The Volatility-Based Envelopes (VBE): a Dynamic Adaptation to Fixed Width Moving Average Envelopes

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Abstract

This paper discusses the limitations of fixed-width envelopes and introduces a new method that addresses these limitations. The new method utilizes the concepts of standard deviation and correlation to produce a dynamic adaptation to the fixed-width envelopes. The paper also offers an example of a useful technique and some guidelines for applying the new method on price charts. The method will be referred to henceforth as the volatility-based envelopes (VBE).

Introduction

Fixed-Width Envelopes

Fixed-width envelopes (FWE) are two boundaries. Each is placed at a fixed percentage above and below a simple moving average (SMA) of the exact same duration. The primary aim of using the FWE is to contain the price action fluctuations and, hence, imply when prices have become over-extended in either direction. FWE are characterized by the same effects of lag and smoothness associated with their corresponding SMA.[1]

Unfortunately, due to the inherent lag effect caused by the FWE, prices would quite often move and remain outside the envelopes' boundaries for a notable period of time. Despite some featured techniques adapted for the FWE that would accommodate and sometimes even depend on these occurrences[2], the initial purpose to contain the price action is not satisfied.

Bryan J. Millard suggested that in order to represent the trend properly and highlight active and dominant cycles using SMAs and FWE respectively, the statistically-correct plot would be to shift it back from the most recent data point by half the span of the SMA duration. This technique is referred to as centering the moving average. The rationale behind this is that since the FWE are properly plotted (centered), the price action fluctuations will be contained within the envelope boundaries.[3]

To its credit, the centered FWE manages to contain a larger amount of price action. However, it still produces challenges. As a result of the centering procedure, the envelopes' values will terminate n-days prior to the most recent closing price, where n = (the SMA span – 1)/2. Moreover, the centered FWE are non-adaptive to the continuous volatility changes of the price action. Depending on the price volatility, this will frequently cause the price fluctuations to move and remain out of the envelope boundaries (during high volatility phases), or even not react with the envelopes at all (during low volatility phases).

Another attempt to address the FWE's lack of adaptability to price volatility was made in the 1980s by John Bollinger. Adopting the statistical concept of standard deviation to the field of technical analysis, Mr. Bollinger introduced the Bollinger Bands (B-Bands). The B-Bands are two bands set at two standard deviations above and below a SMA calculated off the price action. In principle, the B-Bands aim at utilizing the standard deviation concept in order to identify rare and unsustainable price excursions and coin them as overbought (OB) and oversold (OS) conditions.[4]

The B-Bands manage to contain more price action within its boundaries, especially during trendless phases in price action where identifying OB and OS conditions using the B-Bands become quite valuable. However, there are certain price conditions on the near to short term horizon as explained by Bollinger, in which prices tend to breakout and remain outside either one of the 2-standard deviation bands for some considerable time. At other times, even if the price excursion was relatively brief, the price gain (or loss) would be considerable. These conditions will generally occur during trending phases and following periods of low volatility in price action and are dubbed by John Bollinger as volatility breakouts. The technique proposed by Bollinger relies on these volatility breakouts in order to initiate a position in the direction (favor) of the price breakout.[5] Though very successful when properly identified in the price action, these volatility breakouts seem to argue against the general notion that price excursions occurring beyond two standard deviations are deemed rare and unsustainable.

Sustainable price breakouts from the B-Bands are primarily attributed to the difference in tendency and behavior of price action during trending vs. non-trending phases. During non-trending phases, price action visually exhibits a characteristic of oscillatory/mean reversion motion. During these events, price excursions are rare and unsustainable. While during trending phases, this feature becomes less dominant and further diminishes on the near to short term horizon as the trending phase grows stronger. This is attributed to the lagging effect of the SMA which visually appears clearer during trending phases. As you would recall from the B-bands calculation, the 2-standard deviations calculated are added to and subtracted from that lagging SMA to construct the upper and lower bands respectively. Hence, the B-Bands do not fully resolve the lag effect of the SMA.

Although the B-Bands succeed in achieving adaptability, the upper and lower bands do not inherit the smoothness of their corresponding SMA as they are relatively more erratic in motion than the latter. This does not allow them to be as suitable as centered FWE when attempting to highlight active and dominant cycles in the price action.

Introducing the adaptive Volatility-Based Envelopes (VBE)

Using volatility to achieve adaptability

To address the drawback associated with the lack of adaptability of the FWE, we use the measure of standard deviation. Unlike B-Bands' calculation, we use the *historical* percent changes of price returns of a security instead of the historical price action of that security.

Practitioners in the field of statistics and financial engineering have hypothesized over the past decades that the percent changes in a stock price (or security) are normally distributed on the short term.[6] Hence, we use this hypothesis as the basis for the VBE calculation methodology; once the standard deviation calculations were complete, the outcome was added to and subtracted from a SMA of the percent changes of price returns. Then, the outcome was added to/and subtracted from today's (the most recent) closing value on a percentage basis and not over a lagged SMA of the price action. As a result, a dynamic adaptation to the envelopes' boundaries can be achieved, while avoiding the inherent lag effect of the MA of prices. The following steps will explain the VBE's calculation methodology:

Step 1: Calculate the standard deviation (Đ) of the percent changes (or logarithm) of the daily historical price returns (Đ).

The standard deviation is calculated over duration of 21 daily percent change values.

Step 2: Calculate the values of the raw Volatility-Based Envelopes (raw VBE).

Example:
Assuming the following data:

The last given price (S) of the NASDAQ Index is: 2,190.

The simple average (µ) of the percent change is: 0.07%.

The (Đ) of the daily percent change is: 1.00%.

Therefore, we can expect that approximately 95.4% of the daily percent change movements to be maintained within the percentage range of:

0.07% – (1.00% * 2) = – 1.93% (at 2 standard deviation).

0.07% + (1.00% * 2) = + 2.07% (at 2 standard deviation).

To translate those values into a price range for most recent closing value of the index, or in other words, the raw VBE, then:

2,190 * (1 – 1.93%) = 2,147.7 (lower raw envelope at 2 standard deviation).

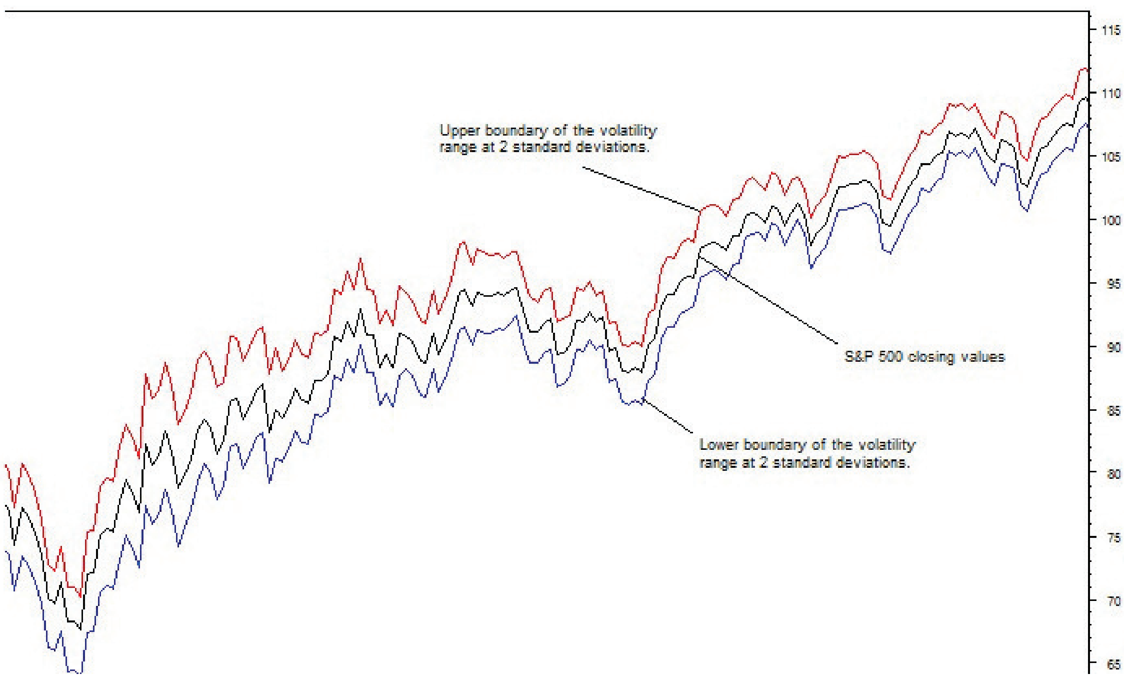
2,190 * (1 + 2.07%) = 2,235.3 (upper raw envelope at 2 standard deviation).

Plotting the raw VBE over the price chart

Using the same calculation method presented above, we can regress and calculate a daily range for all previous historical closing values of the S&P 500 Index and then plot the outcome as shown in Figure 1.

Figure 1 depicts the S&P 500 Index line chart with daily closing values and the raw upper and lower boundaries of the calculated raw VBE. As observed, there exists a strong (almost identical) similarity between the closing values (line chart) of the S&P500 Index and both the upper (red) and lower (blue)

Figure 1: S&P 500 Index – Line chart – Daily closing values – Normal scale



boundaries of the calculated raw VBE. Having said that, both boundaries are choppy (raw), just as the index movement. Thus, a need to smooth out these boundaries is required.

Step 3: Smooth the raw VBE using weighted moving averages

To smooth out the raw VBE, we will use two centered weighted moving averages (CWMA) for both envelopes of the raw VBE. Using CWMAs instead of CSMAs mathematically results in a reduction of lag-time by approximately 40%. This means that instead of lagging the most recent price by (span - 1)/2 as with the case of the SMA, the lag is reduced to be approximately equivalent (span - 1)/3.34. 7

In real life observations, and mainly due to the non-linear nature of price action, the lag tends to be reduced down to equate (span - 1)/4 instead of (span - 1)/3.34. This means that— in real life price action—the lag of the 21-period WMA tends to approximate to 5-periods (and in some cases, 4-periods), but not 6-periods.

Table 1 features CWMAs of different spans and the amount of lag attained by each.

CWMA	lag
span	**periodic**
21.00	5.00
17.00	4.00
13.00	3.00
9.00	2.00
5.00	1.00
2.00	0.25

The smoothed Volatility-Based Envelopes (VBE)

Now let us make a visual comparison between the smoothed VBE vs. both the centered FWE and the B-Bands. This comparison is shown in Figure 2.

Figure 2 depicts the advantages of the VBE over the centered FWE and the B-Bands. The centered FWE failed to mechanically adapt to volatility changes during the movements of the S&P 500 Index, while the VBE was able to contract and expand in accordance to the decrease and increase in volatility of the S&P 500 Index movements. Meanwhile, unlike the B-Bands, the VBE maintains its boundary smoothness, relative to the corresponding moving average of the price action. And finally, the VBE managed to contain more price action than the B-Bands. The VBE is constructed with the primary advantage of its ability to identify overbought (OB) and oversold (OS) conditions in the price chart regardless of the trend status.

Step 4: Forecast the VBE's missing data points using correlation

To forecast the missing data points of the VBE, we use both the CWMA feature previously presented in Table 1, as well as the statistical concept of correlation (Đ). The aim is to use the correlation between the values of other CWMAs of lesser span (independent variables) with the 21-period CWMA or smoothed VBE (dependant variable) to forecast the missing data points of that smoothed VBE. It's worth mentioning that all CWMAs of lesser span are selected with reference to the amount of their missing data points.

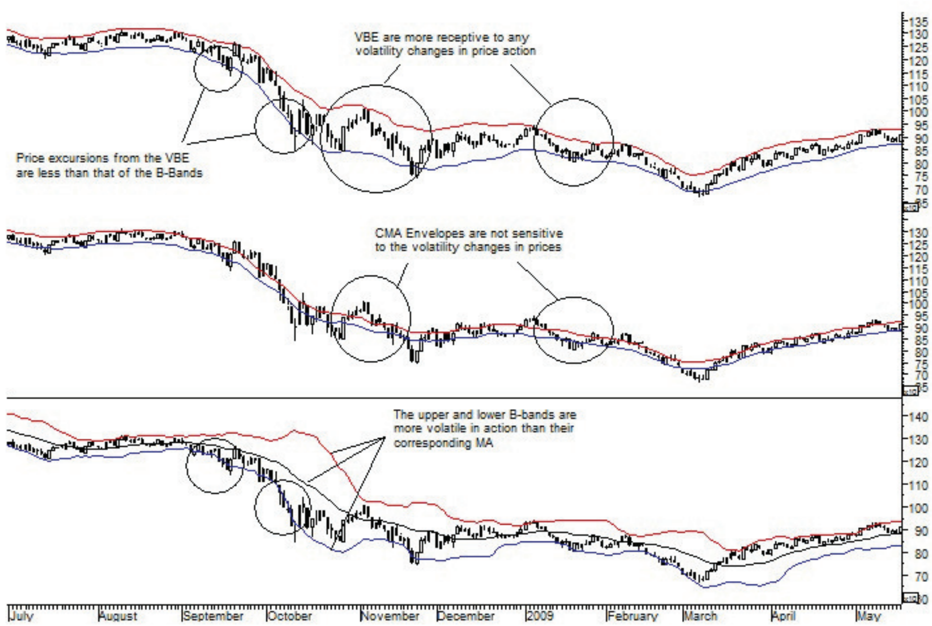
Example:

Using the daily values of the S&P 500 Index, we calculate (Đ) matrix of the daily percentage change of a 21-day CWMA vs. the daily percentage change of a 17-day, 13-day, 9-day, 5-day and a 2-day CWMA over the most recent 63-actual data points as shown in table 2 (below).

Table 2: S&P 500 Index – correlation coefficients (Đ) of 21, 17, 13, 9, 5 and 2-day % change of CWMAs

	21-CWMA	21-CWMA	21-CWMA	21-CWMA	21-CWMA	21-CWMA
21-CWMA	1	0.88	0.76	0.67	0.56	0.31

Figure 2: S&P 500 Index – Candlestick chart – Daily closing values – Normal scale



Using (Đ) to forecast the missing data points of the 21-day CWMA

As previously explained, the 21-CWMA has 5 missing data points, while the 17-CWMA has only 4. This means that we can use the last given value of the 17-CWMA and the (Đ) value of both variables from table 2 to forecast the 1st missing value of the 21-CWMA as follows:

Example:

Referring to the data used in calculation, the last calculated percent change of the 17-CWMA was 0.80%. The last calculated value of the 21-CWMA was 1,122.30. The calculated (Đ) value was 0.88 or 88% (from Table 2).

Then, the forecast of the 1st missing value of the 21-CWMA would be:

1,122.40 * [1 + (0.80% * 0.88%)] = 1,130.38.

This value is placed shifted back from the most recent closing value of the index by 4-days (since the 17-CWMA has only 4 missing data points).

Moving onwards, the following table (Table 3) shows the last calculated percent changes of the 13, 9, 5 and 2 CWMAs as well as the forecast of the 2nd, 3rd, 4th and 5th (i.e. last) missing values of the 21-CWMA:

Table 3

13-CWMA	9-CWMA	5-CWMA	2-CWMA
0.86%	1.07%	0.93%	0.80%
1,137.80	**1,145.99**	**1,151.90**	**1,154.77**

Using that same concept, we can now forecast the five missing data points of the smoothed VBE.

Figure 3 depicts the smoothed VBE (at 2-standard deviation) with a forecast of its missing five data points using the correlation methodology previously presented.

Using the VBE to identify over-extended price action on the price charts

Now that the VBE has been constructed, we will demonstrate a useful trading technique when applying it to price charts. Below are some essential guidelines to be followed when using the VBE.

- Spot the most recent turning phase of the VBE (crest or trough) while it is occurring. The turning phase must be associated with a price excursion. The VBE will guarantee to a high degree that any price excursions are unsustainable regardless of the trend.
- If a price excursion occurred at a low, wait for the price to return back inside the VBE range, and then initiate a long position (or buy-back an old short position) until the next VBE turn (in the opposite direction) takes place.
- If a price excursion occurred at a high, wait for the price to return back inside the VBE range, and then short, sell or reduce your position until the next VBE turn (in the opposite direction) takes place.

Needless to say, the appropriate trading strategy applied will depend on the direction of the overriding trend direction.

The following example (Figures 6 and 7) illustrates how to initiate buy and sell trades using the VBE.

Figure 3: S&P 500 Index — Candlestick chart — Daily closing values — Normal scale

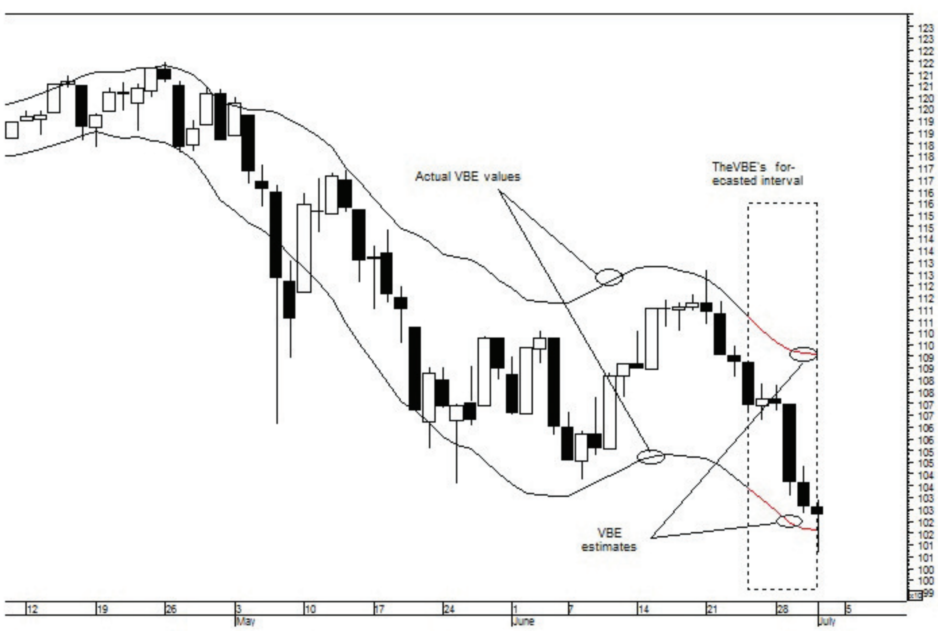


Figure 4: EGX 30 Index – Candlestick chart – Daily closing values – Semi-log. scale

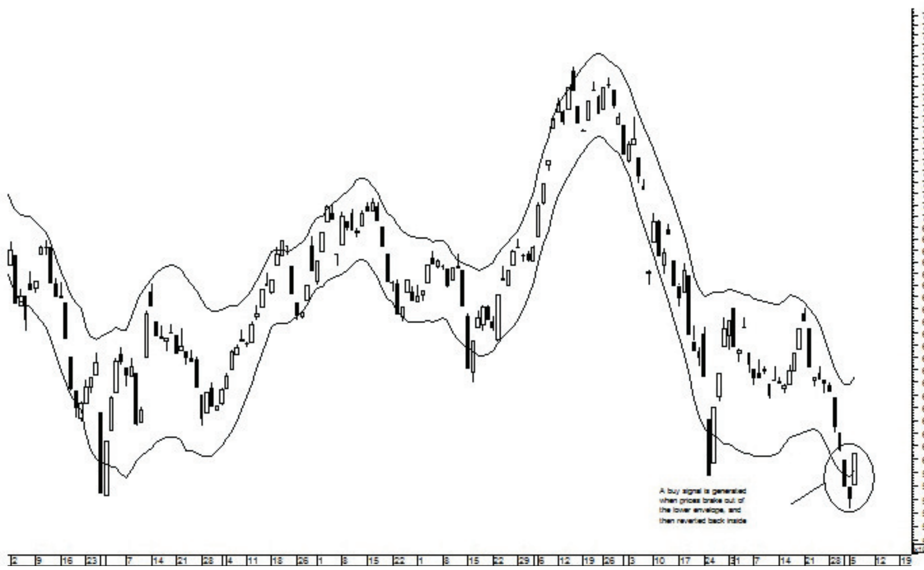


Figure 5: EGX 30 Index – Candlestick chart – Daily closing values – Semi-log. scale

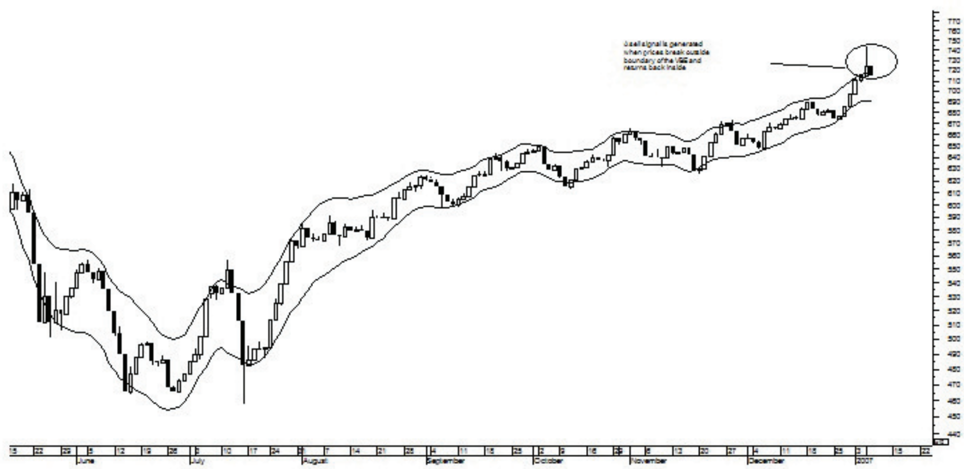


Figure 6: NASDAQ Index – Candlestick chart – Daily closing values – Semi-log. scale

Conclusion

The VBE introduced in this paper dynamically adapts to the volatility changes of the price action and thus, successfully contains the price action within a predefined standard deviation range. Accordingly, the VBE is consistently able to identify over-extended price action regardless of the trend status. This is achieved without compromising the smoothness of its boundaries.

Nevertheless, the VBE is still left with a few challenges. Most importantly, is the fact that the most recent data points on the smoothed VBE are missing and required a forecast. In this paper, we used the concept of correlation and applied it to moving averages of different durations in order to achieve a reliable forecast for the missing data points. Still, the correlation figures tend to lose their significance as they approach zero, since a value of zero implies no correlation between the variables. Thus, the significance of the VBE estimated values will vary depending on the significance of the correlation figures, which tend to change more often than not. Thus, one should always check the (Đ) matrix values for statistical significance (i.e. at least above 0.5 and/or below -0.5).

References

1 Murphy, John J., Technical Analysis of the Financial Markets, New York institute of Finance, 1999.

2 Pring, Martin J., Technical Analysis Explained: The Successful Investor's Guide to Spotting Investment Trends and Turning Points, McGraw-Hill, 2002.

[3, 7] Millard, Brian J., Channels and Cycles: A Tribute to J. M. Hurst, Traders Press, 1999.

[4, 5] Bollinger, John A., Bollinger on Bollinger Bands, McGraw-Hill, 2001.

6 Hull, John C., Options, Futures, and Other Derivatives, Prentice Hall, 2000.

Bibliography

Hull, John C., Options, Futures, and Other Derivatives, Prentice Hall, 2000.

Mason, Robert D., Marchal, William G., Lind, Douglas A., Statistical Techniques in Business & Economics, McGraw-Hill/Irwin, 2002.

Millard, Brian J., Channels and Cycles: A Tribute to J. M. Hurst, Traders Press, 1999.

Bollinger, John A., Bollinger on Bollinger Bands, McGraw-Hill, 2001.

Murphy, John J., Technical Analysis of the Financial Markets, New York institute of Finance, 1999.

Pring, Martin J., Technical Analysis Explained: The Successful Investor's Guide to Spotting Investment Trends and Turning Points, McGraw-Hill, 2002.

VIX White Paper, Chicago Board Options Exchange (CBOE), 2009.

Data courtesy of Bloomberg and Reuters.

Charting software courtesy of Equis International MetaStock v.9.1.

Figure 7: NASDAQ Index – Candlestick chart – Daily closing values – Semi-log. scale