Math Behind Popular Trading Indicators

All the math you need in the stock market you get in the fourth grade.

– Peter Lynch –

PRIME BEHOOF

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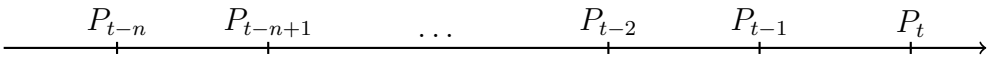
Abstract

Need to update.

DISCLAIMERS

In the discussion below, I will adopt the following conventions:

- Price data points may correspond to one of the following values:
  - O: Open
  - H: High
  - L: Low
  - C: Close
- Unless explicitly specified, P will serve as a placeholder for any of these price data points.
- Let P represent a price value. The observed price at time t is denoted as P_t, the price of the previous candle as P_{t-1}, and the price of the next candle as P_{t+1}.
- If not explicity specified, standard lookback period will have length of n.



Now that we have clarified the conventions of notation and indexing system, let us proceed with the discussion of indicators.

TREND INDICATORS

Definition. ***Simple Moving Average - SMA***
Tool in financial analysis that computes the arithmetic mean of a security's price over a predetermined number of periods. By averaging past prices, the SMA smooths out price fluctuations, aiding in the identification of prevailing market trends.

$$SMA_t(n) \;=\; \sum_{k=0}^{n-1} P_{t-k}$$

Definition. ***Exponential Moving Average - EMA***
Weighted moving average that places greater importance on recent price data. The EMA is calculated by applying a smoothing factor to the previous period's EMA and the current period's price.

$$EMA_t(n) \;=\; \alpha \cdot P_t \;+\; (1-\alpha) \cdot EMA_{t-1}(n)$$

It offers a more responsive average, reflecting current market trends more accurately.

$$EMA_t \;=\; P_t \cdot (\tfrac{\lambda}{n+1}) \;+\; EMA_{t-1} \cdot (1 - \tfrac{\lambda}{n+1}), \quad \text{s.t. } \lambda \in (0,\, n+1)$$

For *smoothing factor* $\alpha \coloneqq \frac{\lambda}{1+n}$, which stays constant during calculation, the most common representation of *EMA* with look back period n at time t is:

$$EMA_t(n) \;=\; P_t \cdot \alpha \;+\; EMA_{t-1}(n-1) \cdot (1-\alpha), \quad \text{s.t. } \alpha \in (0,\, 1)$$

Alternative non-recursive methodology, utilizing a functional series:

$$EMA_t(n) = \alpha \cdot P_t + \sum_{k=1}^{n} (1-\alpha)^k \cdot \alpha \cdot P_{t-k}$$

Common settings:

- *Look back period*: Longer term; $n \in \{50, 200\}$, Shorter term; $n \in \{8, 20\}$
- *Smoothing constant*: $\lambda = 2$ (Determines the weighting of recent data points)
- *Price data point*: $P_t = C_t$ (Closing price serves as standard, because it reflects the final consensus of value for that period after all trading has been completed.)

Strengths:

- *Trend Identification*: If the price is above the EMA, it suggests an upward trend, indicating bullish market conditions. Conversely, if the price is below the EMA, it suggests a downward trend, indicating bearish conditions.
- *Smoothens Price Data*: Reduces market "noise" by smoothing out short-term fluctuations, offering a clearer view of the price trend.

Weaknesses:

- *Emphasizing Recent Price Action*: Overweighting recent dates creates a bias that leads to more false alarms.
- *Lagging Indicator*: Since they are based on past prices, they can lag behind the current market, potentially leading to delayed signals.