Detailed Strategy Report

**Background**

* **Algorithmic Trading Overview:**  
  Algorithmic trading uses automated systems to execute trades based on predefined rules and quantitative models. This approach leverages computing power and vast datasets to make rapid trading decisions that are often impossible for human traders to achieve manually.
* **Technical Indicators:**  
  Technical indicators are mathematical formulas derived from historical market data such as price, volume, and open interest. They help traders identify trends, momentum, and potential reversal points. Two widely used indicators in this field are:
  + **MACD (Moving Average Convergence Divergence):**  
    A momentum indicator that identifies trend direction, strength, and reversals by comparing short-term and long-term moving averages.
  + **RSI (Relative Strength Index):**  
    A momentum oscillator that measures the speed and change of price movements to indicate overbought or oversold conditions. The dynamic version of RSI adjusts these thresholds in response to market volatility, aiming for a more responsive and adaptive trading signal.

**Motivation**

* **Adapting to Market Complexity:**  
  Modern financial markets are increasingly volatile and complex. Traditional, static indicators may lag or generate false signals during rapid market shifts. By exploring a dynamic version of RSI, we seek to address these limitations and improve the responsiveness of trading strategies.
* **Enhanced Signal Accuracy:**  
  The integration of MACD with a dynamic RSI aims to combine trend detection with adaptive momentum analysis. This hybrid approach can potentially filter out market noise, reduce false signals, and provide more timely entry and exit signals.
* **Risk Management Improvements:**  
  With improved signal accuracy and adaptability, the strategy aims to enhance risk management by minimizing premature trades and reducing exposure to sudden market reversals. This is critical for maintaining profitability in algorithmic trading.

**Objectives**

* **Performance Comparison:**  
  Evaluate how the combined use of MACD and dynamic RSI performs relative to each indicator used independently. The goal is to understand if the hybrid approach offers a significant advantage in terms of accuracy and profitability.
* **Optimization of Parameters:**  
  Determine the optimal settings for both MACD and dynamic RSI that balance sensitivity to market movements with the need to filter out noise. This involves testing various configurations to identify the best-performing parameters.
* **Robustness and Adaptability:**  
  Validate the strategy across different market conditions using backtesting. The aim is to ensure that the approach is robust, adaptable, and capable of maintaining performance even in volatile or unexpected market scenarios.
* **Actionable Insights:**  
  Generate insights that can inform future enhancements in algorithmic trading strategies, including potential integration with other indicators or advanced risk management techniques.

**Data Exploration & Data Quality Configurations**

**1. Data Exploration**

**Data Loading & Feature Extraction**

* **Data Source & Symbol:**
  + Loaded data for BTCUSDT from January 1, 2023, to September 24, 2024 at 15‑minute intervals.
* **Feature Extraction:**
  + Utilizes SingleSymbolDataHandler and SingleSymbolFeatureExtractor to compute technical indicators.
  + Key extracted features include RSI, MACD (signal and histogram), stochastic indicators, Bollinger Bands, ATR, VWAP, OBV, SMA, EMA, and ADX.
  + The cleaned ‘close’ price and ‘volume’ data are merged with the indicators.

**Derived Features & Statistical Analysis**

* **RSI Variance & Range Calculations:**
  + **Rolling Variance:**
    - Calculated RSI variance using a rolling window (window\_roll\_var = 20) to capture short-term fluctuations.
    - Derived additional metrics such as rsi\_var\_past to reflect historical variability.
  + **RSI Range:**
    - Computed rolling minimum and maximum values over a window (window\_RSI = 30), providing insight into the spread of RSI values.
  + **Insight for Dynamic RSI Model:**
    - The observed larger variance in RSI, as evidenced by broader ranges between rolling minimum and maximum values, highlights the potential benefits of adapting RSI thresholds dynamically.
    - This analysis motivates the development of a dynamic RSI model that adjusts its overbought and oversold thresholds based on the current variance of the RSI.
* **Price Variance & Return Calculations:**
  + Calculated rolling standard deviation for the ‘close’ price over a defined window (window\_price = 15) to measure volatility.
  + Computed the return as the percentage change in the ‘close’ price.

**Data Scaling and Correlation Analysis**

* **Scaling:**
  + Normalized the indicators DataFrame using MinMaxScaler to enable meaningful comparisons.
* **Correlation Analysis:**
  + Generated a correlation matrix on the scaled data.
  + Key findings:
    - RSI-related metrics (e.g., rsi\_max, rsi\_min, and rsi\_var\_past) show strong correlations.
    - A larger RSI variance is indicated by a wider spread between rolling minimum and maximum values.
* **Visualization:**
  + Produced a heatmap using seaborn to visualize correlations, highlighting relationships among indicators including those relevant to the dynamic RSI approach.

**2. Data Cleaning and Checking Configurations**

**Automatic Data Cleaning (cleaner.json)**

* **Purpose:**
  + Ensures raw trading data is consistent and free of anomalies before analysis.
* **Key Parameters:**
  + **Label Checks:** Validates required labels such as open\_time, open, high, low, close, and volume.
  + **Data Type Validation:** Verifies data types.
  + **Outlier Removal:**
    - Removes outliers based on a threshold of 20.
    - Uses an adjacent\_count of 7 for stability.
  + **Additional Settings:**
    - No resampling or timezone adjustments; applies a UTC offset of 3 with datetime in milliseconds.

**Data Checking (checker.json)**

* **Purpose:**
  + Validates data integrity after cleaning.
* **Key Checking Parameters:**
  + **Missing & Duplicate Data:**
    - Checks for missing values and duplicate entries.
  + **Outlier & Logical Checks:**
    - Reassesses outlier removal and logical consistency.
  + **Datatype Verification:**
    - Confirms each field matches the expected datatype (e.g., open\_time as datetime64[ns, UTC], price fields as float32).

**3. Summary & Implications**

* **Data Exploration Insights:**
  + Robust statistical analysis of RSI, including variance and range calculations, reveals significant fluctuations in the RSI values.
  + The strong correlations among RSI-derived metrics indicate that a static RSI threshold may not be optimal under all market conditions.
* **Dynamic RSI Model Development:**
  + **Motivation:**
    - The observed larger variance in RSI supports the need for a dynamic approach.
    - A dynamic RSI model will adjust its thresholds based on real-time variance, thereby adapting to changing market conditions and potentially reducing false signals.
  + **Expected Benefit:**
    - More responsive trading signals in sideways markets.
    - Improved risk management by adapting to the inherent volatility captured in the RSI variance.
* **Impact of Cleaning and Checking:**
  + The custom cleaning (cleaner.json) and checking (checker.json) configurations ensure high data quality, which is essential for reliable indicator computation and subsequent strategy performance.
  + This data integrity is critical for developing and validating advanced models like the dynamic RSI.
* **Overall Importance:**
  + A comprehensive data exploration combined with robust cleaning and checking routines forms the foundation for developing effective trading strategies.
  + The dynamic RSI model, motivated by the analysis of RSI variance, represents a significant advancement in adapting technical indicators to current market conditions.

**Methodology and Experimental Setup**

**Overall Setup & Data Configuration**

* **Data Source & Timeframe:**
  + Symbol: BTCUSDT
  + Timeframe: 15‑minute intervals (as set in your experiments)
  + Date Range: Examples include ‘2023-01-01’ to ‘2024-09-24’ for initial tests and later testing on untouched data (e.g., ‘2024-09-24’ to ‘2025-03-01’)
* **Feature Set Parameters (from feature\_set\_15m.json):**
  + **RSI:**
    - rsi\_period: 3
  + **MACD:**
    - macd\_short: 15
    - macd\_long: 30
    - macd\_signal: 20
  + **Other Indicators:**
    - stoch\_period: 14; stoch\_smooth\_k: 3; stoch\_smooth\_d: 3
    - bollinger\_period: 20; bollinger\_std: 2
    - atr\_period: 14; vwap\_period: 14; obv\_lookback: 14
    - sma\_period: 20; ema\_period: 14; adx\_period: 14
    - custom\_indicator\_param: 5
    - selection\_method: "correlation"
* **Tools & Environment:**
  + Python notebooks using libraries such as pandas, NumPy, matplotlib, Scipy, and scikit-learn
  + Data handling via SingleSymbolDataHandler and feature extraction via SingleSymbolFeatureExtractor
  + Automated data cleaning performed by your trading bot (details to be documented later)

**Strategy Overview & Experimental Procedures**

1. **Strategy 1: MACD Histogram with Threshold**
   * **Concept:**
     + Calculate the MACD histogram (difference between MACD and its signal line).
     + Use a predefined threshold (e.g., 40) to filter out noise.
   * **Trade Signals:**
     + **Buy:** When the MACD histogram (macd\_diff) exceeds the positive threshold.
     + **Sell:** When the histogram falls below the negative threshold.
   * **Execution:**
     + Invest full capital on a “buy” signal (adjusted for fees).
     + Record trade details and update capital evolution.
   * **Performance Metrics:**
     + Metrics such as Total ROI, Max Drawdown, Sharpe Ratio, Trade Efficiency, win rate, and others are computed using a dedicated function.
2. **Strategy 2: MACD with Trend Confirmation**
   * **Concept:**
     + Augment the basic MACD strategy with trend confirmation using the ADX indicator.
   * **Trade Signals:**
     + **Buy:** Only when macd\_diff exceeds a threshold (typically 0) **and** the ADX is above a specified value (e.g., ≥45) indicating a trending market.
     + **Sell:** When the histogram turns negative while ADX still confirms the trend.
   * **Objective:**
     + Filter out trades in sideways or non-trending markets, reducing false signals.
   * **Outcomes:**
     + Performance is compared by looking at risk-adjusted metrics, win rate, and profit attribution.
3. **Strategy 3: Dynamic RSI on Sideways Markets**
   * **Concept:**
     + Focuses exclusively on sideways (non-trending) markets by leveraging dynamic adjustments to the RSI.
   * **Dynamic Threshold Calculation:**
     + Compute rolling RSI mean and standard deviation over a window (e.g., window=23).
     + Establish dynamic boundaries:
       - **Dynamic Upper:** rsi\_mean + (variance\_factor × RSI\_std)
       - **Dynamic Lower:** rsi\_mean – (variance\_factor × RSI\_std)
     + Typical parameter suggestions:
       - ADX threshold around 20–25
       - Variance factor approximately 1.9–2.1
       - Rolling window near 20–30 (consistent with the 15‑minute timeframe)
   * **Trade Signals:**
     + **Buy:** When RSI falls below the dynamic lower threshold (plus any margin adjustment).
     + **Sell:** When RSI rises above the dynamic upper threshold.
   * **Execution:**
     + Only executes trades when ADX indicates a sideways market (ADX below the threshold).
     + Aims to reduce risk and drawdown by avoiding trades during trending periods.
4. **Strategy 4: Combined Strategy (Dynamic RSI + MACD)**
   * **Concept:**
     + Integrates both approaches to leverage their strengths while attempting to mitigate their weaknesses.
   * **Regime Determination:**
     + **Dynamic RSI Regime:** When ADX is below a set threshold (e.g., rsi\_trend\_threshold ≈20–23), apply the dynamic RSI strategy.
     + **MACD Regime:** When ADX exceeds a higher threshold (e.g., adx\_macd\_threshold ≈45), apply the MACD histogram strategy.
     + **Undefined Region:** For ADX values between these thresholds:
       - Optionally, use an additional trend indicator (SSTI – Smoothed Simple Slope Trend Indicator) to guide exit decisions.
   * **Trade Signals:**
     + Depending on the detected regime:
       - **RSI Side:** Enter long when RSI falls below the dynamic lower boundary; exit when it crosses above the mean or dynamic upper boundary.
       - **MACD Side:** Enter when macd\_diff is positive; exit when it turns negative.
   * **Observations & Challenges:**
     + Signal conflicts and lags may occur when switching regimes, potentially increasing transaction costs due to more frequent trading.
     + Overfitting risk rises with additional parameters and complex decision rules.
   * **Variants:**
     + A version includes an exit strategy using the SSTI to exit positions during ambiguous market conditions.

**Additional Experimental Details**

* **Backtesting Process:**
  + Historical data is processed, and trades are simulated based on the above strategies.
  + Capital evolution is tracked over time, and detailed performance metrics are computed.
  + Visualizations (price vs. capital charts) are generated to illustrate the performance over the backtesting period.
* **Performance Evaluation Metrics:**
  + **Total ROI (%):** Overall return on investment.
  + **Max Drawdown (%):** Maximum loss from a peak, assessing risk.
  + **Sharpe & Sortino Ratios:** Risk-adjusted performance measures.
  + **Trade Efficiency, Win Rate, Profit Attribution,** and **Risk Reward Ratio:** To gauge per-trade performance and overall strategy consistency.
* **Tools & Libraries:**
  + Python libraries used include:
    - **pandas & NumPy:** Data manipulation and calculations.
    - **matplotlib:** Visualization of results.
    - **scikit-learn:** For any additional preprocessing or scaling if required.
  + Custom modules (historical\_data\_handler, feature\_extractor) are used to streamline data handling and feature computation.
  + The automated trading bot ensures that data cleaning is consistently applied before experiments.

**7. Results and Analysis**

**7.1 Presentation of Results**

* **Performance Metrics & Visualizations:**
  + **Tables & Charts:**
    - **Capital Evolution Charts:** Graphs plotting the evolution of capital over time for each strategy.
    - **Signal Plots:** Charts showing entry/exit signals overlaid on the price series.
    - **Summary Tables:** Tabulated metrics including Total ROI, Max Drawdown, Sharpe Ratio, Trade Efficiency, Win Rate, Profit Attribution, and Risk Reward Ratio.
  + **Key Metrics from Each Strategy:**
    - **Strategy 1 – MACD Histogram with Threshold:**
      * Total ROI: approximately -2.36%
      * Max Drawdown: around 39.87%
      * Sharpe Ratio: very low (≈0.00072)
      * Note: Despite a high Symbol ROI (~282.88%), frequent trading and noise filtering challenges resulted in a negative overall performance.
    - **Strategy 2 – MACD with Trend Confirmation:**
      * Total ROI: approximately 142%
      * Max Drawdown: about 28.64%
      * Sharpe Ratio: low (≈0.00817)
      * Advantage: Trend confirmation using ADX (threshold around 45) helped filter trades in non-trending periods.
    - **Strategy 3 – Dynamic RSI on Sideways:**
      * Total ROI: approximately 133.73%
      * Max Drawdown: lower at roughly 18.04%
      * Win Rate: higher (≈57.29%)
      * Insight: Dynamic adjustment of RSI thresholds in sideways markets yielded improved risk management and more consistent performance.
    - **Strategy 4 – Combined Strategy (Dynamic RSI + MACD):**
      * Mixed outcomes were observed:
        + One variant achieved a ROI of around 58% with similar drawdown to the MACD strategy.
        + A further variant incorporating SSTI for exit signals resulted in a very modest ROI (~5.29%), suggesting increased complexity might not always translate to better performance.

**7.2 Comparative Analysis**

* **Effectiveness:**
  + **MACD-based Strategies:**
    - Show strong underlying asset performance (high Symbol ROI) but may suffer from frequent false signals when used in isolation.
    - Adding trend confirmation (Strategy 2) slightly improves performance by filtering out trades during non-trending periods.
  + **Dynamic RSI Strategy:**
    - Provides a robust approach in sideways markets with lower drawdown and higher win rates.
    - Its adaptive nature helps manage risk better by adjusting to the current variance in the RSI.
  + **Combined Strategies:**
    - Integration attempts (Strategy 4) show that simply merging different indicators can lead to signal conflicts, increased trading frequency, and potential overfitting.
    - The added complexity (e.g., using SSTI for exit signals) can sometimes diminish overall performance.
* **Advantages & Limitations:**
  + **Advantages:**
    - **MACD with Trend Confirmation:** Filters out noise in trending markets.
    - **Dynamic RSI:** Adapts to market volatility, reducing false signals and drawdowns.
    - **Combined Approach:** Aims to harness the strengths of both methods.
  + **Limitations:**
    - **Frequent Trading & Noise:** Strategies relying solely on MACD can be overly sensitive, leading to poor risk-adjusted returns.
    - **Parameter Sensitivity:** Both approaches require careful tuning; small parameter adjustments can lead to significant changes in performance.
    - **Signal Conflicts:** Combining strategies sometimes introduces conflicts or lag in signal generation, reducing overall effectiveness.

**7.3 Discussion**

* **Impact of Automatic Data Cleaning:**
  + The **automatic cleaning process** (as configured in cleaner.json) ensures that the raw data is consistent, free of outliers, and properly formatted (with required labels and correct datatypes). This reliability is essential when calculating sensitive indicators like RSI.
  + **Data checking** (checker.json) further validates data integrity by ensuring no missing values, duplicates, or logical inconsistencies exist.
  + **Influence on Results:**
    - **Enhanced Signal Reliability:** With cleaner data, the calculated technical indicators (RSI, MACD, etc.) are less likely to be distorted by erroneous or extreme values, leading to more trustworthy trade signals.
    - **Reduced Noise:** Outlier removal and zero-variance filtering help minimize the impact of sporadic anomalies, although sometimes this might also eliminate extreme events that could have been beneficial in capturing large moves.
    - **Consistent Benchmarking:** Clean, verified data provides a stable baseline for backtesting, enabling a more accurate comparison across different strategy configurations.
* **Overall Insights:**
  + While each strategy exhibits unique strengths, the **Dynamic RSI model** stands out due to its adaptive thresholds that respond to real-time variance, which was motivated by the exploration of RSI variability.
  + The **combination of strategies** requires further refinement to overcome signal conflicts and parameter overfitting.
  + The high performance of some strategies (in terms of Symbol ROI) contrasts with the modest risk-adjusted returns, highlighting the critical balance needed between aggressiveness and risk management.