VICTOR MARCHAND KERLOW

From BBZ To ABZ'

The Adjustable-Bands Z-Test

Markets generally trend or move in a range. If you apply a trending algorithm to a ranging market, you will end up with whipsaws that yield losses. This indicator can help you avoid some of those false entry whipsaws and capture a new trend early.

by Jacinta Chan, PhD

Some traders depend entirely on technical analysis and mechanical technical trading systems, mainly because algorithmic technical trading systems can be backtested and examined to see if they have a statistical edge. Here's a look at quantitative technical analysis on the historical prices of Malaysian futures markets, namely the Kuala Lumpur Composite Index Futures (FKLI) and crude palm oil futures (FCPO), using popular technical indicators like moving averages, adaptive moving averages, and *z*-test statistics.

This article follows my March 2006 STOCKS & COMMODITIES article titled "Trading Trends With The Bollinger Bands Z-Test." The idea of the z-test is derived, in turn, from a 2002 Working-Money.com article by Veronique Valcu. The Bollinger Bands *z*-test (BBZ) uses the concept of *z*-test statistics to determine where the current price is in relation to the moving average and standard deviation. The formula is:

$$Z\text{-test statistic} = \frac{\text{Current price} - \text{Moving average}}{\text{Standard deviation}}$$

If the *z*-test statistic is above 1, the current price is above the upper one standard deviation band. BBZ issues a buy long signal. If the *z*-test is below -1, then the current price is below the lower standard deviation band, at which point BBZ issues a sell short signal. The area enclosed by the bands is deemed to be range trading, which is a no-trade zone for BBZ. This is to avoid some of the range-trading whipsaws. BBZ uses the conventional 21-day moving average and standard deviation.

ADJUSTABLE BANDS

Now let us look at how you can automatically adjust the moving average and standard deviation bands according to the prevailing market condition, either a ranging market or a trending market. Algorithms that function well in either market but not both is a classical limitation in technical analysis. The trading issues resulting from this problem of applying an inappropriate

technical indicator are:

- There are time delays to capture price trend movements early.
- It is difficult to avoid false entry whipsaws when prices move sideways in range movements.
- It is unrealistic to expect future price movements to conform to the parameters optimized to maximize historical performance in simulations. (It is impossible to forecast what optimal parameters to use before the event.)

To overcome these issues, we can incorporate a technical indicator referred to as the "efficacy ratio" into an algorithmic trading system I call the *adjustable-bands z-test (ABZ')*. This system can automatically adjust its moving average and standard deviation bands to the current market condition. ABZ' is my answer to the quest to develop a trading system that is profitable in a trending market.

ABZ' uses the efficacy ratio to adjust its parameters, the moving average and standard deviations, to suit the two different market conditions. The trading rules for ABZ' tell you to buy long above the upper standard deviation band, sell short below the lower standard deviation band, and not trade within the bands. ABZ' is expected to capture a larger portion of abnormal profits by adjusting the parameters according to the prevailing market condition. This system:

- Improves the lagging tendency of most of the trend indicators in a trending market
- Widens the width of the bands, thus increasing the area that prohibits trades when the market is ranging
- Constantly adjusts the parameters to stay with the major trend movement for as long as possible.

This study examines and analyzes the properties of FKLI time series data, designs and develops a mechanical technical trading system (that is, ABZ') that generates abnormal returns in excess to that of the passive buy & hold strategy, and tests ABZ' for robustness using different futures contracts. The test approach is similar to that others have used to test for statistically significant returns and is based on the insights of Benoit Mandelbrot's proof that the market is not random.

EFFICACY RATIO

For the efficacy ratio, I use a ratio of the 34-day standard deviation for the long-term indicator over a six-day standard deviation for the short-term indicator. When the market is ranging, the efficacy ratio generated is a larger-value parameter. This ensures a longer moving average and larger standard deviation bands, and thus, some of the short-term whipsaw losses can be avoided. In a trending market, the efficacy ratio is a smaller-value parameter for moving averages and standard deviations, which ensures a faster entry into the prevailing trend.

Algorithms that function well in either ranging or trending markets but not both is a classical limitation in technical analysis.

ADJUSTABLE-BANDS Z-TEST

Ideally, the ABZ' should possess all the characteristics of a profitable trading system. This includes:

1. Adaptive parameters, moving average and standard deviation to fit historical and current data
2. The ability to be robust in FKLI, the KOSPI, Singapore MSCI, the Hang Seng, FCPO, soybean oil, corn, and wheat futures
3. Capital preservation, low maximum drawdown with an inherent loss-control mechanism due to the adaptive nature of moving averages, and standard deviation
4. The number of winning trades to losing trades is 50:50
5. Average gain that is at least 1.5 times larger than average loss
6. The ability to avoid some of the whipsaws in a range-trading market due to the long-term moving average and standard deviation
7. The ability to enter a new trend early due to the short-term moving average and standard deviation
8. The ability to automatically adjust or fine-tune trend versus range market conditions, according to the efficacy ratio.

GENESIS OF ABZ'

For data, I used the closing prices of FKLI from its inception on December 15, 1995, to December 31, 2008, also noting open, high, low, and volume. The main characteristic in time

series that is of interest to traders is volatility or huge returns, which are found in the heavy tails of the distribution of returns, and so, I will first chart the distribution of returns.

My primary interest is to find statistics on FKLI's mean, standard deviation, skewness, and especially its kurtosis, which is the measure of the shape of the distribution. I want to analyze FKLI's return to find if the distribution of returns exhibits *leptokurtosis*, which is excessive positive kurtosis. A leptokurtotic distribution has a more slender peak around the mean and fatter tails. If the distribution exhibits excess kurtosis from the normal distribution, then it cannot be inferred that the returns are random.

Contract	Mean	Standard Deviation	Skewness	Kurtosis
FKLI	-0.03	13.97	-0.0024	14.97

FIGURE 1: DAILY KULALA LUMPUR COMPOSITE INDEX FUTURES (FKLI) RETURNS DISTRIBUTION (DECEMBER 15, 1995 TO DECEMBER 31, 2008)

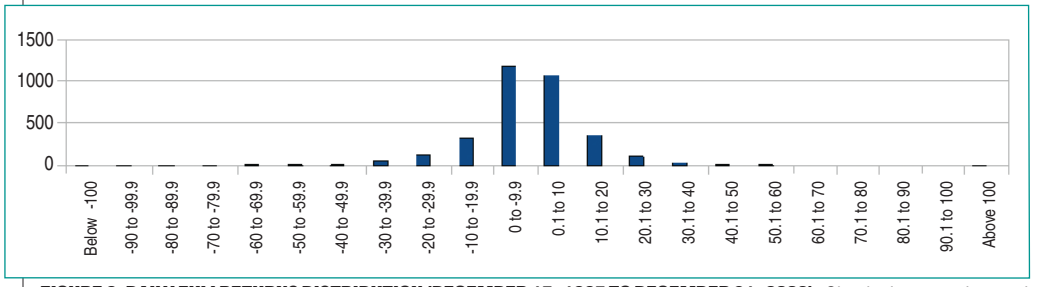

FIGURE 2: DAILY FKLI RETURNS DISTRIBUTION (DECEMBER 15, 1995 TO DECEMBER 31, 2008). Clearly, there are observed price patterns or trends in FKLI prices.

The distribution of FKLI daily price changes is nonnormal for the period of December 15, 1995, to December 31, 2008, with a mean of -0.03, standard deviation of 13.97, skewness of -0.0024, and kurtosis of 14.97, as given in Figure 1. The kurtosis of 14.97 for FKLI exhibits an excess from the normal distribution of 3, and so, we cannot infer that the returns are random.

Figure 2 shows there are notably observed price patterns or trends in FKLI prices. A closer look shows that these uptrends or downtrends occur at or near the Bollinger Bands. Bollinger Bands, by default, are two standard deviation bands from the 20-day moving average. The area between the upper and lower band theoretically covers 95.5% of all observations. Bollinger Bands consist of three curves:

- Middle Bollinger Band = 20-period simple moving average
- Upper Bollinger Band = 20-period simple moving average + 2 standard deviations
- Lower Bollinger Band = 20-period simple moving average – 2 standard deviations

The purpose of Bollinger Bands is to provide relative definitions of high and low. By definition, prices are high at the upper band and low at the lower band. In Figure 3, you can see that the trends seem to begin when the bands widen. In Figure 4, note that instead of using two–standard deviation Bollinger Bands, using one standard deviation makes the trends easier to define.

Whenever the price crosses above the one standard deviation upper band, prices tend to move up, and whenever the price crosses below the -1 standard deviation, lower band prices tend to move down. So when price crosses above the one standard deviation upper band (or slightly less), you can expect an uptrend, and when the price crosses below the -1 (or slightly more than -1) standard deviation lower band, you can expect a downtrend.

The next step is to try to find an adaptive technical indicator that can discern between range trading and trend trading. Instead of expecting the market to adapt to the preset techni-

FIGURE 3: FKLI AND BOLLINGER BANDS. Trends seem to begin when the bands widen.

FIGURE 4: FKLI, 21-PERIOD MOVING AVERAGE, +1 STANDARD DEVIATION UPPER BAND. AND -1 STANDARD DEVIATION LOWER BAND. Using one standard deviation instead of two standard deviations makes the trends more obvious and easier to define.

cal indicators, the new algorithm trading system should be able to adjust its parameters to the different types of market conditions, range or trend. An example of this approach is to incorporate an automatically adjusting technical indicator like the efficacy ratio that uses a long-term 34-day standard deviation of closing prices divided by a short-term six-day standard deviation of closing prices into the ABZ'.

If long-term prices are less volatile than short-term ones, the ABZ' will use a shorter moving average and narrower standard deviation bands. When current prices are more volatile, this allows a faster entry into the new trend. If the long-term prices are more volatile than short-term ones, ABZ' uses a longer moving average and wider standard deviation bands. When current prices are less volatile, ABZ' helps avoid some whipsaws in a ranging market. The efficacy ratio adjusts the moving average length and standard deviation. ABZ' trades only outside the 0.8 standard deviation bands; I chose 0.8 because in the optimization tests for BBZ, it is the most optimal parameter for the bands.

TRADING RULES FOR ABZ'

This study ascertains that a trend begins when the price is above 0.8 (or below -0.8) standard deviation from the moving average. As ABZ' is a mechanical trading system, a set of trading rules can be programmed for it. The trading rules on when to buy and to sell are:

Buy (enter long) when prices are *more* than around 0.8 standard deviation (P>upper band)
Sell (exit long) when prices are *less* than around 0.8 standard deviation (P<upper band)
Sell (enter short) when prices are *less* than around -0.8 standard deviation (P<lower band)
Buy (exit short) when prices are *more* than around -0.8 standard deviation (P>lower band)

The purpose of running empirical tests on mechanical technical trading systems is to ascertain that:

1. Prices are not random.
2. Mechanical technical trading systems can capture abnormal returns in excess of the passive buy & hold policy.
3. ABZ' generates more returns than the moving averages systems tested for FKLI, FCPO, the KOSPI, the Singapore MSCI, the Hang Seng, soybean oil, corn, and wheat futures.

For comparison purposes, I also tested other technical trading rules. The six trading systems I tested are based on the origins of ABZ':

- Simple 21-day moving average
- Three- and 21-day moving average crossover
- Kaufman adaptive moving average (KAMA)
- Bollinger Bands *z*-test (BBZ)
- Optimized BBZ (Opt BBZ)
- Adjustable-bands *z*-test (ABZ')

The most common mechanical trend trading system is the variable moving average (1,21,0%). This simple moving average trading system can be constructed by calculating the average of 21 daily closes and comparing it to the current close. If the current close is above the 21-day moving average, the signal is to buy. If the current close is below the 21-day moving average, the signal is to sell. Another mechanical trend trading system is the variable moving average (3,21,0%).

To construct this crossover trading system, you need to calculate the average of three daily closes and the average of

21 daily closes. If the three-day moving average is above the 21-day moving average, the signal is to buy. If the three-day moving average is below the 21-day moving average, the signal is to sell. Both previous moving average(s) systems are fixed-length moving average(s) and the lengths (three and 21) are arbitrarily chosen. To vary these moving averages according to market conditions, KAMA proposes to apportion weights to the current data and past smoothed data series according to the efficiency ratio in this formula:

$$KAMA_t = a\ ER\ C_t + (1 - a\ ER)\ KAMA_{t-1}$$

where:

$a = [(ER(2/3-2/31))+2/31]^2$ and

$ER = (C_t - C_{t-n}) /$ Absolute sum of $(C_t - C_{t-1})$

However, these systems are turn-and-reverse systems so you will be trading all the time, even when the market is in a trading range. To avoid trading unprofitably during range periods, BBZ proposes that the trader should trade only when volatility increases — that is, when the price moves above the +1 or below -1 standard deviation band.

The BBZ is constructed by calculating the 21-day moving average and one standard deviation. Then you add one standard deviation to the 21-day moving average to get the upper band and deduct one standard deviation from the 21-day moving average to get the lower band. If the close is above the upper band, it is a buy signal, and when the close is below the upper band, it is a signal to exit long. If the close is below the lower band, it is a sell signal, and when the close is above the lower band, the signal is to exit short.

1. Under system tester, in MetaStock, key in the name "BBZ."
2. Program "Enter Buy" to be: "Close>BbandTop(Close, 21, Simple, 1)
   Program "Exit Buy" to be: "Close<BbandTop(Close, 21, Simple,1)
   Program "Enter Sell" to be:
   "Close<BbandBot(Close,21,Simple,1)
   Program "Exit Sell" to be: "Close>BbandBot(Close ,21,Simple,1)
3. Run "Simulation Tests" on the data.
4. View "Results" after the test to check for:
   a) Amount of profit
   b) Number of trades, profitable versus unprofitable trades
   c) Average gain versus average loss per trade
   d) Maximum consecutive gains versus maximum consecutive losses.

However, a fixed-length BBZ(21,1) produces results that only favor trends that begin when prices move beyond one standard deviation band from the 21-period simple moving average. However, for other periods, when the market is moving very fast or not at all, a 21-period simple moving average and one standard deviation may not be the optimal parameters to use. In such cases, you need to run an optimization to find the parameters that generate the most profit with the least consecutive losses. The system tester then generates the most optimized moving average and optimized standard deviation.

In the system tester, steps 1 to 4 are repeated, replacing 21 with "Opt1" and 1 with "Opt2":

1. Under system tester, in MetaStock, key in the name "Opt BBZ."
2. Program "Enter Buy" to be: "Close>BbandTop(Close, Opt1, Simple, Opt2)
   Program "Exit Buy" to be: "Close<BbandTop(Close, Opt1, Simple,Opt2)
   Program "Enter Sell" to be:
   "Close<BbandBot(Close,Opt1,Simple,Opt2)
   Program "Exit Sell" to be:
   "Close>BbandBot(Close,Opt1,Simple,Opt2)
3. Run "Simulation Tests" on the data.
4. View "Results" after the test to check for:
   a) Amount of profit
   b) Number of trades, profit versus unprofitable trades
   c) Average gain versus average loss per trade
   d) Maximum consecutive gains versus maximum consecutive losses.

Optimization can only be performed on past data. So judging by the range of results from optimized BBZ, ABZ' is designed

Contract	Buy-Hold	MA*	MAC	KAMA	BBZ	Opt BBZ	ABZ'
FKLI	-562	433.5	378	498.5	213.5	366	316
FCPO	-1387	820	948	-456	672	1119	690
KOSPI Futures	-95.1	11.55	37.75	-22.6	14.65	55.6	42
SiMSCI Futures	-203.2	44.2	86.6	-28	-56	64.6	27.6
Hang Seng Futures	-13263	9151	9297	1388	-131	7877	2207
FTSE Futures	-2023	201	739.5	1026.9	603.3	673.5	948.9
Soy Oil Futures	-16.49	19.69	29.22	29.64	14.41	27	30.6
Corn Futures	-49.2	134.6	52.8	-31.6	121	328	230
Wheat Futures	-289	216.8	283.2	-194.6	-159.8	327	484

*20-day MA is used after optimization tests revealed that it generally generates more profit than the other parameters.

FIGURE 5: TEST RESULTS FOR TRADING SYSTEMS (JANUARY 2 TO DECEMBER 31, 2008). All trading systems perform better than a buy & hold strategy. ABZ' shows a profit of 316 points versus -562 points for a buy & hold strategy.

to vary the optimal moving average and standard deviation according to the prevailing market condition.

If the market is ranging — that is, the efficacy ratio is a large variable — then a long-term moving average and standard deviation are used to prevent some unnecessary whipsaws that are the direct losses of using a short-term moving average. If the market is starting to trend — that is, the efficacy ratio is a small variable — then a shorter-term moving average and standard deviation are used to allow an earlier entry into the new trend at a more favorable price.

$$ABZ' = MA(\text{Efficacy ratio}) + Stdev(\text{Efficacy ratio})$$

where the efficacy ratio is the number of periods used to determine moving average and standard deviation.

RESULTS

The histogram of daily price returns shows that the distribution for the sample from December 15, 1996, to December 31, 2009, has fat tails denoting large changes that happen more frequently than in a normal distribution. In the test simulations, the empirical results show that the mechanical algorithm trading systems generate abnormal returns that are above the benchmark buy & hold policy for all contracts tested. The results are summarized in Figure 5.

Note that all trading systems perform better than a buy & hold strategy for 2008. In 2008, all the technical trading rules reported profits. The limitations of backtesting are that test results cannot account for intraday movements, which give earlier entry signals and may result in more profits or losses and any slippage (which is usually not a factor to be concerned with in liquid markets).

ABZ' shows a profit of 316 points compared to the buy & hold policy, which yields a negative return of -562 points for the period from January 2 to December 31, 2008. That profit of 316 points is equivalent to ringgits Malaysia (RM)14,600 (about US$4,786) after transaction costs. At the current margin of RM2,500 per contract, the return per year is 5.8 times.

There are 20 trades, of which eight (40%) are losses and 12 (60%) are gains. The total losses amount to -73.4 points, while the total gains amount to 384.6 points. Therefore, the profit to loss ratio is 4.15. The average loss is -11.58 points, while the average gain is 32.05. ABZ' for FKLI from January 2 to December 31, 2008, is displayed in Figure 6.

CONCLUSION

We saw that the prices for FKLI, FCPO, and other futures contracts tested are not random, that mechanical algorithm

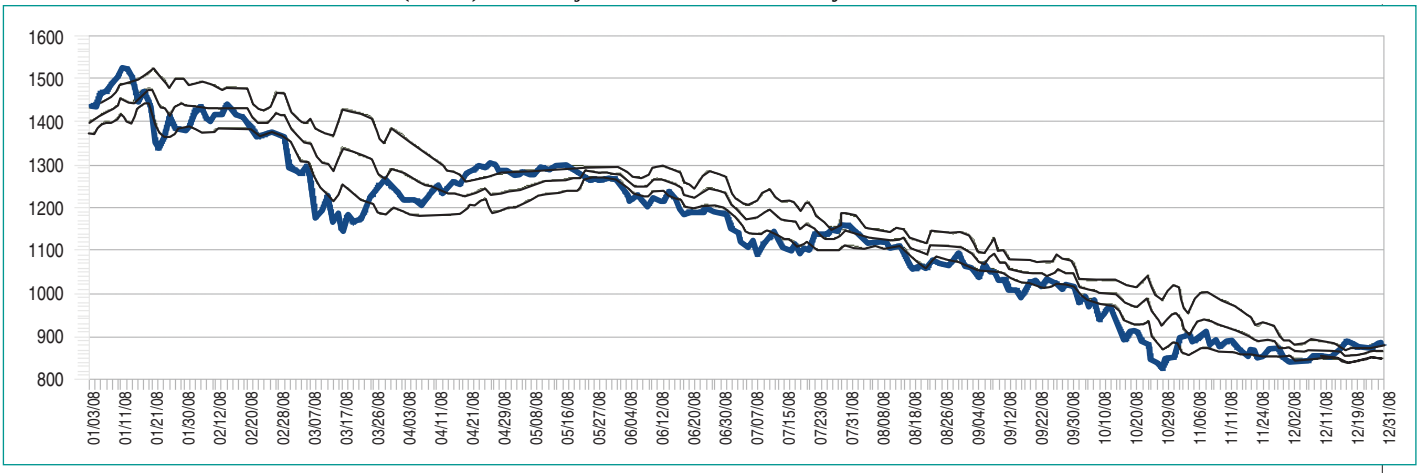

FIGURE 6: ADJUSTABLE BANDS Z-TEST-STATISTICS, ABZ' ON FKLI (JANUARY 2 TO DECEMBER 31,2008)

trading systems like BBZ and ABZ' can be used to capture the nonnormal returns arising from trending behavior, and the ABZ' and efficacy ratio can be used to adjust the moving average and standard deviation to suit either ranging or trending market conditions.

ABZ' is a useful technical analysis tool that adjusts automatically to different market conditions. It uses the efficacy ratio to determine the variable length of the standard deviation to gain earlier entry into a new trend and avoid whipsaws in a ranging market. It can also result in returns greater than a buy & hold strategy.

Jacinta Chan is the author of the books Everything Technical Analysis *and* Financial Times Guide To Technical Analysis. *She can be reached at jacinta@siswa.um.edu.my.*

SUGGESTED READING

Balsara, Nauzer; K. Carlson, and N. Rao [1996]. "Unsystematic Futures Profits With Technical Trading Rules: A Case For Flexibility," *Journal of Financial and Strategic Decisions* 9: 1, 57–66.

Bessembinder, H., and K. Chan [1995]. "The Profitability Of Technical Trading Rules In Asian Stock Markets," *Pacific-Basin Finance Journal*, Volume July, 257–284.

Brock, William; Josef Lakonishok, and Blake LeBaron [1992]. "Simple Technical Trading Rules And The Stochastic Properties Of Stock Returns," *Journal of Finance*, Volume December, 1731–1764.

Chan, Jacinta [2006]. "Trading Trends With The Bollinger Bands Z-Test," *Technical Analysis of* STOCKS & COMMODITIES, Volume 24: March.

_____ [2008]. *Everything Technical Analysis*, Prentice-Hall.

_____ [2011]. *Financial Times Guide To Technical Analysis: How To Trade Like A Professional*, Financial Times/Prentice-Hall.

Chande, Tushar [1997]. *Beyond Technical Analysis*, John Wiley & Sons.

Fama, E. [1965]. "Random Walks In Stock Market Prices," *Financial Analyst Journal*, Volume 16: 1-16.

Gandolfi, Gino; Monica Rossolini; David Sabatini, and Stefano Caselli [2008]. "Dynamic MACD Standard Deviation Embedded in MACD Indicator For Accurate Adjustment To Financial Market Dynamics," *IFTA Journal*, Volume 2008: 16–23.

Irwin, S., and Cheol-Ho Park [2009]. "A Reality Check On Technical Trading Rule Profits In The US Futures Markets," *Journal of Futures Markets*, Volume 30: 633–659.

Kaufman, Perry J. [1998]. *Trading Systems And Methods*, 3d ed., John Wiley & Sons.

Lukac, L.; B.W. Brorsen, and S. Irwin [1988]. "A Test Of Futures Market Disequilibrium Using 12 Different Technical Trading Systems," *Applied Economics*, Volume 20: 623–639.

Mandelbrot, Benoit, and R. Hudson [2004]. *The (Mis)Behaviour of Markets: A Fractal View Of Risk, Ruin And Reward*, Profile Books Ltd.

Taylor, M.P., and H. Allen [1992]. " The Use of Technical Analysis in the Foreign Exchange Market," *Journal of International Money and Finance*, Volume 11: 304–314.

Valcu, Veronique [2002]. "Z-Score Indicator," Working-Money.com, October 29.

‡MetaStock