Bollinger Bands & Mean Reversion Buy/Sell Signals

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Agenda

- Introduction & Background
- Thesis
- Results
- Analysis
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Introduction

Prices have a habit of ping-ponging between bands—especially in range-bound conditions; this makes Bollinger Bounces useful for mean reversion setups. However, these are not blind trade triggers. Not only that, but there can also be a lot of noise which can make it hard to reach conclusions.

Thesis: *This presentation demonstrates a robust quantitative trading strategy that leverages Kalman filters to dynamically estimate the hedge ratio between XLE (Energy Sector ETF) and AMD (Advanced Micro Devices), constructing a mean-reverting spread whose signals are refined using Zero-Lag Moving Averages (ZLMA) and confirmed with MACD crossovers; by integrating statistical filtering and momentum confirmation, the strategy targets optimal entry/exit points to maximize cumulative returns and achieve a Sharpe ratio exceeding 1.0 in volatile market conditions.*

Confirm With:

- Moving Average 
- Kalman Filter 

Implementation: We can avoid trading bands during strong trends—waiting for consolidation or pullbacks to improve odds of returns

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WHAT ARE THEY?

Bollinger Bands and Mean Reversion

Bollinger Bands

Definition: Momentum lines (bands) plotted *x* standard deviations (positive and negative) away from the SMA line

Purpose: Indicate price volatility and help identify potential overbought or oversold conditions

Mean Reversion

Definition: Theory that asset prices tend to revert to their average over time

Purpose: Capitalize on temporary price extremes, with the assumption prices will revert to their means

Equation

$$Bands = x_i \pm \sigma_i * 2$$

$$x_i = SMA20$$

$$\sigma_i = SMA20\ Standard\ Deviation$$

Equation

$$SMA20 = \frac{\sum_{x=1}^{20} Closing\ Price}{20}$$

Key Point: When the upper and lower bands are further apart from each other this indicates high volatility and vice versa

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Key Tools

Market Sentiment: The overall mood of investors towards the market (bullish/bearish). This is useful for our strategy to time the entry and exit points.

- Price changes in relation to the Moving Average, thus sensing greed/fear will help identify buying points.
- Top Band = **Overbought** | Lower Band = **Oversold**

Volume: How much the equity is being traded in a specific period.

- If share prices are rising but there's less volume, this indicates a weak feeling towards the security
- If share prices are falling with high volume, this indicates a strong feeling towards the security

Fear & Greed Index

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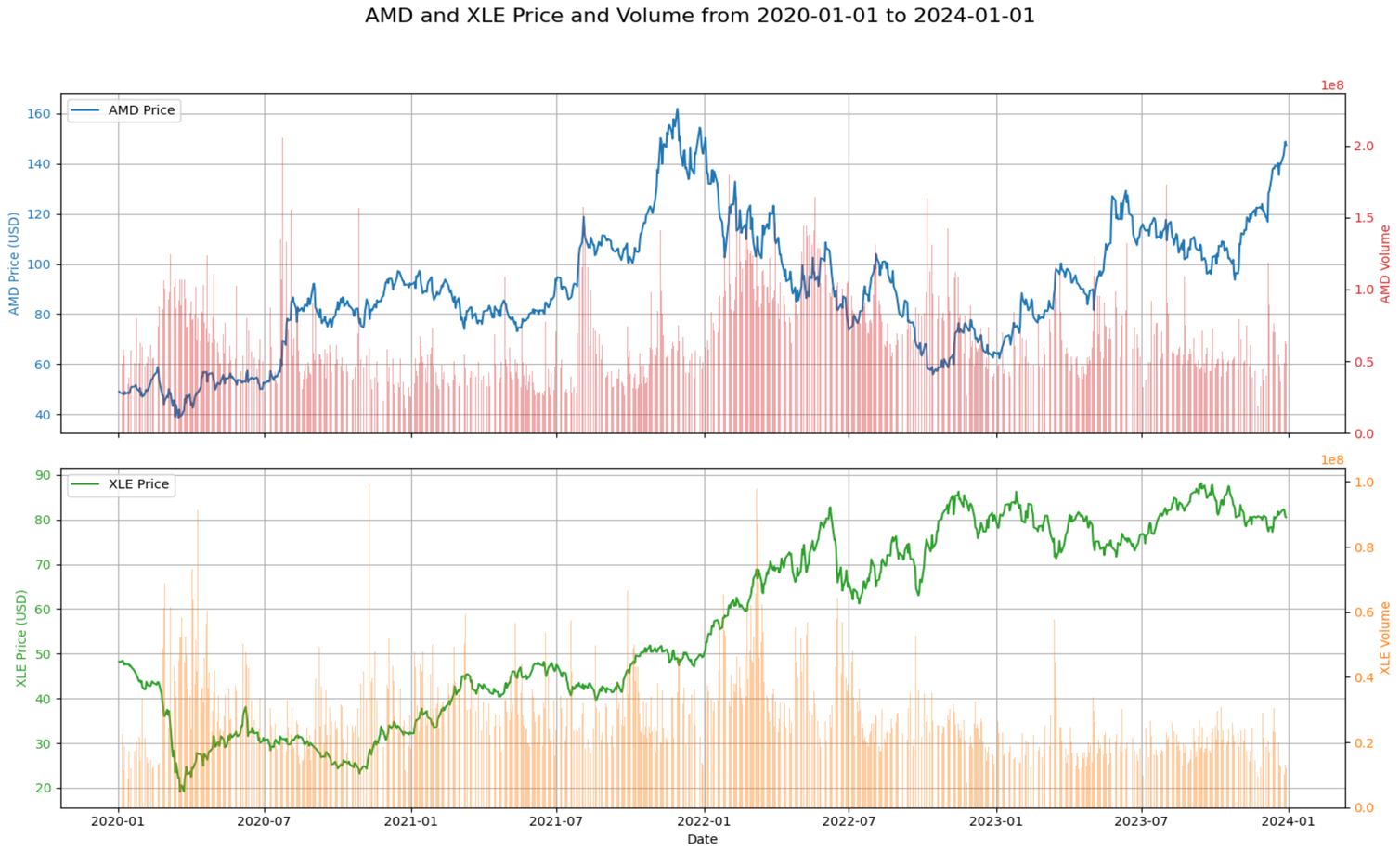
Data

Historical Data Needed:

We will be using a 5-year time frame from

January 2020 to January 2024 to model our data

- Open
- High
- Low
- Close
- Volume



Iteration: The data will loop through the historical data, starting from the period required for the Bollinger Band calculation.

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Strategy

Starting Capital: $100,000

Position Size: 55%

Buy Signal: Checks if both AMD and XLE prices cross above their lower Bollinger Bands. If met, **Buy Signal Generated**

Sell Signal: Checks if either AMD price or XLE price crosses below the upper Bollinger Band. If met, **Sell Signal Generated**

Interpretation: By identifying potential oversold/overbought conditions in these assets, we aim to generate buy and sell signals. Historical data will be used to back test entry and exit rules and assess the strategy's potential for outperformance.

```
START_DATE, END_DATE = "2020-01-01", "2024-12-31"
TICKERS = ["AMD", "XLE"]
INITIAL_CAPITAL = 100_000
TRADE_PCT = 0.55
FEE_PCT   = 0.005
MIN_DIFF_PCT = 0.8
RISK_FREE_RATE, TRADING_DAYS = 0.0, 252
```

```
def kalman_filter(series, q=KF_Q, r=KF_R):
    x = np.empty_like(series, dtype="float64");
    p = 1.0;
    x_prev = series.iloc[0]; x[0] = x_prev
    for i in range(1, len(series)):
        p += q;
        k = p / (p + r)
        x_cur = x_prev + k * (series.iloc[i] - x_prev)
        p = (1 - k) * p; x[i] = x_cur; x_prev = x_cur
    return pd.Series(x, index=series.index)
```

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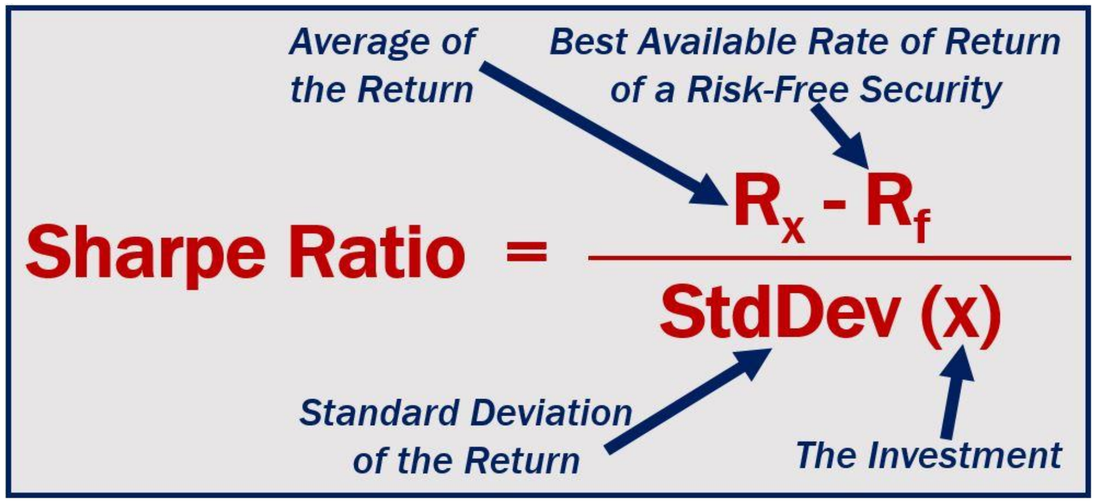
Back Testing Analysis

Sharpe Ratio:

Definition: The Sharpe Ratio is a measure of risk-adjusted return. It allows investors to compare the performance of different investments by considering both the returns and the risks involved. The higher the Sharpe Ratio, the better the investment's risk-adjusted performance.

Strategy Sharpe Ratio: 1.13

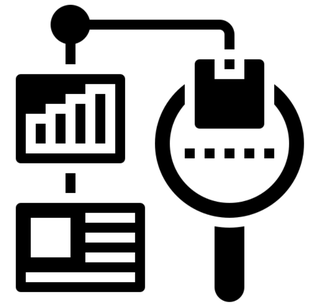


Interpretation Table:

Ratio #	Inference
<1	Bad
1-1.99	Adequate/Good
2-2.99	Very Good
>3	Excellent

Back testing done by looking at key performance **metrics** such as:

- **Sharpe Ratio**
- **Final Cumulative Return**
- **Final Value of Strategy**



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Mean Reversion Algorithm

Kalman Filter:

Definition: Kalman filters were developed by Rudolf Kalman in the early 1960s to solve the problem of managing uncertainty and noise in data. Nowadays, they are great for extracting meaningful information from noisy data. Mathematically, Kalman Filters are called linear quadratic estimators. This is because, in the process of estimating the future based on current and past data, Kalman filters use MR and ZLMA.

- **Mean Reversion in Finance**

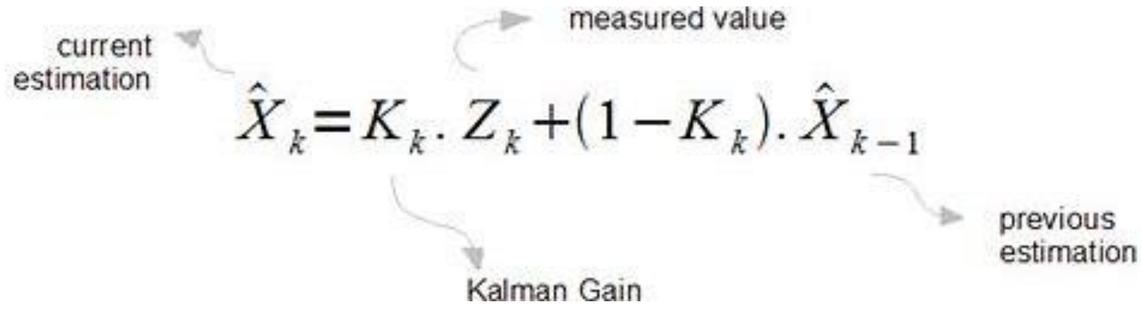
Mean reversion is the tendency of a price or spread to return to a long-term average over time. Strategies like pairs trading and statistical arbitrage often rely on this concept.

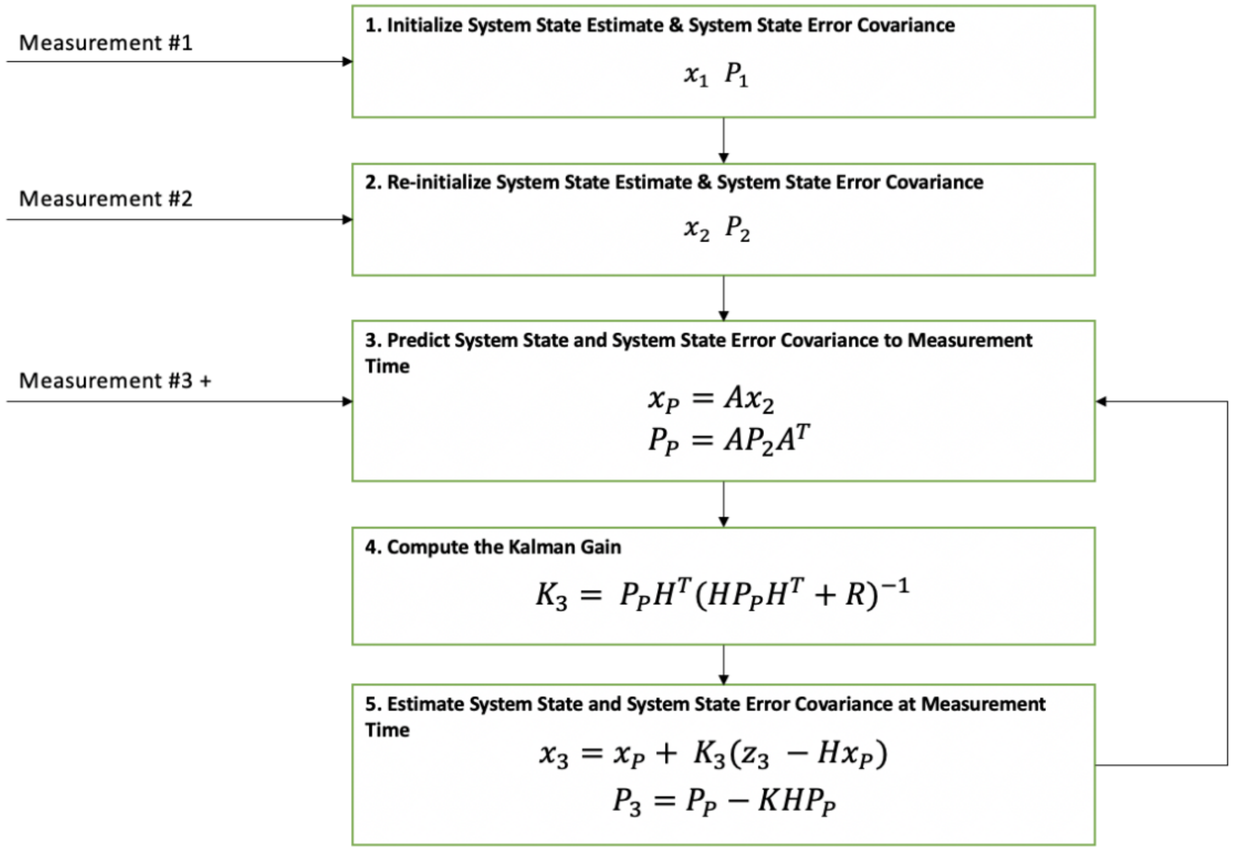
- **Kalman Filters**

Kalman filters are recursive algorithms used to estimate the hidden state of a system over time. In finance, they are often used to dynamically estimate parameters of time-varying models. Basically, a really fancy "MACD" (momentum indicator in technical analysis of securities prices).

- **Zero-Lag Moving Average (ZLMA)**

ZLMA is a type of **smoothed moving average** designed to reduce **lag** compared to traditional moving averages like the simple or exponential moving average. It aims to track price (or another time series) more responsively, making it useful in **real-time trading systems** — including those using **Kalman filters**.





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Results

- **Number of Trades:** 29
- **Ending Capital:** $283,940.28
- **Return:** 183.94%
- **Sharpe Ratio:** 1.129

```
Period: 2020-01-01 → 2024-12-31
Strategy final value:     $283,940.28  |  Return: 183.94%  |  Sharpe: 1.129
Buy-and-hold final value: $211,664.26  |  Return: 111.66%
```

Trades:

date	ticker	act	sh	px	fee	pl
2020-03-23	AMD	BUY	1314	41.639999	273.574796	NaN
2020-05-26	AMD	SELL	1314	53.189999	349.458291	14553.665911
2020-06-09	AMD	BUY	1111	56.389999	313.246447	NaN
2020-09-03	AMD	SELL	1111	82.540001	458.509705	28280.895544
2020-09-25	AMD	BUY	1001	78.059998	390.690288	NaN
2020-12-09	AMD	SELL	1001	89.830002	449.599159	10941.484830
2021-02-08	AMD	BUY	920	91.470001	420.762006	NaN
2021-07-08	AMD	SELL	920	89.739998	412.803990	-2425.169084
2021-07-26	XLE	BUY	1922	43.088043	414.076095	NaN
2021-12-21	AMD	BUY	258	144.250000	186.082500	NaN
2022-02-14	AMD	SELL	258	114.269997	147.408296	-8068.331662
2022-02-25	AMD	BUY	271	121.059998	164.036297	NaN
2022-03-31	AMD	SELL	271	109.339996	148.155695	-3488.312323
2022-04-28	AMD	BUY	345	89.639999	154.628999	NaN
2022-08-04	XLE	SELL	1922	64.999763	624.647727	41075.602548
2022-08-09	AMD	SELL	345	95.540001	164.806502	1716.065026
2022-08-11	XLE	BUY	1414	70.641663	499.436555	NaN
2022-09-09	AMD	BUY	526	85.449997	224.733492	NaN
2022-11-09	XLE	SELL	1414	81.177361	573.923939	13824.116389
2023-05-03	AMD	SELL	526	81.620003	214.660607	-2453.971049
2023-05-05	AMD	BUY	1181	89.839996	530.505178	NaN
2023-06-02	AMD	SELL	1181	117.860001	695.963304	31865.156564
2023-09-28	AMD	BUY	1202	102.760002	617.587613	NaN
2024-01-02	AMD	SELL	1202	138.580002	832.865811	41605.186209
2024-08-08	AMD	BUY	1073	136.320007	731.356839	NaN
2024-08-28	AMD	SELL	1073	146.360001	785.221403	9256.334553
2024-09-11	AMD	BUY	1010	149.860001	756.793003	NaN
2024-10-10	AMD	SELL	1010	164.179993	829.108963	12877.290020
2024-12-24	AMD	BUY	1254	126.290001	791.838306	NaN

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Q&A

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