The adaptive moving average

Making a moving average responsive to volatility changes results in a dynamic, more accurate indicator.

BY CURRENCY TRADER STAFF

Moving averages smooth price data, simplifying the up and downs of a market into a more understandable line that highlights the trend. However, the smoothing process introduces lag: The longer a moving average's look-back period, the more the average trails behind changes in price direction. On the other hand, moving averages with short look-back periods respond more quickly to price changes but, because they reverse direction on minor price moves, they can lead to whipsaw losses.

A moving average length that was appropriate last week might be inappropriate next week as market conditions change. One potential solution to this problem is to use a moving average that adjusts to market volatility by lengthening when the market is moving sideways and trading in a choppy fashion (making it less responsive) and shortening when the market is trending (making it more responsive).

In his book *Smarter Trading* (McGraw-Hill, 1995), Perry Kaufman detailed a method for calculating an adaptive moving average that fit this role. To see how it works, the following examples compare it to a simple moving average (SMA). First, two SMAs with different look-back periods will be compared to highlight the attributes of each. In this case, price crossing the moving average is not important; rather, it is the direction of the moving average that identifies the trend.

FIGURE 1 — ADAPTIVE MOVING AVERAGE

The five-bar SMA (red) and 30-bar SMA (blue) turned up at point A. At the peak (point B), the five-bar SMA turned down while the 30-bar SMA kept rising. However, the five-bar SMA turned down two times before the peak.

Source: CQGNet (www.cqg.com)

Starting out simple

Figure 1 is a 45-minute bar chart of the euro/U.S. dollar pair (EUR/USD) with a five-bar SMA (red) and 30-bar SMA (blue).

Both moving averages turned up quickly in reaction to the dramatic rise at point A. The market advanced to point B and then turned down. Notice the longer 30-bar moving average continued to rise during the uptrend, but did not turn down following the peak point B. At the end of the chart the 30-bar SMA was still indicating the trend was up. By contrast, the five-bar SMA turned down almost immediately after the peak at point B — however, it also turned down twice before the actual peak in the market, which the 30-bar average did not.

Figure 2 shows the same prices with an adaptive moving average (AMA) added. The AMA adapts to market volatility and trend by switching to a shorter-term look-back period when the market is trending up or down and changing to a longer-term look-back period when the market begins to move sideways.

At point A, the AMA joined the five-bar SMA during the initial advance. Then when the market corrected to point B, the five-bar SMA turned down while the AMA stayed nearly flat and the 30-bar SMA continued to rise.

When the market began to advance again, all the moving averages climbed. At point C, the market pulled back and consolidated and the five-bar SMA turned down; the AMA and the 30-bar SMA, however, kept rising.

When the market peaked at point D, the five-bar SMA turned down, the AMA went flat, and the 30-bar SMA kept rising. At point E the market was trending lower. The AMA joined the five-bar SMA to the downside, but the 30-bar SMA was still reflecting an uptrend.

Figure 2 illustrates how the AMA responded as the market changed from trend to consolidation and back. Overall the AMA showed a tendency to stay with the trend better than either the five-bar SMA and the 30-bar SMA.

Let's look at how the AMA is constructed.

FIGURE 2 — ADAPTIVE MOVING AVERAGE

The green line is an adaptive moving average (AMA). During the uptrend that started at A, the AMA advanced like the two SMAs but it did not turn down at points B and C the way the five-bar SMA (red) did. Also, the AMA turned down at point E, although the 30-day SMA (blue) did not.

Source: CQGNet (www.cqg.com)

From exponential...

Kaufman designed the AMA to track the degree of noise in the trend. For example, if a market is advancing with very small countertrend moves, there is very little noise and you would want the moving average to closely track the trend, which would require a moving average with a short look-back period.

However, if the market is moving sideways and the closes are tending to simply reverse from one period to the next, the degree of noise is high and you would want a moving average with a longer look-back period to filter out this noise and avoid false signals. Kaufman's technique was to modify the exponential moving average (EMA) with an algorithm that would adjust the average's smoothing constant (SC) according to the ratio of market direction to volatility.

The formula for the EMA is:

$$EMA = SC * (close - EMA_{(-1)}) + EMA_{(-1)}$$

where:
SC = smoothing constant
close = close of the bar
$EMA_{(-1)}$ = previous bar's EMA reading

The smoothing constant is a value between 0 and 1 that determines the "length" of the EMA. (Typically, to begin calculating an EMA, you use the SMA value for the initial reading.) To convert an SMA look-back period into an EMA smoothing constant, the following formula can be used:

$$SC = 2/(n+1)$$

Where n is the look-back period in an SMA.

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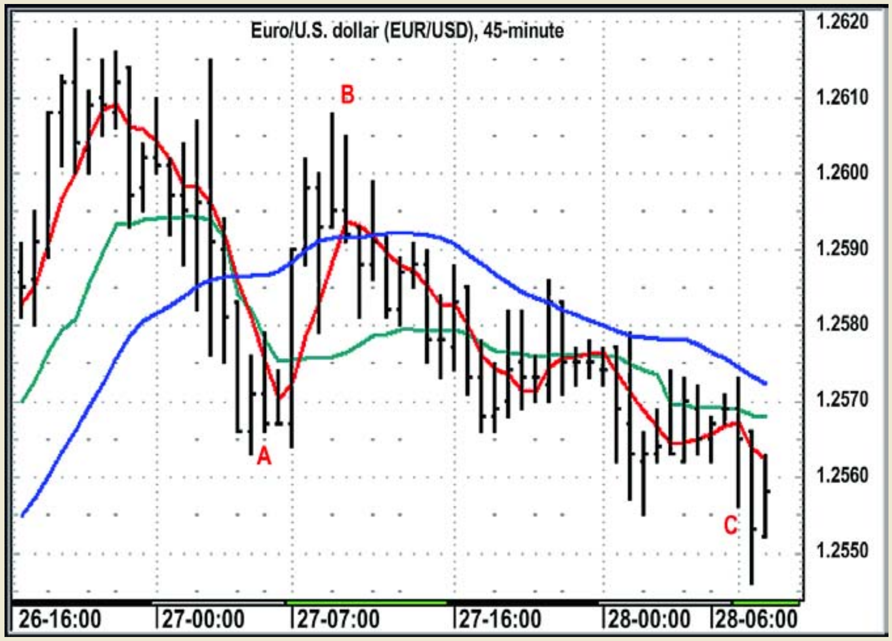
For example, a 10-period SMA equates to an EMA with a smoothing constant of 0.1818 (SC = 2/[10+1]).

One difference between the EMA and the SMA is the EMA calculation is the difference between the close and the EMA. Therefore, if the close is above the EMA, even for the first time, the difference is positive and the EMA will turn up. Similarly, if the close is below the EMA, even for the first time, the difference is negative and the EMA will turn down.

An SMA does not necessarily change direction because of this relationship, because the close is just one of many used in the average calculation. For a 10-period SMA, for example, the current close is only one-tenth of the 10 closes used to calculate the indicator. As a result, the SMA is not as responsive to quick price changes. The EMA is better suited to deal with these attributes of the market.

FIGURE 3 — RESPONSIVE, BUT NOT TOO RESPONSIVE

During the decline to point C the AMA (green) closely followed the market's swings, but not as jaggedly as the five-day SMA. The AMA went flat during sideways periods.



Source: CQGNet (www.cqg.com)

...to adaptive

The AMA builds on the EMA by making it responsive to trend and volatility. The formula is:

$$AMA = C * (close_t - AMA_{(t-1)}) + AMA_{(t-1)}$$

The difference between the AMA and EMA calculations is the adaptive aspect of the smoothing constant, which is designated in the formula by the letter "C." There are a few steps involved to arriving at C. The first is calculating the efficiency ratio (ER), which is the ratio of price direction to price volatility.

1. Direction = $close_t$ - $close_{t-n}$

where:
$close_t$ = current close
$close_{t-n}$ = close *n* bars ago.

2. Volatility = sum (absolute value ($close_t$ – $close_{(t-1)}$),n)
(This formula sums the absolute values of the one-bar close-to-close differences over *n* bars. Kaufman suggested *n* equal 10.)

For example, if a currency closed up 10 bars in a row, the ER would equal 1 because the direction and the volatility would be equal. If the market moved up and down to close unchanged after 10 bars, the ER would equal zero. Therefore, the more the market is trending, the higher the ER, and the more the market moves sideways, the smaller the ER value.

The ratio is used as a scaling constant based on the degree of trend between 0 and 1, but not trend in reference to up or down. Because direction could be a negative number, we will take the absolute value of direction/volatility to not have the ratio scale between -1 and 1.

The next step is to establish boundaries for the length of the AMA — i.e., the shortest (fast) and longest (slow) look-back periods it will reflect (since, technically, these could be unlimited). The following formula is used to create a range for the average's smoothing constant (SSC):

$$SSC = ER * (Fast_{SC} – Slow_{SC}) + Slow_{SC}$$

where:
ER = efficiency ratio
$Fast_{SC}$ = fast EMA smoothing constant
$Slow_{SC}$ = slow EMA smoothing constant

Recall the EMA smoothing constant uses the formula 2/(n+1) to approximate the number of bars in an *n*-bar SMA. Kaufman suggested the AMA range from a two-bar look-back period (fast) to a 30-bar look-back period (slow). In this case, the resulting smoothing constants would be:

Fast = 2/(2 + 1) = 0.6667
Slow = 2/(30 + 1) = 0.0645

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Therefore, $SSC = ER * (0.6667 - 0.0645) + 0.0645$.

If the market is trending, then the ER will be near 1 and the SSC will be weighted toward the fast smoothing constant. If the market is moving sideways, then the ER will be near 0 and the SSC will be weighted toward the slow smoothing constant.

Finally, Kaufman noted if the market was trading sideways, which would push the AMA to behave like a 30-day EMA, the AMA would still edge up and down. Squaring the smoothing constant reduces this effect. Therefore:

$$C = SSC^2$$

and finally,

$$AMA = C * (close_t - AMA_{(t-1)}) + AMA_{(t-1)}$$

Now that the math is finished, let's look at more examples using the AMA in the Euro/U.S. dollar pair.

Figure 3 continues the price action from Figure 2. The market trended down to point A and then rallied to point B. The 30-bar SMA continued to rise and did not turn down until well after the second, lower peak at B. The market then stair-stepped its way down to point C. The 30-bar SMA trended lower during this period while the five-bar SMA zig-zagged up and down with each price swing. The AMA followed the market's shorter-term swings as price moved gradually lower, and it also went flat during sideways price action (which the five-day SMA did not do). Overall, the AMA was a better smoothed representation of the market.

Figure 4 jumps ahead in time. The market rallied dramatically, and again the AMA moved horizontally when EUR/USD moved sideways around point A. The five-bar SMA began to turn slightly lower.

Flexibility and responsiveness

The adaptive moving average's strength is its ability to respond to changing market conditions, which is a problem for studies that use fixed look-back periods.

Using a fixed look-back period is like trying to fit the market to a template. Because the market is always changing, static approaches are likely to have limited success. Using adaptive studies is a potential way to improve results. Also, the AMA might be appropriate for smoothing other indicators.

Related reading

"Weighted and exponential moving averages"
Currency Trader, January 2005.

A detailed introduction to weighted and exponential moving averages that includes performance comparisons to the simple moving average.

"Measuring trend momentum" by Tushar Chande
Active Trader, June 2001.

Most technical analysis indicators monitor either price direction or price momentum. Here's an indicator that does both, changing its behavior with the dynamics of the market.

"Thom Hartle Trading Strategy and Analysis collection, Vol. 1: 2001-2004"

In this collection of 15 *Active Trader* articles from 2001 to 2004, trader, analyst, and contributing editor Thom Hartle tackles various aspects of strategy, analysis, and trade execution. (This collection is available for a 30-percent discount through the *Active Trader* store.)

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FIGURE 4 — TRACKING THE TREND

The AMA tracked the trend upward, but went flat at point A when the market moved sideways. It turned up again quickly when the uptrend resumed.

Source: CQGNet (www.cqg.com)