Explaining Mean Reversion using Z-scores

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Mean Reversion within trading refers to the financial theory that asset prices will eventually return to their historical average, which allows investors to access a "guide" in making decisions based on significant deviations from this mean. When an asset's current market price is less than its average past price that we are looking at, you would take a long-position and vice versa.

This document will introduce the math behind reversion, and walk through an example of how Mean Reversion is used specifically in the development of this strategy:

Given the core idea that if a stock's price deviates far enough from its recent average, it will tend to "revert" back to that average. To quantify "how far" its deviated, we can compute a Z-score:

$$Z_t = \frac{P_t - \mu_t}{\sigma_t}$$

Where:

- Z_t refers to the z-score
- P_t refers to the price of the asset at time t
- μ_t refers to the rolling mean over N days (N refers to the "rolling window")
- σ_t refers to the rolling standard deviation over N days

Based on these z-scores that are continually generated over time, you can set a Z-score "threshold' that allows you to make long/short decisions:

- Go **long** if $Z_t < -Z_{threshold}$ as the price is excessively below the recent average
- Go **short** if $Z_t > Z_{threshold}$ as the price is excessively higher than the recent average

Example of mean-reversion applied on Asset "X"

Assume we have the following data:

Day	Closing Price of Asset "X"
1	100
2	101
3	102
4	101
5	100
6	98
7	97
8	99
9	100
10	102
11	103
12	101
13	100
14	99
15	98

Start by setting your independent variables:

- $Rolling\ Window\ (N)\ =\ 5\ days$
- $Z_{threshold}\ =\ 1.0$

Given the rolling window is 5 days, we can start to calculate the rolling mean and rolling standard deviation from day 6.

Calculate the mean for the last 5 prices (Days 2-6) = [101, 102, 101, 100, 98]

$$\mu_t = \frac{(101+102+101+100+98)}{5} = 100.4$$

Calculate the standard deviation for the last 5 prices:

Price	Deviation from the mean ($x - \mu_t$)	Deviation squared
101	$101 - 100.4 = 0.6$	0.36
102	$102 - 100.4 = 1.6$	2.56
101	$101 - 100.4 = 0.6$	0.36
100	$100 - 100.4 = -0.4$	0.16
98	$98 - 100.4 = -2.4$	5.76

$$Variance = \frac{(0.36+2.56+0.36+0.16+5.76)}{4} = 2.3$$

$$\sigma_t = \sqrt{2.3} = 1.52$$

$$Z_t = \frac{98-100.4}{1.52} = -1.58$$

Given that on day 6, we have -1.58 < -1.0, the algorithm suggests a long position to be taken on Asset X. Following the same steps for day 7, you would get a z-score of -1.41, so you remain long, and then on day 8, you would get a Z-score of 0.10, which indicates that you can exit your position.