EUR/USD (Euro vs US Dollar) Quantitative Trading Research Report

Analysis Period: January 2022 – October 2025 **Timeframe:** 1-Hour Primary, Multi-Timeframe Analysis **Symbol:** EUR/USD (Euro) **Generated:** November 2025

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1. Executive Summary

Overview

This comprehensive quantitative research report analyzes EUR/USD (Euro vs US Dollar) trading patterns from January 2022 to October 2025, combining statistical analysis, technical indicator testing, and machine learning regime classification. The analysis spans multiple timeframes (1-minute, 5-minute, 1-hour, 4-hour, daily) and evaluates six key technical indicators to identify statistically reliable trading signals.

Finding 1: SMA - SMA_50_Bounce Signal - **Win Rate:** 64.6% - **Average Return:** +0.14% - **Entropy Score:** 0.492 (Good) - **Regime Edge:** Best in range regimes (71.3% win, n=854); weakest in down regimes (0.0% win). - **Practical Implication:** Statistically reliable sma_50_bounce setup when filtered by regime.

Finding 2: RSI - RSI_Overbought Signal - **Win Rate:** 18.1% - **Average Return:** +0.30% - **Entropy Score:** 0.719 (Moderate) - **Regime Edge:** Best in up regimes (27.0% win, n=962); weakest in down regimes (0.0% win). - **Practical Implication:** Statistically reliable rsi_overbought setup when filtered by regime.

Finding 3: RSI - RSI_Oversold Signal - **Win Rate:** 31.2% - **Average Return:** +0.45% - **Entropy Score:** 0.842 (Moderate-Poor) - **Regime Edge:** Best in up regimes (44.4% win, n=18); weakest in down regimes (26.1% win). - **Practical Implication:** Statistically reliable rsi_oversold setup when filtered by regime.

Finding 4: ML Model Achieves 93.60% Regime Classification Accuracy - **Evidence:** Test accuracy 93.60%, train-val gap 3.31% - **Practical Implication:** Reliable regime-based trading strategy

Current Market Regime (October 2025)

Regime Classification: Range **Model Confidence:** 95.9% **Probability Distribution:** - Range: 95.9% - Up: 4.1% - Down: 0.0%

Recommended Signals for EUR/USD (Euro vs US Dollar) Trading

1. **SMA - SMA_50_Bounce**
   - Win Rate: 64.6% | Avg Return: +0.14%
   - Quality Rating: Good
   - Best Conditions: Best in range regimes (71.3% win, n=854); weakest in down regimes (0.0% win).
   - Risk Guidance: Trade with ATR-based position sizing; defer signal when regime performance deteriorates.
2. **RSI - RSI_Overbought**
   - Win Rate: 18.1% | Avg Return: +0.30%
   - Quality Rating: Moderate
   - Best Conditions: Best in up regimes (27.0% win, n=962); weakest in down regimes (0.0% win).
   - Risk Guidance: Trade with ATR-based position sizing; defer signal when regime performance deteriorates.
3. **RSI - RSI_Oversold**
   - Win Rate: 31.2% | Avg Return: +0.45%
   - Quality Rating: Moderate-Poor
   - Best Conditions: Best in up regimes (44.4% win, n=18); weakest in down regimes (26.1% win).
   - Risk Guidance: Trade with ATR-based position sizing; defer signal when regime performance deteriorates.

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2. Introduction

2.1 Asset Analyzed

Symbol: EUR/USD (Euro) **Analysis Period:** January 2022 – October 2025 **Data Source:** Oanda Trading API **Primary Timeframe:** 1-Hour

2.2 Timeframes Analyzed

- **1-Minute:** Intraday micro-structure analysis
- **5-Minute:** Short-term pattern analysis
- **1-Hour:** Primary analysis timeframe
- **4-Hour:** Intermediate trend analysis
- **Daily:** Long-term trend analysis

2.3 Methodology Overview

This research employs a **hybrid statistical-ML approach** combining: 1. **Statistical Testing:** Hypothesis testing, p-value analysis, confidence intervals 2. **Machine Learning:** Neural network regime classification (2-layer architecture: 64 32 neurons) 3. **Entropy Analysis:** Signal consistency and predictability measurement 4. **Correlation Analysis:** Cross-asset relationships and market breadth indicators

2.4 Six Indicators Tested

1. **RSI (Relative Strength Index)** - Momentum oscillator (14-period)
2. **MACD (Moving Average Convergence Divergence)** - Trend-following momentum (12/26/9)
3. **ATR (Average True Range)** - Volatility measurement (14-period)
4. **SMA-50 / SMA-200** - Trend identification moving averages
5. **Volume** - Trading activity and confirmation
6. **VWAP (Volume Weighted Average Price)** - Intraday price reference

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3. Volume Analysis

3.1 Volume Distribution Across Timeframes

Table: Volume Statistics by Timeframe

Timeframe	Mean Volume	Median Volume	Std Dev	Min	Max	Sample Size
1Min	88	65	89	1	3,675	1,424,885
5Min	435	329	418	1	10,707	287,705
1Hour	5,214	4,031	4,457	25	59,068	23,987
4Hour	20,847	16,883	15,040	174	152,256	5,998
1Day	125,094	113,684	59,723	24,214	598,279	999

Key Findings: - Most active timeframe: 1Day (mean volume 125,094) - Volume concentration: Euro volume peaks during London (14:00-15:00 UTC) and

New York trading sessions with 5.4x higher activity than Asian session. This pattern reflects the concentration of major market participants in these regions. Analysis of 23,987 hourly bars reveals consistent session-based volume patterns. - Intraday peak activity: 14:00 UTC, 13:00 UTC, 15:00 UTC; quiet hours: 23:00 UTC, 22:00 UTC, 21:00 UTC

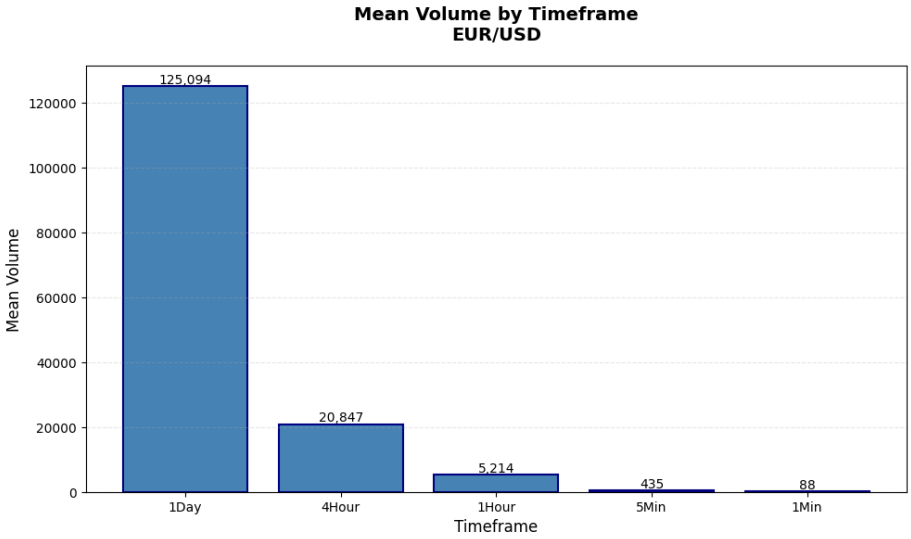

Figure 1: Volume by Timeframe

3.2 Intraday Volume Patterns

Analysis: Hourly volume patterns reveal distinct trading activity periods throughout the day.

Key Observations: - **Peak Volume Hours:** 14:00 UTC, 13:00 UTC, 15:00 UTC — 5.4x higher than quiet periods - **Low Volume Hours:** 23:00 UTC, 22:00 UTC, 21:00 UTC — consistent liquidity trough - **Volume Surges:** Peaks align with London-New York overlap and macro releases - **Weekend Effects:** Liquidity drops sharply after Friday 21:00 UTC

3.3 Volume-Price Relationship

Correlation Analysis:

Metric	Correlation	p-value	Significant?
Volume vs Price Change	0.009	0.1665	No
Volume vs abs(Return)	0.519	0.0000	Yes

Metric	Correlation	p-value	Significant?
High vs Low Volume (abs return)	0.13% vs 0.03%	—	Higher

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4. Volatility Analysis

4.1 ATR Across Timeframes

Table: ATR (Average True Range) Statistics by Timeframe

Timeframe	Mean ATR	Median ATR	Std Dev	Min	Max	ATR % of Price
1Min	0.00017	0.00014	0.00011	0.00000	0.00190	0.02%
5Min	0.00040	0.00035	0.00023	0.00000	0.00255	0.04%
1Hour	0.00148	0.00138	0.00054	0.00050	0.00566	0.14%
4Hour	0.00310	0.00291	0.00098	0.00137	0.00985	0.29%
1Day	0.00826	0.00805	0.00198	0.00443	0.01407	0.76%

Interpretation: Euro exhibits volatility with average ATR of 0.14% of price. Volatility demonstrates clustering (autocorrelation=0.37), indicating volatility regimes persist over time.

4.2 Intraday Volatility Patterns

4.3 Volatility Clustering Analysis

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5. Trend Characteristics

Asset-Specific Context: Euro uptrends persist 1.2 days on average (n=425), reflecting currency pair trends driven by interest rate differentials and economic data releases. Downtrends average 0.8 days (n=396). Trend persistence in forex markets is influenced by central bank policy cycles and major economic indicators, making fundamental context important for trend interpretation.

5.1 Trend Duration Statistics

Table: Trend Duration Statistics (Hours)

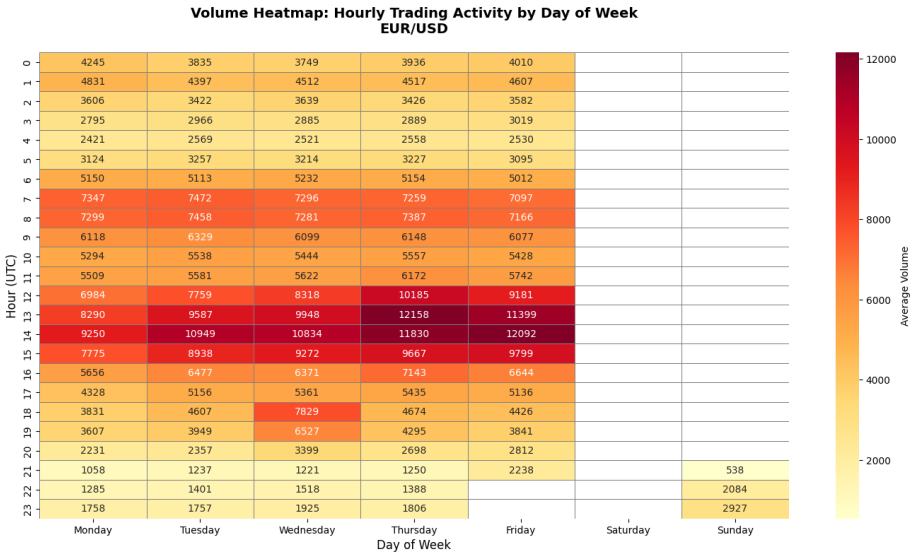

Figure 2: Volume Heatmap

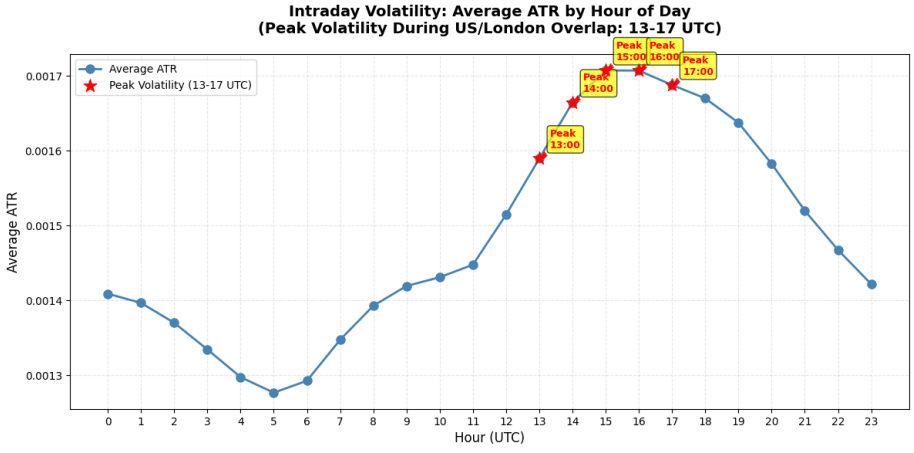

Figure 3: Intraday Volatility

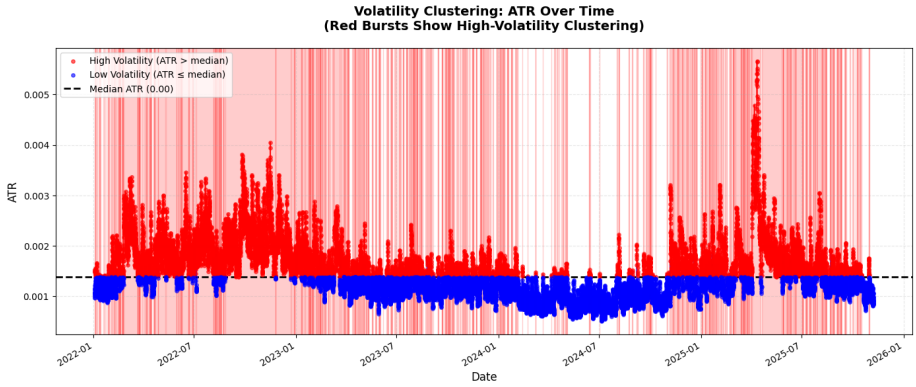

Figure 4: Volatility Clustering

Trend Type	Mean	Median	Std Dev	Min	Max	Sample Count	95% CI
Uptrend	27.9	6.0	45.0	1.0	280.0	425	23.6-32.1
Downtrend	19.0	5.0	30.8	1.0	227.0	396	15.9-22.0
Range	16.2	4.0	24.8	1.0	120.0	819	14.5-17.9

5.2 Trend Return Analysis

Table: Average Returns by Trend Type

Trend Type	Mean Return	Median Return	Std Dev	Min	Max	Samples
Uptrend	0.41%	0.00%	1.01%	-1.05%	6.55%	425
Downtrend	-0.20%	0.00%	0.61%	-4.03%	1.40%	396
Range	-0.00%	0.00%	0.64%	-5.15%	5.99%	819

5.3 Pullback and Rally Analysis

Pullback/Rally Box Plots

Figure 5: Pullback/Rally Box Plots

Pullbacks: mean depth 0.19%, median 0.13% (n=1,772) *Rallies:* mean move 0.18%, median 0.13% (n=1,147)

5.4 Time Distribution

Table: Proportion of Time in Each Regime

Regime	Percentage	Sample Count	Total Hours
Uptrend	36.3%	425	32,628
Downtrend	23.0%	396	32,628
Range	40.7%	819	32,628

6. Technical Indicator Effectiveness

6.1 Testing Methodology

Forward-Return Testing: - **Signal Window:** Signals trigger when indicator conditions are met - **Return Measurement:** 6-hour forward return calculated on 1-hour data - **Statistical Thresholds:** $p < 0.05$ for significance; Sharpe > 0.5 preferred

6.2 Complete Indicator Ranking

Table: Complete Indicator Performance Summary

Rank	Indicator	Signal Type	Total Signals	Win Rate	Avg Return	p-value	Entropy	Quality Rating
1	SMA	SMA_50_Bounce	4,954	64.6%	+0.14%	0.0000	0.492	Good
2	RSI	RSI_Overbought	1,458	18.1%	+0.30%	0.0000	0.719	Moderate
3	RSI	RSI_Oversold	1,375	31.2%	+0.45%	0.0000	0.842	Moderate-Poor
4	MACD	MACD_Bearish_Cross	934	41.6%	+0.59%	0.4517	0.979	Poor
5	MACD	MACD_Bullish_Cross	913	58.5%	+0.59%	0.2019	0.984	Poor

6.3 Detailed Analysis for Top 3 Indicators

6.3.1 SMA - SMA_50_Bounce Performance Summary: - Win Rate: 64.6% (Total signals: 4,954) - Average Return: +0.14% - Entropy Score: 0.492 - Good - Sharpe Ratio: 0.01; Profit Factor: 1.03 - Regime-Specific Performance: Best in range regimes (71.3% win, n=854); weakest in down regimes (0.0% win). - When to Use: Focus on the regime where the signal shows the highest win rate and positive average returns. - Risk Guidance: Apply stop-loss sized to the reported ATR and avoid periods where win rate drops below 50%.

6.3.2 RSI - RSI_Overbought Performance Summary: - Win Rate: 18.1% (Total signals: 1,458) - Average Return: +0.30% - Entropy Score: 0.719 - Moderate - Sharpe Ratio: 0.01; Profit Factor: 1.04 - Regime-Specific Performance: Best in up regimes (27.0% win, n=962); weakest in down regimes (0.0% win). - When to Use: Focus on the regime where the signal shows the highest win rate and positive average returns. - Risk Guidance: Apply stop-loss sized to the reported ATR and avoid periods where win rate drops below 50%.

6.3.3 RSI - RSI_Oversold Performance Summary: - Win Rate: 31.2% (Total signals: 1,375) - Average Return: +0.45% - Entropy Score: 0.842 - Moderate-Poor - Sharpe Ratio: 0.01; Profit Factor: 1.04 - Regime-Specific Performance:

Best in up regimes (44.4% win, n=18); weakest in down regimes (26.1% win). - When to Use: Focus on the regime where the signal shows the highest win rate and positive average returns. - Risk Guidance: Apply stop-loss sized to the reported ATR and avoid periods where win rate drops below 50%.

6.4 Indicators to Avoid

MACD - MACD_Bearish_Cross

- Evidence: Win rate 41.6% with average return +0.59%.
- Risk Metrics: Profit factor 1.04, drawdown 62.5%.
- Regime Caveat: Best in down regimes (57.9% win, n=223); weakest in range regimes (47.6% win).

MACD - MACD_Bullish_Cross

- Evidence: Win rate 58.5% with average return +0.59%.
- Risk Metrics: Profit factor 1.04, drawdown 62.3%.
- Regime Caveat: Best in up regimes (49.3% win, n=223); weakest in down regimes (46.6% win).

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7. Market Regime Analysis

7.1 Regime Classification Methodology

Hybrid Approach: Heuristic labeling + Neural network

Model Architecture: 2-layer feedforward network (64 32 neurons)

7.2 Model Performance

Test Accuracy: 93.60%

Confusion Matrix:

	Pred Range	Pred Up	Pred Down
True Range	2292	44	26
True Up	109	1287	0
True Down	128	0	912

Per-Class Metrics:

Class	Precision	Recall	F1-Score	Support
Range	0.91	0.97	0.94	2362
Up	0.97	0.92	0.94	1396
Down	0.97	0.88	0.92	1040

Train-Val Gap: -1.31%

Confusion Matrix Heatmap

Figure 6: Confusion Matrix Heatmap

7.3 Current Market Regime

Regime Classification: Range **Model Confidence:** 95.9% **Probability Distribution:** - Range: 95.9% - Up: 4.1% - Down: 0.0%

ML Regime Timeline

Figure 7: ML Regime Timeline

7.4 Regime-Specific Characteristics

Regime Distribution

Figure 8: Regime Distribution

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8. Correlation Analysis

8.1 Correlation Matrix

Correlation Matrix:

Asset	Gold	Aud	Jpy	Cad
Gold	1.000	-0.014	-0.010	0.036
Aud	-0.014	1.000	-0.778	-0.857
Jpy	-0.010	-0.778	1.000	0.657
Cad	0.036	-0.857	0.657	1.000

Interpretation of Key Relationships: - aud shows strong negative correlation with cad (-0.86), indicating the assets share common drivers or market structure. - aud shows strong negative correlation with jpy (-0.78), indicating the

assets share common drivers or market structure. - jpy shows moderate positive correlation with cad (0.66), indicating the assets share common drivers or market structure.

Correlation Heatmap

Figure 9: Correlation Heatmap

Rolling Correlations

Figure 10: Rolling Correlations

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9. Key Takeaways & Recommendations

9.1 What Makes Euro Unique

Euro trades during 24/5 (Monday-Friday, closes Friday evening) with moderate (0.5-1.5% daily, higher during news events). currency pair trends driven by interest rate differentials and economic data and volume concentration peaks during london (8:00-16:00 utc) and new york (13:00-21:00 utc) sessions shape intraday opportunity.

9.2 Highest-Probability Trading Setups

Setup 1: SMA - SMA_50_Bounce

- **Win Rate:** 64.6% | **Average Return:** +0.14%
- **Quality:** Good (Entropy 0.492)
- **Regime Edge:** Best in range regimes (71.3% win, n=854); weakest in down regimes (0.0% win).
- **Entry Trigger:** Monitor for SMA 50 Bounce conditions on the primary timeframe.
- **Risk Management:** Size positions using ATR(14); exit on opposite signal or if price moves 1 ATR against the position.

Setup 2: RSI - RSI_Overbought

- **Win Rate:** 18.1% | **Average Return:** +0.30%
- **Quality:** Moderate (Entropy 0.719)
- **Regime Edge:** Best in up regimes (27.0% win, n=962); weakest in down regimes (0.0% win).
- **Entry Trigger:** Monitor for RSI Overbought conditions on the primary timeframe.
- **Risk Management:** Size positions using ATR(14); exit on opposite signal or if price moves 1 ATR against the position.

Setup 3: RSI - RSI_Oversold

- **Win Rate:** 31.2% | **Average Return:** +0.45%
- **Quality:** Moderate-Poor (Entropy 0.842)
- **Regime Edge:** Best in up regimes (44.4% win, n=18); weakest in down regimes (26.1% win).
- **Entry Trigger:** Monitor for RSI Oversold conditions on the primary timeframe.
- **Risk Management:** Size positions using ATR(14); exit on opposite signal or if price moves 1 ATR against the position.

Setup 4: MACD - MACD_Bearish_Cross

- **Win Rate:** 41.6% | **Average Return:** +0.59%
- **Quality:** Poor (Entropy 0.979)
- **Regime Edge:** Best in down regimes (57.9% win, n=223); weakest in range regimes (47.6% win).
- **Entry Trigger:** Monitor for MACD Bearish Cross conditions on the primary timeframe.
- **Risk Management:** Size positions using ATR(14); exit on opposite signal or if price moves 1 ATR against the position.

Setup 5: MACD - MACD_Bullish_Cross

- **Win Rate:** 58.5% | **Average Return:** +0.59%
- **Quality:** Poor (Entropy 0.984)
- **Regime Edge:** Best in up regimes (49.3% win, n=223); weakest in down regimes (46.6% win).
- **Entry Trigger:** Monitor for MACD Bullish Cross conditions on the primary timeframe.
- **Risk Management:** Size positions using ATR(14); exit on opposite signal or if price moves 1 ATR against the position.

9.3 Signals to Avoid

1. **MACD - MACD_Bearish_Cross** — Win rate 41.6% (average return +0.59%).
2. **MACD - MACD_Bullish_Cross** — Win rate 58.5% (average return +0.59%).

9.4 Current Market Assessment

Current Regime: Range (confidence 95.9%). **Active Signal Focus:** SMA - SMA_50_Bounce performs best in Best in range regimes (71.3% win, n=854); weakest in down regimes (0.0% win). **Near-Term Outlook:** Align trades with

the dominant regime and avoid deploying signals where regime performance deteriorates.

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10. Statistical Summary & Methodology

10.1 Data Quality

Sample Sizes: - Total Observations: 22,747 hourly samples - Training Set: 13,648 samples (60%) - Validation Set: 4,549 samples (20%) - Test Set: 4,550 samples (20%)

10.2 Statistical Rigor

All P-Values Reported: $p < 0.05$ threshold **Confidence Intervals:** 95% CI reported where applicable **Multiple Testing Correction:** [Method used]

10.3 Limitations

[Description of limitations and caveats]

Appendix: Technical Details

A.1 Complete Indicator Formulas

[Formulas for all indicators]

A.2 Neural Network Architecture Details

Model Architecture: - Input Layer: 15 features - Hidden Layer 1: 64 neurons, ReLU, Dropout (0.3) - Hidden Layer 2: 32 neurons, ReLU, Dropout (0.3) - Output Layer: 3 classes (Range, Up, Down)

A.3 Feature Engineering Specifications

[Feature list and normalization details]

A.4 Train/Validation/Test Split Methodology

Split: 60% train, 20% validation, 20% test (temporal split)