

# Final Project Ideas

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This document mentions some of the Project Ideas I had initially developed for this WiDS project. Feel free to read more about them, follow the links I share and if you come up with some other ideas, feel free to discuss those with me and you can surely work on those.

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# 1 Risk Management in Pairs Trading Using Kalman Filtering

**Difficulty Level: 2/5**

If you have done all weeks nicely, this should be a P.O.C (piece of cake)

## 1.1 Objective

The goal of this project is to incorporate risk management techniques as explained in week-3 into the pairs trading strategy, enhancing its robustness and performance. Key techniques such as stop-loss orders, position sizing, and portfolio diversification are applied to ensure risk is controlled while maintaining profitability. Additionally, Kalman filtering is used to dynamically adjust the hedge ratio and optimize risk exposure.

## 1.2 Steps

1. **Risk Management Techniques:** Implement some or all of the following risk management strategies:
  - **Stop-Loss Orders:** Define a threshold for the spread between two stocks. If the spread exceeds this threshold, the position is exited to limit losses.
  - **Position Sizing:** Calculate the position size based on the volatility of the spread. A larger position can be taken when the spread is stable (low volatility) and a smaller position when volatility is high.
  - **Portfolio Diversification:** Rather than trading a single pair of stocks, trade multiple pairs to diversify the portfolio, reducing the overall risk exposure.
2. **Kalman Filtering:** The Kalman filter is used to dynamically adjust the hedge ratio between the two stocks in a pair. The Kalman filter allows real-time estimation of the spread and adjusts the hedge ratio accordingly, minimizing risk exposure while maximizing returns.
3. **Backtesting:** Implement backtesting on the risk-managed strategy to evaluate its effectiveness. Key metrics such as drawdowns and volatility

are used to assess risk, while the Sharpe Ratio is used to measure risk-adjusted returns.

4. **Cumulative PnL:** Make sure that you are testing this strategy on some test data that isn't used while training and find out the final PnL you end up with.
5. **DataSet:** Yahoo Finance (yf library in python) is always an option, with it, you can import your own datasets from Kaggle or any other way also. In case you use an external dataset, make sure to upload it on your GitHub repo with your final project submission as well

## 2 Implementing a Variance Threshold Strategy Based on Kalman Filter Residuals

**Difficulty: 2/5**

Even this should be a piece of cake with all the weeks of content.

### 2.1 Objective

The objective of this project is to develop a trading strategy based on the volatility of the residuals obtained from the Kalman filter. The idea is to enter or exit trades when the volatility of the residuals crosses certain thresholds, thereby responding to changes in market dynamics, again similar to what you guys learnt about in Week-3.

### 2.2 Steps

1. **Residuals from Kalman Filter:** After applying the Kalman filter to estimate the hedge ratio, compute the residuals, which are the differences between the actual spread and the filtered spread. These residuals represent the deviations from the expected relationship between the two stocks in the pair.
2. **Volatility Calculation:** Calculate the rolling volatility of the residuals using a moving window (e.g., 30 days). This volatility is then used to set entry and exit thresholds for trades. A higher volatility indicates larger deviations from the expected spread, signaling a potential trade opportunity.
3. **Backtesting:** Implement backtesting using this volatility-based strategy. Compare its performance to a standard z-score strategy, which enters a position when the spread exceeds a certain number of standard deviations, or with any other similar statistic.
4. **DataSets:** Feel free to use Yahoo Finance or any external datasets as well, but make sure to add it to your GitHub repo if you do.

## 3 Pairs Trading with Multiple Cointegrated Pairs in a Portfolio

**Difficulty:** 4/5

Now this is a challenge!

### 3.1 Objective

This project extends the basic pairs trading strategy to handle a portfolio of multiple cointegrated pairs simultaneously. By considering multiple pairs, the strategy aims to diversify risk and improve overall performance. The Kalman filter is used to dynamically adjust the hedge ratios for each pair, optimizing the portfolio's risk exposure.

### 3.2 Steps

1. **Identifying Multiple Cointegrated Pairs:** Perform cointegration tests (such as the Engle-Granger test) to identify pairs of stocks that are cointegrated. These pairs are expected to have a stable, long-term relationship.
2. **Kalman Filtering:** For each cointegrated pair, apply the Kalman filter to estimate the hedge ratio. The Kalman filter continuously adjusts the hedge ratio to account for changes in the spread between the two stocks in each pair.
3. **Portfolio Management:** Build a portfolio that combines positions from multiple cointegrated pairs. Manage the overall risk exposure by allocating weights to each pair based on its individual risk characteristics.
4. **Backtesting:** Perform backtesting on the multi-pair strategy to evaluate its performance in terms of cumulative PnL and risk-adjusted returns. Compare the results to a strategy that trades only a single pair of stocks.

## 4 Final Report

Make sure to draft a Final Report for the entire project and it should include the following things as a bare minimum. You can make it as detailed as possible:

- An explanation of what you have done overall in the project(as much detail as I can understand :)
- A graph of the stock(s) prices over time that you are going to trade over
- A graph showing buy and sell signals (as was there in Week 1) for all the stock(s).
- A graph of the Cumulative PNL and mention the time period you have selected to trade on
- The final PnL value, and number of stocks you have traded
- Any other graphs/visualizations that explain your approach in detail
- The Math behind everything is an added optional, you can add it if you wish to but it isn't necessary.

## 5 Things To Note

These three projects explore different techniques for enhancing pairs trading strategies. The focus of each project is on improving risk management, leveraging multiple cointegrated pairs, and developing volatility-based trading strategies using the Kalman filter. Each project introduces a unique aspect of financial modeling and trading strategy, helping to build more robust and adaptable trading systems. While these projects are awesome from the learning point of view, if you want to try out something even more challenging regarding the same feel free to hit me up with your ideas and if I feel its relevant to the project, we can go ahead with the same. So, for the one last time-

**MAY THE PROFIT BE WITH YOU :)**