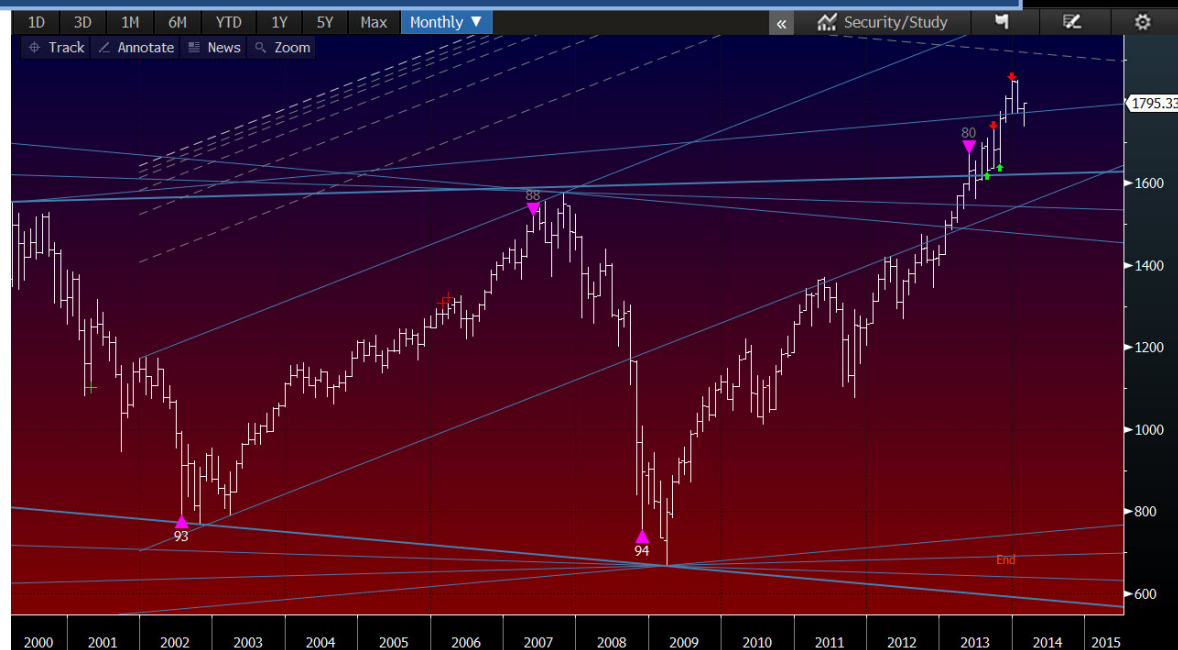


Users Guide for ExtremeHurst™ on Bloomberg



Parallax Financial Research

6/27/2014



Users Guide for ExtremeHurst™ on Bloomberg

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What is ExtremeHurst?

ExtremeHurst is a quantitative detector of extreme investor behavior that signals the beginning or end of a trend. Strong trend-persistent stock price movements are evidence of positive feedback (i.e., investors buying because the price is rising, driving prices higher), while extremes of mean reversion are evidence of negative feedback. Extremes of both trend persistency and mean reversion are quantified via multiple measurements of the Hurst exponent. Parallax found that Hurst extremes coupled with other characteristics, signal the beginning or end of market trends. ExtremeHurst signals are fully characterized by the presence of discrete scale invariance, accelerating price, log-periodic cycles, and volume anomalies. This App allows the user to search global markets for signals on intraday, daily, weekly, monthly, and quarterly time scales. Signals have been found to persist for up to 20 bars.

ExtremeHurst exploits the science of non-linear dynamics to identify unique and predictive signals occurring in freely trading auction markets. There are two types of ExtremeHurst signals that we call “**Extensions**” and “**Compressions**”. These correspond to the extreme high and low ends of the Hurst exponent distribution.



Figure 1. This is an example of a weekly scale Extension top signal.

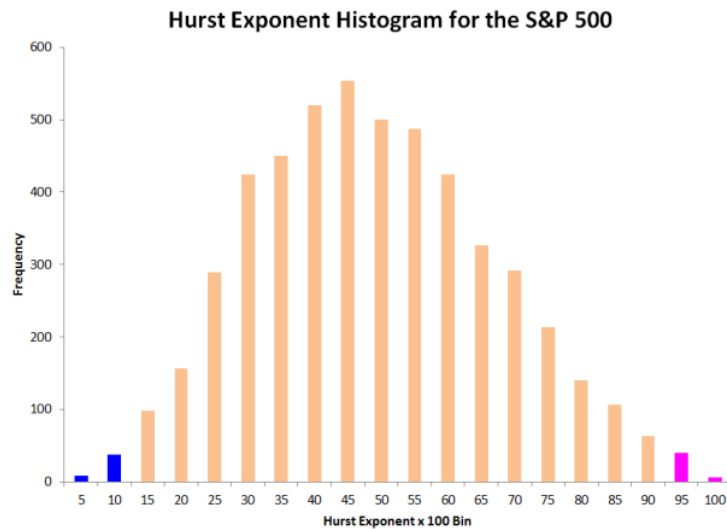


Figure 2. Histogram of Hurst exponent measurements taken from the S&P 500

The Hurst exponent, as applied to a financial series, represents the degree of randomness which is present. Deviations from random take the form of mean-reversion or trend persistency. The picture below shows five time series with different Hurst exponents. The topmost example is the most mean-reverting, while the bottom example shows the most trend persistency. The middle one is random.

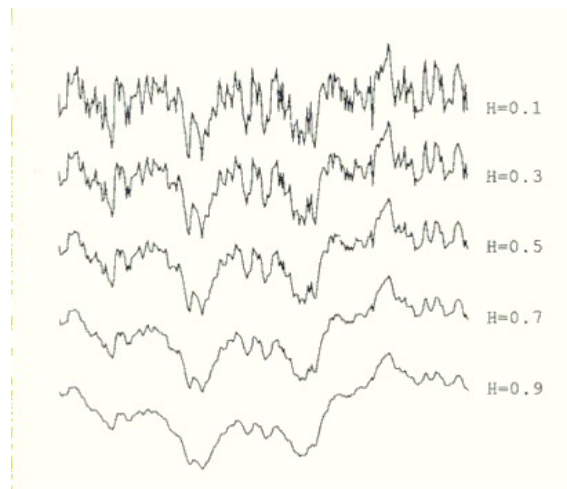


Figure 3. Time series generated with different Hurst exponents

Extensions correspond to extreme levels of trend persistency on multiple scales, and mark the end of trend persistent periods, either at market tops or bottoms. The picture below shows multiple Hurst

exponent measurements for a particular security at different scales. The shortest scales are on the bottom. Red represents persistent down trends. Green represents persistent up trends. Gray shows random price movement, and blue represents mean-reverting exponents. Note the column of red at the price low.

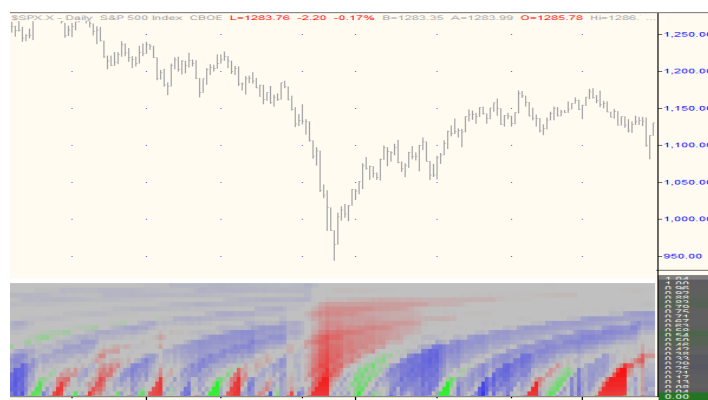


Figure 4. Color-coded Hurst exponents at multiple scales (graph not available on BB)

Many factors influence investors, but we choose to focus on the extremes of competitive or cooperative behavior from a macro perspective. Feedback is at the heart of why ExtremeHurst works. Investors sometimes behave as herds, selling because the price is dropping, or buying because it's going up. Panics and manias are large scale examples of this. However, when most investors agree that a stock is going up or down, they've probably already acted on their belief, and the buying or selling dries up, leading to a reversal.

Panic

Mania

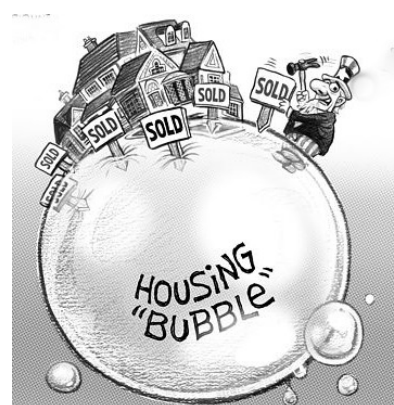


Figure 5. Extreme investor behavior.

Because these events are scientifically similar to critical failure points in materials, log periodic “foreshocks” are visible preceding most signals, as well as mirror image “aftershocks” following signals.

Aftershocks are also log-periodic, but are expanding, which means the highs and lows are getting farther apart logarithmically over time. The picture below is a simulated example:

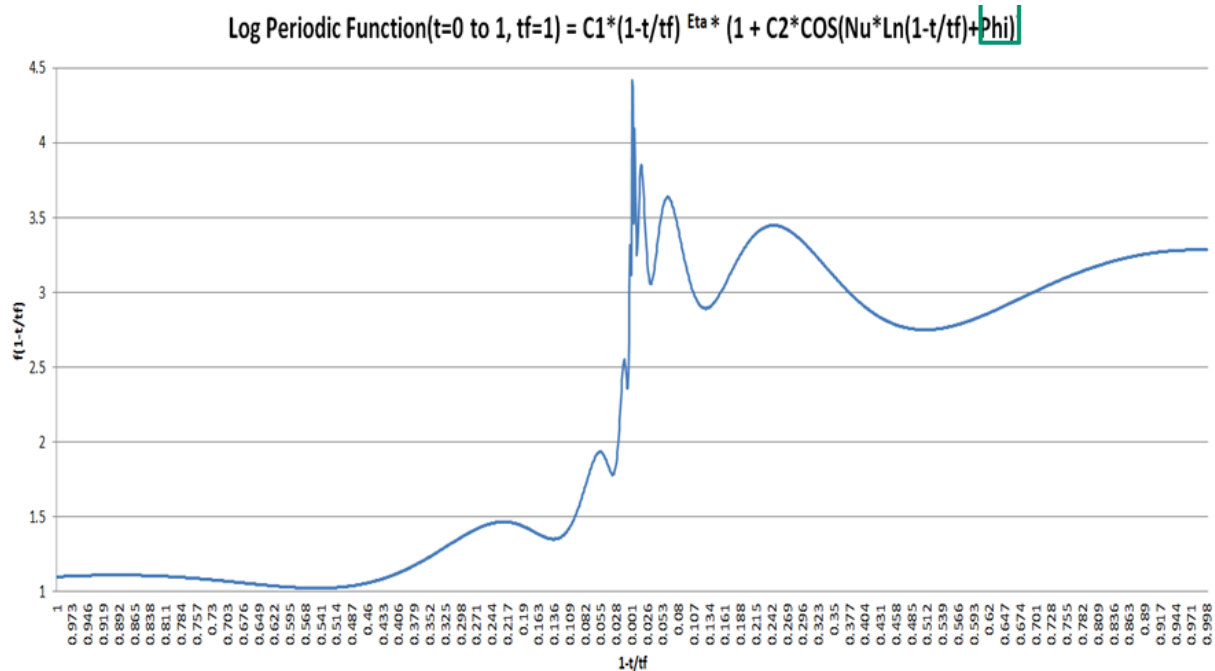


Figure 6. Simulated log-periodic oscillations culminating in a critical reversal point and then expanding away from the critical point (Top Extension)

Compressions correspond to extreme levels of mean-reversion, or investor competition, on multiple scales. These signals mark the beginning of trends by finding when the vigorous competition between supply and demand has reached a critical point. Price is expected to move very rapidly away from its current price following a compression.

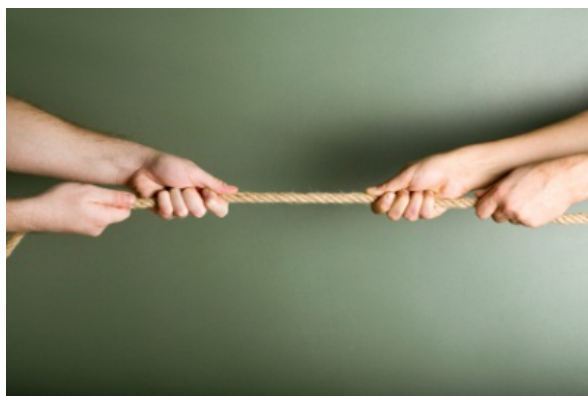


Figure 7. Competition between supply and demand reaches a crescendo at compression signals

Another way to think of these signals is to envision a mass on a spring. When the spring is compressed, the system has high potential energy. When the mass is released, it will move very fast away from its starting position. In fact, it will then move too far. An extension occurs as the spring reaches its full extent, just before it settles back:

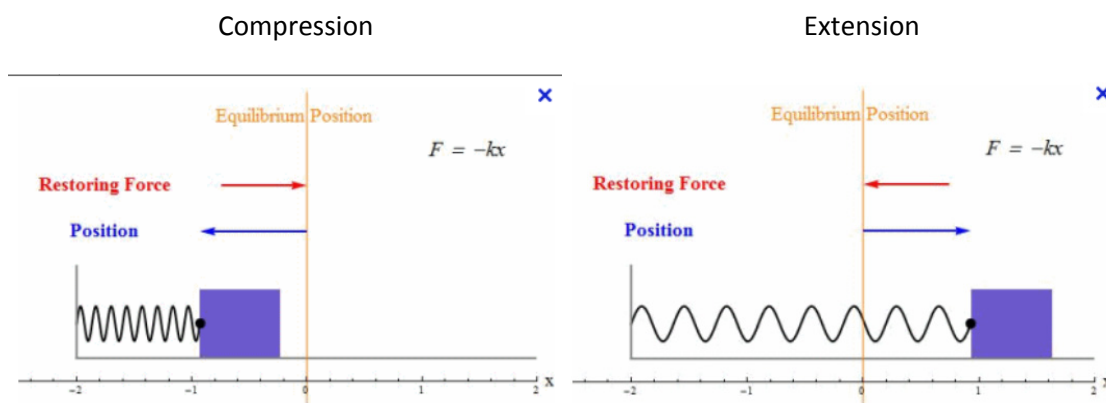


Figure 8. A harmonic oscillator is a great way to envision a compression and extension

How do I use ExtremeHurst?

The ExtremeHurst signals work on all freely traded securities and on all time scales, provided sufficient liquidity is present. For a “crowd effect” to occur, a crowd must be present.



Figure 9. Examples of each ExtremeHurst signal type

The predictive edge lasts 15-20 price “bars”, so for monthly scale data, this means the effect might continue for as long as 20 months.

The Extension signals predict retracement or sideways periods, so redeployment of capital may be the best strategic move. Aggressive speculators like to play the log-periodic cycles, so we have included the expected top and bottom timing marks on the charts and in the signal file.

Compressions mark the start of new trends, but we never know the direction, so a straddle or triggered L/S entry is required.

Signals have at least four important uses:

1. Trade positioning
2. Profit taking.
3. Identifying transitions from a trending to a sideways market or from a sideways to a trending market.
4. When the crowd runs a security too far up or down, prices can deviate significantly from a reasonable valuation and diminish portfolio performance. Having an idea about when these effects are occurring can be very valuable.

Signals are ranked from 1 to 100 depending on how closely they correspond to the ideal signal

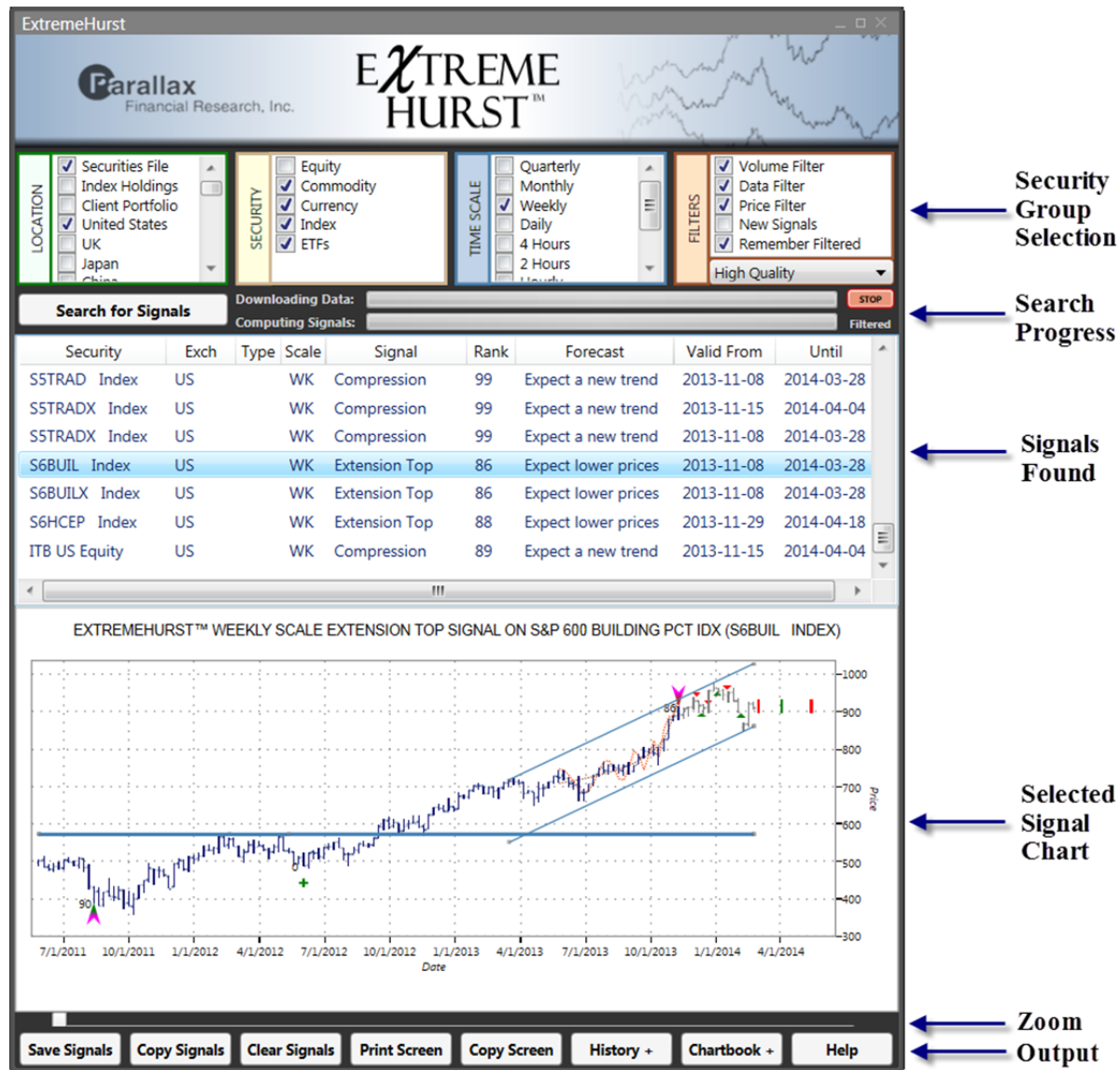
An ideal signal exhibits four characteristics:

1. A price acceleration that deviates significantly from normal Gaussian expectations
2. Extreme Hurst Exponent measurements on multiple scales
3. Log-periodic price ripples which converge to the signal date
4. Unique price and volume sequencing

We combine factors using a pre-trained neural net to produce our final signal rank

We have created the ExtremeHurst App on Bloomberg to enable users to search world markets for these predictive signals on intraday, daily, weekly, monthly, and even quarterly time scales.

The Application (on Bloomberg at APPS HURST <Go>)



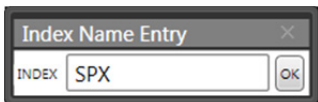
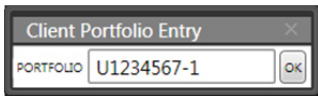
ExtremeHurst App Window	ExtremeHurst is a single Windows dialog box. It is divided into six sections from top to bottom that correspond to the workflow sequence. These sections include security and filter selection, the search progress bars, the signal list, the chart area, the zoom control, and the output options.
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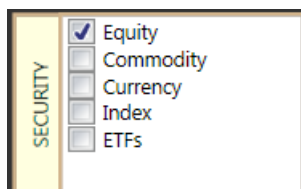
CPU Usage	ExtremeHurst performs millions of complex mathematical calculations including Fast Fourier transforms, neural network math, and trigonometry calls during each run. You will notice a sharp increase in CPU usage during searches and on occasion the processing may even appear to halt. Be patient, it will complete.
Bloomberg Data Limits	Bloomberg clients have monthly data usage limitations. We recommend that you carefully select a security universe, search <u>once</u> after the close each day for daily signals, <u>once</u> a week after the weekly close for weekly scale signals, etc., so you stay within your limits. ExtremeHurst reads 129 historical bars worth of OHLCV data for each security that passes through the filters.

Security & Filter Selection

Let's take a closer look at security and filter selection: The user can select which securities to search by either reading in a text file with one security name per line, retrieving each security holding from an index (SPX for S&P 500, NKY for Nikkei, CAC, DAX, etc.), reading securities from a Bloomberg client portfolio (PRTU <Go>), or by selecting a region or country to access all their respective securities. The next step is to select the type of security, and time scale desired. Keep in mind that our signals remain active for an average of 20 bars. This means that a single quarterly signal may be predictive for 5 years, while a daily scale event lasts for a month or less. The next menu has a list of filters to apply. The volume filter ensures that securities with volume actually have volume on every trading day. It also ensures a sufficient level of volume for reasonable investment. The data filter guards against spikes, excessive gaps, missing data, or improperly sequenced data. The price filter sets a minimum price level. Checking "New Signal" results in signals that have just occurred; while unchecked it results in new AND older signals that are still active. By checking "Remember Filtered", the program will remember which securities were excluded and not search them again. Three signal quality thresholds are provided. We have found that some researchers don't mind seeing less predictive signals, while others just want the few best ones. We recommend leaving this on "High".



Single Security	Enter any single security
Securities List	A text file created using NotePad or other text editor with a list of securities, one per line, in the following format: <security name> space <exchange code> space <yellow-key>. For example: <pre>AH US Equity KAR US Equity MSFT US Equity IBM US Equity EURUSD Curncy USDCAD Curncy GC1 Comdty CA1 Comdty</pre>
Index Holdings	Search just the securities that make up an index by typing the Bloomberg index name at the prompt. For example, SPX for the S&P 500 index: 
Client Portfolio	Bloomberg offers clients the ability to keep portfolios on their system using PRTU <go>. If you wish to search only your portfolio securities then enter your portfolio name at the prompt. It should be in the following format: U1234567-1 
Country	Search all securities by country.
Region	Search all securities by region.

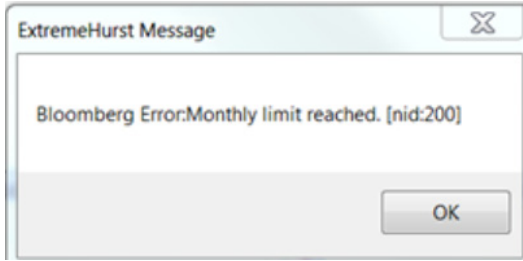


Security	Select which type or types of securities to search for ExtremeHurst signals
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Time Scale	Select which time scale to search for ExtremeHurst signals
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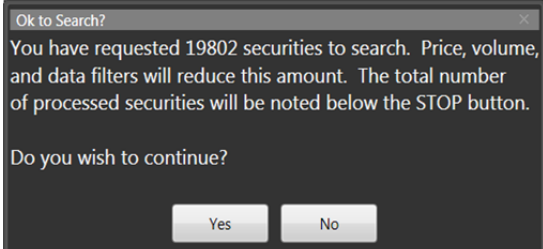
Liquidity Filter	With this option checked, the average daily dollar trading volume for Indices and equities must exceed a minimum limit to be considered.
Data Filter	Check this option to filter out securities with missing data, recent data spikes, inactive bars, insufficient history, excessive gapping, or improper sequencing
Price Filter	This option limits the minimum allowable price of an equity or index
New Signals	Check this option to search for new signals only. If it is unchecked the search will find all signals that are still active....but it will take longer.
Remember Filtered	Check this option for the program to remember all the securities that have been disqualified for signal search. This memory will persist even when the program is closed
Preferences	Certain combinations of search options can enable users to have either more signals (at the expense of compute time), better signals by applying still more stringent filters, or faster calculations (at the expense of getting fewer signals).
Best Quality	Select this option to find only signals that have the highest possible quality (90+)
High Quality	This is our recommended setting for finding signals (80+)
Medium Quality	Some users like to see lots of signals even if they have a lower overall quality. (70+)
Explore Quality	These are low quality at 50+ but have been requested by some users. Not recommended for trading

Signal Search and Progress

Search for Signals	Press the search button to download historical price data from Bloomberg for the selected securities and then search that data for ExtremeHurst signals. The download procedure first checks that the average daily dollar volume is greater than the limit before requesting additional data. Look at the “Filtered” section below the STOP button to find out how many securities passed all the filters and have finished being run through the ExtremeHurst signal processor. In the example above, we show the search section before and during a search of S&P 500 stocks. Note that the search button is grayed-out until all downloading and calculations are complete. As shown above, out of 275 securities downloaded, 228 had been passed to the processor, and 27 had completed so far.
STOP	The search procedure gathers data in chunks and then processes that data before gathering the next chunk. Press STOP to break the cycle and stop the processor from gathering additional data. It will complete the signal search using the data already downloaded however.
CPU Usage	ExtremeHurst performs millions of complex mathematical calculations including Fast Fourier transforms, neural network math, and trigonometry calls during each run. You will notice a sharp increase in CPU usage during searches and on occasion the processing may even appear to halt. Be patient, it will complete.
Data Usage	Bloomberg clients have monthly data usage limitations. We recommend that you carefully select a security universe, search for “New Signals” only, and then search once after the close each day for daily signals, once a week after the weekly close for weekly signals, etc., so you stay within your limits. ExtremeHurst reads 129 historical bars worth of OHLCV data for each security that passes through the filters. If you uncheck the New Signals button the application will take longer to run and require 15% more data. If you hit your limits you’ll see: 

Data Warning

If you ask for more than 1000 securities then this message comes up. As an example, In the US, the almost 20,000 listed equities are cut down to less than 2,000 by the filters. If you are unsure, press the STOP button part way through, or just make a security list in a text file and read it in.

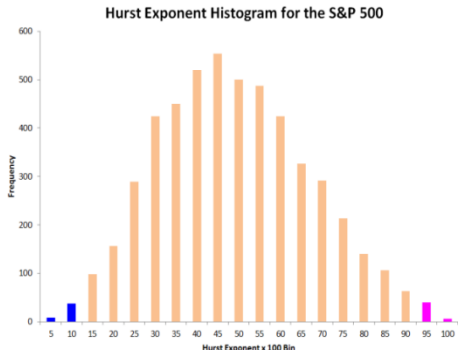


ExtremeHurst Signal List

Signals are listed in the window as the search progresses. The list has one signal per line and is described by its symbol name, exchange, security type, time scale, signal type, quality rank, forecast, and active dates. The button marked “More” is used to find historical signals and do a statistical test on them. A yellow box indicates that insufficient data was present to do this test. Green means the test was significant, while red means the opposite. Use the scroll bars to move through the signal list.

Security	Exch	Type	Scale	Signal	Rank	Forecast	Valid From	Until
AAPL UW Equity	UW	EQ	DY	Extension Bottom	87	Expect higher prices	2012-11-08	2012-12-06
AIV UN Equity	UN	EQ	DY	Extension Bottom	93	Expect higher prices	2012-11-14	2012-12-12
APA UN Equity	UN	EQ	DY	Extension Bottom	99	Expect higher prices	2012-11-16	2012-12-14
BF/B UN Equity	UN	EQ	DY	Extension Top	86	Expect lower prices	2012-11-27	2012-12-25
BMV UN Equity	UN	EQ	DY	Extension Bottom	93	Expect higher prices	2012-11-15	2012-12-13
BXP UN Equity	UN	EQ	DY	Extension Bottom	93	Expect higher prices	2012-11-15	2012-12-13
BXP UN Equity	UN	EQ	DY	Extension Bottom	87	Expect higher prices	2012-11-14	2012-12-12
CHK UN Equity	UN	EQ	DY	Extension Bottom	94	Expect higher prices	2012-11-09	2012-12-07

Symbol	The Bloomberg symbol for this security
Exch	The Bloomberg composite exchange where the security is listed
Type	Abbreviation for the Bloomberg yellow key. EQ=Equity, CM=Commodity, CR=Currency, IN=Index, ET=Exchange traded fund
Scale	Abbreviation for the sampling frequency, DY=Daily, WK=Weekly, MO=Monthly, and QT=Quarterly

Signal	There are two types of ExtremeHurst signals that we call “Extensions” and “Compressions”. These correspond to the extreme high and low ends of the Hurst Exponent distribution. There are two types of Extensions, top and bottom. Extensions mark the end of trends on that scale. Compressions are points of high potential energy that occur just before a new trend erupts.	
Rank	Rank varies from 0 to 100 corresponding to the signal quality. To be a high quality signal, extreme high or low consistent Hurst Exponents, log-periodic oscillations (Sornette), and expected volume behavior need to be easily distinguishable once data corrections and filters are applied. The higher the rank, the better the signals expected outcome.	
Forecast	Abbreviation for the behavior we expect from the three signal types.	
Valid From	Date from which the forecasted behavior should start to appear.	
Until	This is the Date after which it is unlikely that signal effects will be evident. Note here that this is set at 20 bars currently. Expect signals that had longer build-up times to have effects lasting longer, and vice versa.	

You can also right click on each line to bring up a convenient Bloomberg terminal task menu:



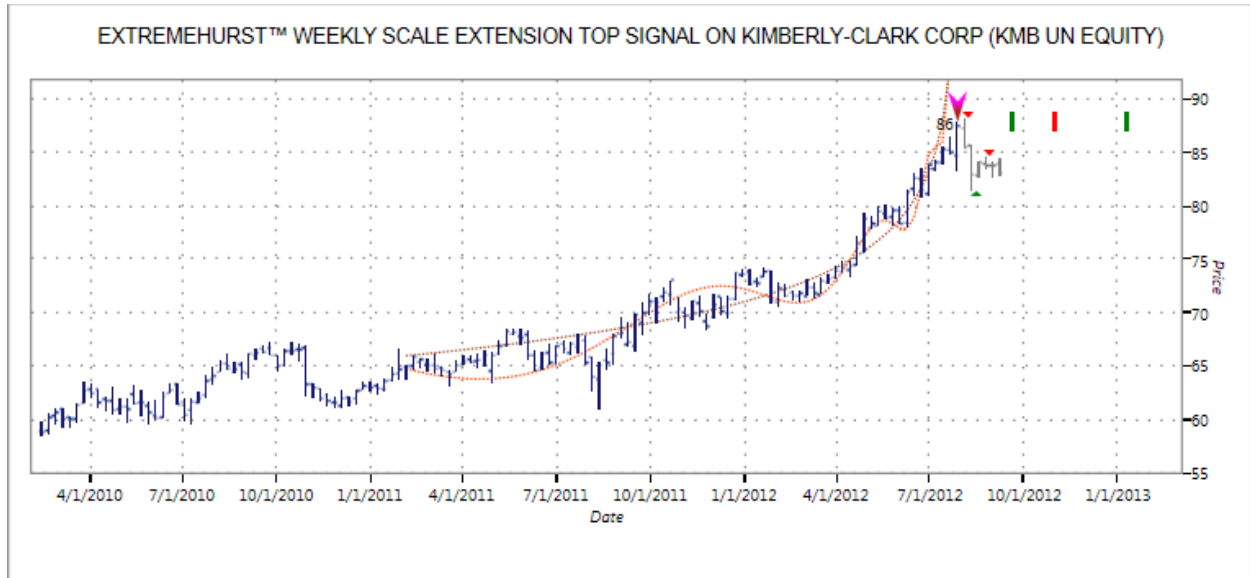
GP: Display Bloomberg Chart



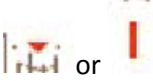
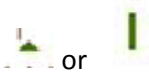
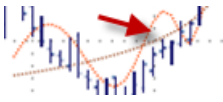
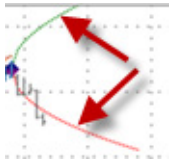
DES: Security Description



Chart of Selected Signal



Marker	Symbol	Float over
Extension Top marker		Active Signal Date: 8/28/2012 Type: Extension Top Price: 58.3 Scale: daily Rank: 86
Compression marker		Active Signal Date: 9/4/2012 Type: Compression Price: 423.61 Scale: daily Rank: 89
Extension Bottom marker		Active Signal Date: 8/10/2012 Type: Extension Bottom Price: 31.67 Scale: daily Rank: 92
Price bars		Price Data Date: 8/6/2012 Open: 32.8 High: 32.8 Low: 32.53 Close: 32.59
Marker	Symbol	Float over

Extension Cycle Top markers		Extension Cycles Date: 9/7/2012 Type: Top expected Price: 33.5 Scale: daily Rank: 92
Extension Cycle Bottom markers		Extension Cycles Date: 8/31/2012 Type: Bottom expected Price: 32.74 Scale: daily Rank: 92
Accelerating Trend		Price
Log-Periodic Oscillations		Price
Average Compression trend path		Average Post-Compression Uptrend Path or Average Post-Compression Downtrend Path
Price Volume Cross Sell		PV Cross Sell Date: 3/30/2012 Type: PVX Price: 93.34 Scale: daily Rank: -8.54
Price Volume Cross Buy		PV Cross Buy Date: 4/19/2012 Type: PVX Price: 71.5 Scale: daily Rank: 8.61

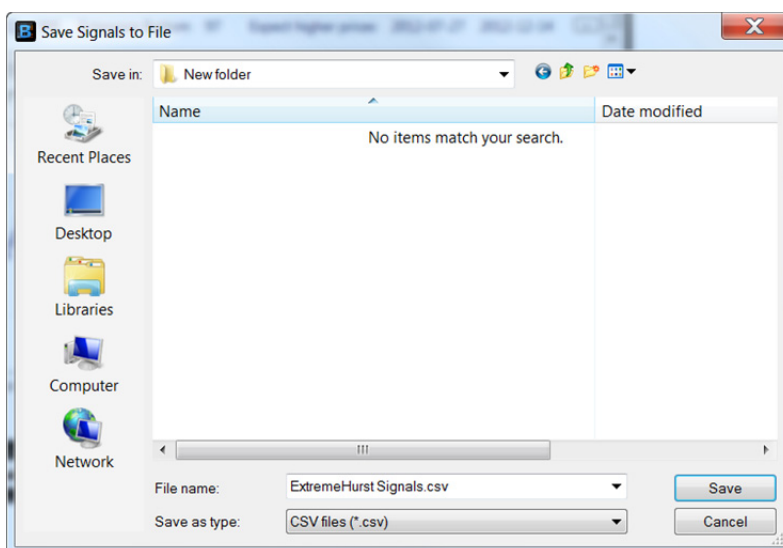
ExtremeHurst Output Options

Save Signals **Copy Signals** **Clear Signals** **Print Screen** **Copy Screen** **History +** **Chartbook +** **Help**

There are seven output-related buttons across the bottom. “Save Signals” allows the user to write the signals to a CSV file. The “Copy Signals” button places the same signal data in the clipboard, so it can be pasted in a spreadsheet or other compatible document. “Clear Signals” wipes the signal list clean. The “Print Screen” button sends an image of the current dialog box to the printer. It does not save all the signals. “Copy Screen” sends an image of the current dialog box to the clipboard. The “Add History” adds historical signals and other studies to the chart. Finally, the “ChartBook+” button accumulates the user’s favorite chart images for later printing and viewing.

Save Signals

Press this button to save the signal list to a comma delimited text file.



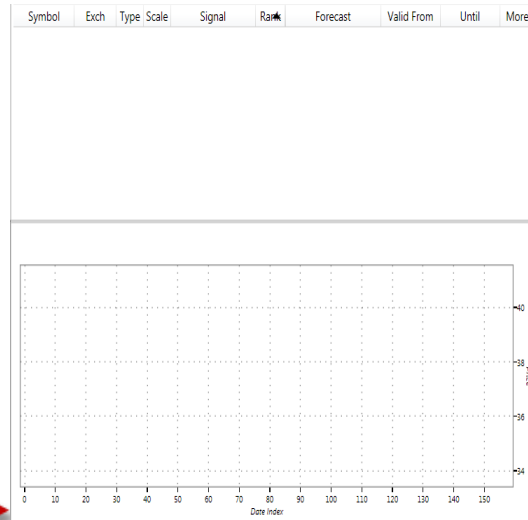
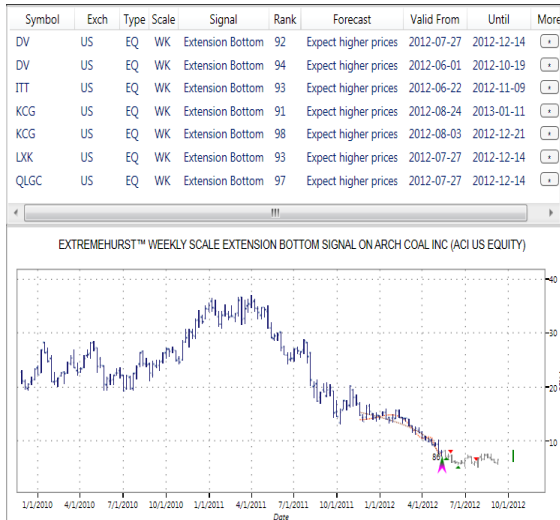
Copy Signals

Press this button to save the signal list to the Windows clipboard. Below is the signal list pasted into EXCEL.

	A	B	C	D	E	F	G	H	I	N	O	P	Q	R
1	Symbol	Region	Type	Scale	Signal	Rank	Forecast	ValidFrom	Until	Name	Sector	Industry	Cycle1_Date	Cycle1_Dir
2	DLTR	UN	EQ	WK	Extension Top	95	Expect lower prices	4/27/2012	9/14/2012	DOLLAR TREE INC	Consumer Cyclical	Retail	5/30/2012	Top
3	FTI	UN	EQ	WK	Extension Bottom	87	Expect higher prices	6/1/2012	10/19/2012	FMC TECHNOLOGIES INC	Energy	Oil&Gas Services	7/5/2012	Top
4	KMB	UN	EQ	WK	Extension Top	86	Expect lower prices	7/27/2012	12/14/2012	KIMBERLY-CLARK CORP	Consumer Non-cyclical	Household Products/Wares	8/7/2012	Top
5	LXK	UN	EQ	WK	Extension Bottom	90	Expect higher prices	7/27/2012	12/14/2012	LEXMARK INTERNATIONAL INC-A	Technology	Computers	8/7/2012	Bottom
6	ORLY	UN	EQ	WK	Extension Top	87	Expect lower prices	4/27/2012	9/14/2012	O'REILLY AUTOMOTIVE INC	Consumer Cyclical	Retail	5/14/2012	Bottom
7	RAI	UN	EQ	WK	Compression	99	Breakout w/trend	6/8/2012	10/26/2012	REYNOLDS AMERICAN INC	Consumer Non-cyclical	Agriculture	7/3/2012	Bottom
8	RAI	UN	EQ	WK	Compression	99	Breakout w/trend	6/1/2012	10/19/2012	REYNOLDS AMERICAN INC	Consumer Non-cyclical	Agriculture	6/28/2012	Top
9	ROST	UN	EQ	WK	Extension Top	89	Expect lower prices	5/4/2012	9/21/2012	ROSS STORES INC	Consumer Cyclical	Retail	5/16/2012	Top
10	SHW	UN	EQ	WK	Extension Top	96	Expect lower prices	6/8/2012	10/26/2012	SHERWIN-WILLIAMS CO/THE	Basic Materials	Chemicals	6/18/2012	Top
11	VLO	UN	EQ	WK	Extension Top	87	Expect lower prices	9/7/2012	1/25/2013	VALERO ENERGY CORP	Energy	Oil&Gas	9/21/2012	Bottom

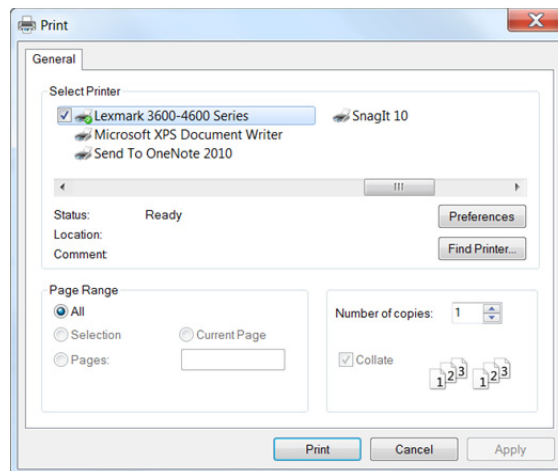
Clear Signals

Press this button to clear the signal list and chart.



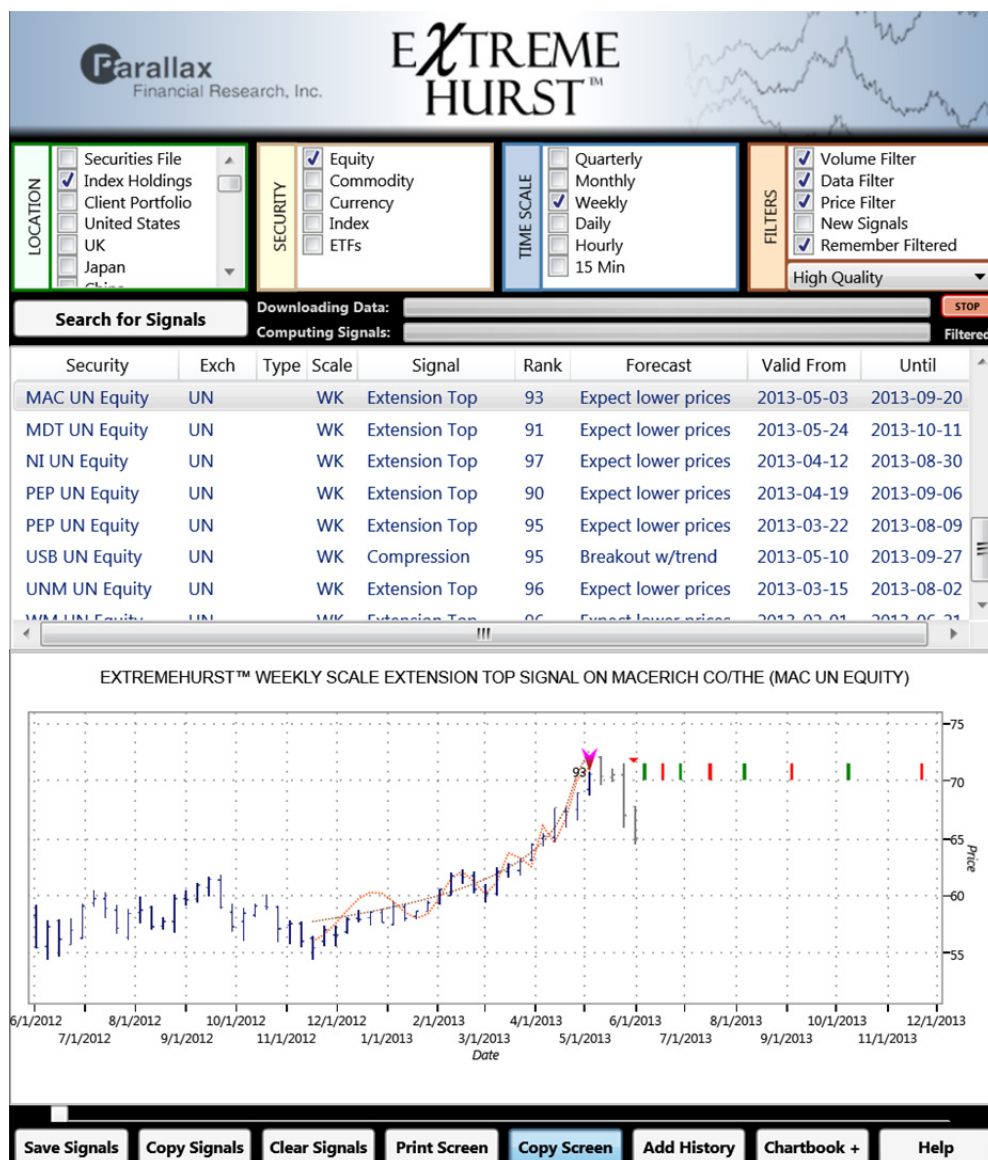
Print Screen

Press this button to print a copy of the screen image.



Copy Screen

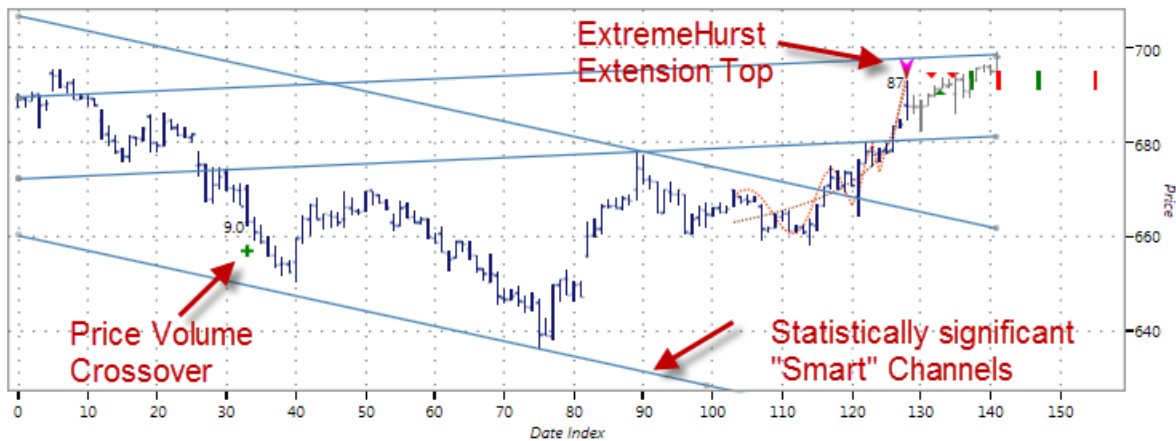
Press this button to copy an image of the screen to the windows clipboard. This allows you to paste the image in a report or email.



History +

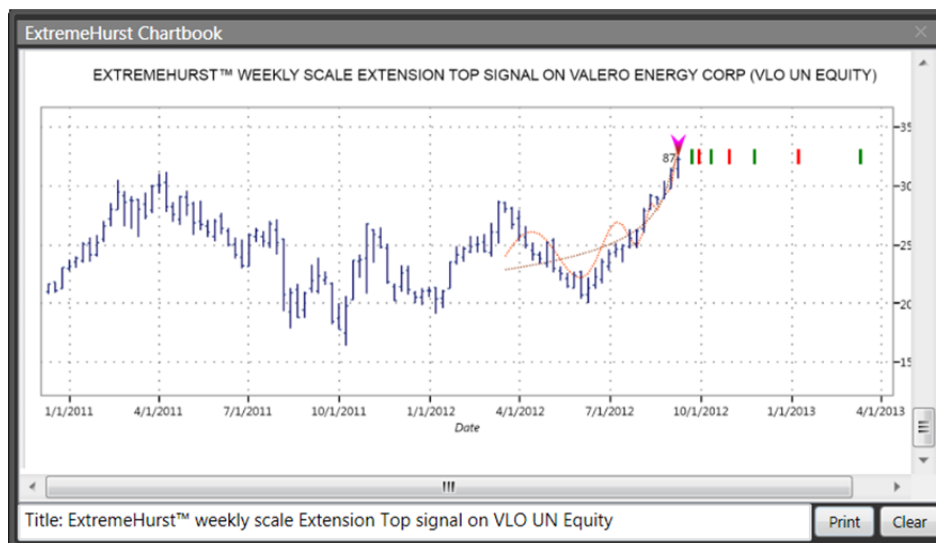
Press the "History+" button to add historical signals and additional studies to each chart. Once pressed, we gather additional data for the particular security and do a statistical calculation to see if other ExtremeHurst signals in the past behaved as expected. We also add two other signal types, SmartChannel (Custom Study "PFSC") and Price-Volume Crossovers (Custom Study "PPVC"). The Price-Volume crossover signals are useful bottom and top indications that last for about up to 6 bars.

EXTREMEHURST™ 60 MIN SCALE EXTENSION TOP SIGNAL ON GOOGLE INC-CLA (GOOG UW EQUITY)



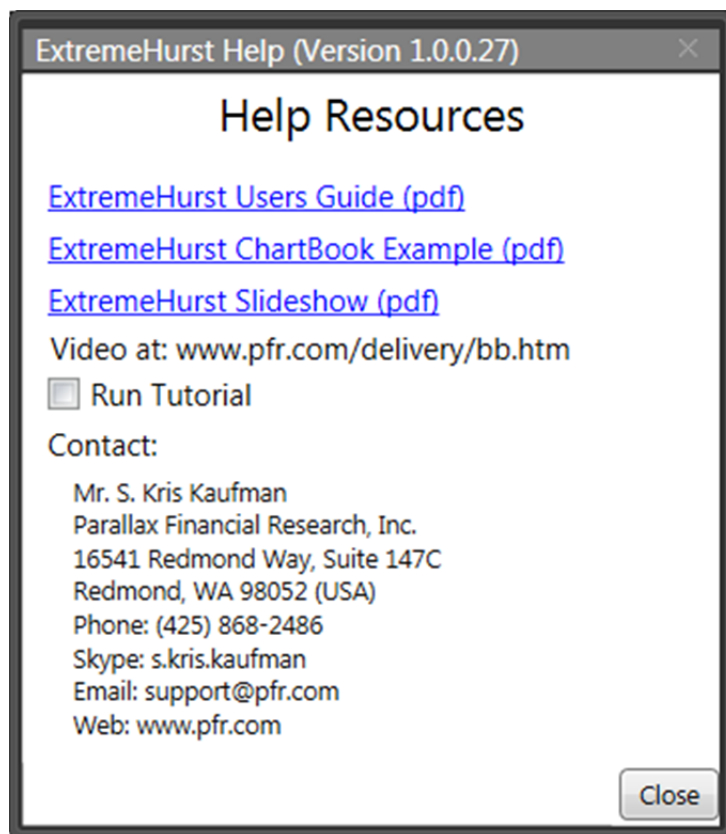
Chartbook +

Press this button to accumulate the current chart image to a book for later printing and review.



Help

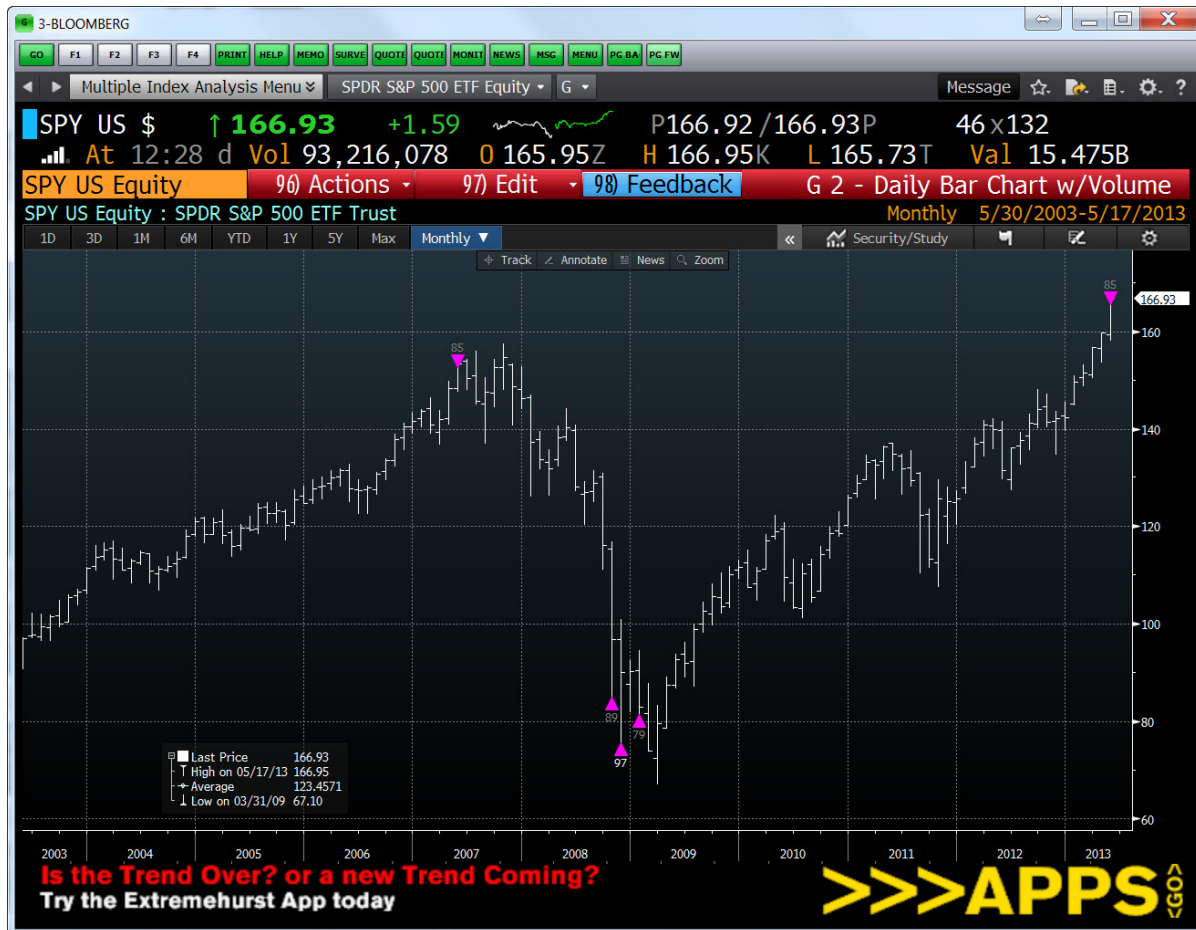
Our Help screen is shown below. Our links were not allowed to be live.



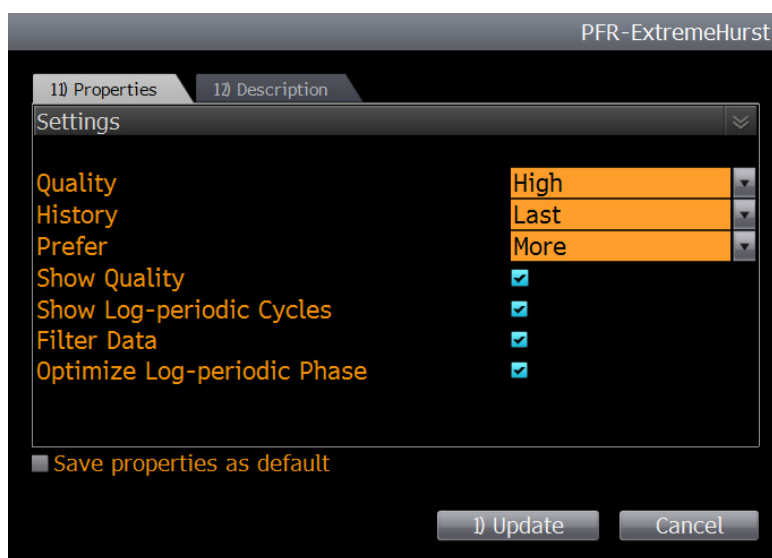
Parallax Financial Research, Inc. is a small scientific research boutique in Redmond, WA. The firm empowers professional money managers with a distinct edge through its unique fundamental and quantitative stock and commodity models. Our models are composed of individual "predictors" which are based on the financial application of both chaos and complexity theories, and presented in clear visualizations. These predictors are blended into forecasting models using genetically-enhanced neural networks. Our careful application of these mathematical modeling techniques yields unique and powerful solutions to enhance manager performance. Visit our website at www.pfr.com

The Custom Studies (APPS CS: PFR <Go>)

The ExtremeHurst™ custom study (“PFEH”) allows the user to overlay our study on a Bloomberg chart. Once in the Bloomberg charting screen, it is easy to change time scales, look at long signal histories, or follow ExtremeHurst in real time.



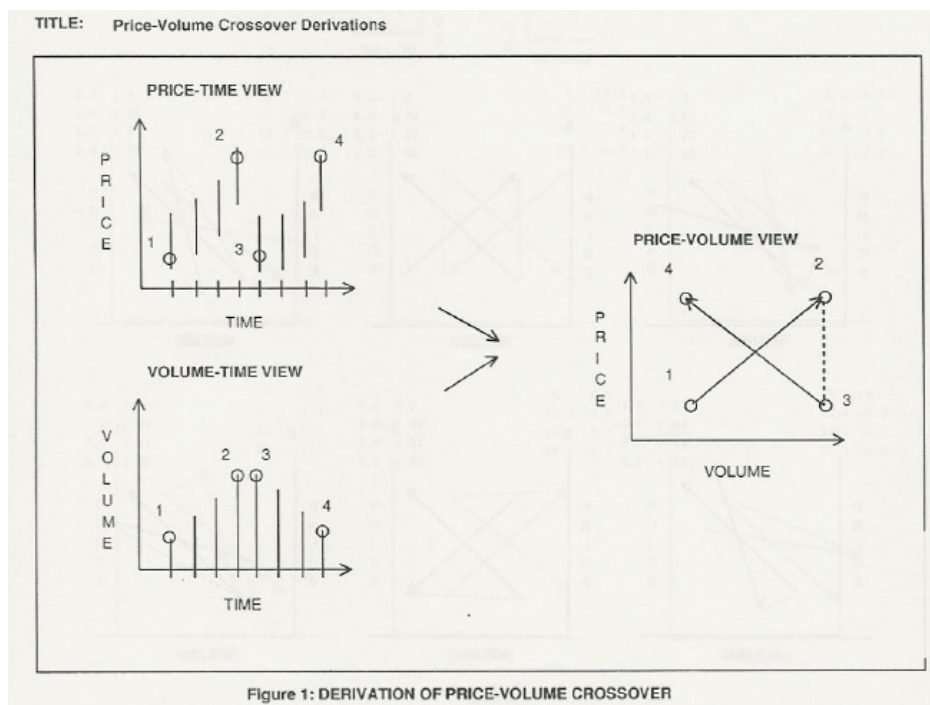
There are a few settings associated with our custom study: The signal quality varies between medium and superior. Medium quality signals have ranks of 70-80, High quality signals have ranks from 80-90, and Superior signals have ranks of 90-100. It is often useful to examine charts using a medium minimum signal quality so that more signals are visible. The Historical Signals setting allows you to speed up the study by choosing to just display the most recent signal.



ExtremeHurst signal commentary can be accessed using the Bloomberg Commentary tool as shown below:



Price Volume Crossover (Custom Study “PFPVC”) patterns are an attempt to capture a pattern of crowd investment behavior prior to a significant rise or fall in prices. Marc Chaikin and I studied 24 of these patterns and found 4 that were significant. They are located using this indicator. The plot below shows how a price view and volume view of stocks may be combined into a “price-volume” view.



PFR Paper: **Forecasting Stock and Commodity Prices using Price-Volume Crossovers, Kaufman and Chaikin, MTA Journal, 1991**

Recommended Usage: Best used as to identify significant upcoming directional price movement

Output:



The red plus signs mark bearish predictions as of the close of the bar where they are plotted, while the green plus signs mark bullish predictions.

Performance:

Name	Parameters	Direction	Excess %Winners	Peak Duration	Half-Life Duration	Sample Size
PriceVolumeCross	None	Buy	5.02%	1 bars	9 bars	89079
PriceVolumeCross	None	Sell	5.68%	4 bars	16 bars	89079

SmartChannel (Bloomberg Study “PFSC”)

Parallax’s SmartChannel study uses an advanced geometric algorithm to quickly find and display the most statistically significant parallel price channels. Users have the option to extend these channels into the past or future, and also plot offset log-periodic cycles when price breaks out of these channels.



Note the log-periodic offset projection lines

PFR SmartChannel

1) Settings 13) Description

Probability < 1	In 1000	▼
Extend	Right	▼
Max Channels		5
Log-periodic Projections		5
Log-periodic Wavelength		2
Filter Data	☒	

1) Update Close

This “Settings” menu allows users to customize SmartChannel

ExtremeHurst Science

This section covers the basic science and the empirical results from our ExtremeHurst™ market predictor model. Our research started in the late 80's with the observation that market series appeared to have no unique trend. An uptrend on a 5 minute chart might be embedded in a daily scale downtrend, and a monthly scale up trend, etc. It also made intuitive sense that no unique trend exists. After all, if it did, then all investors would quickly exploit it for profit. So following this line of thought, we wondered what would happen next if a financial series simultaneously showed a measurably strong trend on at least two adjacent time scales, or even three. This is a deceptively simple question, but how is trend measured? How much trend is a strong trend? Are there preferred time scales? How much data is needed to evaluate trend? The answers to these questions led eventually to the discovery that elements of chaos theory, namely self-organized criticality [13, 30] and discrete scale invariance [25-27, 30] (discovered independently and named by Didier Sornette), have a statistically significant predictive power in financial markets and elsewhere. Here are the highlights of the journey.

Most scientists and engineers graduating in the 80's or earlier were trained that experimental data usually approximated some smooth function, but with a bit of random measurement error. To the untrained eye, stock price data looks very similar to a smoothly trending signal covered up by a large amount of random noise. Even the price returns appear to resemble a Gaussian distribution, which often implies a random process. The standard engineering approach in cases like this would be to fit a regression curve to the market series and write off the remainder to random noise [1]. Once a smooth curve was found that fit prices well enough, one would just find the slope ("trend") at each point. The trend would be unique by definition, and its direction would dictate the trade direction.

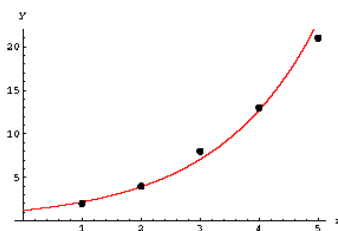


Figure 10. Typical regression curve fitted to data with the remainder attributed to random sources

If this sounds too simple to be true, you have graduated to the rest of the story.

Chaos theory covers the dynamics of feedback systems [3, 8, 12, 18, 22, 30, 31]. Generally, feedback means that the outputs of the system are fed back into the system as new inputs to produce more outputs....and then this process continues until the loop is broken. Feedback can be negative, like in the case of a thermostat, or positive, as seen by placing a microphone near a speaker. In the financial markets we can imagine that price movement, news, or possibly influential people produce investment bias “output” that is fed into the brains of the investor community, who then produce new outputs in the form of buy and sell decisions. If this bias is positive, buying occurs, which leads to higher prices and more positive bias, etc. Feedback systems exhibit certain characteristics, which strangely enough, seem to match the kinds of phenomena that market technical analysts have attributed to markets over the last 100 years. Self-similarity is the primary example.

Financial series appear to have the same “look” on many different time scales. This is called self-similarity, and it happens to be one of the best ways to confirm that a series is governed by the rules of chaos theory. Put another way, the market is what Mandelbrot [14] called a “fractal.” Not quite like a fern or a snowflake, but more of a statistical fractal like a shoreline. We chose a fractal function developed by Weierstrass to model a market series [8]. Weierstrass functions are continuous, meaning you can draw one without lifting your pencil, but they have no unique slope. They look like a cycle inside a cycle inside a cycle as shown in the next figure. Market technicians call this effect the “Elliot Wave”, but self-similarity has a much deeper theoretical meaning firmly based in non-linear dynamics.

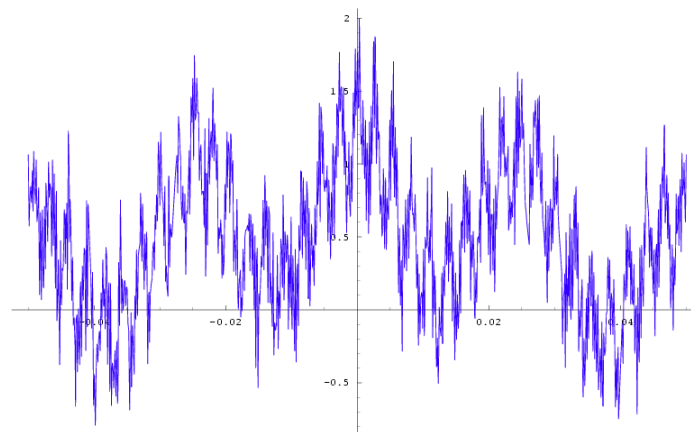


Figure 11. Weierstrass functions[8] show nested cycle patterns. It has no unique slope at any point.

Equation:

$$f(t) = \sum_{k=1}^{\infty} \lambda^{(s-2)k} \sin(\lambda^k t), \quad 1 < s < 2, \lambda > 1$$

According to our model, a 5 minute chart will exhibit a different slope at a given moment than the same chart viewed on a 60 minute, daily, weekly, or monthly scale. It all depends on the length of your time

sampling. Again, this is nothing new to traders, but it represents a radical shift for scientists and engineers. Faced with a non-unique trend, we decided to make multiple measures of trend on different scales. This naturally led to the research question of what might happen if they all agreed. To measure trend we used a special local form of the Hurst exponent [35]. The Hurst exponent has a simple formula and ranges in value between 0 and 1. Values above ½ indicate that there is a trend to events, with very high values (towards 1) corresponding to strong trends, with a marked tendency to persist. Values below ½ correspond to mean-reverting behavior, which becomes more and more tightly constrained as the exponent approaches 0. The formula for the exponent is:

$$\left(\frac{R}{S} \right)_N = (cN)^H$$

Where $(R/S)_N$ is the range of the cumulative deviations from the mean divided by the standard deviation, c is a constant and H is the Hurst exponent. The following picture shows the Hurst exponent placed on a percentile rank scale of our choosing.

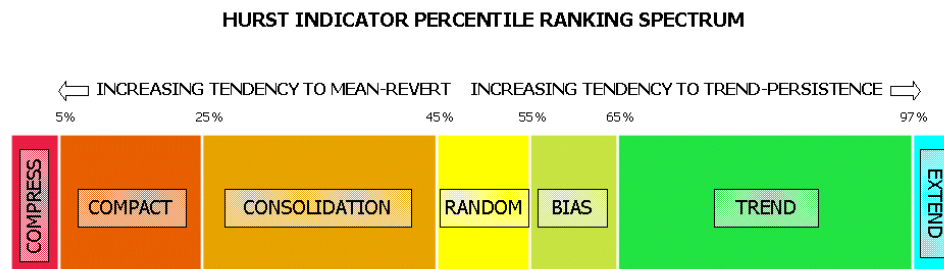
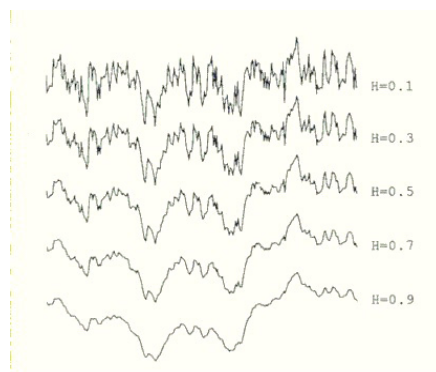
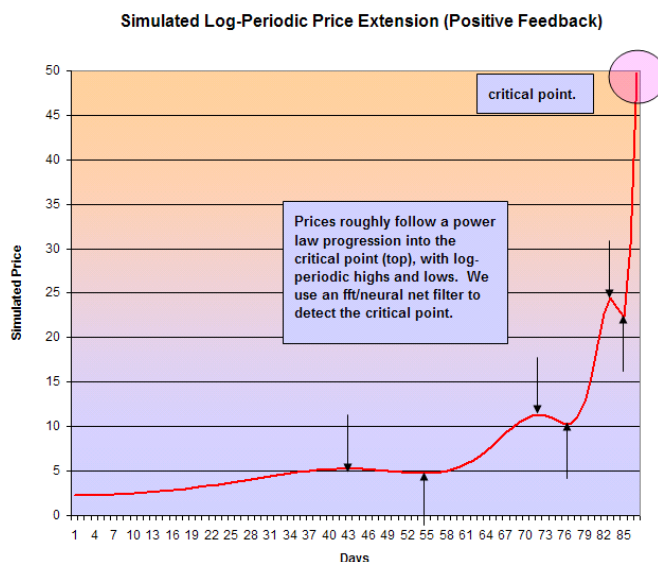


Figure 12. This shows the Hurst exponent percentiles and our interpretation of the various domains.

The following picture is an example of what a time series might look like using different Hurst exponents [34]:



Using the Hurst exponent, we are able to identify price swings which have high autocorrelation and resemble power law upswings or downswings such as the one shown in the following picture [30]:



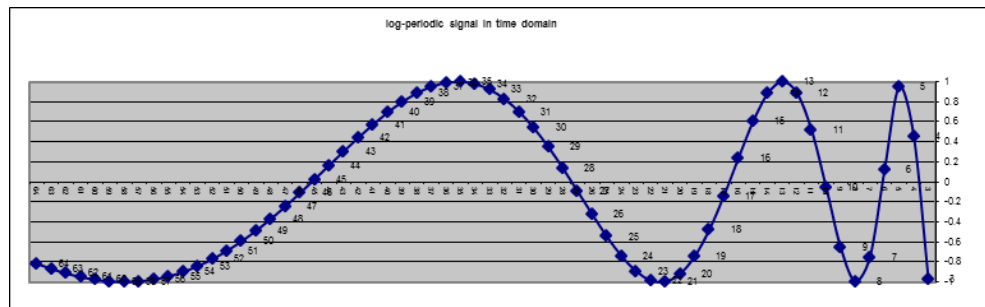
There was another key timing factor in addition to the parabolic price move which we literally stumbled upon while trying to limit our Hurst sampling look back periods. Cycles were present during these parabolic moves, and by exploiting them, we were better able to time the critical point. The next section discusses log periodic cycles and the science that ties it all together.

Extremes of investor behavior are most evident in large scale market manias or crashes, but like earthquakes, significantly more low magnitude events occur than large ones. It is our contention that markets set themselves up in critical states through feedback, like earthquakes, and then we see tremor-like activity of all sizes and scales at both highs and lows. This area of scientific research is called “Self-Organized Criticality” or SOC for short. Bak, Tang, and Weisenfield (BTW) [36] first introduced SOC in 1987 by studying the occurrences of avalanches in sand pile models. It was their contention that large systems with many constituent parts, organize themselves into states that resemble systems in equilibrium at critical points.

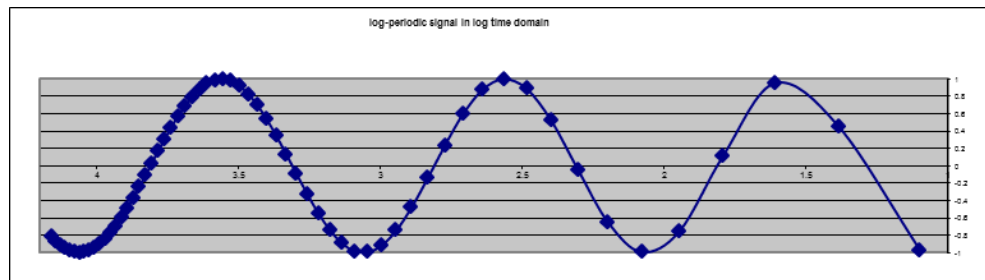
In the case of the markets, investors are influenced by news, price changes, and other investors within their local social network. This influence conditions their willingness to buy or sell, which in turn affects price and influences others, and so on. One of the methods used to understand the dynamics of large critical systems is called the Renormalization Group Method [10, 13, 27, 30] this method uses scaling to make sense of complex systems. We have applied this method to learn some basic principles about

markets: First, it takes very few net buyers or sellers to trigger a buying or selling trend, or end one. Second, the buildup to a critical point resembles the power law function $C1 \cdot (1 - t/t_c)^x$, where $C1$ is a constant, x is a negative power, t is time, and t_c is the time of the critical point. Thirdly, there is often a log-periodic ripple in price that converges to the critical point that has the form: $1 + C2 \cdot \cos[p \cdot \ln(1 - t/t_c) + q]$, where $\ln(x)$ is the natural log function, $\cos(x)$ is the cosine function, and $C2$, p , and q are real constants[30].

In the time domain the small ripple signal we search for looks like this:



While in the log time domain it becomes a sine wave:

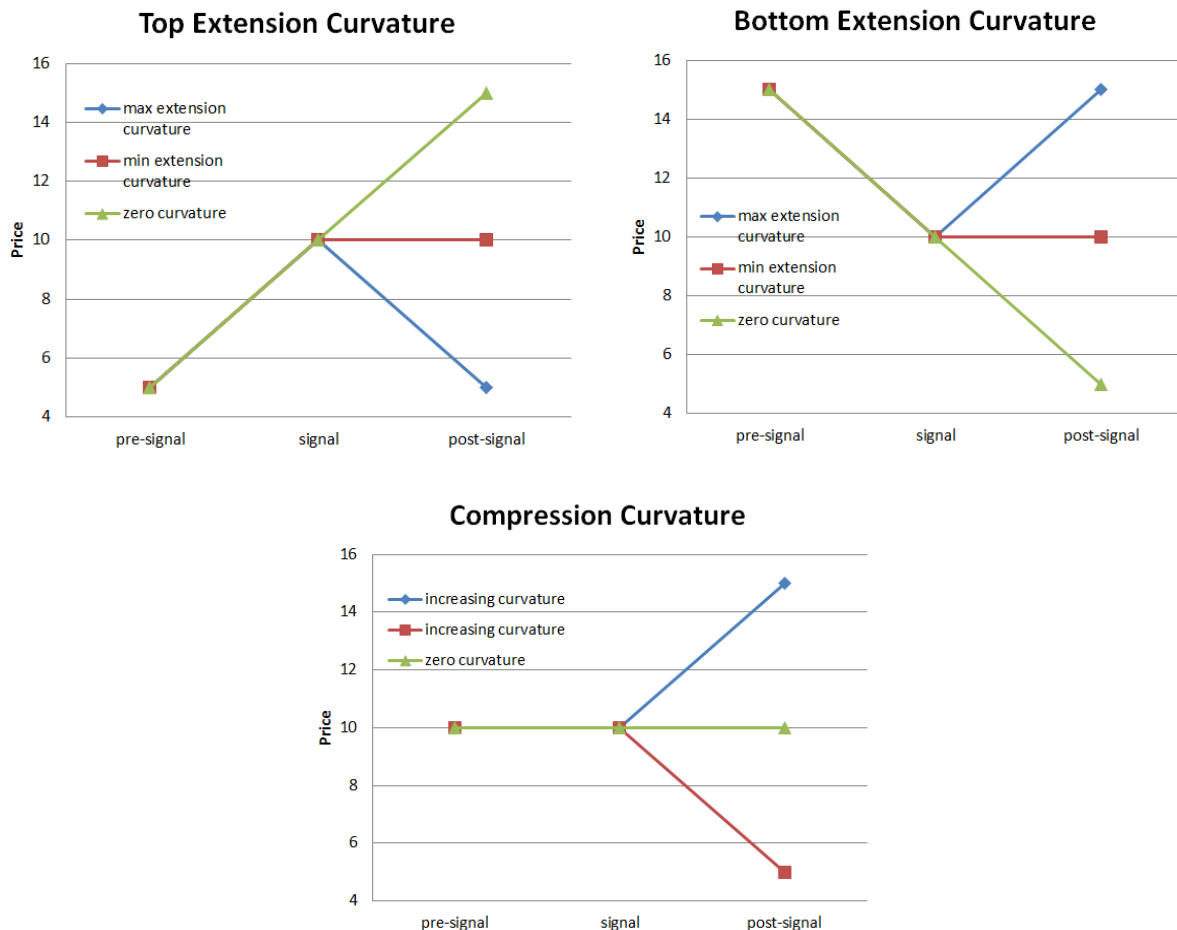


Sornette [26] attributes this ripple to what he has called “discrete scale invariance” which means that the price series is only scale invariant at certain discrete times. He attributes this effect to fractal dimensions being complex numbers instead of real numbers. Translation: Discrete scale invariance occurs when all trend measurements at all scales agree with each other. Our filter is designed to find these critical points.

The filter we have created finds these critical points at the end of power law advances and declines. These we call “extensions.” There is another critical point not yet written about in the literature that we call “compressions.” A compression has the same log periodic behavior shown above, but without the power law advance or decline. A compression occurs at points of extreme mean reversion, and is followed by the start of a new trend, usually with a volatile breakout.

ExtremeHurst Testing and Statistics

ExtremeHurst signals predict market critical points which mark a change in trend, or in mathematical terms, increasing price curvature. There are three types of ExtremeHurst signals: Top and Bottom Extensions and Compressions. The predicted price behavior following a top extension is for price to cease moving up. Likewise, for bottom extensions we expect price to cease moving down. Compressions are preceded by flat periods, so the post-signal period must see price move away from current price and begin to trend:



These charts show the simulated periods before and after each of our signal types. The green lines show no trend change across the signal. We have created a tool to measure curvature called the Turn Measurement Index (TMI) which is an approximation to the second derivative of a series using the following differential formula from Calculus:

2nd Order Central

$$f''(x) \approx \frac{\delta_h^2[f](x)}{h^2} = \frac{f(x+h) - 2f(x) + f(x-h)}{h^2}.$$

We have manipulated the formula to work with financial data on all scales using a “random walk” assumption. The final form looks like this (Taken from a Parallax research document):

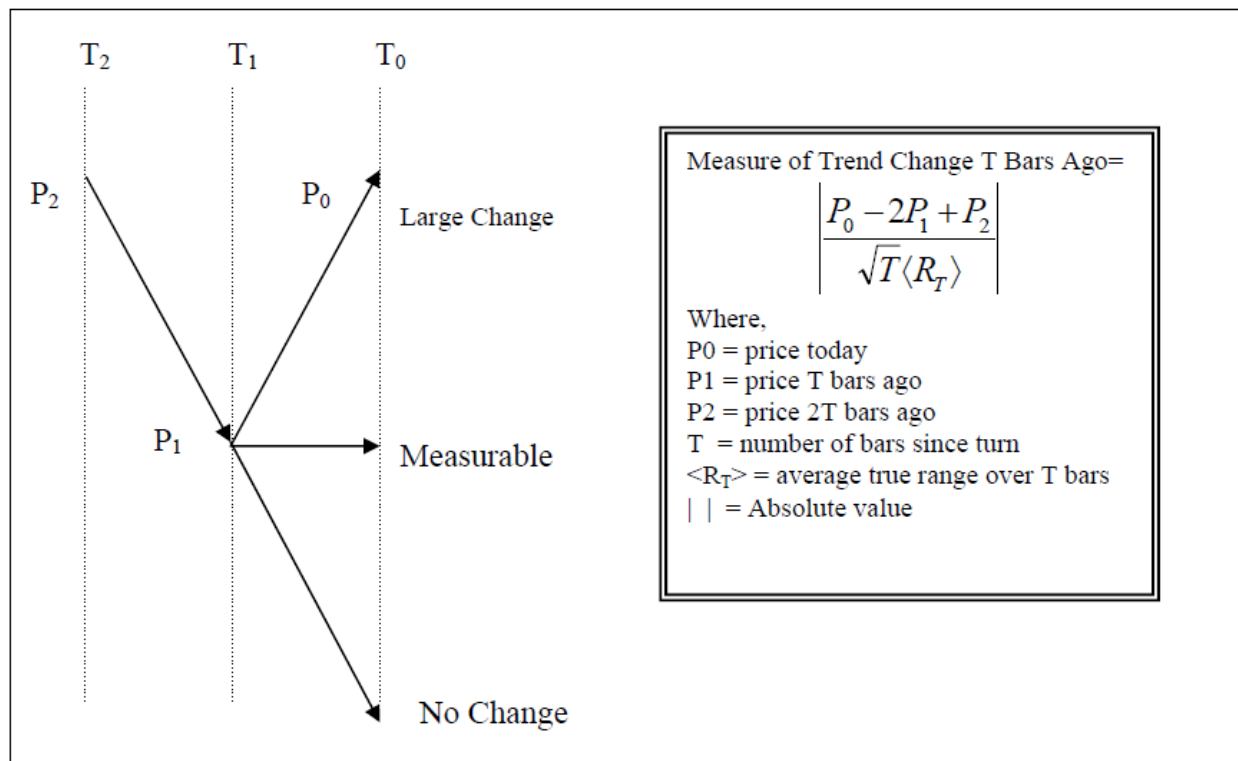


Figure 1. The Turn Measurement Index (“TMI”)

The graphic in Figure 1 illustrates how the **TMI** is calculated. When prices form a straight line, then the numerator goes to zero, meaning that there is no change in trend between the P2 to P1 segment, and the P1 to P0 segment. The $\langle R_T \rangle$ factor refers to the average true range over the whole period. Regular range is simply the change in price between today's high and low. The "true" range fills any gaps from the prior day. If yesterday's close is higher than the high today, then it is used in place of the high, likewise yesterday's close is used if it's lower than today's low. The length of time for this measurement can be varied, and different **TMI**s be compared with each other.

The next picture is an example of the TMI formula applied to Microsoft stock prices over lengths of 7 and 15 days:

TMI Calculation Example: Microsoft Price Series

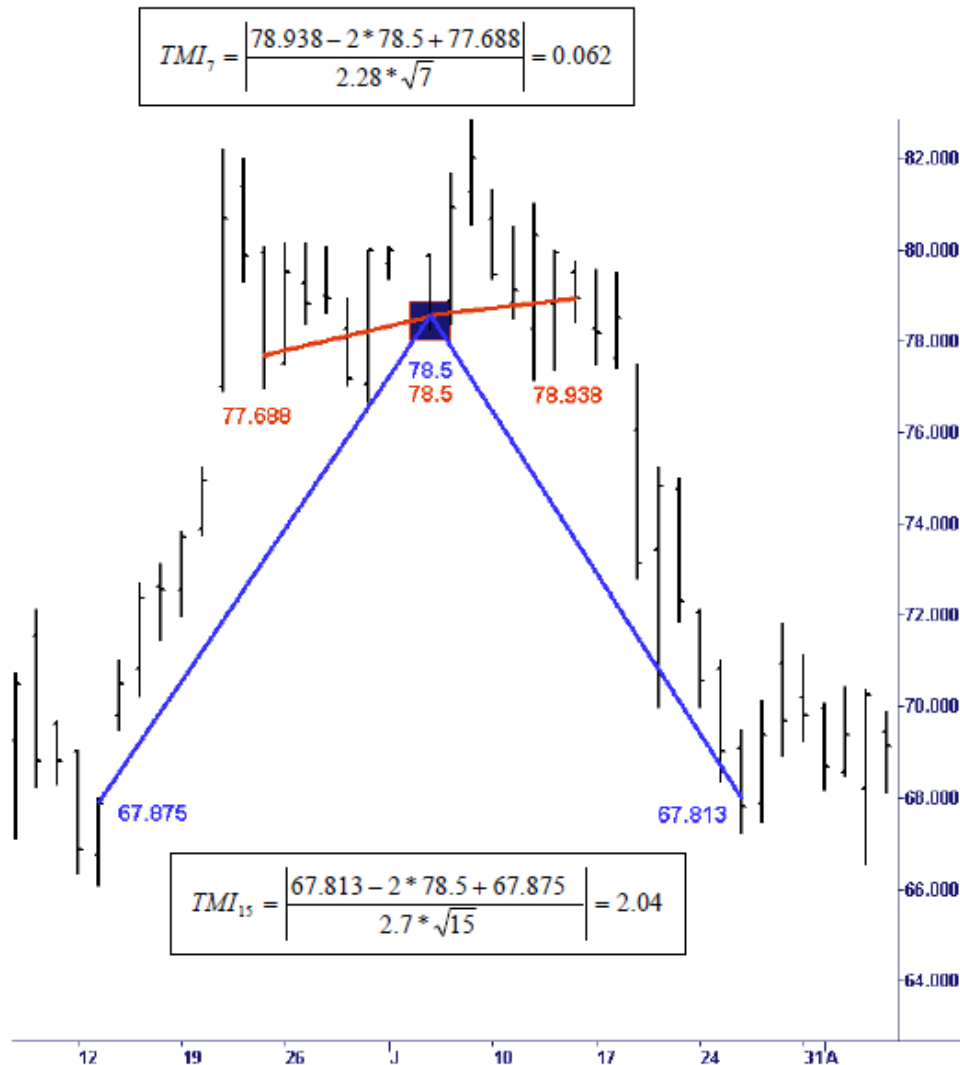
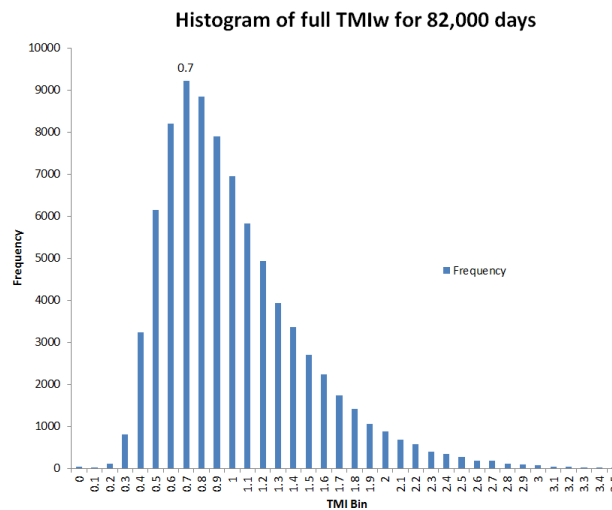


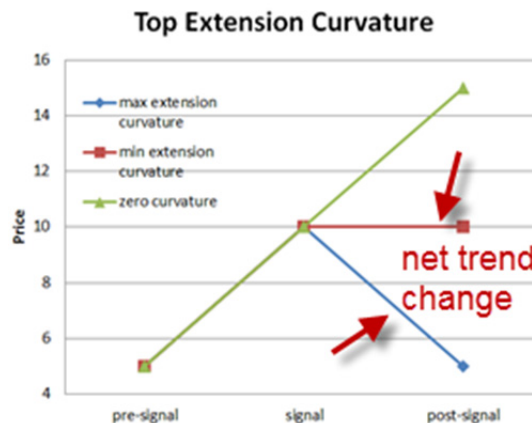
Figure 2. The TMI calculation for two different time intervals (7 and 15 days) surrounding the price of Microsoft stock on July 5, 2000 yields very different answers. We will use the maximum number to express “how much” trend-change occurred that day.

Note that the 15 day TMI picked up the large trend change, but the 7 day TMI did not see it.

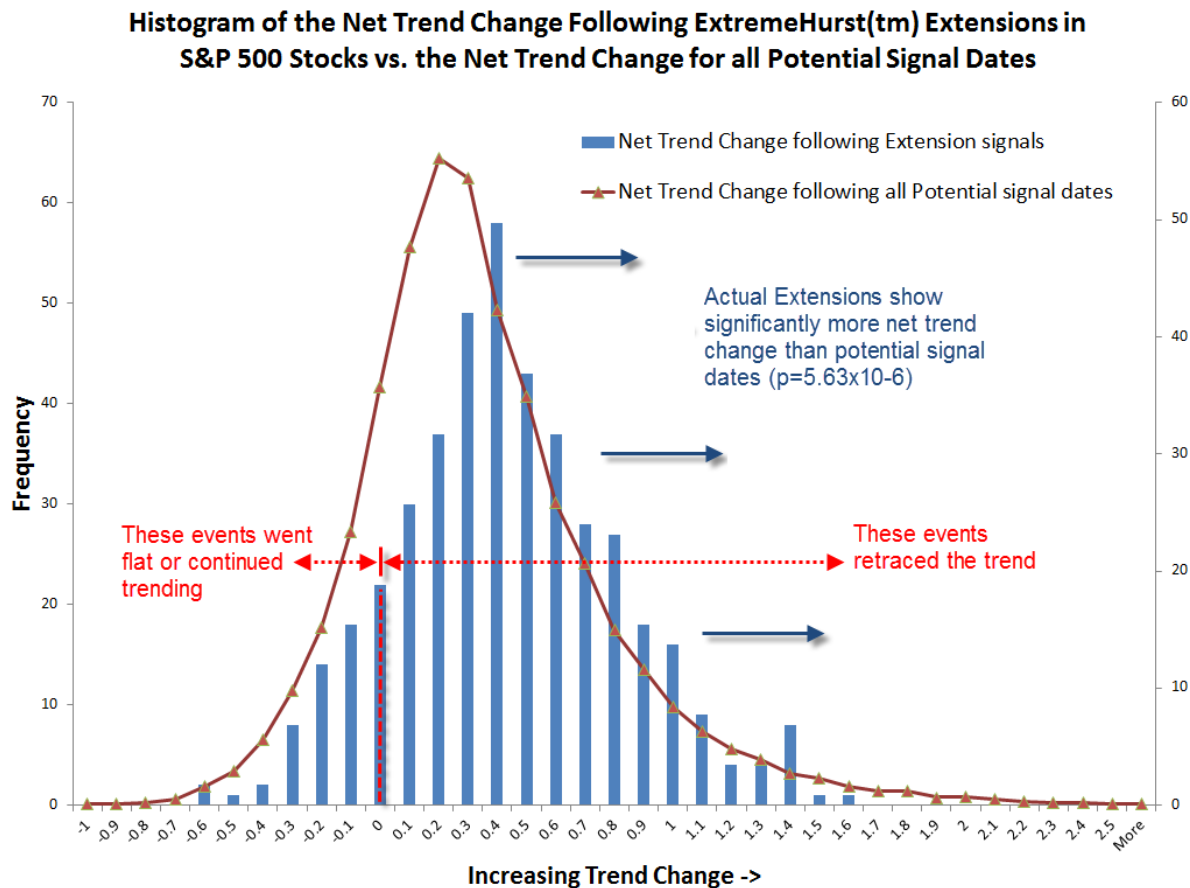
We expect that there will be significant net increase in TMI across all of our signal dates when compared with the set of all potential signal dates. We have applied the Students t-statistical test to measure this hypothesis. First though, we will introduce the weighted average of different length TMI measures, called TMI_w. We need multiple measurement lengths since using only one length is likely to miss some trend changes. We chose lengths ranging from about 1 to 6 weeks, with an average of 13 days. This length is close to the length over which ExtremeHurst signals are known to have an effect. In the next graph we have calculated the daily TMI_w for a random set of S&P 500 stocks over 20 years and made a histogram. Remember that high TMI_w means that there was a very high amount of trend change across a given date.



We have a slightly different need however. We need to know how much **net trend change** occurred across a given date. This is simply calculated taking the difference between the two-sided (pre and post-signal) TMI_w above, and a one-sided TMI_w which assumes flat post-signal prices as shown below.



When we plot the histogram of the net trend change for potential Extension days, and then compare it to the net trend changes from our actual Extension signal days, we get the following picture:



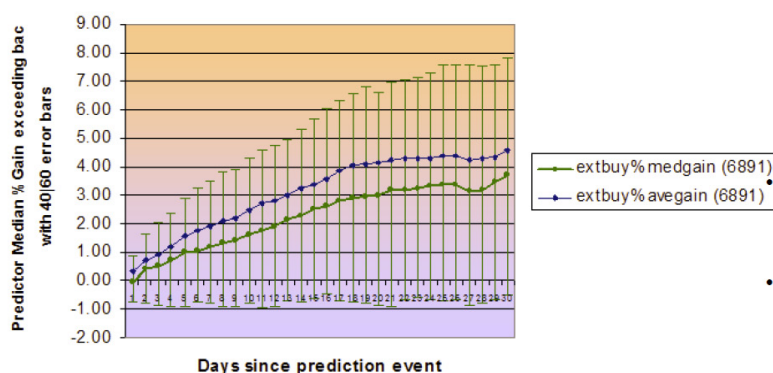
In the plot above, the amount of net trend change increases as we move to the right, so our signals, shown in blue, clearly have more “bend” than the potential signal days. The potential signal days are those days whose one-sided TMIw is greater than or equal to the minimum of that seen on our actual signal dates. In other words, potential signal date have strong trends leading into them.....but the market fails to bend as much coming out of them as it does when an actual Extension signal hits. Our statistic measured $p \leq 5.63 \times 10^{-6}$ which means there is less than a 1 in 177,000 chance that the two histograms above were generated by the same process. In the few pages which follow, some additional tests are shown for a prior version of ExtremeHurst.

ExtremeHurst Testing and Statistics (older)



ExtremeHurst™: Buy Predictor Test Results

ExtremeHurst daily extension Buy Predictor
Median & Average %Gain Exceeding
Random Daily Background (2500 stocks during 1996-2004)



- Price moves following a critical low point are shown for 6,891 cases over 8 years

- Average and median returns day by day through a 30-day holding period are shown. Error bars represent the 60th and 40th percentile bounds.

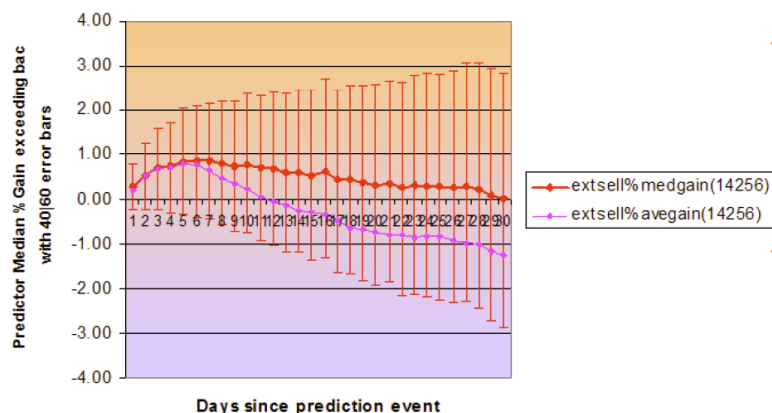
The gains are progressive throughout the test period.

- Annualized returns are about 33%



ExtremeHurst™: Sell Predictor Test Results

ExtremeHurst daily extension Sell Predictor
Median & Average %Gain Exceeding
Random Daily Background (2500 stocks during 1996-2004)



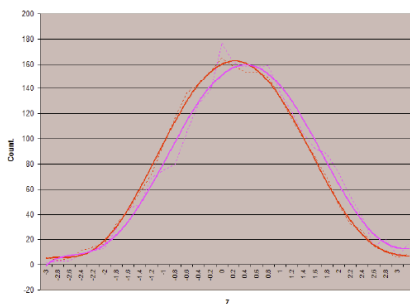
- Price moves following a critical high point are shown for 14,256 cases over 8 years

- Average and median returns day by day through a 30-day holding period are shown. Error bars represent the 60th and 40th percentile bounds.

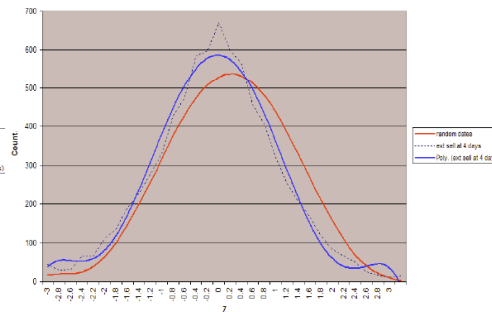
- Sell signals are effective for the first 6-7 days and then diminish

ExtremeHurst™: Predictor Test Results

Parallax ExtremeHurst™ Extension Buy Predictor(slf=3) on Day 11
vs Random Background Distribution (1996-2004, 2500 stocks)
Chi2 test $p=0.000000054$



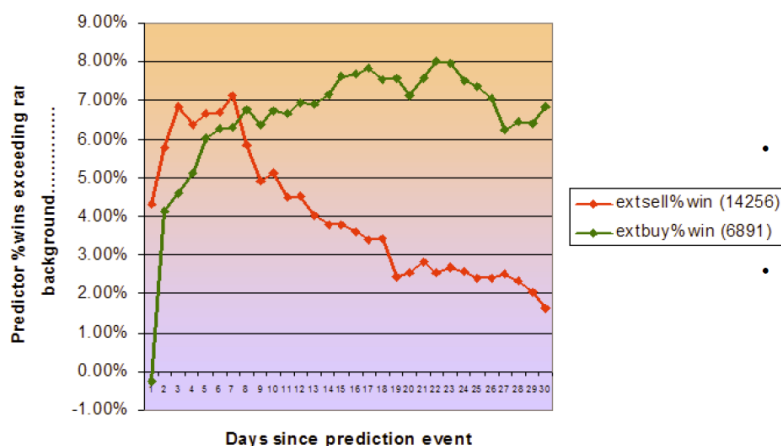
Parallax ExtremeHurst™ Extension Sell Predictor(slf=1) on Day 4
vs Random Background Distribution (1996-2004, 2500 stocks)
Chi2 test $p=6.7 \times 10^{-124}$



Z Scores for buy and sell predictors vs a random event background distribution, several days after event.

ExtremeHurst™: Test Results

ExtremeHurst daily extension predictors Net Advantage vs.
Random Daily Background (2500 stocks during 1996-2004)



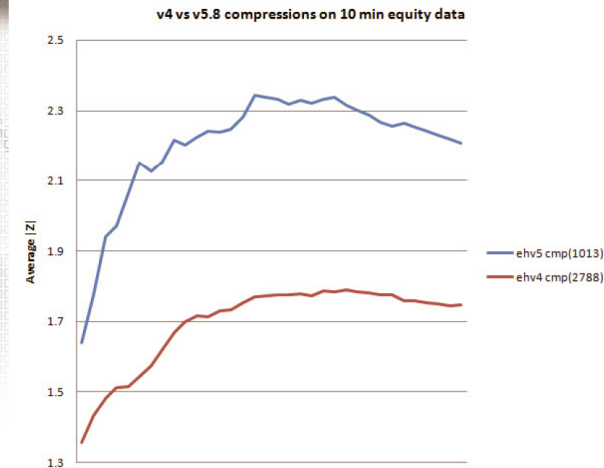
- This figure shows the percentage of winners following a critical point, minus the background %wins, during the 8 year period 1996-2004 for 2500 stocks

- A 6-7% edge over the background win rate is attained for buys and sells

- The effect duration is asymmetric. Sells loose strength faster than buys.

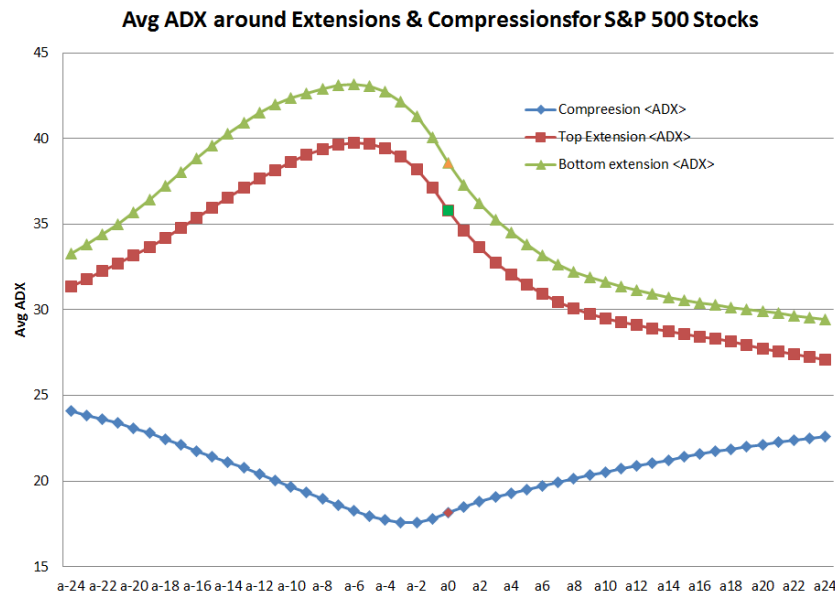


Compression Signals Performance

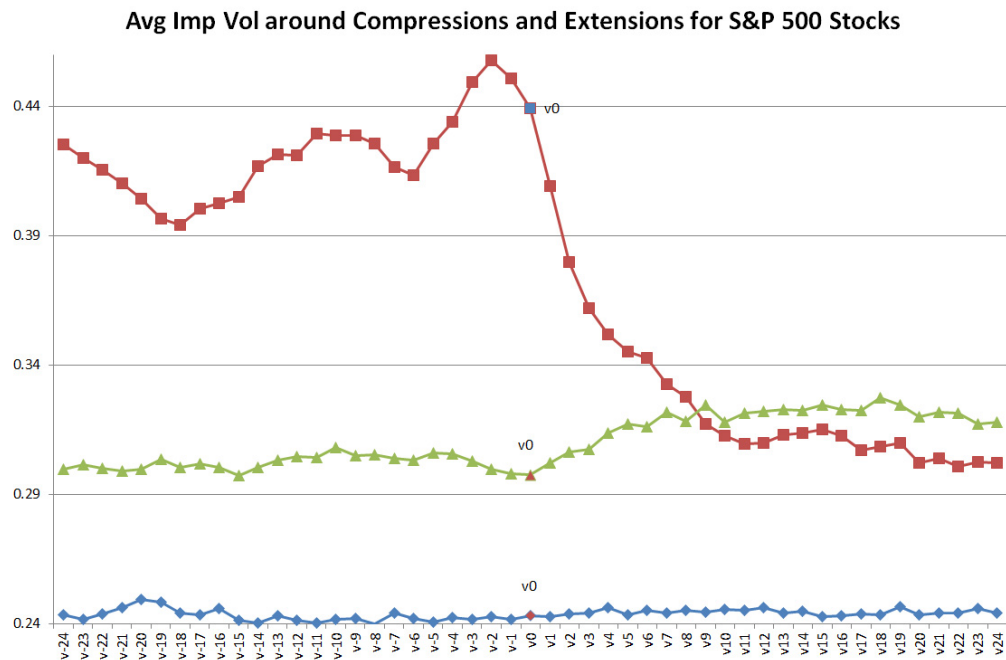


- We can measure how many standard deviations that price moves following a compression ("Z")
- V5.8 with $TrZ < -0.3$ exceeds 2.3 absolute value of standard deviations
- V5.8 beats v4 by far

The question usually arises as to how ExtremeHurst signals effect standard indicators like ADX and Implied Volatility. ADX is a directionality measure, so extensions should lead to a drop in ADX, while compressions precede directional movement and so should lead to higher ADX values. We have confirmed this.



The next plot shows average implied volatility (from options) before and after the three signal types. The red line is due to extension bottoms, and shows that volatility drops 32% following a bottom signal. The green line is the average volatility before and after a top extension. In this case we see a 10% increase after a top. There is no change at all in volatility around a compression signal, and volatility is also relatively low.



ExtremeHurst Users

Several money managers are using or have used the ExtremeHurst product as a part of their management business and have consented to be listed as references for potential users:

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