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Pairs Trading Analysis

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PAIRS TRADING

Investors can ideate and apply a pair trading strategy in a multiple number of ways. A dominant strategy used by institutional investors, will utilize intrinsic valuation techniques or catalysts such as earnings reports to recognize long-short pairs trade opportunities. Another application, which will be discussed later, uses historical pricing data to create a backwards-looking, quantitative arbitrage strategy in which investors use two assets to price one against the other (hence the name “pair”). This strategy involves investors taking a short position in one asset and a long one in the other to ultimately capture a spread.

The “risk-free” application of the pairs strategy would be to use two truly equal assets. For example, by pairing an ETF with the securities it contains, an investor could take advantage of the split second it takes the ETF issuer to adjust for the movement of the individual securities. Unfortunately for retail and smaller market participants, executing such a strategy is only possible for a select few market makers and hedge funds due to the massive amounts of capital and technological processing power required.

What is a Pairs Trading?

The strategy discussed in through this research is using historically cointegrated assets and trading them against one another. The underlying thesis of this **pair trading strategy** is that the two assets are so closely related (cointegrated) that their prices should always be proportionate to one another. In practice, a long-short enter signal would be the diversion of one asset’s price from the historical pair price relationship, which is typically represented as a ratio. Conversely, a signal to exit the trade would be the pair’s price reversion back to the historical mean.

An attractive aspect of this application of pair trading is its market-agnostic nature; the movement of the whole market becomes irrelevant because of the cointegrated relationship between the selected assets. For example, say a trader noticed that the price of silver was trading at a discount relative to gold. They would enter a short position in gold and a long position in silver. In this case, the trader profits if either silver increases in value or gold falls in value. In the case of external market conditions driving the price of both gold and silver down, the trade would still break even due to the nature of the positions. As a result, when a market downturn occurs, the trader would still see profits as long as the relationship between the two assets holds. The objective of this strategy is to generate alpha and can be particularly attractive in periods where beta (risk) is difficult to realize.

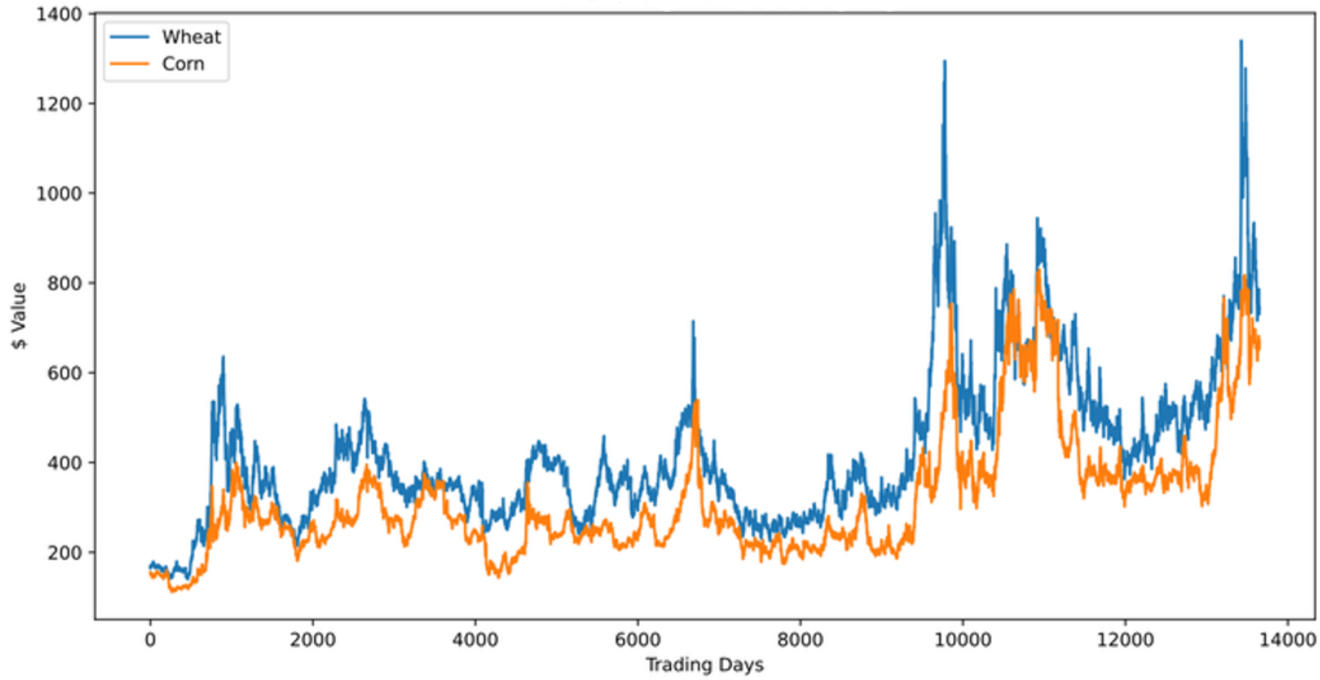
Applying the Pair Trading Strategy Using Wheat and Corn

We have applied the strategy to wheat and corn futures to demonstrate the power of trading pairs.

To identify an effective trading pair, we completed the following three steps:

(1) We chose two assets whose **prices historically follow similar trends**. Looking at their price relationship in Exhibit 1, wheat and corn futures can be seen to track each other. This pair relationship will form the basis of our strategy.

Exhibit 1: Wheat and Corn Prices (since 1974)

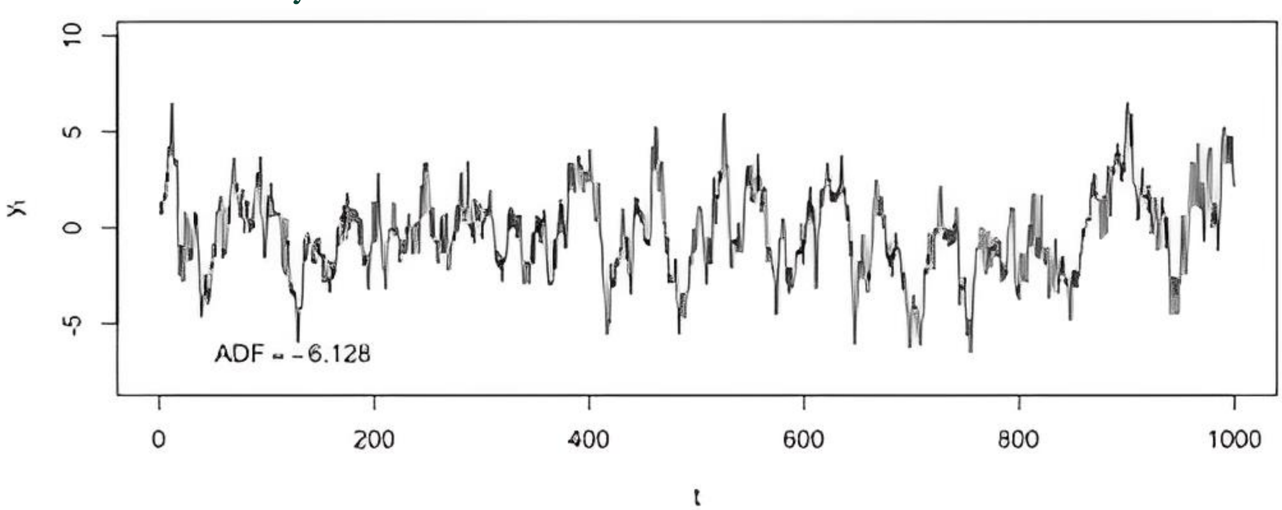


Source: Federalreserve.gov

(2) We checked to see if the wheat-corn **relationship was stationary**:

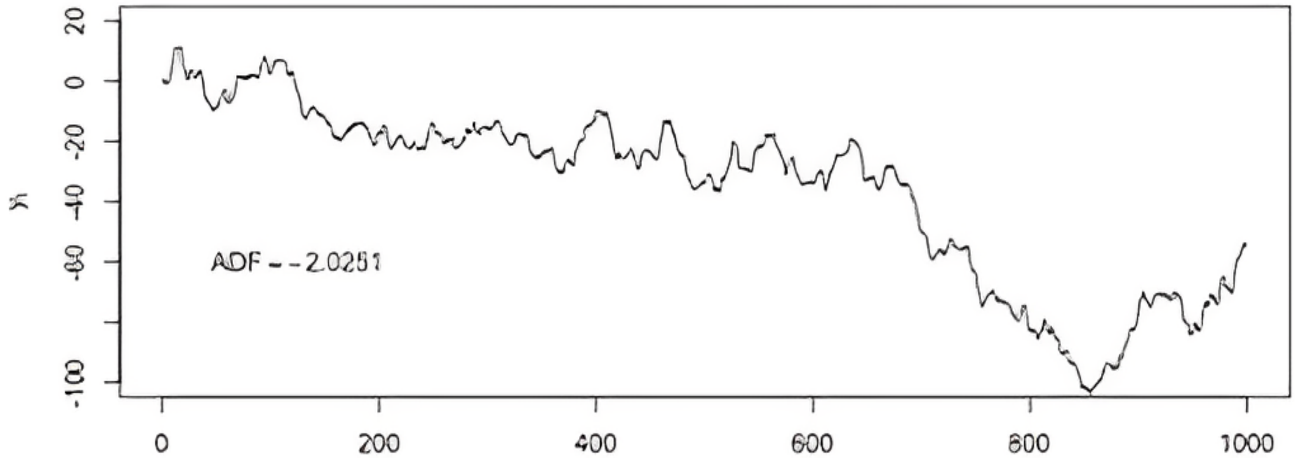
(a) To do so, we **plotted the price pair ratio over time** (price of asset 1/ price of asset 2). Shown below is an example of a stationary and a non-stationary time series. The ratio line graph should resemble the Exhibit 2, showing its mean does not change over time, ensuring their price relationship regresses to the mean. If the ratio resembled Exhibit 3, a pairs trading strategy would not be feasible.

Exhibit 2: Stationary Time Series



Source: towardsdatascience.com

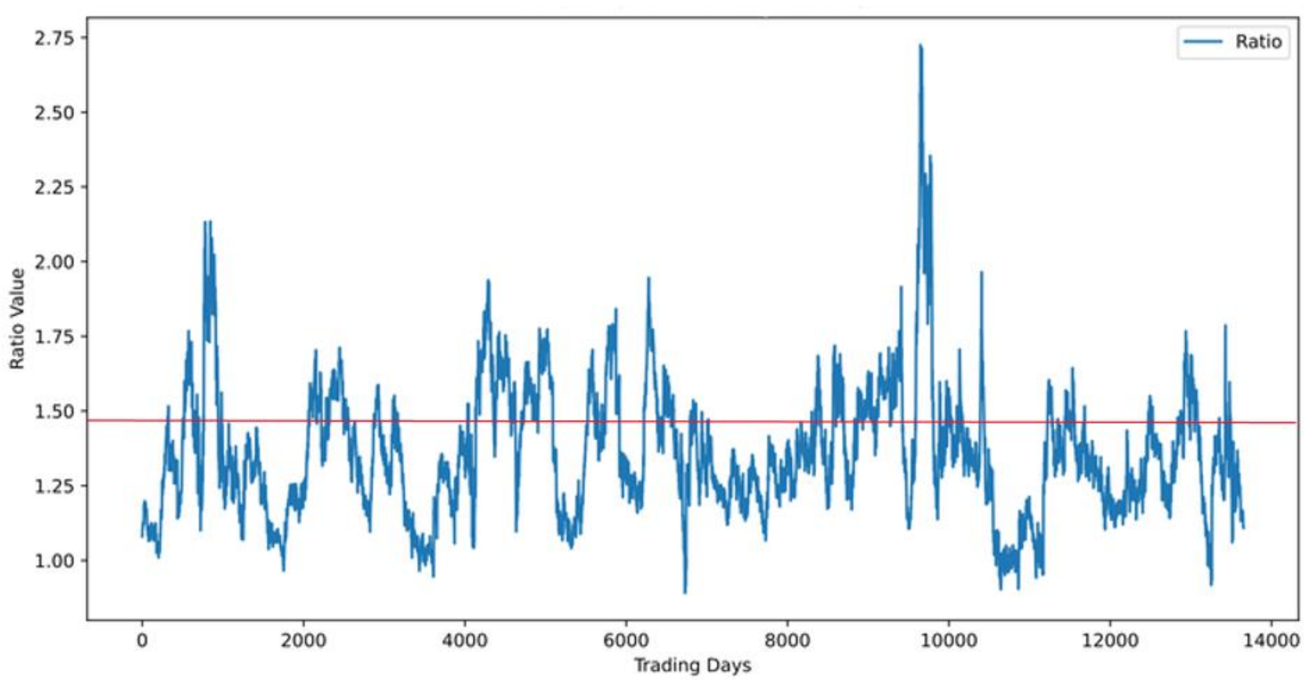
Exhibit 3: Non-Stationary Time Series



Source: towardsdatascience.com

Using wheat and corn, we plotted the following graph. As shown, the red line representing the mean is centred throughout the time period.

Exhibit 4: Ratio of Wheat/Corn (since 1974)



Source: Federalreserve.gov

(b) Conduct the **Augmented Dickey-Fuller (ADF) test**. The ADF tests to see if a unit root is present in the data set. Essentially, if there is a unit root present, the time series is non-stationary. If not, the time series is stationary. Though tedious to calculate manually, you can use the Python function "adfuller()" from the *statsmodels* library. To implement this using wheat and corn, we do "adfuller(ratio)," where ratio = wheat/corn. The adfuller function outputs a "Test Statistic" and a "p-value." In statistics, a p-value of less than 0.05 is used as a general threshold for significance. Therefore, if the output's p-value is less than 0.05, the time series is considered stationary. In the wheat-corn example the test's p-value is less than 0.05, confirming that its time series is stationary.

(3) Check if the two assets are cointegrated using the Python function "coint()" from the *statsmodel* library. To implement this function, we do "coint(wheat, corn)," where wheat and corn are data sets with their respective historical prices. Then, prompt Python to print the p-value – if it is less than 0.05, the pair is cointegrated.

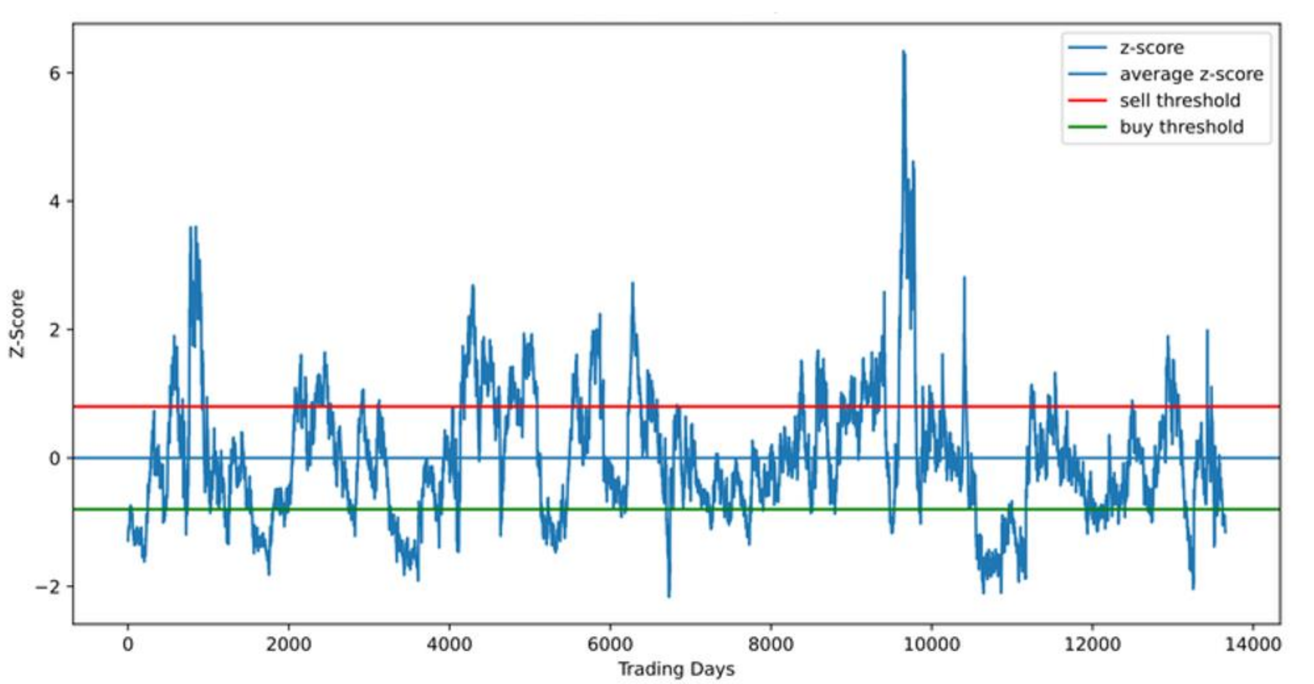
Implementing the Pair Trading Strategy Using Corn and Wheat

Now that we have identified the relationship between wheat and corn futures prices as an effective trading pair on the basis of their cointegration, we can use this relationship to inform trades. To use the wheat-corn ratio to define the relationship, we must standardize the data using Z-scores. This is the number of standard deviations a data point is from the mean. It is calculated using the following formula:

$$z_i = \frac{x_i - \bar{x}}{s}$$

After plotting the last 50 years of Z-scores, we see that the ratio tends to revert to the mean. As such, we can denote a threshold of deviance as our trading signal, where we enter into a trade to capitalize on the expected reversion. We chose to set our trading signals at 0.8 standard deviations above and below the mean. This effectively enters a trade whenever the daily ratio is in the upper or lower 9% of historical ratios, expecting a reversion to the mean. This can be seen in the Exhibit 5.

Exhibit 5: Z-Scores of Wheat/Corn (since 1974)



Source: Federalreserve.gov

Put simply, whenever the ratio of Wheat to Corn (expressed as a z-score) is 0.8 or more standard deviations above the mean, we buy corn and sell wheat, as we expect the ratio to fall back to the mean. This suggests that the price of corn should rise and the price of wheat should fall. Conversely, when the ratio is 0.8 or more standard deviations below the mean, we buy wheat and sell corn, as we expect the opposite to occur.

We then made some other key assumptions about when to close trades and how much of the portfolio value to use in daily trades. We settled on a trade exit boundary of 0.3 standard deviations above or below the mean and a maximum trade of 70% of the portfolio value. We were then able to apply our pairs trade to the market.

Historical Performance of the Wheat-Corn Trading Model

Looking at data since 1993, we can see that the Wheat-Corn pair trading model performs very well. Applying a simple backtest, where a long-short position is entered daily based on wheat and corn's relative prices, an annual growth rate of 12.45% is realized over an approximately 20-year horizon. Assuming no leverage or trading costs, this grows a $100,000 investment in 1993 into $538,589 today shown in Exhibit 6.

Exhibit 6: Wheat/Corn Pair vs. S&P500 (since 1993)

Source: Federalreserve.gov

Comparing these returns to our benchmark, the S&P500, which yielded an annual return of 9.14% over the same time horizon, our pairs trade strategy provides relatively attractive returns. Over the approximately 20-year time horizon, the wheat-corn pairs trade provides 3.31% of incremental annual returns or $151,366 of incremental earnings with our initial $100,000 portfolio.

Additionally, we are not exposed to directional risk because of the aforementioned market-neutral nature of this trading strategy. This results in even more attractive risk-adjusted returns. The standard deviation of our pairs trading strategy is around 1.02, while the standard deviation of the S&P500 is significantly higher at 1.09. This means that the S&P500 experiences more volatility and is riskier to hold.

Overall, this effectively demonstrates the power of cointegration in providing market returns. However, in reality, there are some key risks to consider that may impact the trading strategy.

Key Risks and Other Considerations

One consideration of risk is the impact of rolling futures contracts. Within the backtesting process, we did not consider the risk that we might hold a future past its maturity, therefore, it would be important if applied in real markets to take this into consideration. Furthermore, rolling futures could impact your returns.

Another consideration that would impact the returns of the model would be trading costs. Most retail investors incur costs of around $10 to execute a trade. Our trading model actively enters and exits positions, which would be costly at scale. At a corporate level, these costs would be negligible through negotiated trading costs. However, it would be difficult for a standalone investor to execute this strategy. Additionally, there is a cost associated with shorting a stock which entails borrowing a stock from a broker and selling it in the open market. The trader would have to pay borrowing fees which our model does not incorporate.

When trading pairs, your thesis is that the pair's prices will always revert to the mean. With this consideration, the largest risk is that prices diverge for an extended period of time. To mitigate the risk of huge losses, investors should set a stop loss which matches their comfort level and factors in expected spread.