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# IFTA JOURNAL

Journal for the Colleagues of the International Federation of Technical Analysts

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**2002 Edition**



# Editorial

Larry V. Lovrencic, ASIA

Some IFTA colleagues, on picking up this *Journal* and leafing through the articles, may ask, "Why bother reading this article? What is the purpose of this Journal?" These questions raise fundamental issues concerning the need and purpose of continuing education. Is continuing education necessary for a successful career in the finance industry or as an educator of others? Do the authors write to impart their knowledge to fellow members or to gain respect within the community of technical analysts? The whole issue of education and continuing education is one that needs to be explored if we are to establish the practitioners of technical analysis as professionals. The concept of a profession involves the adoption of standards, ethics and an obligation and commitment to higher learning. This *Journal*, in its own small way, is a medium for education in technical analysis. The purposes of education include:

1. To produce competent, and capable technical analysts who can act professionally,
2. To produce 'enlightened' technical analysts who can think critically and independently, and
3. To produce technical analysts who may contribute to the body of knowledge of technical analysis.

#### IFTA achieves these educational goals by:

1. Holding the IFTA Conference each year, offering colleagues the opportunity to attend presentations by leading technical analysts
2. Offering the Diploma in International Technical Analysis (DITA). DITA is a three stage process. Levels I and II are completed by coursework and examination. Level III is fulfilled by submission of a research paper that:
  - a) must be original,
  - b) must deal with at least two different international markets,
  - c) must develop a reasoned and logical argument and lead to a sound conclusion supported by the tests, studies and analysis contained in the paper,
  - d) should be of practical application, and
  - e) should add to the body of knowledge in the discipline of international technical analysis.

Two such papers have been offered for publication in this issue of the IFTA Journal:

Ingo Bucher's article demonstrates the 'behaviour' of J. Welles Wilder Jr's 'Relative Strength Index' (RSI) from a Fibonacci point of view. Ingo's paper was borne out of seeking a 'flexible' solution to the widely used 70/30 overbought/oversold-levels for the RSI. In the conclusion of his paper Ingo wrote "My observations are not a pioneering innovation, but if only one reader of this paper takes a piece of my ideas which supports, completes or improves an existing trading strategy, that would be great!" I know of at least one technical analyst who plans to investigate further.

Felix Gasser's article examines the need for performance evaluation in technical analysis. Felix believes that technical analysis has become a melting pot of all kinds of tools and theories mixed in with some statistical methods and computer science. He questions how we determine a valid method from a non-valid one. Felix hypothesises that validity must be determined by the resulting

investment performance. He discusses the significance of performance outcomes as a tool to evaluate indicators, strategies and market behaviour.

3. Publishing articles and research papers by leading practitioners, educators, academics and DITA III candidates in the *IFTA Journal*.

One such leading practitioner/educator is John Bollinger. John's article seeks to increase our awareness of volume and it's derivatives. He wrote that volume is "an important key to understanding the dynamic balance of the marketplace...". He discusses the importance and the proper use of many volume indicators.

The final article that I wish to bring to your attention has been submitted by four academics: Andrew C Pollock and Alex Macaulay, both from Glasgow Caledonian University, United Kingdom, Mary E Thomson, from Glasgow Caledonian Business School, United Kingdom, and Dilek Önköl-Atay, from Bilkent University, Turkey. The article examines the derivation and utilization of estimated probabilities in the currency markets. They provide us with a framework for the formation of probability statements that enables a detailed evaluation of probability predictions, which provide an indicator of the strength and direction of movement and momentum.

As editor, I hope that every reader of this *Journal* finds something of benefit that he or she can apply. I hope that this *Journal* stimulates further thought or discussion and in the longer term, leads to the continuing education of our IFTA colleagues.

There are three persons, other than the authors who should be acknowledged for their efforts in producing the *IFTA Journal*. One is the IFTA Administration/Business Manager, Michael Smyrk. Michael decided to step down as *Journal* editor at the IFTA Board meeting in London in October this year. The most difficult task that any editor faces is obtaining suitable articles for publication. That task was made easy for me because Michael had all of the articles in this *Journal* at hand to pass over. I would like to thank Michael for his hard work over the years and congratulate him for handing down one of the finest technical analysis publications in the world. I am grateful to him, not only as the incoming editor, but also as an IFTA colleague who has enjoyed the results of his effort over many years.

The second person I would like to acknowledge is Barbara Gomperts of Financial & Investment Graphic Design in Boston, MA, USA. Ms Gomperts, who created the look and feel, is the backbone of this publication. I am truly amazed at the speed, precision and quality of her work. She has shown great patience with your new editor and has always been available to assist and offer advice, for which I am extremely grateful.

The third person to be acknowledged is my fellow IFTA Board member and Editorial Committee member John Schofield (TASHK). John's contribution is very much appreciated. He assisted by passing a keen eye over the articles during the editorial process and the proof reading of this *Journal*. With John's involvement this *Journal* may truly be called international as it is the result of a collaboration of the continents of Europe, North America, Asia and Australia.

– Larry Lovrencic, Editor

# A Survey of Volume Indicators

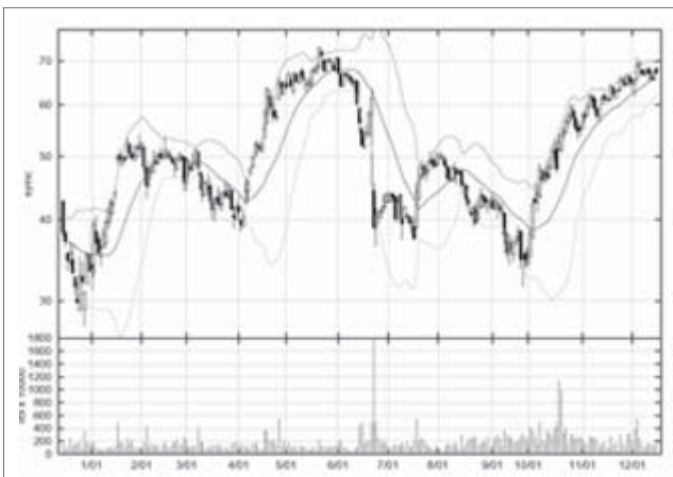
John Bollinger, CFA, CMT

Volume, and the indicators created from it, constitute an underutilized series that offers the analyst fertile ground for exploration in the already well-turned field of security price analysis. This survey will discuss the most important volume indicators, give credit as best as is possible, and note the proper names along with some of the other names that have been used. The purpose of this survey is to increase awareness of these valuable tools and their respective purposes so they can be properly identified and deployed in a rational manner.

Money flow, supply/demand, accumulation/distribution, buying power and selling pressure are all terms designed to convey the issue at the heart of technical analysis, the sometimes not so delicate balance between buyers and sellers. Technical analysis gets at this balance by examining the price structure and related variables. A large number of indicators have been created to clarify the relationship between supply and demand. Some are derived from price, some are based on sentiment and some are based on volume.

An important key to understanding the dynamic balance of the marketplace is the actual balance of trade, volume. In volume we see the sum total of all fact and opinion translated into action. Delicate balance or landslide, feint or blow, confusion or conviction, ebullience or depression, victory or capitulation, all is finally portrayed in the volume of trade.

**Chart 1**  
**Volume**



Unfortunately there is a great deal of confusion about how to employ volume indicators. Relative obscurity is one factor in this confusion. Volume indicators are far less common in market literature than the more familiar momentum and trend indicators and they are less used than indicators derived primarily from price. This is a shame, as the technician's data set is small enough to start with, consisting primarily of (in order of diminishing use) closing prices, highs, lows and volume, with opening prices and the occasional relative comparison or psychological indicator rounding out the set.

A major factor inhibiting wider use of volume indicators is the confusion created by the lack of a consistent naming scheme for volume indicators. Some volume indicator formulations have had two, three, or more names applied to them, while some common

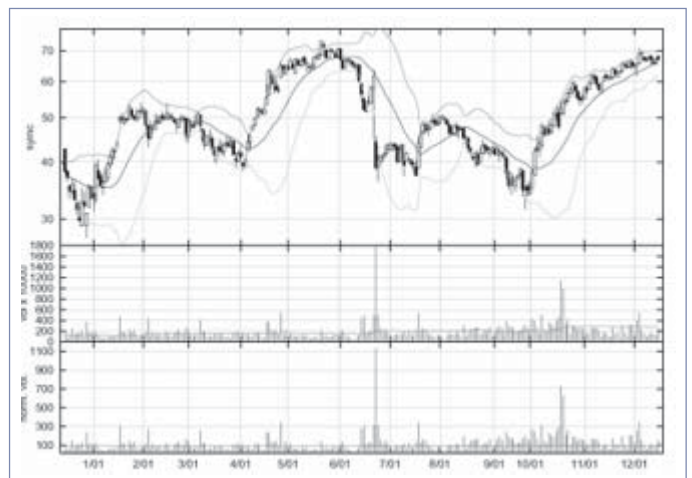
names such as accumulation distribution masquerade in front of numerous different formulas. At the end of this paper you will find the formulas and names paired properly. You can use this information to verify the tools you employ.

A constant theme in my lectures and writings on Bollinger Bands is the use of a set of non-correlated indicators to aid in the interpretation of price action within the Bollinger Bands. There are many possibilities to select from including trend, momentum, supply/demand and psychological indicators. The "one-from-column-A, one-from-column-B" method provides the most robust approach in that it gathers the maximum amount of information with the least amount of duplication. Volume indicators are very useful in this regard as in most approaches volume is not already utilized and volume indicators can offer new, non-correlated inputs.

One of the key underpinnings of volume analysis is the notion that volume precedes price. This basic technical concept is discussed in the earliest technical analysis writings. For example, early 1900s authors such as Schabacker and Wyckoff covered volume extensively in their works. However, it was not until the 1950s and '60s that indicators based on volume began to be widely appreciated.

The earliest use of volume was to confirm chart patterns. The classic description of a head and shoulders pattern includes a pattern of diminishing volume across the formation followed by increasing volume on the break of the neckline. Typically a bar chart with volume plotted at the bottom was used to aid this type of analysis. But, there can be interpretation problems. How are we to know what is high volume and what is low volume? The eye can guess, but it is better to employ an average. By definition days where volume is above the average are high-volume days and vice versa. Typically 20- and 50-day averages are used in this regard, with the latter being preferred by many practitioners. A useful refinement is to divide volume by its moving average and plot the resulting ratio multiplied by 100 instead of volume. This transformation creates a relative volume framework that perfectly complements the relative price framework created by Bollinger Bands. This normalized measure of volume is called %v.

**Chart 2**  
**Volume with 50-Day Moving Average and Normalized Volume (%v)**



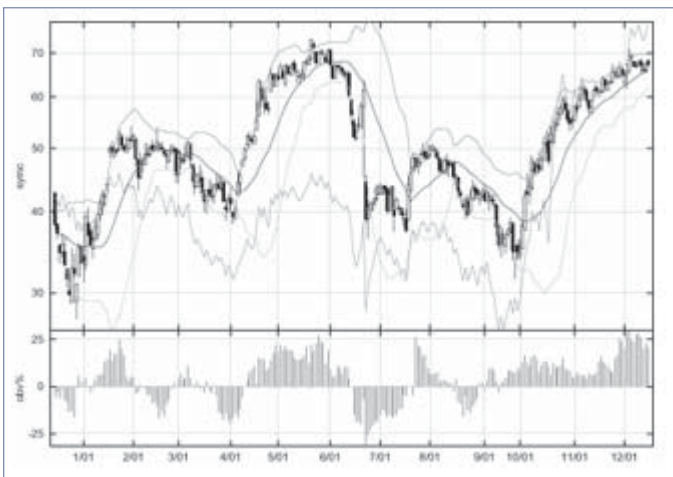
There are five basic approaches to creating volume indicators. First, one can look at the change in price from the prior period. Second, the trading patterns of the period being considered can be used to create the indicator. Third, the change in volume from the prior period can be used to drive the calculation. Fourth, one can compare the ebb and flow of volume to itself. Finally, one can include volume in the calculation of other indicators such as RSI or MACD. Roughly, that is the order in which volume indicators were developed.

We present ten indicators in this survey, two for each of the construction methods. The first category uses change in price to parse volume.

In 1963 Joe Granville introduced an indicator to the public called On Balance Volume (OBV) in "Granville's New Key to Stock Market Profits" published by Prentice Hall. OBV is a simple accumulation – running total – of volume times the sign of the price change. To calculate the OBV start at some convenient figure such as 0, then on days when price rises add the daily volume to the indicator and on days when price falls subtract that day's volume. The idea is that volume is the motive force behind price action. Therefore volume on days when price rises is seen as a positive indication, while volume on declining days is a negative indication. It appears that Frank Vignola originally developed OBV. However it was Mr. Granville who popularized OBV and it is Joe Granville who is associated with OBV and its numerous derivatives today.

Typically price and OBV are plotted together on the same chart, though with different scales. Interpretation involves comparison of the indicator and price. Action is taken on divergences; selling if price goes to a new high and the indicator does not, or buying when price records a new low but the indicator does not. Typical of the patterns OBV can help clarify are advances on low volume resulting in weak OBV, or in a base increasing volume on up days that results in an OBV pattern that starts up before price. Many technicians consider OBV to be a good trend indicator.

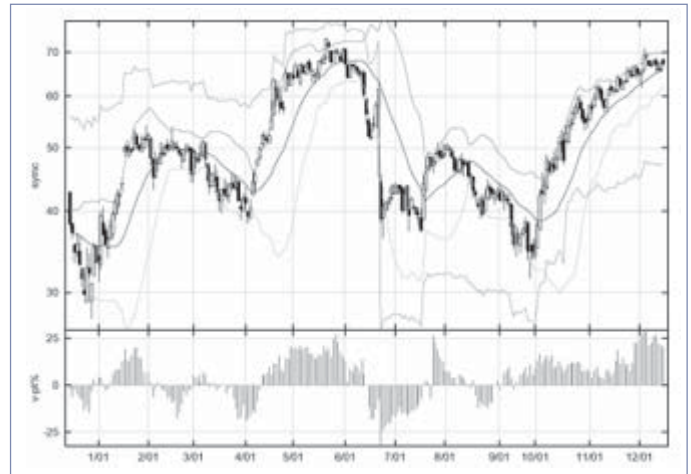
**Chart 3**  
**On Balance Volume (OBV)**



The next development, Volume-Price Trend (V-PT), came in 1966 from David Markstein in "How to Chart Your Way to Stock Market Profits." V-PT is a variation on OBV that substitutes multiplication of volume by the daily percent change of price for multiplication by the sign of the daily price change. V-PT considers not only whether prices rise or fall, but by how much. Interpretation is along the same lines as OBV.

The indicators in the second category make no reference to price change. Instead they parse volume as a function of the day's activity to uncover underlying strength and weakness.

**Chart 4**  
**Volume-Price Trend (V-PT)**



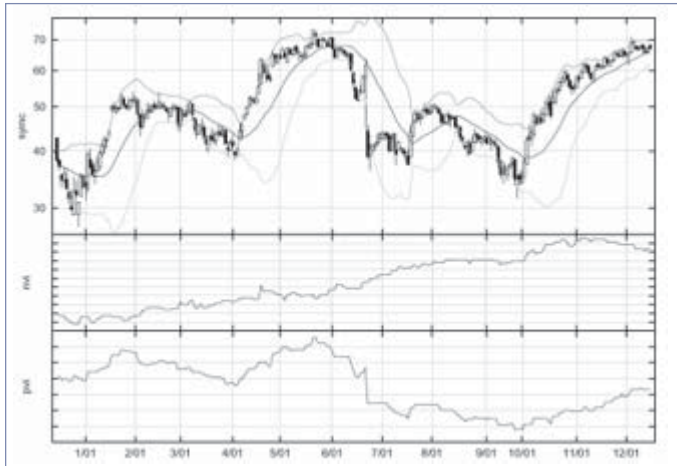
Up to this point the nomenclature is fairly well agreed upon. Beyond here there is tremendous disagreement about indicator names. The term money flow has been applied to many different concepts and calculations. For example, Marc Chaikin deliberately changed the name of Intraday Intensity to Money Flow to aid in the absorption of technical concepts by Bomar clients. Every effort to get the indicator nomenclature correct has been made, but there still may be some unavoidable controversy.

The economist David Bostian created the Intraday Intensity Index, called Money Flow by Instinet, Accumulation Distribution by MetaStock and the Daily Volume Indicator by TechniFilter. Bostian's original monograph on the subject appeared in 1967 and can be found in the "Encyclopedia of Stock Market Techniques" published by Investors Intelligence. Intraday Intensity compares the close to the range of the day. Closes near the highs result in positive values for the indicator; closes in the middle of the range in small or zero values; and closes near the lows in negative values. The idea behind Intraday Intensity is that the need for institutional traders to complete their positions gets ever more urgent as the close of trading looms. As they move to fill their needs late in the day their actions cause prices to rise or fall, effectively tipping their hands via the relationship of the close to the day's range.

Accumulation Distribution (AD) was created by Larry Williams in 1960s and published in his "The Secret of Selecting Stocks for Immediate and Substantial Gains" in 1972. AD is based on the same concept as Japanese candlestick charts. The Japanese have long focused on the relationship of the open and the close within the context of the day's trading range; the open and the close define the body of a candle, while the high and the low define the shadows. AD mathematically compares the relationship of the open and close to that of the high and the low and multiplies the result by volume. A day where the open is at the low and the close is at the high results in a strong reading; a day where the open and close are relatively close together within a wider daily range will result in a flat indication; and a day where the open is at the high and the close at the low creates a strong negative reading. A study of the basic concepts of Japanese candlestick charting will greatly help you understand the function of this indicator.

(Many people used Intraday Intensity as a substitute for AD during the years when the opening price wasn't available and AD couldn't be calculated.)

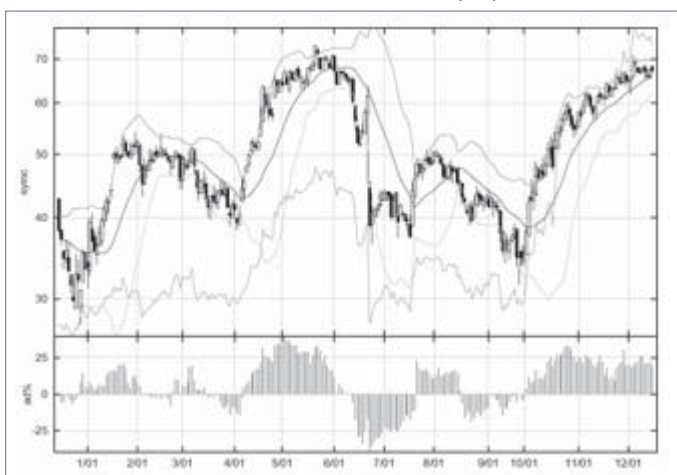
**Chart 5**  
Negative and Positive Volume Indices (NVI and PVI)



The first two categories of indicators in this survey parsed volume using price. The third category of volume indicators reverses that process and accumulates price change based on volume action.

The Negative Volume Index (NVI) and its sibling the Positive Volume Index (PVI) are indicators based on changes in volume. The credit for NVI apparently belongs to Paul Dysart. The PVI – antimatter to the NVI – may have been created by Paul’s son Richard. Unfortunately neither father nor son published beyond their advisory service, Trendway, as far as can be determined, so the correct attribution is hard to determine. These indicators accumulate price change when volume falls, NVI, or rises, PVI. The idea behind the Negative Volume Index is a contrarian one. Price change is accumulated on days when volume falls versus the prior day, as it is thought that these days reveal the underlying action of the so called “strong hands” versus the irrational exuberance of the “crowd” on days when volume rises. The NVI is most often used these days as an analysis tool for the broad market, while some have found the PVI to be a useful trend indicator for individual stocks. (When the negative Volume Index is used for market timing it is often driven by the advance decline figures instead of volume. This was the original formulation.)

**Chart 6**  
Accumulation-Distribution (AD)

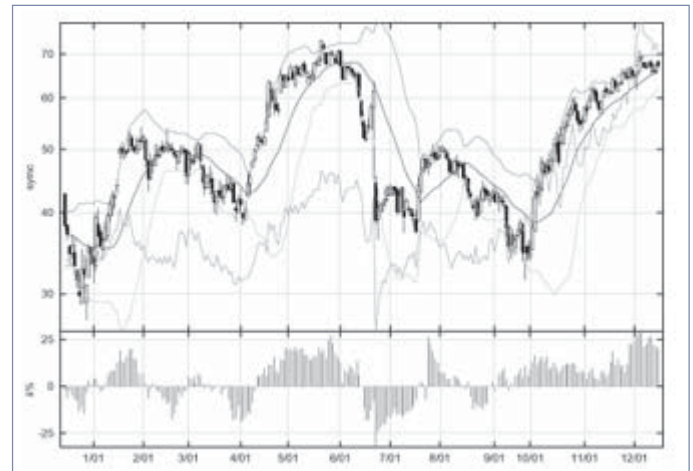


The fourth category considers only volume. No reference is made to the price structure at all, simply the ebb and flow of volume itself is used to inform the analyst. This category contains two indicators, one of my own construction, %v, and the Volume Oscillator.

%v was presented earlier in this paper. The Volume Oscillator (VO) is a classic indicator for which proper attribution is unknown. To create a VO, two moving averages of volume are calculated and the longer average is subtracted from the shorter average. 10- and 20-day averages are commonly used, but many other combinations are found in practice. (The VO can be normalized for comparability by dividing the difference by the longer average or an even longer average such as the 50-day.) The VO portrays the pure ebb and flow of volume; the idea is to separate cause, volume, from effect, price. Tuning the VO average periods to model the major and minor swings of the item being analyzed can increase model accuracy. For example securities that trade in choppy patterns should employ shorter constants than securities that trend a great deal of the time.

The members of the fifth and final category of volume indicators are modifications of existing indicators to include volume: first RSI, then MACD.

**Chart 7**  
Intraday Intensity (II)

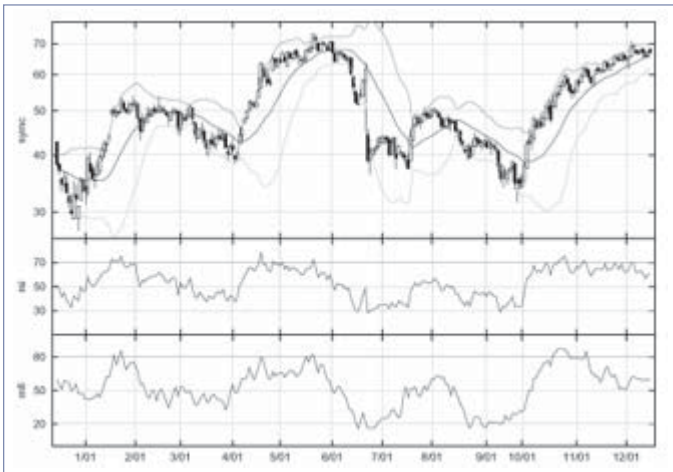


The adaptation of Welles Wilder’s Relative Strength Index (RSI) is called the Money Flow Index, or MFI for short. Gene Quong and Avrum Soudack introduced MFI in the March 1989 issue of *Technical Analysis of Stocks and Commodities*. RSI is a normalized comparison of the average price action on up days versus down days. MFI includes volume by multiplying the price changes by volume. Thus we have the marriage of a classic price-momentum indicator and the driving force behind the price movements, volume. For example, a rally in which volume is stronger on the advances than on the pullbacks will produce a stronger MFI pattern than it would an RSI pattern.

(MFI places the emphasis on the typical price rather than the close,  $(high+low+close)/3$  or  $(open+high+low+close)/4$ . The use of the typical price is recommended for Bollinger Band calculations, but not all software allows you to do so.)

The idea for the adaptation of Gerald Appel’s Moving Average Convergence Divergence indicator, MACD, was presented in an unpublished CMT\* paper by Buff Dormeier as a moving-average crossover system and then subsequently applied to MACD. The author shows in his paper that the inclusion of volume improves the performance of the system in several dimensions. This is a fairly simple adaptation; volume-weighted moving averages were substituted for the first two exponential moving averages Mr. Appel used in his original formulation. (The signal line remains an exponential average.) The VW-MACD draws its value from the improved sensitivity of the indicator derived from volume confirmation/nonconfirmation of the trend.

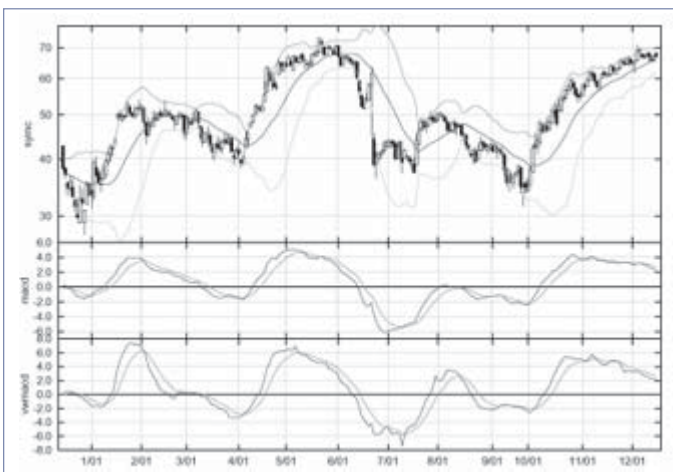
**Chart 8**  
**Relative Strength Index (RSI) and Money Flow Index (MFI)**



Now to shift gears a bit, let's focus on the presentation volume indicators. With the exception of MFI and volume-weighted MACD, all of the indicators presented here are open-ended, that is they are free to rise or fall in an unlimited manner. Some analysts find this presentation disconcerting and prefer to see the indicators in oscillator form—swinging above and below the zero line like rate of change or other momentum indicators, bounded by 0 and 100 like Stochastics, RSI or MFI, or in some other contained form. All open-ended accumulators can be converted to oscillator form by taking a simple n-day sum of the single-period figures rather than continuously accumulating them; a 10 or 20-day sum can be tried as a starting point. The idea is to pick a time period short enough to maintain sensitivity, but not so short that the signal is lost in the noise. Our procedure is to start short and lengthen the accumulation period until you get satisfactory signals.

It is also possible to normalize these oscillators so that they offer comparability from issue to issue. The easiest way to do so is to divide the oscillator value by the sum of the volume from the same period used to calculate the oscillator. Thus normalized 21-day Intraday Intensity is 21-day Intraday Intensity divided by a 21-day sum of volume.

**Chart 9**  
**Volume-Weighted MACD (V-WMACD)**



The choice between the open and closed forms is really a function of time frame. In our work we look for the confirmation/nonconfirmation of Bollinger Band tags and tend to focus on the oscillator forms of these indicators for trading signals. However for

longer-term investment considerations and trend analysis we tend to look at the open forms.

The applicability of these indicators is not universal. For any given application some may be found superior to others. For example, some stocks work beautifully with II while others work well with AD and make II seem like a broken clock. Some dimensions that may have an impact on volume indicator effectiveness include listed versus over-the-counter, company size, market development/efficiency and pricing rules such as minimum tick and decimals versus fractions.

In most technical analysis heavy reliance is placed on momentum and trend indicators derived from price with little information being derived from volume. For most traders this means that volume indicators are a rich new source of trading information that are not strongly correlated to the indicators already in use. Volume indicators are no panacea. The successful use of volume indicators entails testing on the instruments that you trade, in the manner that you trade or plan to trade. Luckily, these days it is a fairly simple matter to test which of these indicators fits your approach to the market best. I think you will find that the addition of the appropriate volume-based indicator(s) will add a new and profitable dimension to your process.

A final note: Transaction analysis, a special type of volume analysis where each trade is considered, is beyond the scope of this survey. Transaction indicators are usually called tick volume or money flow. Typically an accumulation is made of each trade using the formula price times volume times the tick, where the tick is +1 if the trade rose in price from the previous trade and -1 if the trade fell. There are many fiddles possible: Block trades versus non-block trades, how sequential trades at the same price are handled (stale ticks), etc. Don Worden developed the concept in the early 1960s. He computed money flow by hand from the printed records of each trade. After many years he felt that the technique no longer conveyed an advantage and abandoned it, choosing to focus on proprietary indicators, such as Time Segmented Volume, more akin to those discussed above. Sam Hale and Laszlo Birinyi are the best-known modern-day exponents of transaction analysis.

\* The Market Technician's Association's Chartered Market Technician program. [www.mta.org](http://www.mta.org)

A preliminary version of this paper was presented to the Market Technicians Association at their annual seminar in Atlanta, May 2000.

**VOLUME FORMULAS**

Where c=close, h=high, l=low, and v=volume and the subscript -1 refers to the prior day.

50-day Volume Moving Average

$$\sum_{t=1}^{50} v_t / 50$$

Normalized Volume - %v

$$v / \left( \sum_{t=1}^{50} v_t / 50 \right) * 100$$

On Balance Volume

$$\sum_{t=1}^{\infty} ((c > c_{-1}) - (c < c_{-1})) * v$$

Volume-Price Trend

$$\sum_{t=1}^{\infty} ((c / c_{-1} - 1) * v)$$

Intraday Intensity

$$\sum_{\uparrow} ((2c - h - l) / (h - l)) * v$$

or

$$\sum_{\uparrow} (((c - l) - (h - c)) / (h - l)) * v$$

Accumulation Distribution

$$\sum_{\uparrow} ((c - o) / (h - l)) * v$$

Or Clay Burch suggests this if the open isn't available

$$\sum_{\uparrow} ((c - c_{-1}) / (h - l)) * v$$

Negative Volume Index

$$\sum_{\uparrow} ((v < v_{-1}) * (c / c_{-1} - 1))$$

Positive Volume Index

$$\sum_{\uparrow} ((v > v_{-1}) * (c / c_{-1} - 1))$$

Volume Oscillator

$$\sum_{\uparrow}^{10} v_i / \sum_{\uparrow}^{20} v_i$$

Money Flow Index

$$100 - \left( 100 / \left( 1 + \sum_{\uparrow}^n (tp > tp_{-1} * tp * v) / \sum_{\uparrow}^n (tp < tp_{-1} * tp * v) \right) \right)$$

Where the typical price is tp = (h+l+c)/3 and the default for n is 14.

Volume-Weighted MACD

$$\sum_{\uparrow}^{12} c_i * v_i / \sum_{\uparrow}^{12} v_i - \sum_{\uparrow}^{26} c_i * v_i / \sum_{\uparrow}^{26} v_i$$

Volume-Weighted MACD Signal Line

9-day exponential average of VWMACD (0.2 weighting factor)

20-day OBV Oscillator

$$\sum_{\uparrow}^{20} (((c > c_{-1}) - (c < c_{-1})) * v)$$

21-day Normalized II Oscillator (II%)

$$\sum_{\uparrow}^{21} ((2c - h - l) / (h - l)) * v / \sum_{\uparrow}^{21} v_i * 100$$

BIBLIOGRAPHY

- Bollinger, John, Bollinger Bands, video, Bollinger Capital Management, 1999, Manhattan Beach, CA.
- Bollinger, John, Bollinger on Bollinger Bands, McGraw-Hill, 2001, New York City
- Bollinger, John, Volume Indicators, video, Bollinger Capital Management, 2001, Manhattan Beach, CA.
- Bostian, David Jr., Intraday Intensity Index, 1967, originally published as a monograph, available in The Encyclopedia of Stock Market Techniques, 1985, Investors Intelligence, New Rochelle, New York
- Dormeier, Buff, Volume, Does it Add Weight?, 2000, unpublished paper, Indianapolis, Indiana

- Dysart, Paul/Richard, The Trendway Advisory, 1930, Florida...
- Fosback, Norman, Stock Market Logic, The Institute for Econometric Research, 1986
- Granville, Joseph, Granville's New Key to Stock market Profits, Prentice-Hall, 1963, Englewood Cliffs, New Jersey
- Markstein, David L., How to Chart Your Way to Stock Market Profits, 1966, Parker Publishing, West Nyack, New York
- Pring, Martin, Technical Analysis Explained, second edition, McGraw Hill, 1985, New York City
- Quong, Gene and Soudack, Avram, Volume-Weighted RSI: Money Flow, volume 7 issue 3, March 1989, Technical Analysis of Stocks and Commodities
- Richard W. Schabacker, Technical Analysis and Stock Market Profits, 1932, republished in 1997 by FT Pitman in London as part of Donald Mack's Trader's Master Class series
- Williams, Larry, The Secret of Selecting Stocks for Immediate and Substantial Gains, 1972, Conceptual Management, Carmel, California

BIOGRAPHY

John Bollinger, CFA, CMT is the president of Bollinger Capital Management, Inc., an investment management company that provides technically driven money management. Bollinger Capital Management also develops and provides proprietary research for institutions and individuals.

Mr. Bollinger presents weekly market analysis and commentary on CNBC and is a frequent speaker at financial confederacies worldwide.

John Bollinger is probably best known for his Bollinger Bands, which have been widely accepted and integrated into most of the analytical software currently in use. His book "Bollinger on Bollinger Bands" was published by McGraw Hill in 2001.

His Capital Growth Letter provides investment advice for the average investor employing a technically driven asset allocation approach.

www.GroupPower.com provides industry group analysis using a group structure developed by Mr. Bollinger. The service provides market statistics designed to assist in making market timing and investment decisions.

Mr. Bollinger has developed several investor websites: www.BollingerOnBollingerBands.com, www.FundsTrader.com, www.EquityTrader.com and www.PatternPower.com

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# The Application of Fibonacci Retracements and Extensions to J. Welles Wilder Jr.'s Relative Strength Index<sup>1</sup>

Ingo W. Bucher

## INTRODUCTION

Technical analysts often refer to Fibonacci proportions when they are commenting on price and, less commonly, time<sup>2</sup>.

Nobody, as far as I know, talks about Fibonacci proportions in respect of indicators. I find this surprising since (common) charting techniques are now and again applied to price-based indicators. I thought about the reason why there is no literature available on that topic. Is it because of the standardisation (the range is between 0 and 100) of many indicators? I was unable to find a single reference in literature.

Why consider the combination of an indicator (14-period RSI) with Fibonacci proportions? Firstly, the idea was born when I realised that Bollinger Bands<sup>3</sup> are superior to 'fixed' envelopes. I therefore thought about transferring that impressive idea to another area. Of course, it is not the same issue, but I believe that a 'flexible' solution might have some advantages over the widely used 70/30 overbought/oversold level for the Relative Strength Index (RSI). Secondly, the RSI contains a great deal of information lying between the two above-mentioned levels that could probably be exploited in a more effective way by using a combination of 'traditional' charting and Fibonacci proportions. In my article, I investigate whether there is a possible advantage in looking at an indicator from a Fibonacci perspective rather than using only the default settings. I think that each market has its own 'character' and has therefore to be treated individually.

For example, Fibonacci proportions in indicators may act as a type of filter which will provide additional information for one's analysis.

## APPLICATION OF FIBONACCI RETRACEMENTS AND EXTENSIONS TO THE 14-PERIOD RSI

### The Relative Strength Index (RSI) by J. Welles Wilder Jr.

The RSI compares the strength of price advances in relation to price declines over a specified period. Overbought and oversold conditions are measured with the RSI (in contrast to trend indicators which show trend strength). The term 'relative strength' is slightly misleading because it does not show the relationship of two different securities; instead, it measures the internal strength of one security. It was developed by J. Welles Wilder Jr. in 1978 to overcome insufficiencies of 'simple' momentum oscillators. The RSI is (still) one of the most popular oscillators (some authors criticise the RSI as old-fashioned and almost useless; they suggest the use of 'state-of-the-art-indicators' such as the Projection Oscillator<sup>4</sup>). System tests by Bauer/Dahlquist failed to show that a RSI crossover system outperformed a 'buy-and-hold' strategy<sup>5</sup>. I do not wish to comment on the advantages or drawbacks of using that indicator in this article, because this has been done on many other occasions and my approach will be focused on how I use the RSI.

## CALCULATION OF THE RSI

Table 1

### Calculation of the 14-period RSI

The equation for the Relative Strength Index (RSI) is [see Table 1]:

$$RSI = 100 - [ 100 / ( 1 + RS ) ]$$

where:

$$RS (\text{Column G}) = \frac{\text{[Average of 14 days' closes UP (Column E)]}}{\text{[Average of 14 days' closes DOWN (Column F)]}}$$

#### DaimlerChrysler (DCX) in EUR

Col.	A	B	C	D	E	F	G	H	I	RSI (14)
Line	Date	Close	Pos. Chg	Neg. Chg	Up Avg	Down Avg	E/F	G + 1	100/H	100-I
5	01. Jul 99	86.86								
6	02. Jul 99	85.60	0.000	1.260						
7	05. Jul 99	87.51	1.910	0.000						
8	06. Jul 99	89.10	1.590	0.000						
9	07. Jul 99	88.92	0.000	0.180						
10	08. Jul 99	87.90	0.000	1.020						
11	09. Jul 99	88.65	0.750	0.000						
12	12. Jul 99	88.15	0.000	0.500						
13	13. Jul 99	87.68	0.000	0.470						
14	14. Jul 99	87.85	0.170	0.000						
15	15. Jul 99	87.85	0.000	0.000						
16	16. Jul 99	88.10	0.250	0.000						
17	19. Jul 99	87.60	0.000	0.500						
18	20. Jul 99	84.68	0.000	2.920						
19	21. Jul 99	83.50	0.000	1.180	0.3336	0.5736	0.5816	1.5816	63.2283	36.7717
20	22. Jul 99	82.20	0.000	1.300	0.3097	0.6255	0.4952	1.4952	66.8794	33.1206
21	23. Jul 99	80.31	0.000	1.890	0.2876	0.7158	0.4018	1.4018	71.3355	28.6645
22	26. Jul 99	79.18	0.000	1.130	0.2671	0.7454	0.3583	1.3583	73.6207	26.3793
23	27. Jul 99	78.62	0.000	0.560	0.2480	0.7321	0.3387	1.3387	74.6973	25.3027
24	28. Jul 99	80.00	1.380	0.000	0.3289	0.6798	0.4837	1.4837	67.3977	32.6023
25	29. Jul 99	74.00	0.000	6.000	0.3054	1.0598	0.2881	1.2881	77.6323	22.3677
26	30. Jul 99	71.20	0.000	2.800	0.2836	1.1841	0.2395	1.2395	80.6803	19.3197
27	02. Aug 99	70.51	0.000	0.690	0.2633	1.1488	0.2292	1.2292	81.3546	18.6454
28	03. Aug 99	71.10	0.590	0.000	0.2866	1.0668	0.2687	1.2687	78.8214	21.1786
29	04. Aug 99	70.90	0.000	0.200	0.2662	1.0049	0.2649	1.2649	79.0594	20.9406
30	05. Aug 99	69.47	0.000	1.430	0.2472	1.0352	0.2387	1.2387	80.7273	19.2727

**Column C:**  
if Close(today)>Close(yesterday)  
then Close(today) less Close(yesterday)  
else "0"

**Column D:**  
if Close(today)<Close(yesterday) ...

**Column E:**  
Line 19: Sum of Cells C6 to C19 divided by 14  
Lines 20ff.: [13x(Value E19) + C20] divided by 14  
(Column F analogous)

## THE FIBONACCI SUMMATION SERIES

Leonardo Pisano, known as 'Fibonacci,' was an Italian mathematician who lived in the 13th century. He described one of the most important mathematical presentations of natural phenomena ever discovered. The Fibonacci summation series is built by summing up the previous two numbers to form the next number. Table 2 illustrates this phenomenon.

**Table 2**  
**Calculation of the Fibonacci Summation Series and Retracement & Extension Levels**

Fibonacci Figures	Fibonacci Retracement Levels			Fibonacci Extensions		
	$n = n_1 + n_2$	$n = n_2 / n_1$	$n = n_1 / n_2$	$n = n_2 / n_1$	$n = n_1 / n_2$	$n = n_1 / n_2$
1	0.000000					
1	1.000000	0.000000		1.000000		
2	0.500000	0.500000	0.000000	2.000000	2.000000	
3	0.666667	0.333333	0.333333	1.500000	3.000000	3.000000
5	0.600000	0.400000	0.200000	1.666667	2.500000	5.000000
8	0.625000	0.375000	0.250000	1.600000	2.666667	4.000000
13	0.615385	0.384615	0.230769	1.625000	2.600000	4.333333
21	0.619048	0.380952	0.238095	1.615385	2.625000	4.200000
34	0.617647	0.382353	0.235294	1.619048	2.615385	4.250000
55	0.618182	0.381818	0.236364	1.617647	2.619048	4.230769
89	0.617978	0.382022	0.235955	1.618182	2.617647	4.238095
144	0.618056	0.381944	0.236111	1.617978	2.618182	4.235294
233	0.618026	0.381974	0.236052	1.618056	2.617978	4.236364
377	0.618037	0.381963	0.236074	1.618026	2.618056	4.235955
610	0.618033	0.381967	0.236066	1.618037	2.618026	4.236111
987	0.618034	0.381966	0.236069	1.618033	2.618037	4.236052
1,597	0.618034	0.381966	0.236068	1.618034	2.618033	4.236074
2,584	0.618034	0.381966	0.236068	1.618034	2.618034	4.236066
4,181	0.618034	0.381966	0.236068	1.618034	2.618034	4.236069
6,765	0.618034	0.381966	0.236068	1.618034	2.618034	4.236068
10,946	0.618034	0.381966	0.236068	1.618034	2.618034	4.236068
17,711	0.618034	0.381966	0.236068	1.618034	2.618034	4.236068
28,657	0.618034	0.381966	0.236068	1.618034	2.618034	4.236068
46,368	0.618034	0.381966	0.236068	1.618034	2.618034	4.236068
75,025	0.618034	0.381966	0.236068	1.618034	2.618034	4.236068
121,393	0.618034	0.381966	0.236068	1.618034	2.618034	4.236068
196,418	0.618034	0.381966	0.236068	1.618034	2.618034	4.236068
317,811	0.618034	0.381966	0.236068	1.618034	2.618034	4.236068
514,229	0.618034	0.381966	0.236068	1.618034	2.618034	4.236068
832,040	0.618034	0.381966	0.236068	1.618034	2.618034	4.236068
1,346,269	0.618034	0.381966	0.236068	1.618034	2.618034	4.236068

The Fibonacci Sequence plays an important role in science and art (for example, in architecture, biology and music). Technical analysts apply these proportions to their time series, namely prices. They look for retracement levels and extensions which are based on Fibonacci proportions. Incidentally, Fibonacci numbers are the mathematical foundation of the Elliott Wave Theory<sup>6</sup>.

The reason for using Fibonacci proportions derives from the theory that if you discover these proportions in nature and you assume that human beings (as a part of nature) behave in line with nature, then the actions (i.e. trades) of human beings should reflect these natural proportions and prices should follow the Fibonacci sequence, at least to a certain degree<sup>7</sup>. If we assume that prices do follow, then derivatives of prices (price-based indicators) should follow as well. Arguing over the veracity of the theory is beyond the scope of this article. That would be a philosophical matter. My objective is solely pragmatic: if it works, I shall use it.

**METHODOLOGY AND TESTING**

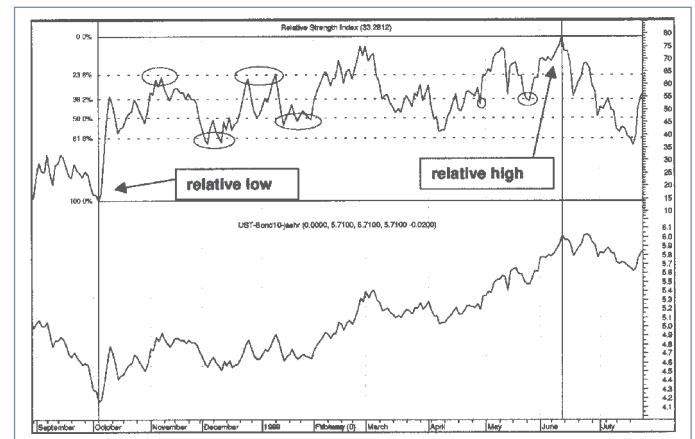
**Definition of Relative Highs and Lows**

We need a local (or temporary) high and a local low in the RSI in order to calculate the retracement or extension levels which could probably work in the future. I am looking back for any remarkable levels (see the circles in Chart 1) which give me an indication that they might work again in the future. I know this might

be criticised as subjective, but from my point of view this is part of a technical analyst's job. Skill, knowledge and experience are needed in any area in order to perform well. One might call this approach a type of 'visual backtesting,' but does this not also apply to support and resistance or trendlines in classic charting?

To clarify my approach, I shall give an example of my definition of relative highs and lows:

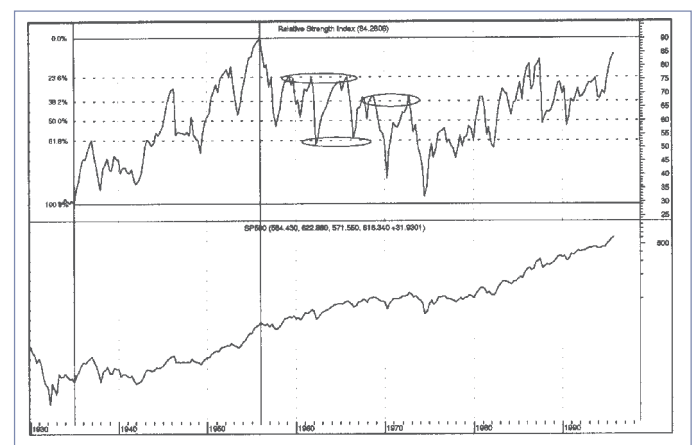
**Chart 1: 10-Yr. U.S. Treasury-Bond-Yield (daily)**



**Selection of Relevant Periodicity**

It is important to be aware of the type of data to be checked with regard to the degree of compression used. If you think about this topic in connection with Benoit B. Mandelbrot's theory of fractal structures in nature (a part of chaos theory) and you assume that the same structures (in the area of technical analysis chart patterns) do recur just in different scales, Fibonacci proportions in the RSI should be observed in every degree of compression. I checked daily, weekly, monthly and even quarterly (see Chart 2) data. Fibonacci proportions in the RSI have been identified by myself in every time frame. It therefore seems not to be an accidental observation. The question of whether it may add to the arsenal of technical analysis in order to generate above-average returns or to avoid extraordinary losses will be discussed later.

**Chart 2: S&P 500 Index (quarterly)**

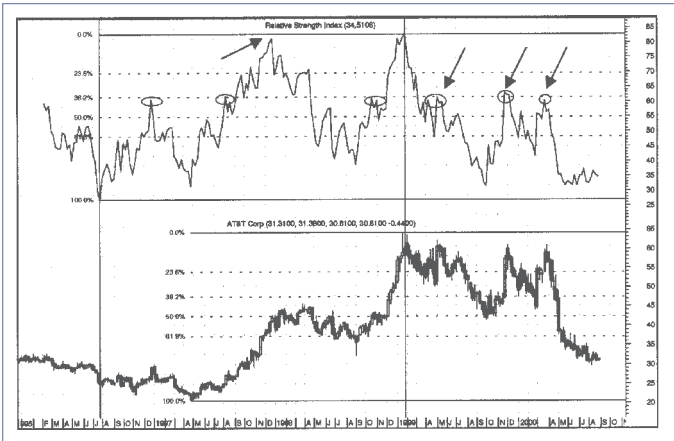


**RESULTS AND STRIKING OBSERVATIONS OF THE TESTS**  
**Tests of Various Markets**

The following tests are just a selection of the studies I made. These tests should show how I applied my approach to the various charts of equities, indexes, futures, currencies, commodities and even yields. Mostly, I focused on retracement levels, but Fibonacci extensions work as well.

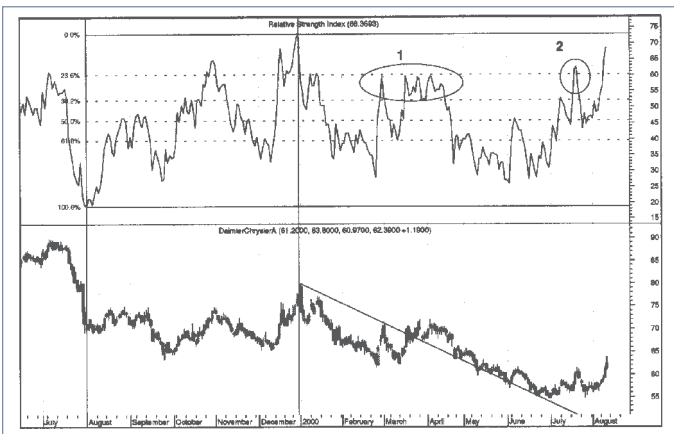
As I mentioned before, there is no 'holy grail' in technical analysis. No method works all the time. The strength of technical analysis is its combination of various tools and their application to an individual underlying. Nevertheless, I shall focus on Fibonacci proportions in the RSI and ignore other technical indicators in order to emphasise the key observations.

**Chart 3: AT&T (weekly)**



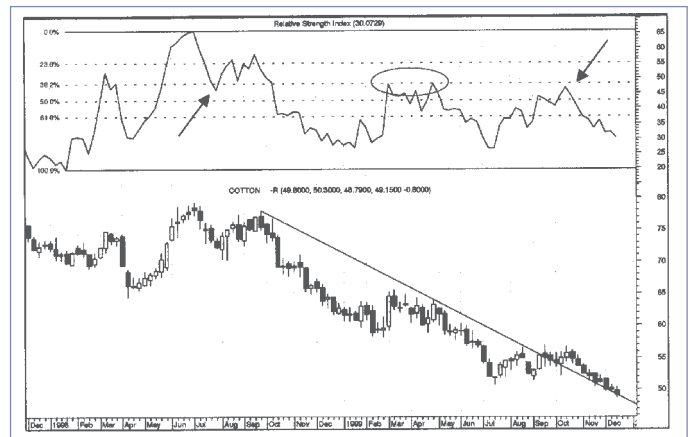
After the definition of the relevant high and low in the RSI (the look-back period is fairly long, I admit, but the use of the high [left-hand arrow] would not change much), it may be seen that the 38.2% retracement seems to be the most important level here (marked with arrows on the right). The failure to take out this level is an indication that the high (in price) will not be exceeded that easily. A trading idea based just on this observation (I do not recommend initiating trades based solely on this observation in real life!) could be the writing of at-the-money calls at the 38.2% level with a stop-loss on a decisive break ('decisive' means regarding a price or a time filter<sup>8</sup>).

**Chart 4: DaimlerChrysler (daily)**



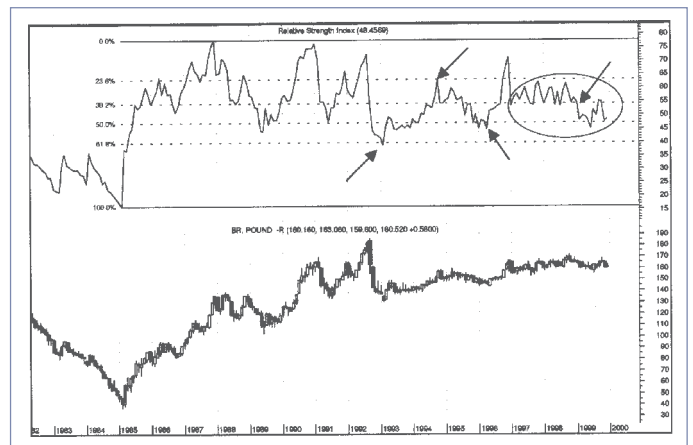
The 23.6% retracement level has been tested some times between the end of February and April 2000 (see label 1 in the chart). Although the short-term downtrend in the price chart was broken, the failure to take out the above-mentioned level in the RSI was – from my point of view – an indication of further weakness. In this case the Fibonacci/RSI-combination acted as a filter for a 'false breakout.' It is important to bear in mind, however, that false breakouts may even occur in your indicator from time to time (see label 2). I again recommend using a time filter, because no method works so precisely that there are just 'black-or-white' decisions. However, this is more a question of individual trading style or your 'risk appetite' and not of the method explained here.

**Chart 5: Cotton (weekly)**



We are able to identify some type of 'Fibonacci behaviour' in the RSI, not only in equities but even in commodities. How should we interpret that observation? In this context, the labelled level in the RSI shows the failure to take out the 38.2% retracement twice, which now acts as resistance (watch the left-hand arrow – before, it was a support area!)<sup>9</sup>. Thus, the least we can say is not to be going long before this level in the RSI, in this situation, is broken. The right-hand arrow shows the failure in the RSI even to touch the retracement level. The break of the downtrend in the price chart was therefore more than suspicious.

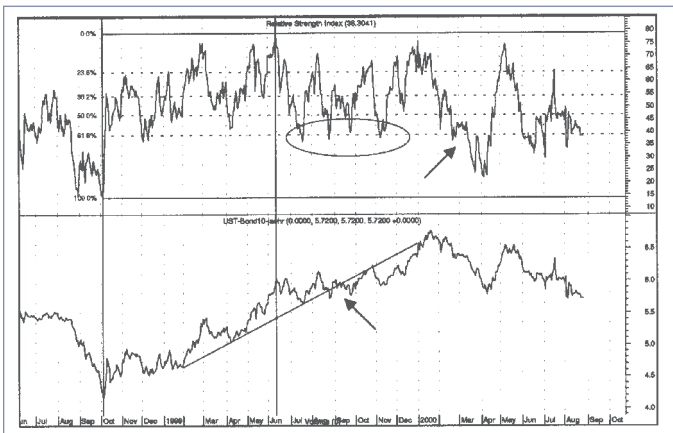
**Chart 6: GBP/USD (monthly)**



Here is a long-term chart of the relationship between pound Sterling and the U.S. dollar. Watch the arrows and you will immediately identify support and resistance levels in the RSI which coincide with Fibonacci retracements. These were also the turning points in the rate of exchange. The labelled area shows the movement of the GBP/USD ratio within a fairly tight boundary formed by the 23.6% and the 38.2% retracement levels. After the 38.2% level gave way [right-hand arrow], the next support area was the 50.0% retracement. It was tested briefly, and the market (i.e. the U.S. dollar) recovered.

One trading rule for this market could be to wait for a break of the 23.6% retracement and then to go short after the RSI is heading south. Clearly this produced very few signals (remember, it is a long-term chart!), but this suggestion might be considered for the unwinding of positions of long-term investors.

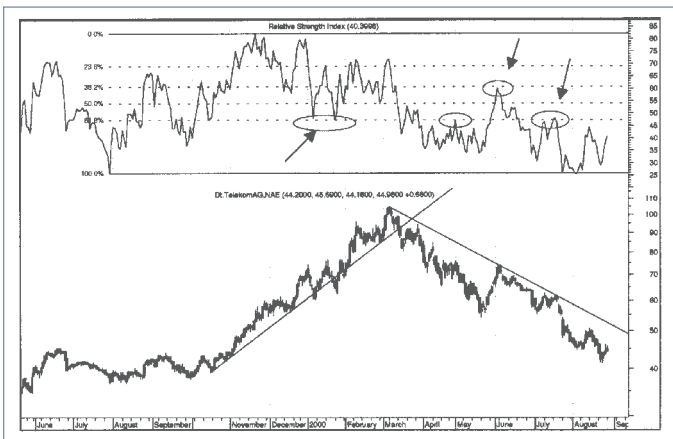
Chart 7: U.S. TBond 10-Yr Yield (daily)



Again, here is the question of whether you will trust that the uptrend of the 10-year yield has been successfully broken or not (see arrow at the bottom window). The support zone in the RSI (61.8% retracement) has been defended four times between July and October 1999 (see circle at the upper chart). That's from a Fibonacci point of view an indication that - at least - the uptrend in yields may not be over yet.

After the retracement was giving way (see arrow in the upper window) in March 2000, the yield went down sharply and the pullback, in RSI terms, stopped at the retracement level, which has now turned into resistance. The rally in the bond market (equivalent to falling yields) went on until the 61.8% retracement was broken.

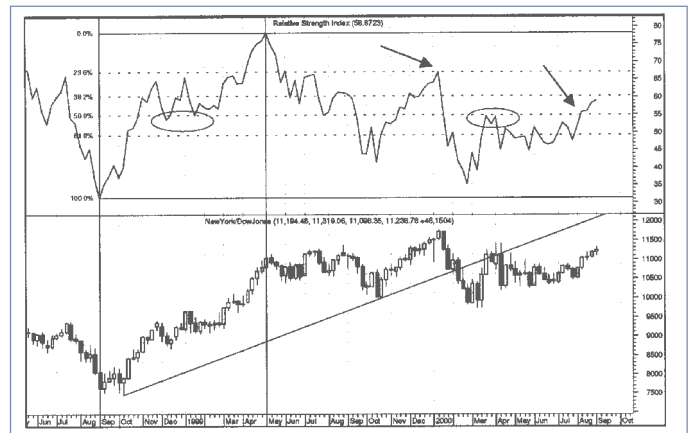
Chart 8: Deutsche Telekom (daily)



The fascinating bull run in Deutsche Telekom was not yet over after the steep upward trendline was slightly broken in January 2000. If your stop loss was too tight, you missed all the way up from about 62 € to an absolute high of more than 104 € in early March 2000. One possibility of not getting stopped out early could be watching the RSI. The 61.8% retracement was tested twice (watch the left-hand arrow) and it held.

After Deutsche Telekom went south, have a look at shorting opportunities. Watch the right-hand arrows: the price stopped at the down-sloping trendline, which coincided with the failure to take out the relevant Fibonacci retracements in the RSI.

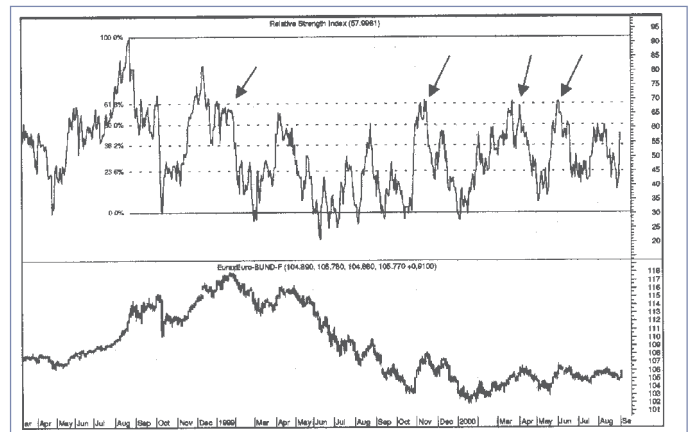
Chart 9: Dow Jones Industrial Average (weekly)



The Dow shows here that the 50.0% retracement in the RSI seems to be significant. After the breaking of the uptrend in the price chart in February 2000, the pullback stopped twice at the RSI resistance level. In early August 2000 (right-hand arrow), we broke the RSI resistance and the index moved higher. Altogether, the Dow is a fairly good example for studying Fibonacci behaviour in the RSI. The left-hand arrow points at the 23.6% retracement, where the index marked an all-time-high. In classic technical analysis this is called 'negative divergence,' because the new high was not confirmed by the indicator.

[At the time of writing this comment (Sept. 2, 2000) the next resistance level in the RSI (38.2%) has a value of 60.42. If you use the MS-Excel Solver application, you can simulate to what level of the DJIA this corresponds on the next (weekly) close [11,340 points]. If we fail to close above this level, it could be an initial indication that the upmove is decelerating and one should think about adjusting the stops.]

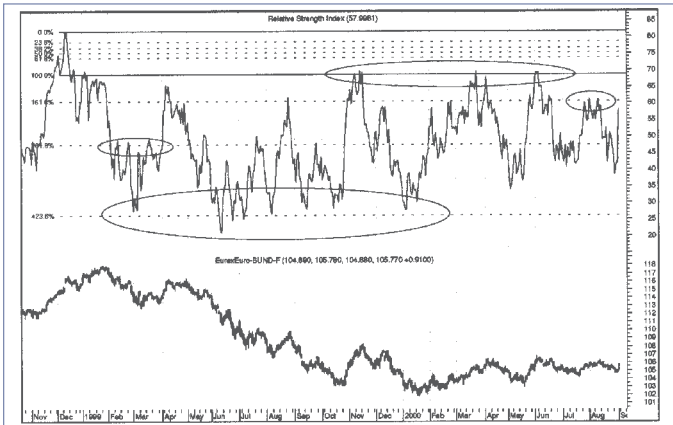
Chart 10: EUREX EUR-Bund Future (unadjusted/daily)



Here is a slight modification of the charts shown previously. The relevant (relative) low was not the absolute low in the RSI during the observed period. If you watch the arrows in the upper chart, it becomes clear that experience (question: which is the relevant level?) plays an important role and subjectivity is even required.

The major bear market was impressively confirmed by four (!) tests to take out the 61.8% retracement level, which all failed. The following chart shows almost the same period of time, but from a Fibonacci extension perspective. I have circled the relevant levels and it can be discerned that extensions could also support the interpretation of the current market state. Nevertheless, from my point of view, the use of retracement levels in comparison with extensions is more promising.

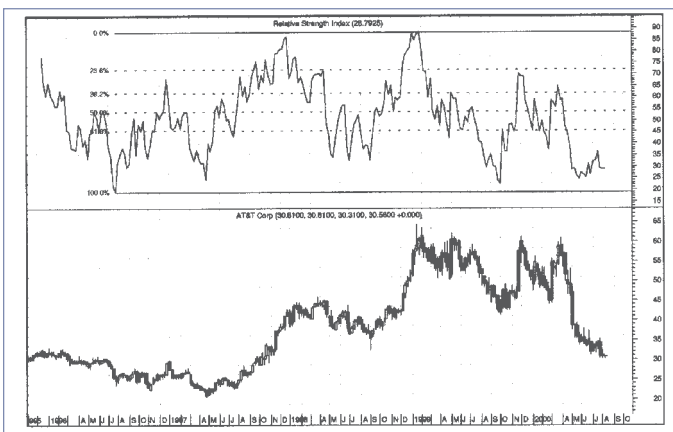
**Chart 11: EUREX EUR-Bund-Future with Extensions (unadjusted/daily)**



**DIGRESSION: MODIFICATION OF THE RSI**  
**Variation of the Number of Time Periods**

I performed some tests with (also recommended by some analysts) a 9-period RSI (see Chart 12) and a 13-period RSI (because it is the Fibonacci figure closest to Wilder's recommendation of 14 periods; but there was no visible improvement and so I did not pursue this work). The 9-period RSI was (naturally) more responsive, and I doubt that this might be an advantage while focusing on the 'major' penetrations of the retracement levels. There is too much 'noise' and that is why I prefer the smoothing effect of a 14-period RSI.

**Chart 12: AT&T (weekly) with a 9-Period RSI**



**Using the Close-to-Open-Difference in a (14-Period) RSI**

I modified the calculation of the RSI slightly in order to test if this improved or changed the outcome. I did not measure the close-to-close difference as it is done in the original formula (see Table 1). Instead, I replaced the close-to-close difference with the close-to-open difference (comparison of today's close with today's open). The motive: Wilder did not use open prices in his calculation. The importance of the 'opening price' was - from my point of view - stressed particularly by Steve Nison who brought 'candlestick charts' to the Western world [you need open and close prices for the body of a candlestick]<sup>10</sup>.

I therefore performed an alternative RSI calculation with some time series. Both RSI values were highly correlated (between  $\approx 0.9$  [time frame 4 years] and  $\approx 0.97$  [one year]) and my approach showed no significant advantage or disadvantage in comparison with the original formula and I did not perform any further testing (the correlation was lower in futures markets which had a couple of 'limit-up' or 'limit-down' days, but I do not trust in a market - nor

do I perform an analysis on a market - where the power play of supply and demand is grossly disturbed).

**CONCLUSION**

**Purpose of My Approach: Taking Advantage of the Area Between 'Overbought' and 'Oversold' Levels in the RSI**

Most traders and analysts use the RSI just when the indicator reaches its extreme readings, i.e. above 70 or below 30, while few look for classic chart information like patterns, support and resistance or divergences. The extreme zones, as their name implies, are touched and crossed not that frequently. But what does an analyst do when the indicator shows some repetitive behaviour in its 'normal' range? He tries to deduce some rules in order to evaluate future behaviour. That is what I did.

**Support and Resistance Levels**

The interpretation of the Relative Strength Index from a Fibonacci point of view shows that important support and resistance levels in the RSI (which are mentioned in J. Welles Wilder Jr.'s fundamental work) often - this is my observation - coincide with Fibonacci levels. This acts as a confirmation of 'valid' support and resistance in the RSI and could therefore be seen as an extension of Wilder's basic work.

Fibonacci proportions in the RSI seem to be useful for the discovery of 'hidden' support and resistance zones in the price chart which are not discovered at first glance. This is possibly the most important point of my article. Most of the time it is one specific Fibonacci retracement level in the RSI which is especially critical (e.g. 38.2% in Chart 3 or 23.6% in Chart 4, etc.). At this level supply and demand are in equilibrium. After the multiple test of such a level - whether it is successful or not - often a sharp move of the price in one direction is following.

I feel more comfortable with my analysis when I get something like 'independent' information on how to weight price action and having an early signal for what the market might do. All decisions in trading are never 100% certain, so my approach may increase the probability that you are on the right side.

**Identification of 'False Breakouts'**

Some of the previous examples showed the break of various trendlines on the price charts. As I mentioned before, a fully developed filter technique is needed to concentrate on valid breakouts in order to avoid whipsaws. A filter could be a time or a price filter on the one hand or on the other hand an indicator like the RSI. I would regard a breakout as a 'valid' one if it coincides with the successful penetration of a Fibonacci level, otherwise I would stay on the sidelines and take no action.

**CRITICISM**

Fibonacci proportions in the RSI have also some shortcomings. It is very difficult to program it and thereby difficult to lay the base for an automated trading system. That has to do with the necessary degree of subjectivity and experience in order to define the relative highs and lows. As I mentioned before, this approach is not a 'stand-alone' solution, nevertheless the focus of this article was solely on Fibonacci proportions in the RSI. It is just an additional instrument and should only be used in combination with other tools on offer to technical analysts.

It is not a complete trading system, therefore it is almost impossible to prove the value of my idea via backtesting in a style which is used in risk-management. But I think I have demonstrated the robustness of my approach in another way, by testing various markets (equities, yields, futures, indexes, currencies, commodities) and periodicities (daily, weekly, monthly, quarterly) and having showed that Fibonacci proportions in the RSI are not an accidental observation.

BIBLIOGRAPHY

- Richard J. Bauer/Julie R. Dahlquist, Technical Market Indicators, New York, 1999
- John Bollinger, Using Bollinger Bands, in: Technical Analysis of Stocks & Commodities, Seattle, 1992
- Robert D. Edwards/John Magee, Technical Analysis of Stock Trends, 6th Edition, New York, 1992
- Robert Fischer, Fibonacci Applications and Strategies for Traders, New York, 1993
- Erich Florek, Neue Trading-Dimensionen, Munich, Germany, 2000
- Joachim Goldberg/Ruediger von Nitzsch, Behavioral Finance, Munich, Germany, 1999
- Mark Jurik (Editor), Computerized Trading, New York, 1999
- Perry J. Kaufman, Trading Systems and Methods (3rd edition), New York, 1998
- John J. Murphy, Technical Analysis of the Futures Markets, New York, 1986
- John J. Murphy, Technical Analysis of the Financial Markets, New York, 1999
- Steve Nison, Japanese Candlestick Charting Techniques, New York, 1991
- Steve Nison, Beyond Candlesticks, New York, 1994
- Tony Plummer, The Psychology of Technical Analysis, Chicago, 1993
- Van K. Tharp, Trade Your Way To Financial Freedom, New York, 1998
- J. Welles Wilder Jr., New Concepts in Technical Trading Systems, Greensboro, 1978

ENDNOTES

- 1 J. Welles Wilder Jr., New Concepts in Technical Trading Systems, Greensboro, 1978, Section VI
- 2 for example: John J. Murphy, Technical Analysis of the Futures Markets resp. ... Financial Markets, New York, 1986 resp. 1999 or Perry J. Kaufman, Trading Systems and Methods (3rd edition), New York, 1998
- 3 John Bollinger, Using Bollinger Bands in: Technical Analysis of Stocks & Commodities, 1992, V. 10:2 (47-51)
- 4 Erich Florek, Neue Trading-Dimensionen, Munich, Germany, 2000, p.212 ff.
- 5 Richard J. Bauer / Julie R. Dahlquist, Technical Market Indicators, New York, USA, 1999, p.138 ff.
- 6 Robert Fischer, Fibonacci Applications and Strategies for Traders, New York, 1993
- 7 Psychology plays an important role in Technical Analysis (e.g. Tony Plummer, The Psychology of Technical Analysis, Chicago, 1993 or Van K. Tharp, Trade Your Way to Financial Freedom, New York, 1998 or Joachim Goldberg/Ruediger von Nitzsch, Behavioral Finance, Munich, Germany, 1999)
- 8 A helpful introduction into the application of filters: Averill J. Strasser, Developing a Trading system using Intermarket Analysis in: Mark Jurik (Editor), Computerized Trading, New York, 1999, Chapter 14, p. 236ff.
- 9 The importance of support and resistance levels is known since the beginning of chart analysis (e.g. Robert D. Edwards / John Magee, Technical Analysis of Stock Trends, 6th Edition, New York, 1992, Chapter XIII, p. 263 ff. (the first edition was published in 1948))
- 10 Steve Nison, Japanese Candlestick Charting Techniques resp. Beyond Candlesticks, New York, 1991 resp. 1994

BIOGRAPHY

I did not intend to present a trading system which is based solely on the ideas I developed. I understand technical analysis as a combination of various tools for the definition of entry and exit points of a trade, with a reasonably high degree of confidence that your investment will become profitable. My observations are not a pioneering innovation, but if only one reader of this paper takes a piece of my ideas which supports, completes or improves an existing trading strategy, that would be great!

Ingo W. Bucher, is a Member of VTAD, Germany. He wrote this paper in October 2000.

# Probability Predictions of Currency Movements: Judgement and Technical Analysis

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## INTRODUCTION

For the effective use of technical analysis in the volatile environment of the world's financial markets, it is important to realise:

1. the critical role played by human judgement, and
2. the need to enhance the analyst's ability to express this judgement in a probabilistic form.

Chartist techniques, which form the basis for technical analysis, are effectively based on human judgement. Currency movements are heavily influenced by prevailing market sentiments that manifest themselves via varying levels of optimism, pessimism and differing degrees of uncertainty in the minds of market participants. It is this mindset that the Chartist approach aims to capture by examining patterns in the time path of exchange rates. The efficient use of judgement in extracting information from the plethora of pattern swings and volume spikes requires not only an interpretation of the predicted movement (direction of change) but also an associated probability assessment (probability of a rise or fall) which accompanies the prediction. There is, therefore, a need for technical analysis techniques to express financial price movements in a probabilistic form. This can be achieved by calculating moving period estimated probabilities (EPs) from first differences in the logarithms over a specified period. EPs are based on the assumption that for a short number of data points (e.g., less than 50 days for daily data) the changes in the logarithms of currency series will be approximately Normally distributed with a stable mean and standard deviation. Over a longer range of data points, however, the distribution can be subject to changing means and standard deviations due to the influences of optimism, pessimism and uncertainty. In contrast to simple directional predictions or buy and sell statements, probability statements convey much more comprehensive and effective information to the user.

Probability statements, provided by analysts, need to be made in a framework that incorporates information on the nature and characteristics of exchange rate series. There are several issues that need to be considered in relation to the making of probability statements regarding currency movements. It is necessary to have a clear structure in the formation of probability statements, that is, to have a clear and appropriate statistical distribution in mind and to be able to form statements regarding the relevant parameters of the distribution. It is also necessary that, when the resulting probability statements have been formed, procedures are available to evaluate the accuracy and validity of probability predictions at the end of the predictive horizon. This provides valuable feedback that can be used to improve future probability predictions. EPs provide a natural method on which an analyst can base his/her judgemental probability predictions in a form that is consistent with the framework. These issues are examined below.

## TECHNICAL ANALYSIS AND THE ROLE OF JUDGEMENT

There are two distinct aspects of technical analysis: the traditional chartist approach and mechanical technical analysis. The effective application of human judgement in a technical analysis context requires a clear understanding of the distinction between the two approaches.

The chartist approach examines market action, primarily with the use of price charts, in order to predict future price trends. Chartists see the market price as encompassing all aspects of the market, and balancing all the forces of supply and demand. The chartist approach is subjective and its effective use depends on the

skill of the individual chartist. As such, charting is often described as an art rather than a science. Its effective use, therefore, depends heavily on the quality of the analyst's judgement.

Mechanical technical analysis, on the other hand, attempts to apply the chartist principles by using statistical analysis to quantify aspects of the chartist approach. This approach essentially attempts to convert the subjective principles of the chartist approach into quantitative indicators that can be mechanically used to signal buy and sell decisions. In practice, however, decision making is usually not that simple and the effective use of mechanical technical analysis requires a choice between a number of different indicators as well as input from traditional chartist approaches. Technical analysis as a tool for predicting financial price movements is heavily influenced by the analyst's judgement.

There are various problems associated with evaluating technical analysis techniques in practice. The appraisal of chartist techniques is difficult given their highly diverse and subjective nature. The chartist approach involves the subjective interpretation of financial price behaviour based on the underlying views of market psychology. There is, therefore, no direct method of evaluating individual aspects of the chartist technique, as the approach is holistic. It is only possible to examine the judgement of the individuals using the techniques via an examination of the realised financial price values after predictions have been made.

Mechanical technical analysis would, however, appear much easier to evaluate as the specific procedures are statistically defined. The problem, however, even in evaluating these techniques, is that there exists an element of judgemental interpretation as in the chartist approach. Mechanical technical analysis should be viewed as a guide to decision making and not as providing definitive answers.

Technical analysis can provide clear buy and sell signals and convey information about the confidence in such signals. But how can an analyst express this confidence? A probability statement with the directional prediction (e.g., the probability that a specific currency will have risen by the end of a 5-day period) provides this measure and conveys more comprehensive and useful information to the user than the directional statement alone. This is because the probability statement explicitly communicates the embedded uncertainty. This uncertainty reflects the degree of predictability and volatility in the market. Probability predictions are, however, more difficult to form than simple predictions of directional change.

## ESTIMATED PROBABILITIES, PROBABILITY PREDICTIONS AND THE STATISTICAL DISTRIBUTION OF CURRENCY MOVEMENTS

When directional probability predictions are made, the evaluating framework should provide a mechanism whereby information concerning the nature of currency movements can be incorporated. Keren's (1991) work suggests that analysts should be guided into using the appropriate distribution when making their predictions. The distribution should reflect the series that is being predicted. In the case of currency movements as well as movements of most financial series, it is appropriate to consider the changes (first differences) in the series from one data point to the next, rather than the actual series. In fact, as the magnitude of changes in

financial series is usually related to their levels, it is better to use first differences of the series after converting to logarithms. This results in a series that has the desirable statistical attribute of stationarity. That is, the mean and variance are constant over time and the autocovariance decreases as the lag increases. One of the features of financial series is that they are not, in general, stationary. In particular, the mean changes over time, the variance tends to increase over time, and first order serial correlation occurs with a value close to unity. In other words, the series tend to follow what is described by Nelson and Plosser (1982) as a difference stationary process. These authors distinguish between two different views concerning non-stationarity in economic time series: trend stationarity (i.e., stationary fluctuations around a deterministic trend) and difference stationarity (i.e., non-stationarity arising from the accumulation over time of stationary and invertible first differences). Within this framework difference stationary series, such as exchange rates can be made approximately stationary via the simple transformation of taking first differences (of logarithms) of the series. Taking first differences of a difference stationary series removes a linear trend and first order serial correlation of unity resulting in a differenced series with constant drift and zero first order serial correlation. Hence currency series are often described as representing a random walk with drift. It is the drift (trend in the actual series) that is of the most interest to the technical analyst.

It is important for the analyst to be aware of the difference stationary characteristic of currency series. Mechanical technical analysis approaches do not make the distinction between trend stationarity and difference stationarity clear. Some of the scepticism of mechanical technical analysis from statisticians arises from the fact that the mechanical techniques used do not appear to be related to standard statistical approaches and the difference stationary nature of financial series. Rather, mechanical technical analysis represents an ad-hoc application of chartist approaches with an attempt to remove the subjective elements. For example, the use of the standard deviation of the actual series in the construction of Bollinger Bands does not seem to take allowance of the fact that the standard deviation will not be constant over time and that over longer periods of time (e.g., over 50 days for daily data) there can be substantial changes in the mean and consequential changes in the standard deviation. The construction of bands, therefore, based on plus or minus two standard deviations from the mean, exasperates statisticians, particularly where reference to the Normal distribution is made, as actual values of a financial price series are extremely unlikely to be Normally distributed.

The present authors have shown, however, that using first differences of the logarithms results in currency series that, at least over a relatively small number of data points (fewer than 50 days for daily data) have a stable mean and variance, and serial correlation close to zero (Pollock and Wilkie, 1996; Wilkie and Pollock, 1996; Pollock, Macaulay, Önköl-Atay and Wilkie-Thomson, 2002). Over longer periods of time, this transformed series has time varying mean and standard deviation. This form of distribution is consistent with the technical analysis philosophy that history repeats itself and price action reflects human psychology (Murphy, 1999). For instance, chart patterns, which have been identified and categorised over the last century, reflect certain representations that frequently appear on price series graphs, representations that illustrate the bullish or bearish psychology of the market. The task of the analyst is to assess the nature of the price series pattern and extrapolate this into the future because the future is assumed to be a repetition of the past.

Psychological factors influencing market participants have a key effect on the distribution of changes in currency series. Changes in

exchange rates are the product of the diverse views of market participants - their optimism, pessimism and uncertainty. These views generate expectations that are aggregated to form the market sentiment that prevails in a particular period, in turn influencing the currency movements. The bullish and bearish sentiments in the market manifest themselves in a trend (non-zero mean drift in the original series). Primary trends may be viewed as lasting for more than one year and are perceived as reflecting the underlying sentiment of the market. As primary trends reflect the underlying psychology of the market they are more likely to continue than to reverse (Murphy, 1999). They are, therefore, associated with a relatively stable distribution over time. On the other hand, secondary trends are of much shorter term (i.e., one to three months) and basically mirror corrective actions of the financial players. For example, market participants may feel that short-term excessive bullish sentiment regarding a specific currency has been too strong in that the mean change has been excessively large; hence, they review their positions. This can result in a lower positive mean change or even a negative change in the short run reflecting a short-term reversal. Secondary trends can, therefore, cause the location parameter of the daily distribution to change in relatively short periods. This can explain why the mean of the distribution may be relatively stable over short periods of time but appears to change over longer horizons. In addition, the market will also be influenced by periods of stability and instability that are associated with collective uncertainty in the minds of the market participants associated with changing secondary trends. This causes variability in the dispersion parameter over relatively short periods of time.

One of the problems with technical analysis is that it does not easily fit into the statistical framework described above. The chartist's use of visual representations of the actual series is, of course, very relevant. The graph of the actual currency series represents a pictorial presentation of potential returns that could accrue to holding the asset. For example, if over a specific time period, the exchange rate for the Euro with respect to the USD (Euro/USD) rises from 0.8 to 0.9, an initial amount of \$1 million invested in euros at the beginning of the period would be valued at \$1.125 million (i.e.,  $0.9/0.8 * 1 = 1.125$ ) at the end of the period. The actual series, therefore, gives an insight into the underlying psychological factors such as fear, greed, and related uncertainties experienced by a breadth of market practitioners who will mainly concern themselves with what is happening to their returns from their positions. For the calculation of profit from a given position, however, it is necessary to consider the changes in the series over a period of time. The magnitude of these changes would, however, be related to the initial price. It is, therefore, appropriate to consider the percentage profit. In the above example, a profit of \$0.125 million or 12.5% would have been made. As noted above, in the analysis of currency series, it is desirable to examine changes in the logarithms of the series. These show similar statistical characteristics to percentage changes in the series. Some aspects of mechanical technical analysis do use changes in the series, particularly oscillators and measures of momentum, but they do not really take into account the characteristics of the series.

There is a need, therefore, to extend mechanical technical analysis to take these issues into account. It is a fairly simple procedure to construct the first differences in the logarithms of a series and then, after setting an appropriate moving period (e.g., 9 days for daily data), obtain the mean as a measure of drift (trend in the original series) and standard deviation as a measure of volatility. A graph of these differences, means and standard deviations will clearly display characteristics in the series and, in addition, highlight any extreme (daily) movements in a specific moving period.

This fairly simple presentation can aid the analyst in making a prediction of future directional movements as well as the magnitude of movements. Results given in the form of changes in logarithms can easily be converted back to actual changes.

The next stage is the calculation of moving estimated probabilities (EPs) using these mean and standard deviation measures. At least for a limited number of data points (e.g., fewer than 30 days for daily data), there is evidence that these movements approximately follow a Normal distribution (Friedman and Vandersteel, 1982; Boothe and Glassman, 1987; Pollock and Wilkie, 1996; Wilkie and Pollock, 1996; Pollock et al, 2002 have illustrated this in relation to currency series). The moving estimated probabilities can be obtained from the moving means and standard deviations discussed above on the assumption that the first differences of logarithms are Normally distributed. This involves using the Student's *t* distribution with degrees of freedom equal to the number of data points in the moving period less one (i.e., for a 9 day moving period the degrees of freedom would be 8). The Student's *t* value is calculated by taking the square root of the number of data points in the moving period (i.e., square root of 9 = 3) and multiplying this by the ratio of the mean to the standard deviation. Then the cumulative probability is calculated to give the EP. A more formal explanation of the procedure is set out in Appendix 1 and the calculation of estimated probabilities is more fully explained in Pollock et al (2002).

The moving period EPs can also be presented on a graph and used to examine the characteristics of the financial price movements and to make buy and sell predictions. These probabilities can be used as a technical analysis indicator that reflects the strength of the direction of movement and momentum. EPs not only provide an extension to the traditional momentum indicators used in technical analysis but also have considerable advantages over them. These advantages are:

1. An upper bound of unity and a lower bound of zero. Technical analysis momentum measures do not necessarily have this property although the Relative Strength Index (RSI) and Stochastic oscillators have similar bounds in percentage terms.
2. Statistically significant movements can be directly identified. For instance EPs with values below 0.025 and above 0.975 can be viewed as being statistically significant, at the 5% level, from the zero change condition. While the RSI and Stochastics provide overbought and oversold bounds (e.g., above 70% and below 30%) they are essentially ad-hoc and do not have a statistically defined meaning.
3. A profit or loss over the horizon, on which the EPs are calculated, can be easily seen. That is, values below 0.5 indicate a loss and values above 0.5 indicate a profit. The traditional technical analysis momentum measures, with the exception of the simple Momentum and Price Rate of Changes oscillators, do not do this.
4. Volatility is directly incorporated into the EPs via the inclusion of the standard deviation of changes (in logarithms) in their construction. Traditional analysis momentum indicators do not directly take into account volatility.
5. The EPs can be used to make a direct ex-post comparison with probability predictions made at the beginning of the prediction period. Hence probability predictions can be evaluated on an interval scale and not just on the buy and sell decision basis.
6. EPs of various horizons can be presented on a multiple EP graph, e.g., a two EP graph displaying the 9-day EPs and the 25-day EPs. In using a graph of multiple EPs the shortest EP (e.g., 9-day) is the most important in detecting changes in momen-

tum and indications of changes in trend and for timing purposes. The longer EP (e.g., 25-day) is used particularly to give a longer period view of the identify direction and strength of the trend. The use of multiple EPs has the advantage that the indicators can be used under various trend conditions. EPs can be used for daily, weekly and less frequent sampling intervals to determine actions in the presence of both secondary and primary trends moving in opposite directions and where there exists strong upward trends or flat trend conditions.

EPs are interpreted in a similar way to traditional technical analysis momentum indicators. They are, unlike the RSI, Stochastics and Moving Average Convergence / Divergence (MACD), equally applicable to trending and flat trend markets. In flat trend markets EPs will show activity as alternating values above 0.5 and below 0.5. In trending markets, however, EPs will tend to have values concentrated in the upper section of the chart (i.e., above 0.5) for upward trends and values concentrated in the lower section of the chart (below 0.5) for downwards trends. EPs also have the additional advantage that they can be used as an indicator of a change in the trend. This is shown up by large movements in the EPs. The interpretation of EPs is, like many technical analysis indicators, very dependent on the experience of the analyst using the technique. If a single EP is used it is generally better to use the EP chart in conjunction with a chart of the logarithms of the actual series. Traditional technical analysis can, therefore, be used in line with the EP approach. The multiple EP chart can, however, be used on its own as it contains much more market information than the single EP chart. A multiple EP chart can, however, be used in conjunction with other technical indicators.

#### FORMING PROBABILITY PREDICTIONS

In practice, when an analyst attempts to form probabilistic predictions for currency movements, it is critical for the supporting framework to effectively aid this process. Hence, it is essential that the adopted framework is

1. relatively easy to understand,
2. easy to use, and
3. flexible in allowing for quick predictions and updates.

The Normal distribution assumption with time varying means and standard deviations, in addition to being an appropriate specification for currency movements, provides such a framework. Specifically, for short periods of fewer than 50 days for daily data, the mean and standard deviations can be assumed approximately constant such that an analyst needs only to specify these two parameters in order to identify the subjective probability distribution. Furthermore, the framework can easily be extended to predictions for longer horizons. For instance, with weekly data on currency movements, Pollock and Wilkie (1996) illustrated that the Normal distribution is appropriate for predictions of up to a three-month horizon. With monthly data Wilkie and Pollock (1996) illustrated that it is appropriate for horizons of up to one year.

The assumption of Normally distributed changes in the logarithms of financial price series over short periods of time eludes the problem of identifying an alternative probability distribution. The three-stage procedure of forming subjective probabilities suggested by Cottrell, Girard and Rousset (1998) (i.e., the forecast of the mean (level), the standard deviation (scatter) and a normalised profile (shape)) is hence reduced to a two-stage procedure. That is, the formation of a subjective probability only requires subjective estimates of two parameters, the mean and the standard deviation of the distribution. From these assessments, a subjective prediction interval for the mean change may be obtained.

There are, however, a number of requirements for an analyst to make effective judgemental probability predictions (or point estimates, or predictions of directional change). In particular, the analyst has to:

1. possess “structural knowledge” (Kurz, 1994), including knowledge of the process generating the series (e.g., difference stationary) and the form of the probability distribution of change (e.g., Normal);
2. be able to construct subjective estimates of the parameters of the distribution (i.e., estimates of the mean and standard deviation);
3. be able to use these estimated parameters in the formation of probability predictions;
4. receive feedback on previous performance to enable comparisons with probability and parameter estimates obtained from the realised values of the series at the end of the predictive horizon.

To form probability predictions the analyst first needs to undertake some analysis of the series. This can be carried out using traditional technical analysis that could be supplemented using, for instance, the graphical presentations of the mean, standard deviations and probabilities discussed above. The latter would provide a benchmark from which the judgementally assessed means, standard deviations and probabilities could be formed. In addition, further statistical techniques could be used to support the analyst's efforts in constructing the judgemental predictions.

The analyst's next step, for a given predictive horizon, is to specify the subjective parameters (mean and standard deviation of the daily changes) and the probability of a price change over the predictive horizon. The stages involved in this process are:

1. make a subjective prediction for the daily mean change;
2. make a subjective prediction for the standard deviation of daily changes;
3. use these predictions to obtain a subjective Normalised Z value, which is equal to the square root of the number of data points in the predictive horizon multiplied by the ratio of the predicted mean to the standard deviation;
4. obtain the implied subjective probability via the cumulative distribution function of the Standard Normal; and
5. make any revisions to the subjective mean and standard deviation in the light of the derived subjective probability.

This iterative process can be continued until the analyst is content with the subjective mean, standard deviation and probability. A more formal explanation of this procedure is set out in Appendix 2.

Using the above procedure, an analyst can make probability predictions based on the Normal distribution. If, within this framework, an analyst gives a high probability for a positive move, as compared with a probability close to 0.5, it implies that he or she feels that the movement in the series, scaled by the standard deviation, will be a relatively large positive one. If the analyst gives a low probability for a positive move it implies that the analyst feels the movement in the series will be a relatively large negative one. On the other hand, if the probability is close to 0.5 it suggests the analyst feels that there will be little or no change in the series. In other words, the forecaster's assessment of the probability of a movement in a particular direction can be viewed as a transformation of his or her assessment of the subjective mean and standard deviation, via a cumulative distribution function, to the probability domain.

### EVALUATION OF PROBABILITY PREDICTIONS

It is also important for performance appraisal purposes that the forecasting performance is effectively evaluated at the end of the predictive horizon so that feedback becomes available on the accuracy of predictions. Specifically, at the end of the predictive horizon, a comparison of the subjective mean, standard deviation and corresponding probability can be made with the mean, standard deviation and associated probability estimated from the series. This can be extended to calculating values for a number of consecutive, non-overlapping periods (that form the whole period) to evaluate the accuracy of the predictions. These results can then be used to identify strengths and weaknesses in the predictions, highlighting areas for improvements in predictive strategies and pinpointing additional information needs. The framework can easily be extended to compare recommendations given by an analyst grouped into a number of categories. For example, an analyst could set bands for the GBP/USD exchange rate associated with probability statements as follows:

- 0 to 0.2 – buy USD assets and sell GBP assets;
- 0.21 to 0.4 – hold existing USD assets but reduce holdings of GBP assets;
- 0.41 to 0.59 – attempt to balance holdings of USD and GBP assets;
- 0.6 to 0.79 – hold GBP assets and reduce holdings of USD assets, and;
- 0.8 to 1 – buy GBP assets and sell USD assets.

The estimated probabilities and analyst's recommendations can then be presented, and grouped, into a simple cross tabulation to provide a straightforward method of examining the analyst's predictive performance.

### CONCLUSION

It is illustrated that moving period EPs can be used to examine financial price movements and generate buy or sell signals in a profitability context. These EPs measure the strength and momentum of market movements in an integrated form that gives considerable advantages over traditional analysis momentum indicators. Furthermore, they are derived from a statistically formulated framework based on the Normal distribution and the behaviour of currency. Accordingly, these EPs do not suffer from the problem often associated with mechanical technical analysis tools that may portray ad-hoc measures of chartist concepts. The framework also has considerable practical application to the evaluation of predictive performance when probability recommendations are made accompanying the prediction of a directional move.

The suggested framework set out above may carry considerable advantages in the practical formation of probability recommendations accompanying directional predictions of currency movements. Firstly, the process involves the setting of probabilities where the forecaster has a clear probability distribution defined (i.e., Normal). Secondly, the formation of probabilities is integrated into a process that incorporates predictions inherently framed by views as to future optimism and pessimism in the market (mean) and volatility (standard deviation). That is, the construction of predictive probabilities is directly related to forecasts of exchange rate changes and the uncertainties that prevail. Thirdly, the framework allows the performance of subjective predictions of all three components (mean, standard deviation and probability) to be evaluated using estimates at the end of pertinent predictive horizons, hence utilising the information content of forecast errors. It has been suggested that the uncertainty enveloping the point and directional forecasts may better be expressed in formats that explicitly recognise and communicate this uncertainty, e.g., via prediction intervals (Chatfield, 1993) or probability forecasts (Murphy and Winkler, 1984)). The procedure set out above provides a promising framework that clearly acknowledges the financial dynamics resulting

from prevailing uncertainties in such markets.

The framework described in this paper has considerable implications for technical analysts. It may be argued that subjective probability predictions need to be made in an integrated framework that allows for explicit performance feedback (Önkal-Atay, 1998). This framework should be related to the statistical distribution of the series being predicted, with subjective predictions of the parameters of the distribution elicited in addition to the subjective probabilities. Performance analysis can then be directly applied to the subjective predictions using realised estimates to provide valuable feedback to further enhance performance. In practice, it has been illustrated that the Normal distribution tailors an appropriate model of changes in the logarithms of currency series for forming subjective probabilities on tactical market movements. The suggested framework further provides a foundation for the development of consistent subjective probability predictions for currency movements while enabling promising extensions of current work on probability judgement accuracy such as combining probability currency predictions.

#### APPENDIX 1

##### Calculating Estimated Probabilities

The procedure for obtaining the estimated probabilities is detailed below.

Specifically the framework involves the following stages.

- 1 For day  $i$ ,  $i=1,2,\dots,n_j$ , for a moving period  $j$  of length  $n_j$ , let  $\Delta x_{ij} = x_{ij} - x_{i-1,j}$  denote the change in the logarithm of the exchange rate. The mean of the daily changes,  $m_j$ , is then obtained.
- 2 The standard deviation of the daily changes,  $s_j$  is calculated.
- 3 The quantity,  $t_j$  is obtained where  $t_j = \sqrt{n_j} (m_j/s_j)$ .
- 4 The cumulative probability  $F(t_j) = P(t \leq t_j)$  is calculated, where  $t$  has Student's  $t$  distribution with  $n_j - 1$  degrees of freedom. This quantity gives the estimated probability. Values greater than 0.5 indicate a rise in the rate and values below 0.5 indicate a fall in the rate.

To illustrate this framework and calculation of estimated probabilities, suppose that the GBP/USD exchange rate moves from an initial value of 1 GBP=1.60 USD in Day 0 to a value of 1 GBP=1.65 USD in Day 5 as given below:

Day No.	0	1	2	3	4	5
Ex. Rate (X)	1.60	1.61	1.59	1.62	1.64	1.65
Log. Ex. Rate ( $x$ )	0.20412	0.20683	0.20140	0.20952	0.21484	0.21748
Change Log. Ex. Rate ( $\Delta x$ )		0.00271	-0.00543	0.00812	0.00533	0.00264

The first row gives the day number and the second row gives the exchange rate. The third row gives the logarithms to base 10 of the exchange rate. The fourth row gives the first differences in the logarithms of the rate. It is this last row that provides the basic input data to derive the estimated probabilities.

The four stages used to derive the estimated probabilities for this series can be applied as follows:

1. Calculate the mean,  $m = 0.00267$ .
2. Calculate the standard deviation,  $s = 0.00506$ .
3. Obtain the  $t$  value,  $t = \sqrt{5} (0.00267 / 0.00506) = 1.182$ .
4. Obtain the cumulative probability,  $\Phi(1.182) = P(t < 1.182) = 0.849$ , using Student's  $t$ -distribution with  $n-1 = 4$  degrees of freedom.

The estimated probability is then 0.849, corresponding to a rise in the exchange rate.

#### APPENDIX 2

##### Forming Probability Statements

The stages involved in the process of forming subjective probability statements are set out below:

- 1) Make a subjective prediction for the mean ( $\mu$ ).
- 2) Make a subjective prediction for the standard deviation ( $\sigma$ ). This can involve a direct or an indirect assessment. Indirect assessment would require the subjective specification of a symmetric  $(1 - \lambda)100\%$  confidence interval. The standard deviation would then be directly obtained from the upper confidence limit  $c^*$  such that  $\sigma = [(c^* - \mu)\sqrt{n}]/Z_{\lambda/2}$ , where  $n$  is the length of the predictive period and  $Z_{\lambda/2}$  is the upper critical value from the Standard Normal distribution. (e.g., for a 95% confidence interval  $Z_{\lambda/2}$  is 1.96).
- 3) Use the  $\mu$  and  $\sigma$  estimates to obtain a subjective Normalised  $Z$  value, where
 
$$Z = \sqrt{n} (\mu/\sigma).$$
- 4) Obtain the implied subjective probability ( $\alpha$ ) via the cumulative distribution function ( $\Phi$ ) of the Standard Normal, where
 
$$\alpha = \Phi \{\sqrt{n} (\mu/\sigma)\}.$$
- 5) Make any revisions to the subjective mean and standard deviation (i.e.,  $\mu$  and  $\sigma$ ) in the light of the derived subjective probability ( $\alpha$ ). This iterative process can be continued until the analyst is content with the subjective mean, standard deviation and probability.

## REFERENCES

- Boothe, P. & Glassman, D. (1987). *The Statistical Distribution Of Exchange Rates: Empirical Evidence And Economic Implications*. Journal of International Economics, 2, 297-319.
- Chatfield, C. (1993). *Calculating Interval Forecasts*. Journal of Business and Economic Statistics, 11, 121-135.
- Cottrell, M., Girard, B. & Rousset, P. (1998). *Forecasting The Curves Using A Kohonen Classification*. Journal of Forecasting, 17, 429-439.
- Friedman, D. & Vandersteel, S. (1982). *Short Run Fluctuations In Foreign Exchange Rates: Evidence From The Data, 1973-79*. Journal of International Economics, 13, 171-186.
- Keren, G. (1991). *Calibration And Probability Judgements: Conceptual And Methodological Issues*. Acta Psychologica, 77, 217-213.
- Kurz, M. (1994). *On The Structure And Diversity Of Rational Beliefs*. Economic Theory, 4, 877-900.
- Murphy, A.H., & Winkler, R.L. (1984). *Probability Forecasting in Meteorology*. Journal of the American Statistical Association, 79, 489-500.
- Murphy, J.J., (1999), The Technical Analysis of Financial Markets, New York Institute of Finance, Paramus, New Jersey.
- Önkâl-Atay, D. (1998). *Financial Forecasting with Judgment*, in G. Wright and P. Goodwin (eds.) Forecasting with Judgment, Chichester: John Wiley & Sons, 139-167.
- Nelson, C.R. & Plosser, C.I. (1982). *Trends And Random Walks In Macroeconomic Time Series: Some Evidence And Implications*. Journal of Monetary Economics, 10, 139-162.
- Pollock, A.C., Macaulay, A., Önkâl-Atay, D. & Thomson, M.E. (2002). *Consistent Probability Currency Predictions Between Related Cross Rates*.
- In K.D. Lawrence, M.D Geurts and J.G. Guerard Jr. (eds.). Advances in Business and Management Forecasting, Volume 3. JAI, Oxford, 161-175.
- Pollock, A.C. & Wilkie, M.E. (1996). *The Quality Of Bank Forecasts: The Dollar-pound Exchange Rate, 1990-1993*. European Journal of Operational Research, 91, 306-314.
- Wilkie, M.E. & Pollock, A.C. (1996). *The Application Of Probability Judgement Accuracy Measures To Currency Forecasting*. International Journal of Forecasting, 12, 25-40.

## BIOGRAPHIES

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# The Need for Performance Evaluation in Technical Analysis

## *A Critical Study of Performance Statistics for Trading Systems in Changing Market Behavior*

Felix Gasser

### INTRODUCTION

#### The Importance of Performance Evaluation

Technical analysis (TA) is defined as the analysis of pure market price movement as a time series. Although this is a clear definition, anyone who has read a book on TA knows it's not necessarily that straight forward. If we include all the tools and theories labeled technical – from the highly scientific to the rather esoteric – the subject can become controversial and confusing.

The flood of technical instruments has turned TA into an alchemist melting pot, resulting in skepticism especially among the academic community. On the other hand, the influx from other disciplines, most of all statistics and the computer sciences, has added powerful analytical tools, strengthening the position of TA as a valid discipline in the investment community and increasingly in academia as well.

The question of who can now be the objective judge of what is valid and what is not can only have one answer. Consequently, it must be determined by the resulting investment performance measured in dollars and cents. Valid are those strategies which give us, in the long run, a financial edge in the market. It is the aim of this article to explain and highlight the importance of performance results as an instrument to evaluate indicators, strategies and market behavior. I will discuss the pros and cons of standard performance figures and add some of the tools I have developed.

### TOOLS AND DEFINITIONS

#### Trading Report Performance Summary

There are an increasing number of technical analysis tools on the market. Most charting packages – especially those included by data-service providers – are limited to visual display, without the option of a statistic performance evaluation. The main handicap of visual charting is the deception of the naked eye, when it subjectively tries to recognize pattern. On the other hand, a strategy defined as an algorithm in the form of a trading system produces clear cut buy and sell levels, resulting in a detailed performance report in dollars and cents. Regardless of what is used for analysis, whether a simple spreadsheet or complex proprietary software, one has to be concerned with the same questions regarding performance figures. Accordingly, this article is not only aimed at the classical, visual chartist, but also at users of high-end analytical tools, which provide ready-made performance statistics. While the second group especially runs the risk of drawing wrong and overly optimistic conclusions from their ready made performance reports, the chartist usually does not know the performance statistics of his trading approach at all.

#### Definitions of Performance Data

**Net profit:** The total amount of dollars made or lost by a trading strategy during an observed test period.

**Max drawdown:** The drawdown is the equity decrease from a previous equity high. The max drawdown is the dollar amount (or better the percentage) of the largest equity drop. Remember the drawdown in percentage is not symmetric, a 50% drop needs a 100% recovery to equal the same net equity. The unrealized largest drawdown of a single trade is called the maximum adverse excursion.

**Runup:** The opposite of the drawdown, the max runup is a strategy's maximum profit gain during the course of trading. The runup during a single trade is the maximum profit potential called the maximum favorable excursion of a trade.

#### Trade efficiency:

Long trades = (exit price - entry price) / (highest - lowest price)

Short trades = (entry price - exit price) / (highest - lowest price)

Trade efficiency measures the efficiency as a percentage of how close to the top and bottom within a trade the entry and exit was placed. Unrealized runups for example, are accounted for with a loss of efficiency. Unfortunately, the price moves before the entry and after the trade exit are not accounted for, which severely limits the value of the efficiency numbers. This excludes opportunity losses before a potential trade and after an actual trade. Stopped-out trades on the other hand are considered to exit at the lowest and worst level of a trade and are not credited for avoiding what could have been a possible ruinous equity drop. This results in consistent lower ratings for the exit-efficiency versus the entry-efficiency and severely limits the use of trade efficiency ratings as a whole.

**Largest loser:** Is the largest losing trade and can be directly controlled with the stop loss.

**Average profit per trade:** The average profit or loss of all winning and losing trades. This figure is especially crucial for short-term and intra-day trading and must be large enough to account for all trading costs.

**Percent profitable:** The percentage of winning trades produced by a trading strategy. Trend-following strategies have a winning percentage of 35% to 45%. Although they have more losing trades, these strategies are profitable because winners are larger than the more frequent, but smaller, losers. These strategies are much less focused on predicting the next market move, but more on letting their profits run. A percentage under 30% is dangerous and carries a high probability of financial ruin. There are few strategies with over 50% winning trades because they need the rarely successful element of predicting the next market direction after trade entry. Strategies with over 50% should be carefully performance tested. They are usually a result of over-optimization (curve fitting), or too tightly set stop losses, resulting in many winners, which are critically smaller compared to losers.

**Average winner to loser:** This is the counterpart performance figure of percent profitable and measures the ratio of the size of winners to losers. An average winner to loser of 2.5 would mean that winners are, on average, 2.5 times bigger than losing trades. For all strategies with 35% to 50% winning trades, we look for a ratio over 2. Anything under 1.5 can again be ruinous.

**Number of trades:** The number of trades is crucial for statistical relevance. In a random environment, we would need at least 30 trades for a sound statistical sample. Since we often carry out testing in a non-random environment (hopefully so) of unknown distribution, we look for as many trades as possible before we draw conclusions regarding the robustness and profitability of a strategy. Since testing of one strategy on one market (one market system) produces not enough trades, the same strategy has to be tested across many markets for relevance of performance results.

**Definitions Of Market Conditions**

**Trends:** One-directional price moves that can last for months, but include moves of small magnitude as well. Statistically, trends are serial-correlated moves, in which a higher price has a higher probability to be followed by another price rise again and vice versa. This leads to a series of correlated climbing or falling prices. Moving averages are a statistical tool to capture such serial correlation. If they (usually 2 averages) are systematically profitable over time a trending price chart is underlying.

**Monetary definition of trend:** The point of interest from a trading perspective is how long a directional move has to be to qualify as a trend. As traders, we look for a definition in terms of dollars and cents. A trend has the size of a move long enough to allow us to recognize it as directional and to enter it. On the exit side, we again need the time to recognize the end of the move and to exit it. The trading profit from the trend movements after deducting all costs has to be large enough to cover all unprofitable small moves (false breakouts). In a random market, the unprofitable false breakouts will kill off all profits of the longer moves. If strategies like trend-following breakouts or moving-average systems are profitable in the long run, we have a certain degree of trending tendency in the market, which is also called black noise.

**Black noise:** Market behavior which is partially random and partially trending. Black noise is what we recognize as trending movement, like most of the interest-rate markets. Even the most favorable trending markets do not trend all the time; they are a mix of randomness and directional correlated moves, which result in black noise. Black noise can be profitably traded.

**White noise:** This is pure randomness. In a purely random market, we will always lose money, at least at the same rate of the occurring trading costs. We will experience financial ruin with mathematical certainty in the long run. Markets have changing and different degrees of randomness. Pure white noise cannot be profitably traded. Modern Portfolio Theory taught at most business schools, assumes random markets with a natural distribution. Most price charts display trends with accordingly fat tail distributions (similar to a Levy-Pareto distribution).

**Pink noise:** This is price behavior in which the direction changes more often than randomly. The fast-reversing price direction is typical for range-driven markets and short-term price action. This reversing-price behavior can be illustrated and measured with the parameter distribution resulting from an optimization of an inverted-trend-following strategy. Pink noise can be profitably traded within an unknown and limited time frame. The lag in recognizing the beginning and end of the process constitutes the risk and cost of range trading and limits its practical use virtually to zero. I have not yet come across a stable and profitable range trading strategy.

**PRACTICAL USE OF PERFORMANCE TOOLS**

All tests in this article have been performed with Trade Station and Excel. The concept and ideas do, however, apply to all technical analyses and are not limited to these programs.

**Total Net Profit (NP)**

Since the performance of an indicator or a trading strategy cannot be reduced to one number, technical analysts look at several performance figures to assess risk and return. Of these numbers, total net profit is still the most popular single figure to be optimized. This is not necessarily wrong as long as it does not involve curve fitting and is not done at the cost of uneven performance distribution over time. In particular, tests that only show the final summary reports can obscure the fact that a strategy resulted in total losses several times before it showed a profit. Even if we exam-

ine additional data like maximum drawdown, average annual return or the Sharpe ratio, we cannot see the entire picture. All performance numbers measured at the end of a trading or test period can hide the fact that we earned all profits within one trend, which could have been years ago. There is a need to visualize net profit in form of a chart in order to see the performance data over time.

This allows us to observe performance throughout its entire development and evaluate the probability of future profits in changing markets. The display of single equity curves is available in programs like Trade Station. However, it is better for analysts to custom-build equity curves in a spreadsheet for the following reasons:

- To compare the performance and correlations of different strategies
- To display many P+L curves on the same printout
- To display performance as a percentage of invested capital for comparison of markets
- To compare trading strategy results in different currency denominations
- To add equity curves to market or system baskets and to entire portfolios
- To produce all the necessary performance statistics of combined P+L curves
- To produce the raw material for equity-curve trading
- And finally, to produce great marketing material

The first step in producing equity curves involves sending performance data for each bar of the chart to a file. We can do that in the form of an indicator applied to the chart. For Trade Station, I have written the following indicator that sends all requested performance data to an ASCII file, which can be opened and charted in Excel or Lotus. The input of the indicator allows us to enter the initial margin or starting capital for the market. As soon as the indicator is applied to a chart with a trading system, the accrued, daily percentage return of the initial margin is exported. The resulting graph displays accrued percentage returns over time.

**Indicator to send Performance Date to ASCII file**

```

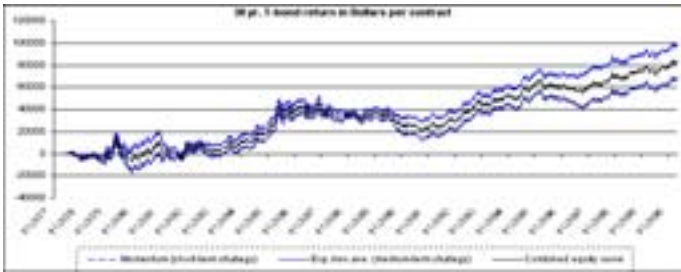
Input: InitialMargin(1600);
vars:OpenEqu(0), TotalEquity(0), RPP(0),PP(0);
{-----}
{This step is only for Trade Station users! It corrects the bug of a wrong open equity function}
OpenEqu=(I_OpenEquity-I_ClosedEquity); TotalEquity=I_OpenEquity;
{-----}
{Accrued P+L in Percent} {Daily P+L change in Percent}
RPP=(TotalEquity/InitialMargin*100); PP=(TotalEquity-TotalEquity[1])/InitialMargin*100;
{-----}
{Sends the accrued and the daily returns to ASCII file}
Print(file("c:\Performance\T-Note.txt"),FixDate(date),",",RPP:4:0;"," PP:3:2);
{-----}
{Plots indicator to screen}
Plot1(RPP,"RPP"); Plot2(PP,"PP");
    
```

The following function called FixDate has to be used with the indicator above to send correct dates after 1/1/2000 from TradeStation to Excel.

**Correction ELDate Function**

```

Inputs: DateSelect(Numeric); Variables: YearPortion(""), StringMonth(""), StringDay("");
YearPortion = NumToStr(1900 + IntPortion(DateSelect * .0001), 0);
If DateSelect >= 1000000 Then StringMonth = MidStr(NumToStr(DateSelect, 0), 4, 2) else
StringMonth = MidStr(NumToStr(DateSelect, 0), 3, 2);
StringDay = RightStr(NumToStr(DateSelect, 0), 2); FixDate = YearPortion + StringMonth + StringDay
    
```



If we look at the equity curves of the two strategies, we see the typical performance gap of the U.S. 30-year Treasury bond from 1986-1991. Most strategies on T-bonds had the same performance difficulties during these years. After 1991, we see good results coming from the medium-term exponential moving average. But the short-term momentum strategy never picked up again, which suggests that it is the wrong strategy for T-bonds.



On the U.S. 10-year T-note, the two strategies perform in reverse order. The momentum strategy performs better than the exponential moving average from beginning to end. Interestingly, it also performs during the difficult 1986-1991 period. The performance comparison of different strategies during varying market behavior gives us useful feedback on both trading strategies and markets. As expected, for a trend-following strategy, the performance of the exponential moving average is heavily dependent on a few, strong trends, and it is advisable that it not be used alone. Although the shorter-term momentum clearly performs better on the T-note, we could choose a position that is split between the strategies to produce a combined equity curve seeking lower volatility and a better Sharpe ratio.



The good news emanating from the combined equity curve is that drawdowns are minimal. The bad news is that the period from 1986-1991 is still a non-performing flat-line period. This chart demonstrates the following points:

- After long periods of non-trending price action, a market can come back to trends
- Most profitable strategies produce similar equity curves in the same market
- Equity curves of trading systems are good indicators of a market's underlying price behavior

### DRAWDOWN AND MAX DRAWDOWN (DD AND MaxDD)

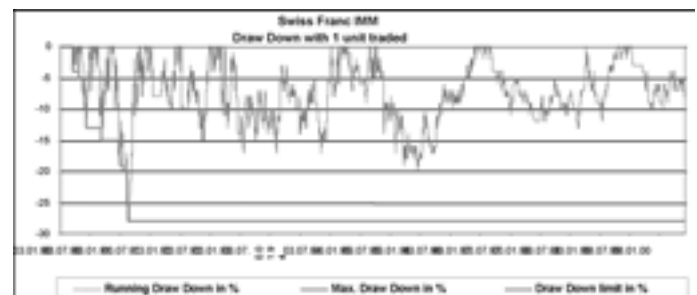
Most trading strategies are in a drawdown state from their last equity high up to 70% of the time. It is important to accept this fact psychologically, and it should encourage efforts to diversify as much as possible. Drawdowns are the result of the size and frequency of losing trades. The size of losing trades can be controlled with a stop-loss. But the frequency of losing trades cannot be easily controlled since it results from the interplay of trading strategy logic and the underlying market behavior, which falls often into randomness. Max drawdown is the largest historical equity dip and has become one of the most widely used measures of risk. In order to compare drawdowns of strategies in different markets, they should be measured as a percentage of capital, referring to the last equity high as 100%. Most software packages calculate DD only in reference to the starting capital, which is dangerous and produces overly optimistic risk expectations, resulting in over-trading and ruin with mathematical certainty as time progresses. Equity swings above the initial starting capital - i.e. from 150% back down to 120% - constitute the same risk as a drop at the beginning of trading. An analyst has to assume that trading can start at any given point in time, including the worst possible moment. Importantly, we may be forced to apply reinvestment, regearing or money management to our trading strategy. From a risk point of view, each time the position size is increased a new trading start is initiated.

The following is the formula of an indicator I have written in Trade Station to calculate the percentage MDD and the daily DD for every bar. It allows us to enter initial starting capital and set a DD limit. If this limit is crossed, an alert is shown.

#### Draw Down Indicator

```

Input: StartEqu(20000), -DDLimit(20);
Vars: MyEquity(0), HighEquity(0), DD(0), MxDD(0), PrcDD(0), MxPrcDD(0), MxCount(0),
TextNumber1(0), TextNumber2(0);
{-----}
[Calculates Draw Down and Max. Draw Down in percent]
MyEquity=StartEqu +I_OpenEquity;
if MyEquity>HighEquity then HighEquity=MyEquity;
DD=HighEquity-MyEquity;
If DD>MxDD then MxDD=DD;
If HighEquity<>0 then PrcDD=DD/(HighEquity/100);
If PrcDD > MxPrcDD then MxPrcDD = PrcDD;
{-----}
[Plots indicator and text to screen]
Plot1(Round(Neg(PrcDD),1),"Current%DD");
Plot2(Round(Neg(MxPrcDD),1),"Mx%DD");
Plot3(Neg(DDLimit)," StopLimitDD");
If Plot2 crosses under Plot3 then begin
Value97=Text_New(Date, Time, High+(C/80), "Close of account");
If GetBackgroundColor=1 then
Value98=Text_SetColor(Value97, Tool_Cyan)
Else begin If GetBackgroundColor<>1 then Value99=Text_SetColor(Value97, Tool_Blue);end;end;
{-----}
[ Sends draw Down to ASCII file]
Print(file("c:\Performance\IMMCHF.txt"),FixDate(date),";", PrcDD:3:0,";", MxPrcDD:3:0,";",
DDLimit:3:0);
    
```



This is the DD in percent, of a strategy with one unit traded and no reinvestment or money management. Most tests are performed like this, which gives misleading risk assumptions. The blue line of the daily DD reaches its maximum of around -27% in the second year.

Breaking below the chosen DD alert limit (red). Later, it never drops below -20% and stays above -15% in the last 5 years. Does this mean that the strategy improves over time? Of course not. It is the growing capital base that makes the drawdown of one unit appear smaller and smaller. In real trading, we are however forced to increase trading size with capital growth to maintain the same percentage returns. Accordingly, we will also maintain the same DD magnitude due to increased positions as seen in the next picture.



This is the same strategy's DD in percent if money management or reinvestment is applied. The position size is increased according to capital growth, with the result that the chosen DD limit of 20% is consistently broken. This demonstrates that DDs remain at the same high level and bear the risk of producing a marginally higher MaxDD at any time in the future. This demonstrates what many analysts agree on: that money management (position sizing) is one of the most important aspects of trading. To summarize, the size of drawdown risk is a function of the following underlying factors:

- Market behavior
- Methodology of the trading strategy
- Size of position

A change in any of these three factors heightens the risk of higher MaxDDs. If the methodology of a trading strategy cannot be improved any further, and the MaxDD in testing is still crossing limit levels, then the trading size has to be decreased until the limit is no longer reached. This tool is not only helpful in determining the DD risk for any strategy, it can also find the optimal investment size and facilitate money management. If we optimize the initial capital as a function of MaxDD, it tells us how much capital for a given trading strategy is needed. Of course, there has to be a safety margin, assuming that marginally larger MaxDDs will occur at some point in the future.

### AVERAGE PROFIT PER TRADE (AT)

In an increasingly competitive trading environment made up of day traders, scalpers and computer-supported traders, profit margins have decreased to a point where trading costs have become a key factor. The average trade is an indicator of the amount of leeway available for commission, slippage or testing errors, including some degree of unwanted curve fitting resulting from testing. A special warning has to go to the optimization of net profit while neglecting the average trade. The result can be strategies with high trading frequency and a very low profit per trade. As soon as we lose a little of our edge in the market or more slippage occurs, these strategies systematically result in losses.

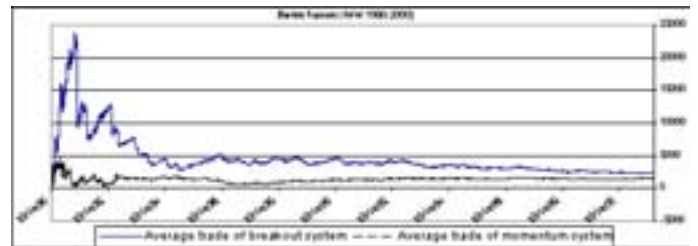
The following is the code I have written to send the average trade from Trade Station to an ASCII file. In this example, I have added

it to a breakout system, but of course it can be added to any other strategy. In the resulting graph, we can monitor the development of the average trade over its entire history.

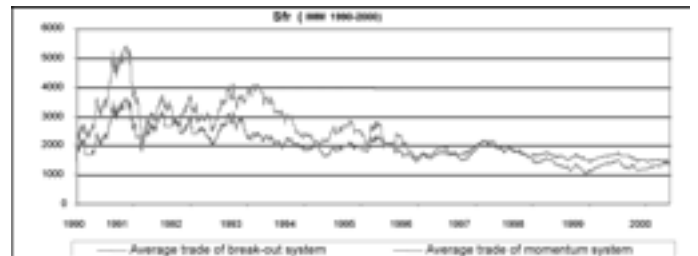
### Send Average Trade to file

```

Input: Length(45); vars: TotalEquity(0), Trades(0), AveTr(0);
{
}
{regular Break-out system}
IF Close >= Highest(c,Length)[1] Then Buy on Close; IF Close <= Lowest(c,Length)[1] Then Sell on Close;
{
}
{ Calculates and sends "Average Trade" to file}
TotalEquity=NetProfit+OpenPositionProfit; Trades=TotalTrades+1; AveTr=TotalEquity/Trades;
Print(file("c:\Averagetrade\file\sfr.txt"),FixDate(date),",",AveTr:5:0) ;
    
```



Looking at the average profit per trade of the Swiss franc from 1980-2000, we see that the trend-following breakout strategy did much better in the beginning of the 1980s. The strong trends back then gave the trend follower such a lead in average profit per trade that the resulting average is still better today, which is misleading (as shown in the following chart).



From 1990-2000, we had considerably less-pronounced trend movement. Looking at the average trade size from 1990-2000, we see that the performance of the two systems is very similar, and that short-term momentum trading has become equally good as the trend follower with regard to average trade size. In fact, it has become the superior strategy because it does not hold trades for as long and has smaller drawdowns. In this example, we can demonstrate how the evaluation of trading strategies documents the long-term change in the markets from long, sustained trends to shorter trends with higher volatility.

The resulting AT chart can also be used for money or risk management, with the aim of decreasing the trading size for strategies that fall under a minimum floor of average profit per trade. The size of this floor must account for trading costs and a margin for white noise (randomness) volatility of a market.

### ROBUSTNESS TESTS

#### Parameter Selection and Distribution

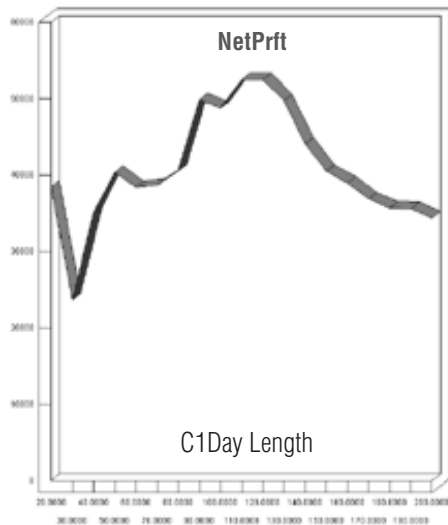
At this point we have to talk about the robustness of performance tests. All tests are built on the assumption that future performance will be similar enough to historical performance to allow some degree of generalization. However, in the unstable stationarity\* of market price distributions, we look for additional tests to assess the robustness of our strategies in a changing environment.

The first and easiest test is to apply the same trading rule or

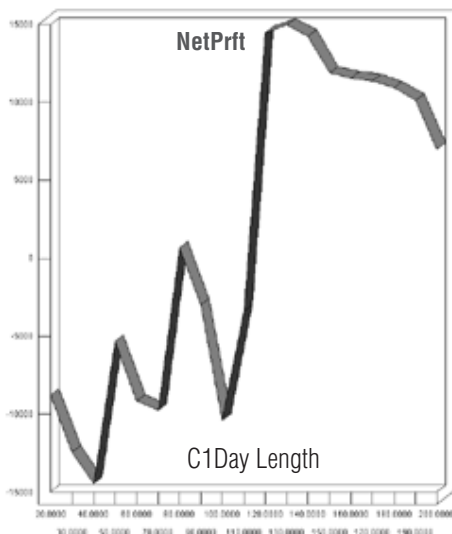
\*see glossary

indicator to different markets, looking for trading strategies with stable performance across markets. Next we test for different parameter inputs of variables. Variables are all elements which allow for different inputs. A 10-day moving average is a variable with the parameter 10. The more variables or trading rules we apply the less general and less robust our strategy will be. We are talking about a loss in degrees of freedom. Robust strategies use between one to four variables, which can be changed or optimized. It is a well-known fact that optimization of historical data tunes parameters and rules to past and often singular price behavior. The result is curve fitting with unreliable future performance. Nonetheless, optimization is a very powerful tool if used correctly. Optimization should, be referred to as visualizing the distribution of parameter performance. We are not interested in the single most profitable setting of the past, but the distribution of profitable parameters across different markets.

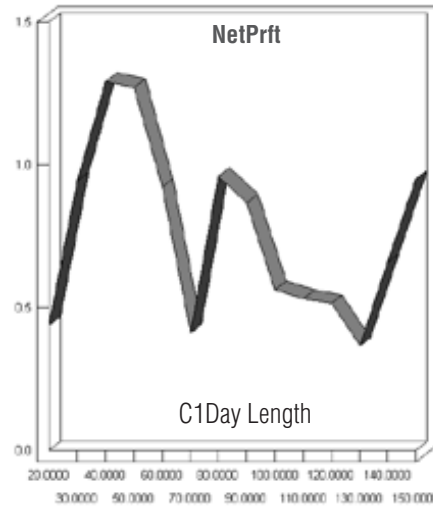
The following diagrams display the Net Profit (NetPrft) for every parameter length of a system called C1 Day



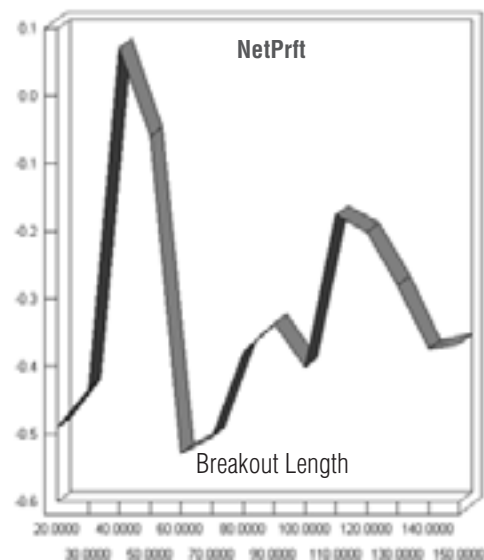
This is a parameter optimization of the number of look-back bars (from 20 to 200) for a breakout strategy on the EuroBund. We see that all parameters are profitable especially between the wide range from 50 to 150 bars look-back. This reflects a very stable strategy on a tradable black noise market, which suggests that this trading system can be traded in the future with the same parameters between 50 and 150.



This is the same optimization on the gold price from 1990 to 2000 which produces a much more unstable distribution with losing parameters from 20 up to 100. This result reflects whether a strategy which is unsuitable for this market, or a market with too much randomness (white noise). From other tests, I see that gold is in fact a difficult market for most strategies, but has in the long run tradable trends and could be included in a trading portfolio as diversification.

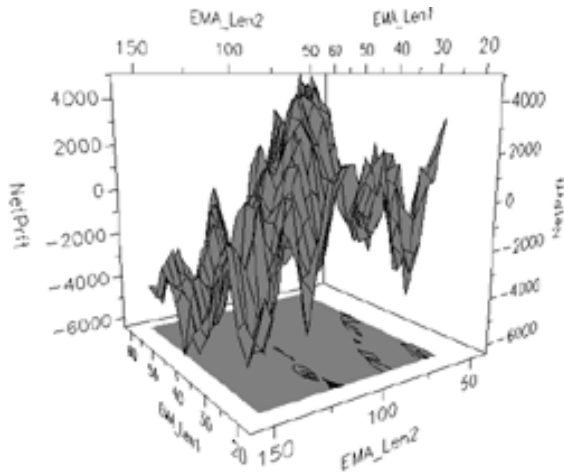


This optimization shows a simple breakout system on the British pound from 1980-1993. Although the performance for different parameters is not very stable, all parameter lengths of the breakout system produced profitable results. This reflects the strong trends (black noise) during that period. After 1993 the British pound changed its behavior from strong trending to volatile mean reverting.



This graph shows the same optimization on the British pound from 1993-2000. All parameters (from 20 to 150 days) produced deeply negative trading results. In this case it would even be possible to trade the breakout system inverted, changing the buy signals to sell signals. The market has changed from a strongly trending to a strongly reversing market. It changes price direction as soon as we are able to measure the beginning of a trend move. This frequent reversing within a range is what we describe as pink noise. This example shows that performance evaluation cannot only produce generalizations about the behavior of trading strategies, but also about the behavior of the underlying market. The price behav-

ior of the British pound is interesting after the year 2000 again, because it has changed with the launch of the Euro, from the reverting range trading back to trend following price action.



This is an example of an optimization of two moving averages on silver, producing a 3-D evaluation. We not only have a lot of negative results, but also a very unstable distribution. Silver has a lot of randomness and is accordingly difficult to trade. Most strategies lose money in silver, especially trend followers like moving averages. If the randomness in silver is, as I suspected, mostly white noise, then there is no strategy that can beat this market in the long-term.

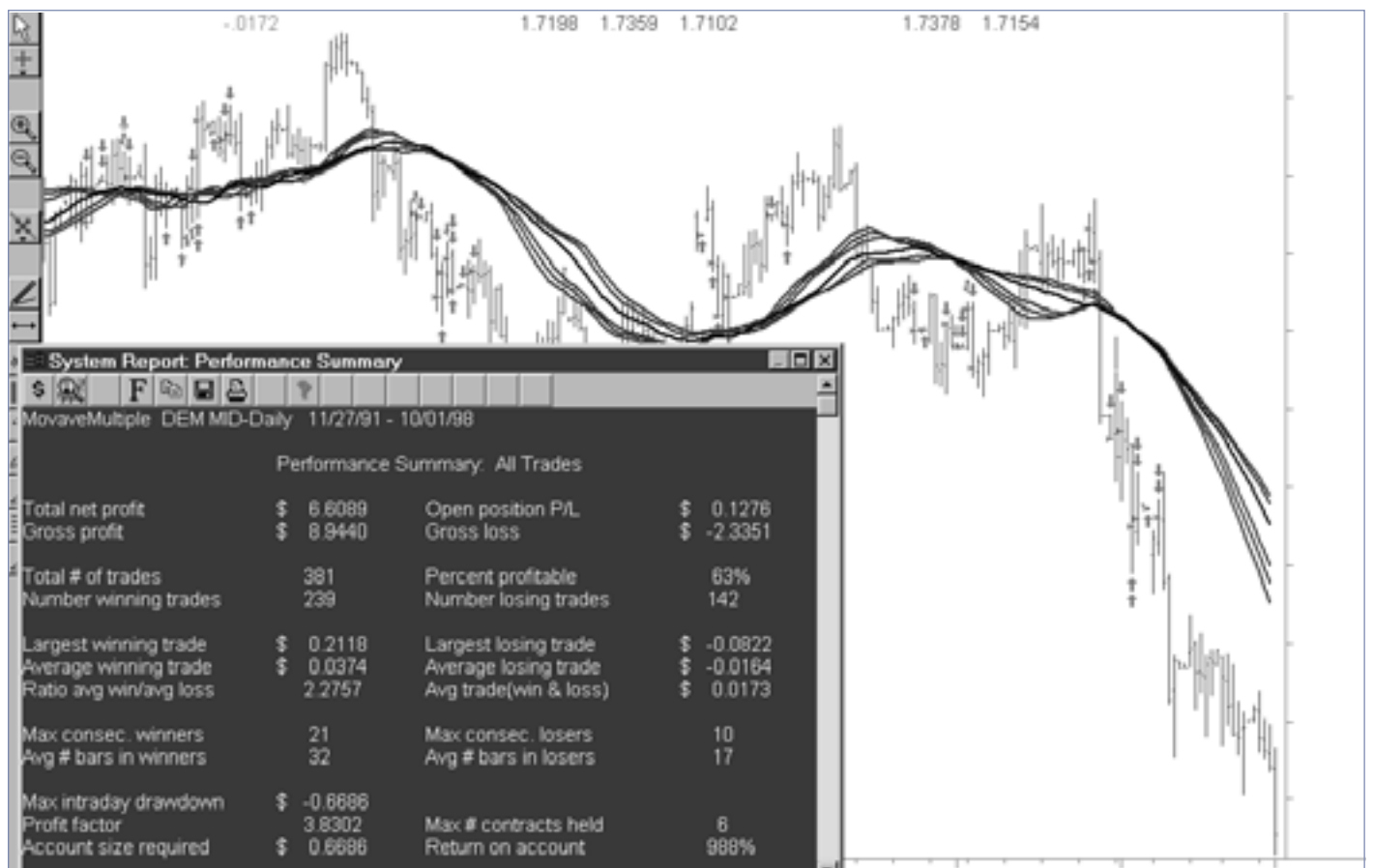
**Parameter Diversification**

As we see from the results above, there are changing optimal parameters for each trading system. This is even more pronounced across different markets and different years. As a result of this instability of parameter performance, we will never be in a position to continuously trade at an optimum. What we are looking for instead is a spread of robust parameters with a high probability to produce continuously profitable results. Since the optimal peaks are instable and move around, we are better off using several parameters diversifying our trading signals.

This is an example of using a combination of moving averages. The buy(up) and sell(down) arrows show how the different parameters are spreading the signals, and with it the risk, across the chart. The resulting performance figures in the left corner of the chart are expectedly good and stable.

**OPTIMIZATION OF DIVERSIFIED PARAMETERS**

To observe the stabilizing effect of diversifying across several parameters, we have optimized a system with multi-parameter inputs by moving all parameter inputs parallel at the same time in percentage moves up and down. The following is the formula of a simple breakout strategy with the option of three inputs (50,100,150) moves together from -90% to +90% in any desired increment (use uneven numbers to avoid a system failure at zero input)



### Multi Parameter Optimization

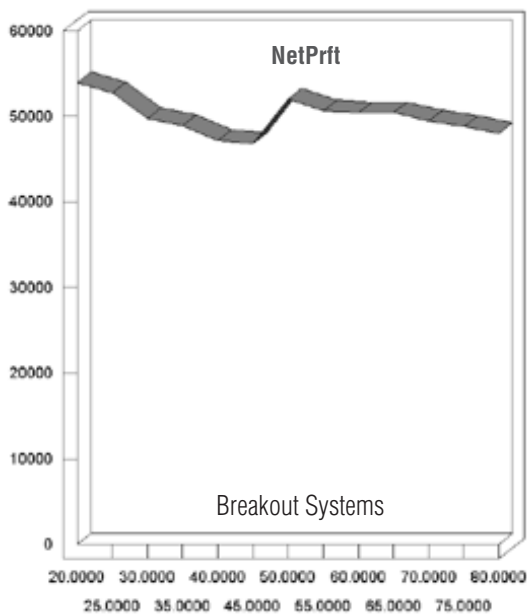
```

Input: Perc(91);{99 bis 99}
vars:perc2(0), Len1(0), Len2(0), Len3(0);

If (50/100*perc)>0 then begin   If (100/100*perc)<0 then begin   If (150/100*perc)<0 then begin
Len1=50+(50/100*perc);end;   Len2=100+(100/100*perc);end;   Len3=150+(150/100*perc);end;

IF CurrentBar > 1 and Close >= Highest(c,Len1)[1] Then Buy("Buy1") close;
IF CurrentBar > 1 and Close <= Lowest(c,Len1)[1] Then Sell("Sell1") close;
IF CurrentBar > 1 and Close >= Highest(c,Len2)[1] Then Buy("Buy2") close;
IF CurrentBar > 1 and Close <= Lowest(c,Len2)[1] Then Sell("Sell2") close;
IF CurrentBar > 1 and Close >= Highest(c,Len3)[1] Then Buy("Buy3") close;
IF CurrentBar > 1 and Close <= Lowest(c,Len3)[1] Then Sell("Sell3") close;
  
```

The following is the optimization of the above formula on the Euro Bund over the last 10 years. The relative flat and even performance distribution, without performance gaps visualizes the diversification effect across 3 parameters very well.



The optimization result shows not only a stable return distribution, but in addition we are also exposed to less risk. This results from the scaling of the contract amount, which has us not continuously engaged with the full size. This results in higher returns per total initial margin requirement.



Above is the equity curve resulting from the use of three parameters trading 3 contracts. Despite a good growth rate, the trading speed diversification (several parameters) cannot avoid the performance stagnation of the last years. This is a sign of changing market behavior and highlights again the fact that equity curves of trading

strategies are the best indicator to analyze market behavior. This opens an entirely new chapter, which I can unfortunately not address here. It involves equity curve trading. The use of equity curves as an analytical tool can define parameter and trading system selection as well as money and risk management.

### CONCLUSION

Valuable analysis is a process of looking at trading results from as many angles as possible. The exclusion of even one single aspect can dramatically decrease reliability of performance test results. In a competitive trading environment characterized by diminishing profit margins, in hand with growing computing power, we cannot forfeit the analytic advantage available to anyone with a computer. This is an appeal to test everything you use in technical analysis - the observed market, the trading strategy or indicators and the evaluation tool itself. One should not only understand the indicators and trading systems that are applied, but also the analytical data used for evaluation. The more transparent everything is - from strategies to evaluations - the greater the chance that future performance will be in line with expectations.

Although I have tried to address all the relevant performance measurement figures of trading in this article, it cannot be regarded as conclusive to the subject. Performance evaluation is an ongoing process that is changing along with the evolution of markets and the trading tools. Everyone who needs to maintain an edge in the market should stop developing and testing on a continuous basis.

### GLOSSARY

- **Algorithm** = The naked formula of a strategy. This can be the basis for a trading strategy or an indicator (i.e. a moving average, average(price, length)).
- **Degrees of freedom** = Every rule uses a degree of freedom with the effect that strategies with a lot of variables and rules use up a great deal of freedom and become less general and robust in changing market behavior.
- **Indicator** = Visual display of an algorithm or trading strategy in the form of lines.
- **Methodology** = Trading method.
- **Money management** = How much money we risk on a trade. MM defines the size of the trade and, with it, the risk we assume with respect to our total trading capital.
- **Optimization** = The search for the best-performing parameter.
- **Parameter** = The number entered as input in indicators or strategies.
- **Robustness** = The reliability of a trading strategy to perform steadily in different market conditions and in the future. We look for robustness or universality in trading strategies.
- **Slippage** = The difference between the actual traded price and the trade signal price calculated by the computer.
- **Stationarity** = A time series is stationary if the underlying rules that generate it, do not change over time. Non stationary distributions change their probability distributions over time. This is the case in trading. An example of a stable probability distribution would be a casino game like roulette.
- **Trading system** = Algorithm or trading strategy that results in trading signals placing orders in the market.
- **Variables** = All elements of an indicator or a strategy that allow different definitions or inputs.

**SUGGESTED READING**

- Peters, E. E. (1994) Fractal Market Analysis, John Wiley & Sons
- Kaufman, J.P. (1998), Trading Systems and Methods, John Wiley & Sons
- Sherry, J. C. (1992), Mathematics of Technical Analysis, Probus Publishing Company
- Vince, R. (1995), The New Money Management, John Wiley & Sons
- Schwager, D.J.(1998), Managed Trading, John Wiley & Sons

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Felix Gasser works as Portfolio Manager in Zug, Switzerland, where he is also responsible for computerized trading development.

He was previously with Credit Suisse in Zurich, publishing daily technical analysis and in technical research responsible for performance testing of systematic futures trading. He began in the 80s as derivative trader and worked for E.D.+ F. Man, the first CTA in Europe, as trader in the funds division of systematic futures trading.

The International Federation of Technical Analysts (IFTA), incorporated in 1986, is a global organization of Member Societies of market analysis professionals. This not-for-profit federation has four main goals:

- to provide a centralized international exchange for information, data, business practices, local customs and all matters related to technical analysis in various financial centers.
- to provide meetings and encourage the interchange of material, ideas and information for the purpose of adding to the knowledge of the colleagues of the individual Member Societies. (The local Society is the IFTA Member and individual members in each society are referred to as Colleagues.)
- to foster the establishment of local (country) societies of technical analysts around the world.
- to encourage the highest standards of professional ethics and competence among technical analysts worldwide.

These goals are accomplished by the dedication and involvement of many IFTA Colleagues around the world.

### Membership Requirements

There are two classes of members: Member Society and Developing Society

#### Member Society

To qualify as a Member of IFTA each society must have at least five individuals showing an interest in technical analysis; these individuals are referred to as Colleagues.

- Member Societies must have regularly scheduled meetings, pay annual dues, can receive all IFTA newsletters, journals and meeting notes, and their Colleagues must meet locally-established ethical standards.

#### Developing Society

- Any individuals can start a Developing Society with the intent of establishing a formal Member Society in the future.
- Developing Societies can attend all IFTA meetings, as observers, will receive all IFTA newsletters, journals and meeting notes for a minimum fee, but cannot vote.



## INTERNATIONAL FEDERATION OF TECHNICAL ANALYSTS, INC.

### LIMITATIONS

Only one Member Society shall be permitted to join from each country. (The U.S. is an exception because two societies existed before IFTA was created: the Market Technicians Association and Technical Securities Analysts Association of San Francisco.)

### APPLICATION

Each application for membership in the Federation shall be accompanied by (a) copies of the applicant society's Constitution or Articles and By-Laws, (b) a brief history of the society, together with a statement of its current activities, (c) a complete roster of its colleagues' history and specialty in technical analysis and occupations, and (d) payment of one year's dues in advance.

### ADMISSION PROCEDURE – MEMBER SOCIETIES

New applications for admission as a Member Society shall be submitted to the Membership Committee chairperson. The Membership Committee is constituted to pass on all applications and present its recommendations to IFTA's Board of Directors. All applications must be approved by the Board of Directors.

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### TERMINATION OF MEMBERSHIP

The membership of any Member Society in IFTA may be terminated or suspended if such termination or suspension is recom-

mended by a vote of two-thirds of the entire Board of Directors and is adopted by the affirmative vote of two-thirds of the total delegate votes at the Annual Meeting or a special meeting. In addition, the membership of any Member Society may be automatically suspended for nonpayment of dues, or as otherwise provided for in the By-Laws.

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### Diploma in Technical Analysis

The Diploma in International Technical Analysis (DITA) examination process started in 1996. The process consists of three stages spread over three to five years, with the examinations normally being taken at 12-month intervals. There are usually two exam sittings per year, in April and October/November.

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Belgium	Brazil	China
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Links to the Societies are on the IFTA Web page:

[www.ifta.org/IFTASocieties.html](http://www.ifta.org/IFTASocieties.html)

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