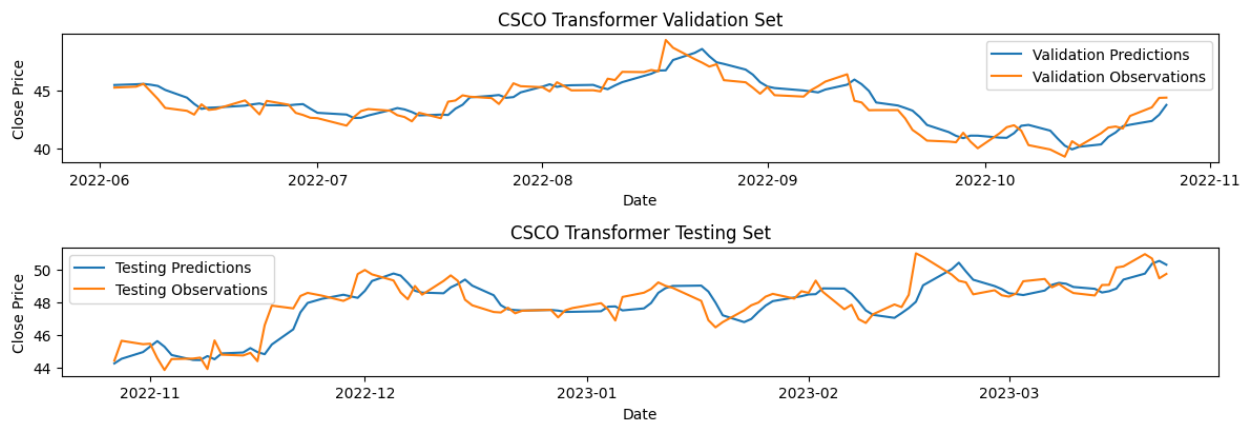

CSCO Validation and Testing Set:
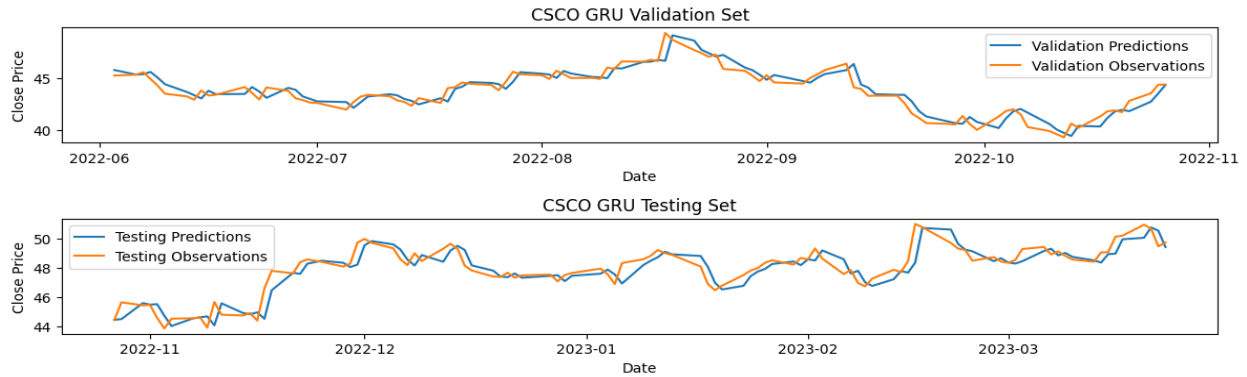
Figure S19: GRU Validation and Testing CSCO, the GRU model demonstrates high precision with a Mean Absolute Error (MAE) of 0.56 for Cisco (CSCO) stock prices. The Root Mean Absolute Error (RMAE) and (R^2) values suggest consistent accuracy, offering insights for financial decision-making but acknowledging the limitations of historical data in predicting unforeseen events.
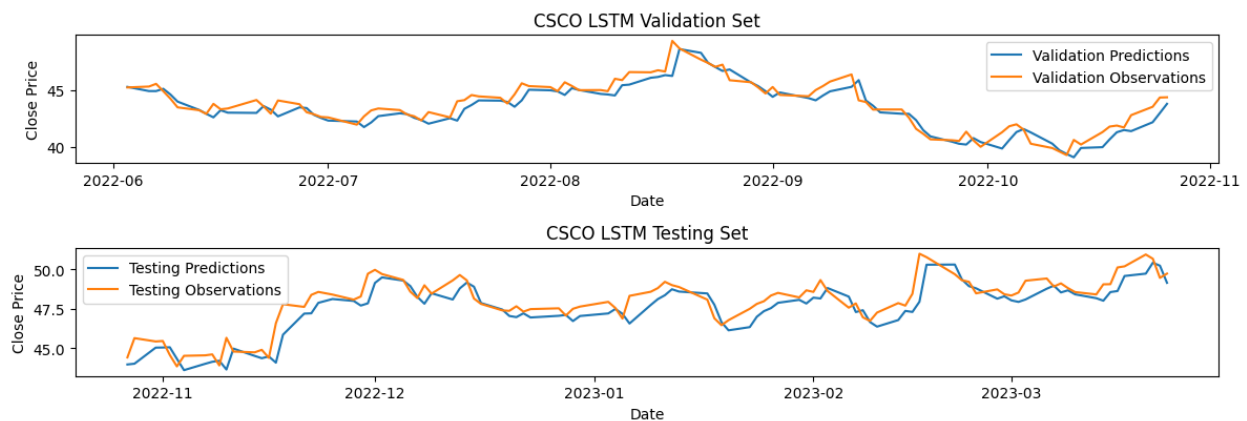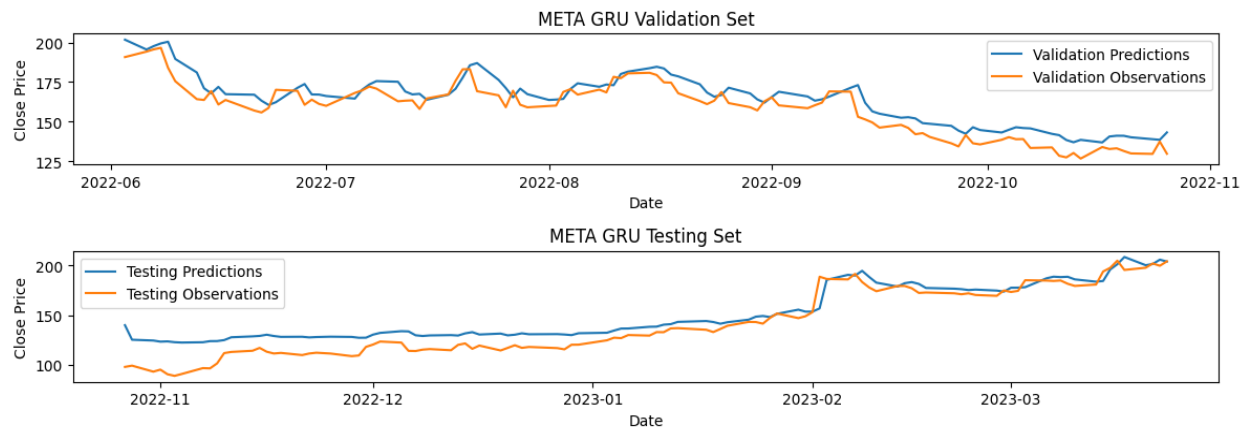

Figure S20: LSTM Validation and Testing CSCO, has a slightly higher MAE than the GRU model, indicating potentially less precision. Despite this, its higher R^2 value suggests better capture of broader trends in stock price movements, highlighting trade-offs between precision and predictive power in financial decision-making.


Figure S21: Transformer Validation and Testing CSCO. The model's MAE and RMAE suggest relatively higher prediction discrepancies and potential financial risks than the GRU and LSTM models. Its R^2 value indicates a lesser fit to historical data, suggesting room for improvement in capturing CSCO's stock price variability.
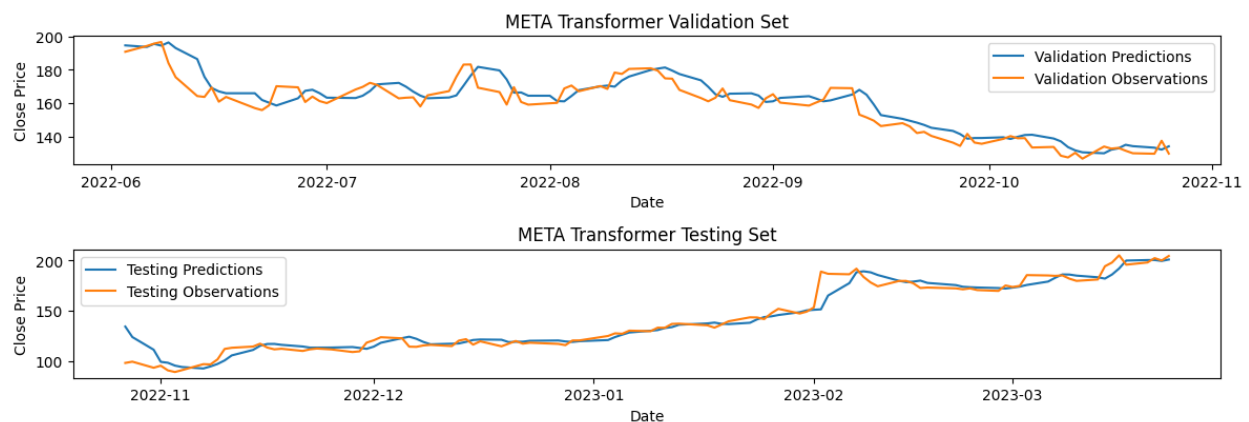
META Validation and Testing Set:

Figure S22: GRU Validation and Testing META. The GRU model's performance on META reveals notable deviations in predicting closing stock prices, with a higher (MAE) and lower (R^2) value than other stocks.
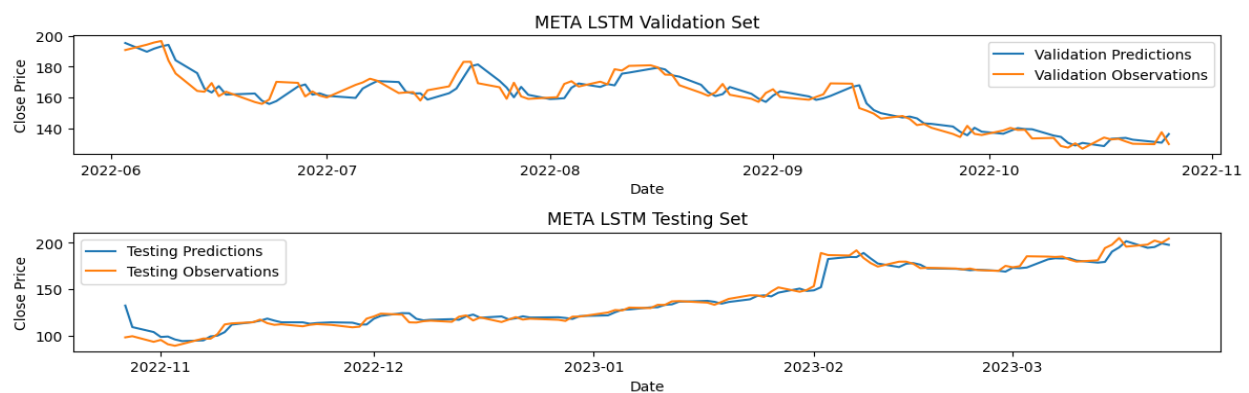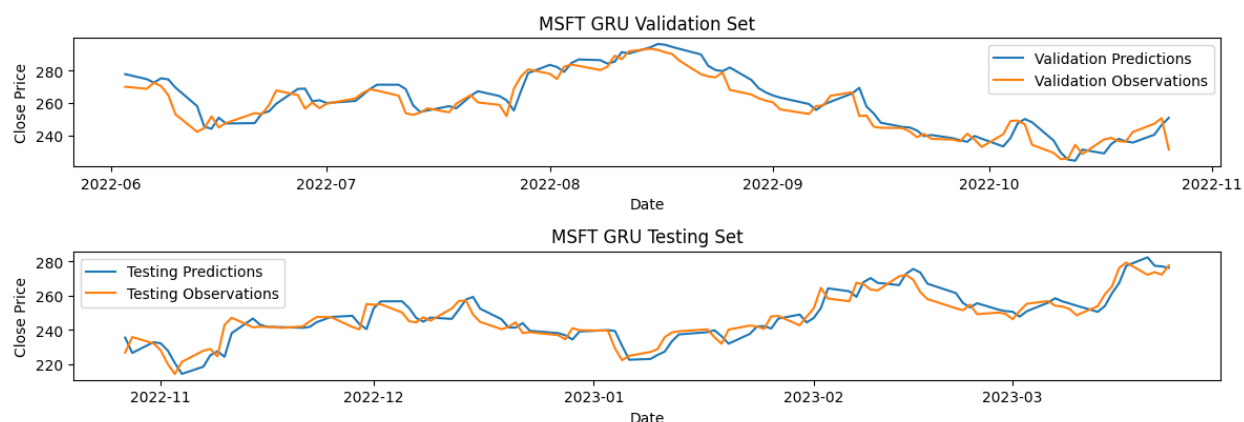

Figure S23: LSTM Validation and Testing META. The model's MAE and R-squared value suggest relative accuracy and a strong correlation with META's stock movements. Still, substantial prediction deviations imply risks in trading decisions. While more reliable than the GRU model, the LSTM's limitations underscore the need for comprehensive analysis to mitigate investment risks in volatile stock markets.


Figure S24: Transformer Validation and Testing META exhibit a sizable MAE and R-squared value compared to LSTM and GRU models. This suggests less accuracy and a weaker fit in predicting META stock prices. Despite its

lower R^2 value, the Transformer's error consistency, reflected by its lower RMSE than the GRU's, underscores its potential reliability in certain trading scenarios, albeit with increased financial risks.
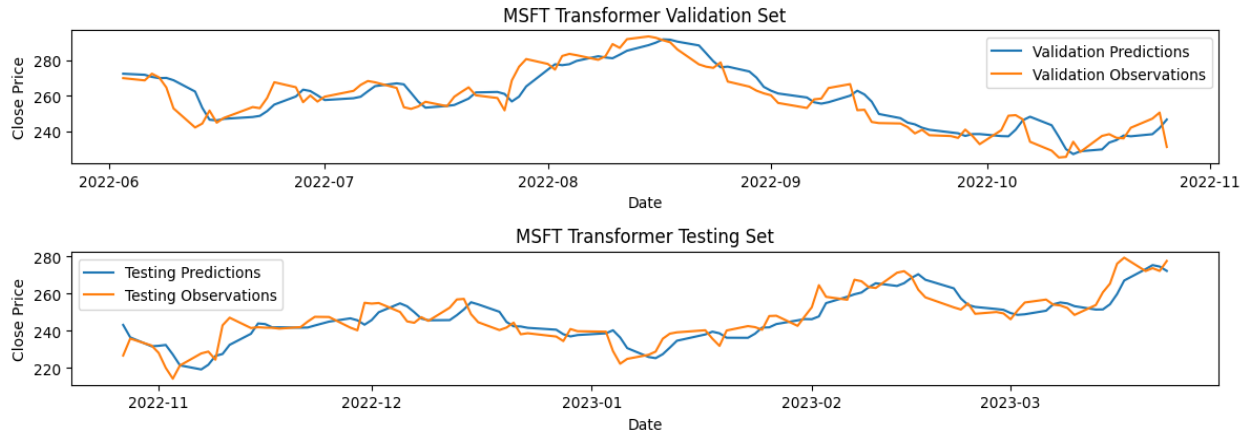
MSFT Validation and Testing Set:

Figure S25: GRU Validation and Testing MSFT The GRU displays an MAE of $4.30 for Microsoft Corporation (MSFT) stock prices, indicating potential risks in trading strategies due to notable deviations from actual prices, despite its strong R-squared value suggesting a robust model fit. Comparatively, its MAE for MSFT is lower than the Transformer's for META but higher than the LSTM's, showcasing varying prediction accuracies across different stocks and models, underscoring the need for cautious interpretation in financial decision-making.
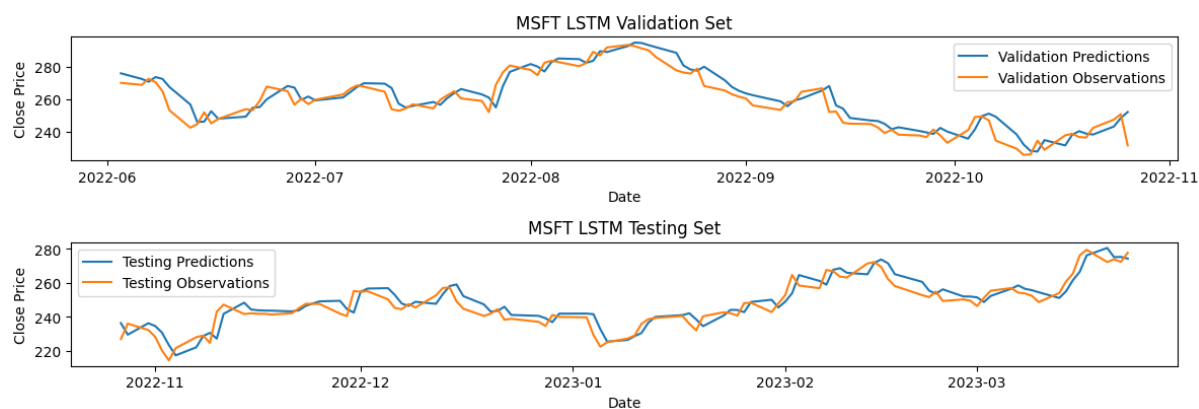

Figure S26: LSTM Validation and Testing MSFT, the model exhibits an MAE of $4.78, indicating potential influence on trading strategies due to prediction inaccuracies. Despite explaining 87% of MSFT stock price variability, its higher MAE and RMAE than the GRU suggest potential concerns for precision in financial decision-making, highlighting the need for careful risk assessment.

Figure S27: Transformer Validation and Testing MSFT exhibit an MAE of $5.69, indicating potential trading risks due to significant prediction discrepancies. Despite explaining 82.84% of MSFT's stock price variance, its higher error margins compared to GRU and LSTM models suggest limitations in precise prediction, urging cautious reliance on its forecasts for economic decisions.
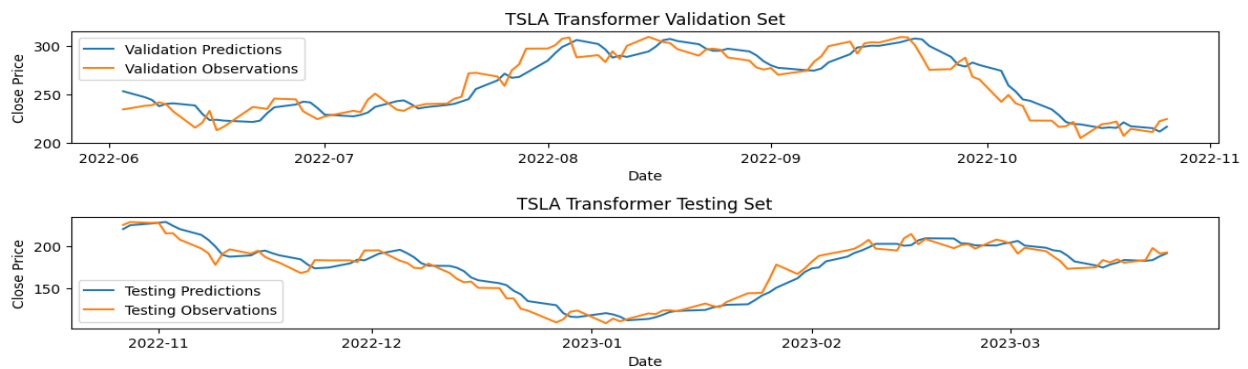
TSLA Validation and Testing Set:
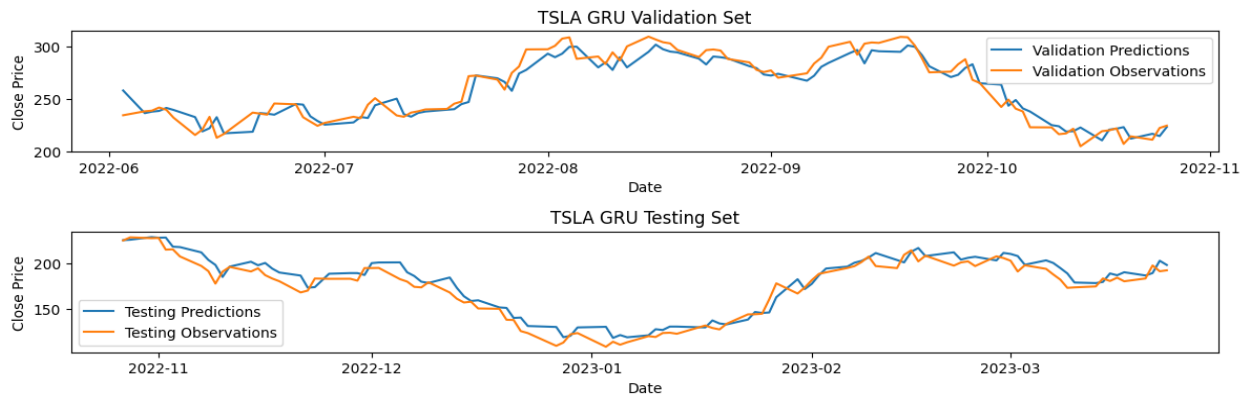
Figure S28: GRU Validation and Testing TSLA, the model has an MAE of $7.44, indicating substantial forecasting deviations, yet it captures 90.88% of Tesla's stock price variance, suggesting strong predictive capability. Despite the model's effectiveness, its higher MAE implies increased challenges in accurately predicting TSLA's stock prices, highlighting the need for cautious risk management strategies in financial decision-making.
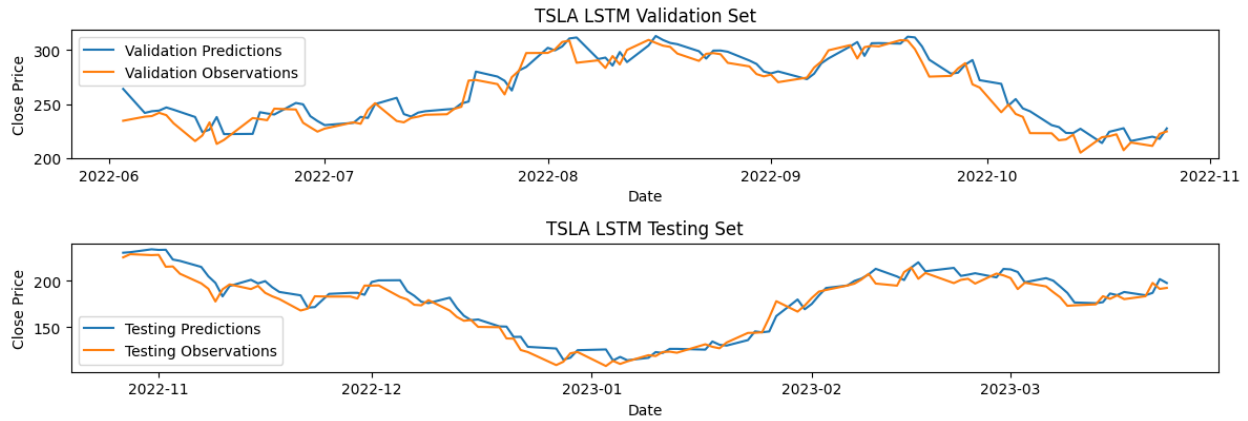
Figure S29: LSTM Validation and Testing TSLA. The model has an MAE of $7.91, indicating significant uncertainty in predictions, yet it explains 89.65% of TSLA's stock price variance with an R-squared value of 0.8965. The model's lower R-squared value suggests the GRU may better capture overall variance, highlighting the need for cautious reliance on these models in TSLA stock trading due to associated volatility.

Figure S30: Transformer Validation and Testing for TSLA. The model has an MAE of $9.20, indicating substantial deviation from actual stock prices. An R-squared value of 0.8810 explains 88.10% of TSLA's stock price variability. However, its higher MAE and RMAE/RMSE values suggest increased risk, urging caution in relying solely on this model for trading decisions in the volatile TSLA stock market.