Building A Variable-Length Moving Average

by George R. Arrington, Ph.D.

Of the tools in the technician's arsenal, the moving average is one of the most popular. It is used to eliminate minor fluctuations in prices, filter data noise and identify any underlying trend. Ideally, a moving average is sensitive enough to signal when a new trend has begun, yet able to ignore short-term random price movements at the same time.

As long as the underlying trend continues, longer averages work well, but shorter averages do a better job of indicating *changes* in trends. As a result, many technicians use two or more averages to identify emerging trends and to generate buy/sell signals.

In a variable-length moving average (VLMA), the length of the average depends on the relative magnitude of recent price changes. If recent price changes are "unusually" large, the length of the moving average is shortened and the average automatically becomes more sensitive to emerging trends. Conversely, if price changes are stable within a given narrow range, the length of the moving average automatically increases.

If we observe price changes that are significantly different from the mean, this may be a signal that a new trend has begun.

If the market is not trending, prices will tend to fluctuate around the arithmetic mean of the data series. A common measure of the degree of dispersion about the mean is the standard deviation. The likelihood of actually observing unusually high or low prices decreases as prices get farther away from the mean (that is, more standard deviations).

Similarly, the change in price will tend to fluctuate around the arithmetic mean of previous changes in

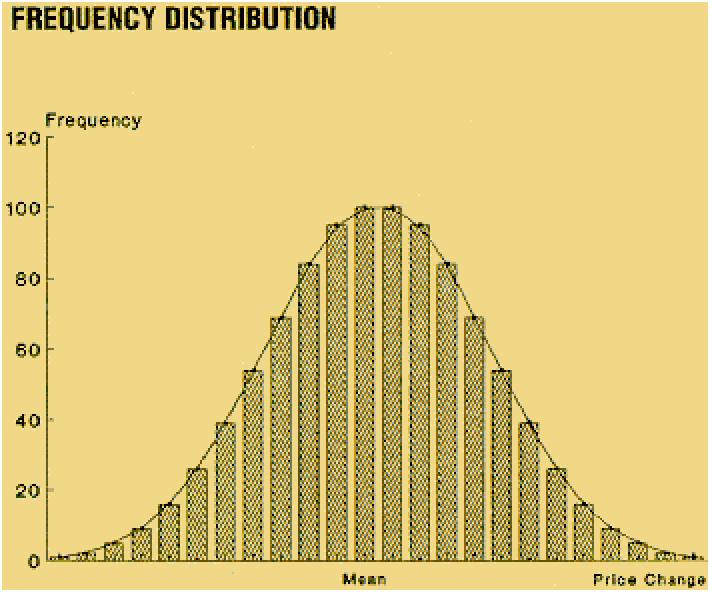

FIGURE 1: *Price changes near the mean are mere frequent than those far from the mean.*

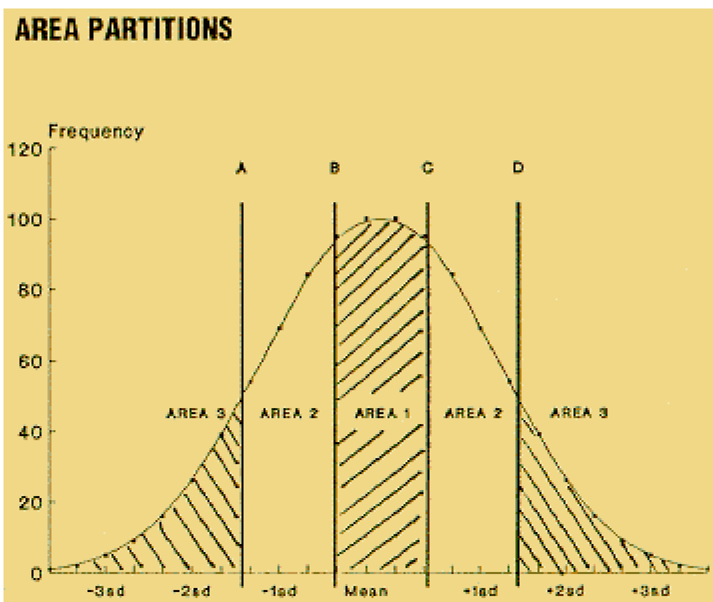

FIGURE 2: *Partition limits A, B, C and D are set by the number of standard deviations from the mean.*

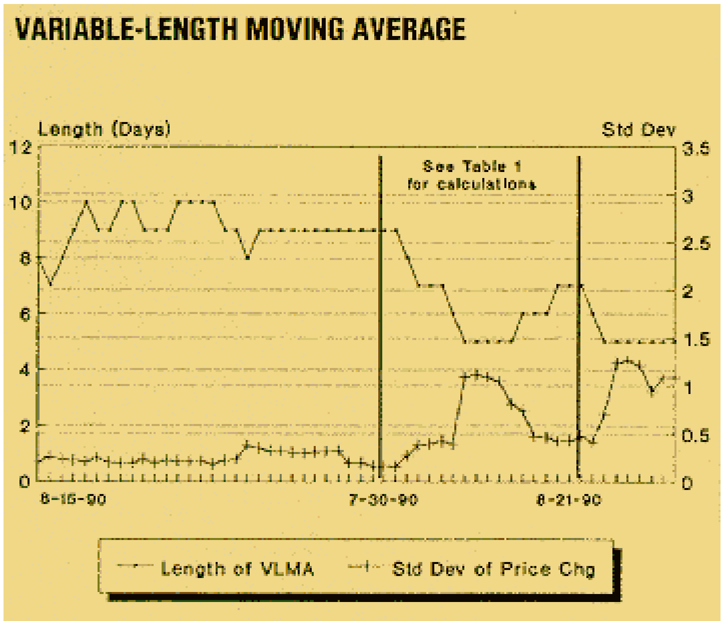

FIGURE 3: *Length of the moving average decreases as prices become more volatile.*

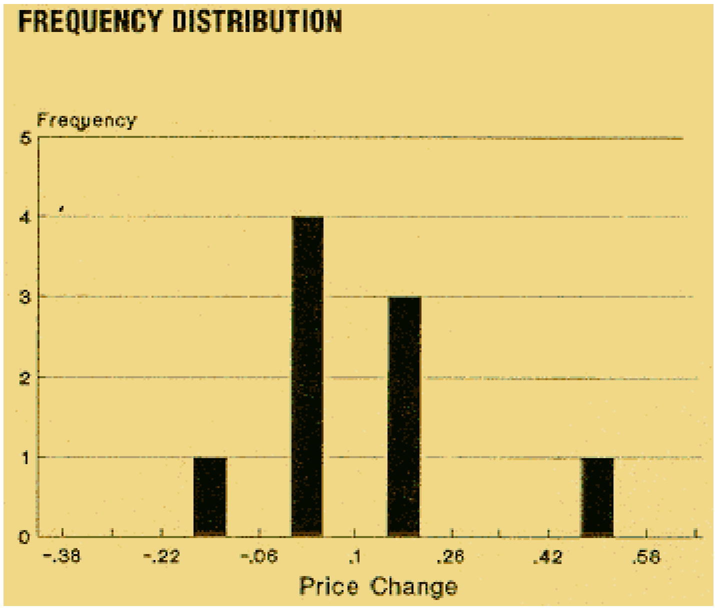

FIGURE 4: *Frequency distribution of previous nine observations viewed on 7/30/90.*

price. But if the market is not trending, the mean price change will be zero. If the market is trending, price changes near the mean will be more frequent, but the mean will be non-zero. For example, if prices tend to increase at the rate of 10 cents per day (an upward trend), the mean change would be +10 cents. The familiar bell curve in Figure 1 depicts the relative frequency of historical price changes in large samples.

If we observe price changes that are significantly different from the mean and, therefore, are very unlikely to occur, this may be a signal that a new trend has begun. If we do observe unusual price changes, most technicians would want to reduce the length of the moving average in question to make it more sensitive to a potential emerging trend.

Conceptually, the length-adjustment process begins by defining "normal" price changes. We construct a frequency distribution of price changes similar to Figure 1. The midpoint of the x-axis is the arithmetic mean of the price changes, and the x-axis typically extends plus or minus three standard deviations from the mean. We then partition the frequency distribution into three action "areas," where the partition boundary limits are based on user-specified distances from the mean (Figure 2)

We expect that most price changes will occur in Areas 1 and 2, which are closest to the mean. If we observe a price change in Area 3 (farthest from the mean and therefore an "outliner"), we want to shorten the length of the moving average to increase its sensitivity. If we observe prices very close to the mean (Area 1), we want to lengthen the moving average (to reduce its sensitivity) in the belief that there is no new trend. If we observe prices in Area 2, we are less confident about emerging trends and will leave the length of the moving average unchanged.

Figure 5 illustrates the calculations for the variable-length moving average using mid-1990 prices for crude oil futures (see sidebar, "Building the Variable-Length Moving Average"). Figure 3 illustrates how the length of the moving average changes over time. Note that the length of the moving average has a range between five and 10 days (as specified), and that its length decreases as price changes become unusually large.

MAYBE, MAYBE NOT

In the real world, price changes may not be normally distributed about the mean in a nice bell curve, as suggested in Figure 1. Price changes may not even have a uni-modal distribution. But this is not a serious disadvantage, because the approach does not require a high level of statistical significance. Our goal is simply to identify price changes that seem "unusually" large relative to recent price changes and to trigger the length-adjustment process accordingly.

Figure 4 illustrates a typical frequency distribution of price changes in the real world. The x-axis takes the mean change (0.10) as the middle point and uses data ranges plus or minus one, two and three standard deviations (0.16) from the mean. There are nine observations, four below the mean and five above. Figure 6 illustrates the same data with a slight curve smoothing, and the partition boundaries are those calculated in Step 4 in the sidebar.

If only a few observations are used to calculate the mean and the standard deviation, the partition boundaries could be quite volatile over time, which may both be an advantage and a disadvantage. In addition, if few observations are used in the calculations, the mean and the standard deviation could

FIGURE 5

VARIABLE-LENGTH MOVING AVERAGE CALCULATIONS

Sample Data Using Crude Oil Futures (November 1990 Contract)

Parameter limits set at +/-0.25 and 1.75 standard deviations from the mean.

Date	Price	Price Change	Area	VLMA Length	Mean Price Change	Revised Std Dev	VLMA	Next Day's Parameter Limits A	B	C	D
900730	21.46	0.19	2	9	0.10	0.16	21.02	-0.19	0.06	0.14	0.39
900731	21.62	0.16	2	9	0.12	0.16	21.14	-0.16	0.08	0.16	0.40
900801	22.42	0.80	3	8	0.23	0.27	21.44	-0.25	0.16	0.29	0.70
900802	23.42	1.00	3	7	0.32	0.39	21.80	-0.36	0.22	0.41	0.99
900803	24.35	0.93	2	7	0.46	0.40	22.26	-0.23	0.36	0.56	1.16
900806	25.35	1.00	2	7	0.58	0.42	22.84	-0.16	0.47	0.68	1.31
900807	26.85	1.50	3	6	0.90	0.40	24.00	0.21	0.80	1.00	1.59
900808	25.28	-1.57	3	5	0.57	1.09	25.05	-1.34	0.30	0.84	2.48
900809	24.98	-0.30	2	5	0.31	1.11	25.36	-1.63	0.03	0.59	2.26
900810	25.61	0.63	2	5	0.25	1.08	25.61	-1.65	-0.02	0.52	2.15
900814	25.86	0.25	1	6	0.25	0.99	25.66	-1.48	0.00	0.50	1.98
900815	25.81	-0.05	2	6	0.08	0.93	25.73	-1.56	-0.16	0.31	1.71
900816	26.59	0.78	2	6	-0.04	0.78	25.69	-1.40	-0.24	0.15	1.31
900817	27.48	0.89	2	6	0.37	0.44	26.05	-0.40	0.26	0.48	1.13
900820	27.96	0.48	2	6	0.50	0.32	26.55	-0.06	0.42	0.58	1.06
900821	28.14	0.18	2	6	0.42	0.33	26.97	-0.16	0.34	0.50	1.00

FIGURE 5: *The above table illustrates the calculations for the variable-length moving average using mid-1990 prices for crude oil futures. Data for 8/13/90 was dropped due to the emergency closure of the exchange.*

AREA PARTITIONS

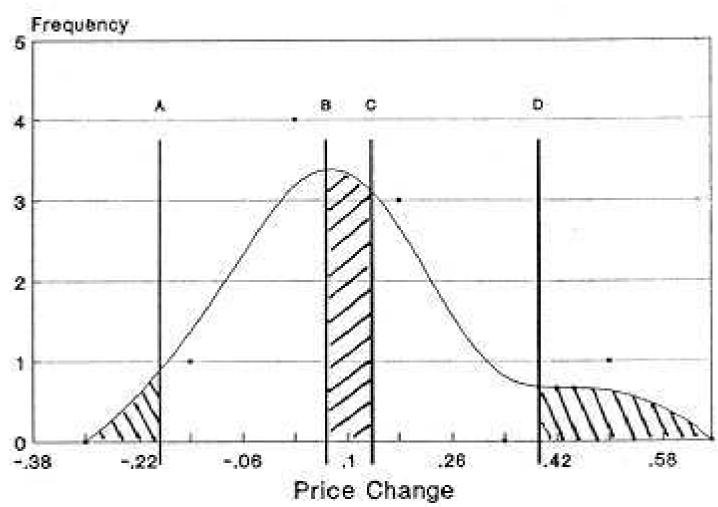

FIGURE 6: *Area partitions set on 7/30/90 based on previous nine observations.*

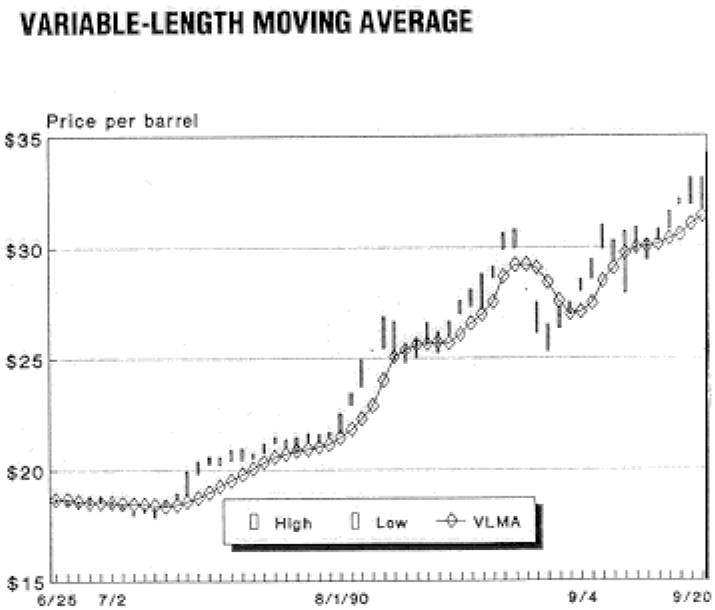

FIGURE 7: *Crude oil futures with a variable-length moving average (VLMA) plotted over it. Notice during early August the price of oil advanced sharply and the VLMA adjusted quickly.*

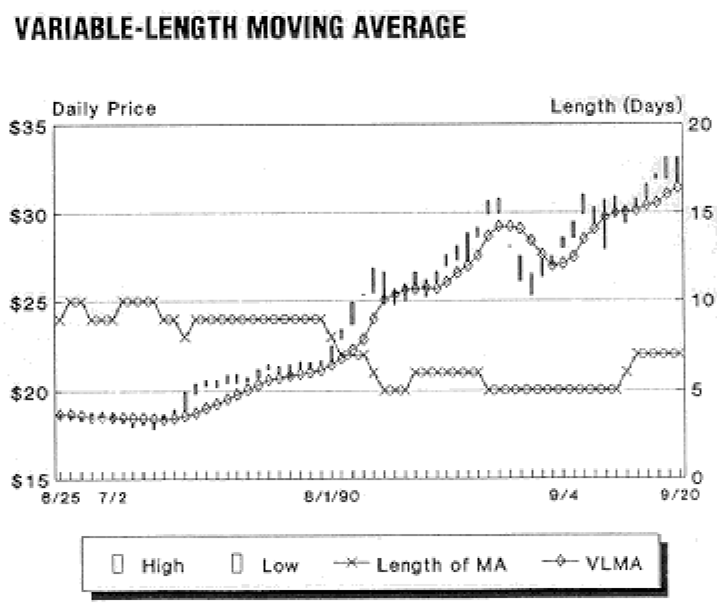

FIGURE 8: *When the magnitude of the daily price changes increases (lower chart), the length of the moving average (upper chart) decreases.*

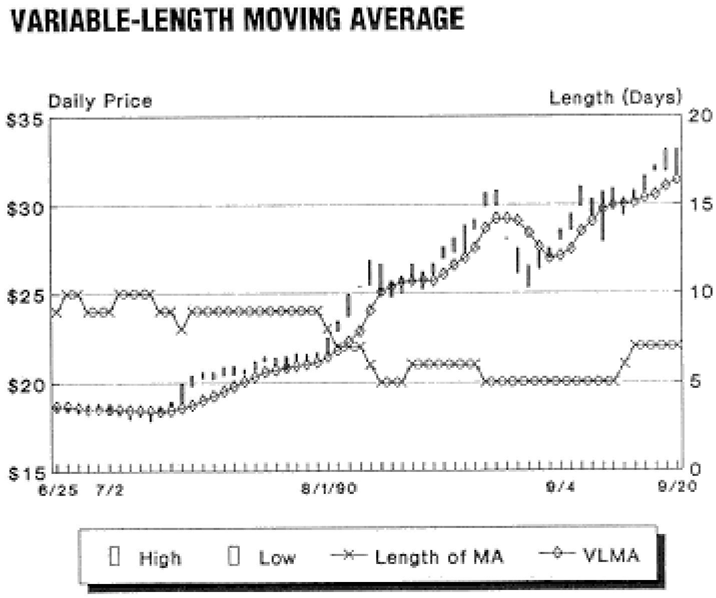

FIGURE 9: *Crude oil futures, a variable-length moving average plotted over it and the length of the average are displayed. As the price of crude oil accelerates, the length of the moving average drops and when the price stabilizes the average lengthens*

contain significant data noise, which would also be present in a similar fixed-length moving average.

The variable-length moving average is extremely flexible in design. The minimum and maximum acceptable lengths of the moving average are specified by the user. In addition, the sensitivity of the length-adjustment process is easily modified by making changes in the partition parameters (that is, number of standard deviations from the mean).

Moreover, the size of the increase or decrease in length (rate of length adjustments) can be specified by the user. In the example, we decreased the length of the moving average by one day when new prices were significantly higher or lower than the mean ($n_t = n_{t-1}-1$). This rate of adjustment can easily be doubled, tripled or otherwise specified by the user. For those who choose to do so, it is also possible to increase the length of the moving average when prices become volatile (for example, $n_t = n_{t-1}+1$).

The variable-length approach works well for simple and linear moving averages and can be adapted to triangular moving averages. The approach does not work well for exponential moving averages.

The variable-length moving average may be useful for traders, even with its limitations. This approach is advantageous primarily because the moving average automatically becomes shorter in length, and therefore more sensitive to emerging trends when price changes seem unusually large. Moreover, the downside risks seem small. If prices are stable but the moving average does not lengthen, we have a sensitive indicator in a stable market; in turn, if a new trend is emerging but the moving average does not shorten, then we have a fixed-length moving average. In short, the variable-length moving average offers something to gain, but little to lose.

George R. Arrington holds a doctorate in economics and finance. He works in New York City for the Federal Reserve System.

FURTHER READING

McGuinness, Charles J. [1990]. "How moving averages are computed, *Technical Analysis of* STOCKS & COMMODITIES, Volume 8: April.

Wonnacott, Thomas H., and Ronald J. Wonnacott [1990]. *Introductory Statistics for Business and Economics*, fourth edition, John Wiley & Sons.

BUILDING THE VARIABLE-LENGTH MOVING AVERAGE

The construction of the variable-length moving average is relatively straightforward:

Step 1. Establish the limits of acceptable lengths for the moving average. To illustrate, let's say that the moving average must be at least five days, but no more than 10 days. (These limits are easily programmed in most computer software using MIN and MAX functions.)

Step 2. Calculate the mean and the standard deviation of price changes for the first *n* observations. A large number of observations increases our degree of confidence in the mean and standard deviation but also increases the distortion due to time lags in the data. I recommend that initially, *n* be at least the number of observations in the maximum length of your moving average.

Step 3. Set the parameters for the partition of the frequency distribution. These parameters establish the sensitivity of the length-adjustment process because they are the trigger points to increase or decrease its length. If price changes are normally distributed, 68% of the observations are expected to fall within one standard deviation of the mean; 95% within two standard deviations; and 99.7% within three standard deviations.

For example, let us define Area 1 to be those price changes bounded by a line plus or minus 0.25 standard deviations from the mean; Area 2 to be those price changes bounded by Area I and a line plus or minus 1.75 standard deviations from the mean; and Area 3 to be those price changes that exceed more than plus or minus 1.75 standard deviations from the mean.

Step 4. Calculate the partition boundaries using Steps 2 and 3 above (see Article Figure 6). In our example,

partition boundary "A" = mean - (1.75 × std dev) = -0.19

partition boundary "B" = mean - (0.25 × std dev) = +0.06

partition boundary "C" = mean + (0.25)× std dev) = +0.14

partition boundary "D" = mean + (1.75 × std dev) = +0.39

Step 5. Establish the rate at which the length of the moving average will change. For our example, say, the length will decrease by one day each time a price is observed in Area 3 (outside of boundaries A or D) and will increase by one day each time a price is observed in Area 1 (between boundaries B and C). (The length of the moving average will not change if prices are observed in Area 2, or if the average is constrained by its specified minimum/maximum length.)

Step 6. At each subsequent time period, observe the price, calculate the amount of change since the last observation, determine which partition area it falls into and adjust the length of the moving average accordingly. Based on the new length, calculate the value of the moving average, average price change and the standard deviation.

Step 7. Recalculate the partition boundaries (A, B, C and D limits) to test for "normalcy" in the next time period. Repeat Step 6.