

How to Use the *QuanTek* Trading Rules

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QuanTek is a stock trading program for short-term traders and long-term investors. Its purpose is to allow the trader to design his or her own custom **technical indicators**, by means of a **Technical Indicators** dialog box, which have maximal **correlation** with future returns. These technical indicators consist of a variety of different types of smoothings of the past price data, on any time scale you choose, and make use of a **Price Projection**. A set of three technical indicators is then displayed in a set of splitter windows, and **buy/sell signals** and **trading rules** are derived from them. The **buy/sell points** are displayed in all nine splitter windows, and in the **Main Graph** (which has four scales). The Main Graph also displays the **Price Projection**, which is the output of the **Price Projection** filter. This (digital) filter, in the present version, consists of a **Fractional Difference** filter. These technical indicators are designed and tested directly

using a **Correlation Test**, to allow the best possible chance of finding technical indicators that show a positive **correlation** with future returns.

Buy/Sell Signals and Points

It should be remarked that there are actually two different types of trading signals in *QuanTek*, which we call **buy/sell signals** and **buy/sell points**. (We hope this will not lead to too much confusion.) Both of these trading signals are derived from the **Trading Rules** indicator (see below). The buy/sell signals are for the purpose of setting buy/sell limit orders. They occupy a range of time around the maxima and minima of the Trading Rules indicator, and their parameters may be set by two controls on the **Trading and Portfolio Settings** dialog. The **threshold** control determines the level of the buy/sell signals, above or below the N -day smoothed price level. This corresponds to the optimum setting for the buy/sell limit price. The **range** control determines the range of the Trading Rules indicator that triggers the buy/sell signal. In this way you can set buy/sell signals only for extremes of price, or more often for smaller maxima or minima of price. The buy/sell signals are listed (for the upcoming day) in the **Short-term Trades** dialog, which you can see at any time just by right clicking. They are also displayed in **scale 4** and **scale 8** of the **Main Graph**. (The Main Graph scale 8 only displays those buy/sell signals that were actually “triggered” as limit orders.) The **buy/sell points** are markers for the single points that are the zero crossings (positive/negative) of the **Trading Rules** indicator. The buy/sell points are displayed as green and red arrows on **scale 2** of the **Main Graph**, which you see when you first open a stock data graph. The buy/sell points are also displayed as green and red vertical lines on all of the nine splitter window panes. These buy/sell points are mainly for the purpose of marking the most favorable points to buy and sell in the range of buy/sell signals, and also as markers to line up the features in all the graphs. In the splitter windows, these buy/sell points are intended to line up the maxima (**max**), minima (**min**), zero crossing moving upward (**Z+**), or zero crossing moving downward (**Z-**), points on each graph, as the case may be, for reference purposes.

Also note that on the *QuanTek* graphs, the buy/sell signals and points to be acted upon are the ones that pass through the *present point in time* on the graphs. On the Main Graph, the present time is marked by the transition from white (or black) vertical bars, denoting the *past data*, to blue squares, denoting the *future projection*. On the splitter window panes, the present time is marked by a vertical yellow line. The buy/sell signals to be acted upon are the ones that are indicated just to the right of the present point in time (actually, for future day 1). These are also listed in the **Day Trades dialog** for each stock. The buy/sell signals and points to the future of the present time are *estimated* ones, based on the future *price projection*. The buy/sell signals and points to the past of the present time are computed based on *perfect hindsight* or knowledge of the future (for the *distant* past, at any rate). These are displayed for the purpose of showing the frequency and range of these signals and points, and showing what they would look like if the future were already known. (To re-compute all of these signals for each day in the past, using only past data relative to each day, would take a very long time to compute. This type of computation can be simulated in the **Diagnostic Test**. We felt it was important to display

the *past* buy/sell signals and points, based on perfect hindsight, for reference purposes, along with the *future projected* buy/sell signals and points.)

Correlation and Price Projection

The *QuanTek* Main Graph contains several important **technical indicators**. Foremost of these is the **Price Projection**. This is based upon what we call a **Fractional Difference** filter, in which the stock price returns are modeled as a *long memory process* with *fractal statistics* (with a *negative fractional dimension*). (This implies that the correlation decays like a power law rather than exponentially.) This filter may be found on p. 520 of Time Series: Theory and Methods [Brockwell & Davis (1991)]. The filter coefficients are very easy to compute from a fixed formula, and do not need to be “estimated” or fitted to the data. This filter gives very good results in the correlation tests, and verifies the idea that the stock returns data employ *fractal statistics* [Peters (1991, 1994)]. **The Price Projection based on the Fractional Difference** filter is used, along with the **Savitzky-Golay** smoothing filter, to construct the technical indicators for the **N-day Trading Rules**. For **Day-Trading**, however, the **Fractional Difference** filter, with a *negative* fractional dimension, is used by itself, to take into account the short-term anti-persistence of the returns. The output of this day-trading projection is displayed in the **Short-Term Trades** dialog.

What we are finding is that there appear to be two different types of correlation in the stock returns data. On very short time scales in the daily returns data, namely 1 to 3 days, we find that the returns are *anti-correlated*, implying anti-persistence and a *return to the mean* mechanism on very short time scales. This has also been documented in The Econometrics of Financial Markets [Campbell & Lo (1997)]. When looking at the display of autocorrelation of the daily returns, there is almost always an anti-correlation with the future one-day return for the returns over the past 1 to 3 days. However, this contradicts the idea of Peters [Peters (1991, 1994)] that stock returns are *persistent* and hence *correlated*, so that the returns follow long-term trends. Since it is well established that this is the case over the long term, say time periods of months to years, evidently the returns are persistent over these long time periods and anti-persistent over the very short time periods. This in turn implies that the **fractional dimension** parameter in the **Fractional Difference** filter is *negative* for very short time intervals and *positive* for long time intervals. According to the theory of long memory processes [Brockwell & Davis (1991)], this **fractional dimension** parameter lies in the range $-0.5 \leq d \leq +0.5$, where the value $d = 0$ corresponds to uncorrelated Gaussian white noise. Thus the stock returns are evidently not a true fractal process, since the **fractional dimension** varies over different time scales. For the short time scales of 1 to 3 days, we find very good correlation using the **Fractional Difference** filter with a *negative* value of d . (You can test this for yourself using the *QuanTek* correlation test.)

The *QuanTek* Main Graph

When you open a stock data file, the **Main Graph** appears. This graph can be switched between four different magnification scales. These scales are denoted **scale 1, 2, 4, and**

8, which indicates their relative magnification value. (Each scale is magnified by a factor of two relative to the preceding one.) When you first open the Main Graph, it is on **scale 2**. Each scale contains some different technical indicators, which are described here. You can move back and forth between scales using the **blue arrows** on the toolbar. You can also move back and forth between blocks of the data using the **magenta arrows**.

By the way, you can see all the graphs with either a **black background** or a **white background**, using the **Toggle Dark Colors** button on the Main Window toolbar. The black or white backgrounds use a different set of colors for the different features of the graphs. Generally, the colors for the black background are the *dark* versions of the colors for the white background. The black background is on by default. Lastly, one nice feature of the **Main Graph** is that, if you rest the mouse pointer at any point in the graph, a **tool tip** pops up, which lists the **price level** at that point and the **date**. This is very handy for finding the price and date of any point on the graph, without having to refer to the **Stock Data** list.

Main Graph – Scale 1

This is the long-term view of the stock data. Each day of data occupies one pixel of the screen, so there is no tick for the closing price on this scale. The future projection, with error bars, is the blue area to the right of the graph. On this scale, a long-term trend line is displayed which is a **robust straight-line fit** to the data (minimizing the sum of the absolute deviations from the line). This is shown as the centerline, in dark yellow. On either side of this line are two sets of **Bollinger Bands**, at one standard deviation (dark cyan) and two standard deviations (dark magenta) away from the centerline, respectively. These may be used to gauge the relative long-term variations of the price away from the long-term robust trend line. This graph is good for seeing the long-term trend of the price data at a glance.

Main Graph – Scale 2

This is the scale which first appears when a stock data file is opened. On this scale, there are two pixels per trading day. Each vertical bar ranges between the high and low for the day, and there is a horizontal tick for the closing price. If you look closely, underneath the data bars is a dark blue curve, representing the N -day (acausal) smoothing curve of the price data, where N is the *trading time scale* that you have selected (in the **Technical Indicators** dialog box). To the right is the **future projection**, which follows this N -day smoothing curve, and the vertical blue bars are the one standard deviation error bars for the projection. By analogy with the *Random Walk*, they can be seen to grow approximately as the square root of the number of days in the future. This future projection is the output of the **Price Projection** filter. The dark yellow curve is a 320-day (acausal) smoothing of the price data. On either side of this curve, in dark cyan and dark magenta, are the **Bollinger Bands** corresponding to one and two standard deviations, respectively, away from the center curve.

Featured prominently in this scale are the **buy/sell points**, which are the green and red arrows. These show the optimum points to buy and sell, given the selected *trading time scale*, and correspond to the positive/negative going zero crossing points of the **Trading**

Rules indicator (on the lower pane of the *Trading Rules* splitter window). These green and red arrows are represented in all the splitter windows as green and red vertical lines, and they serve to line up all the features on the graphs, as well as indicate the optimum buy/sell points on this time scale. The green and red arrows in the *future projection* are estimated buy/sell points, based on the **Price Projection**.

Main Graph – Scale 4

This graph is basically the same as scale 2, except a factor of two larger. There are four pixels per data point on this scale. This makes it easier to see the short-term price fluctuations. The main difference with scale 2 is that, instead of displaying the **buy/sell points**, it displays the **buy/sell signals** instead. The buy/sell signals are ranges of buy points and sell points, designed for setting limit orders, with the optimum point in each range of buy/sell *signals* marked as the buy/sell *point*. It will be noticed that the buy points are a little below the *N*-day smoothing of the prices, and the sell points a little above. The degree that the buy/sell signals are below/above this *N*-day smoothing curve is set by the **Threshold** control on the **Trading and Portfolio Settings** dialog. The range over which the buy/sell signals extend, corresponding to a range of values of the **Trading Rules** indicator (from which they are derived) is set with the **Range** control in this dialog. As just stated, the buy/sell signals may be used as a guide for placing optimal buy/sell limit orders.

Main Graph – Scale 8

This is the largest scale of the four graph scales. This scale uses eight pixels for each day of data. It will be noticed that this scale incorporates **Candlestick Charting** rather than the more usual bar charting of the other scales. The Candlesticks provide a way to display the **high, low, close, and open prices**, whereas with the bar charting the open price is not displayed. The Candlestick consists of a colored rectangle superimposed on a vertical line. The ends of the vertical line mark the high and low prices for the day, as before. However, the upper/lower edges of the rectangle mark the open/close or the close/open prices. If the close is higher than the open (an *up* day), the rectangle is colored sky blue, while if the close is lower than the open (a *down* day) the rectangle is colored dark blue. There is a whole set of technical patterns associated with and unique to the Candlesticks, which can be found in books devoted to Candlestick Charts (see also an appendix to Pring's book [Pring (1991)]). Also displayed on this scale are the **buy/sell signals** that were actually *triggered*, meaning that the low price reached down to the buy point or the high price reached up to the sell point. (These are displayed using little green/red triangles.) From this you can tell the relative frequency with which these buy/sell signals were actually triggered (with the benefit of perfect hindsight, of course), and use this to set the **Threshold** and **Range** controls appropriately. For the **future projection**, *all* the projected buy/sell signals are displayed as green/red rectangles. All the other features of the graph, such as **Bollinger Bands**, are the same as with the other scales (except that the *N*-day smoothing curve is not shown on this scale for the *past* data). This is the best scale to use to study the price action for each individual day.

Other Features

It should also be mentioned that the **logarithmic volume** appears at the bottom of each graph, relative to the mean logarithmic value of the volume. You can also display a **horizontal line** anywhere in the graph simply by pointing the mouse to that price level and left clicking. You can draw a horizontal line for a given price using the **Horizontal Line** button on the toolbar. You can also insert an **exponential Moving Average** (of the *detrended* prices) using the **Moving Averages** toolbar button. You can select a **color** for the horizontal line or exponential MA by using the **Custom Colors** button. Finally, you can **toggle** the **buy/sell points** on and off using the **Buy/Sell Points** button. You can restore the graph to its default appearance using the **Restore Data** button.

Momentum Indicators in *QuanTek*

In the usual nomenclature, the term **Momentum Indicator** means an indicator which signals the onset of a price move, or which is proportional to the rate of movement in price. However, for the purpose of the *QuanTek* program, we would like to give this term a slightly more specific meaning. In the *QuanTek* program, by a **Momentum Indicator** we mean any function of past prices (and perhaps fundamental and other economic data) which shows a positive **correlation** with *future returns*, over some specified holding period. This **correlation** is established by means of the *QuanTek Correlation Test*. So, a *Momentum Indicator* will be some function of the *past* prices, which shows a positive **correlation** with the *future returns* over the holding period. The *Momentum Indicator* is computed for each trading day in the past, using all the *past data* (price data, and perhaps other economic data) up to and including that day. The selected past trading day for which the **Momentum Indicator** is computed, which is the latest day of the past data relative to that day, is called the *present day*. Then the *future returns* are all those returns in the *future* of the *present day*, up to some number of days in the future which is determined by the holding period. (I hope that is not too confusing!) The value of the *Momentum Indicator* computed for each trading day, using only past data up to that day, is correlated with the future returns relative to that day, and the correlation so measured is supposed to be at a positive peak.

The **Momentum Indicator** is computed using a variety of **price projection** and **smoothing** techniques. Given all the past data set, a **Price Projection** filter, such as the **Fractional Difference** filter, is used to project the past prices into the future, using whatever correlation exists in the past data. Then the past data and its future projection may be smoothed by a **Savitzky-Golay** smoothing filter or an **exponential moving average** (also a type of filter), to yield a value for the **Momentum Indicator** which is the value of this smoothing corresponding to the *present day*. However, the smoothing also yields values for all the past and future (projected) days. The smoothed values in the past are just a smoothing of the past data, and can be thought of as values of the **Momentum Indicator** if perfect hindsight from the future is assumed. The smoothed values in the future are projections or estimates of the **Momentum Indicator** into the future. In essence, each of these values of the **Momentum Indicator** may be thought of as an independent indicator. When the **Momentum Indicator** is plotted as a graph, it is this entire smoothing of the past and future projected prices that are plotted. In the

Correlation Test, the correlation between each of these indexed values of the **Momentum Indicator** with the *future returns* is computed and displayed. In this way, only *past data* are used to compute the **Momentum Indicator**, which is supposed to be correlated with the *future returns*.

QuanTek Technical Indicators

Apart from the Main Graph, *QuanTek* displays nine **technical indicators** at a time, in three different splitter windows. These three splitter windows are called **Harmonic Oscillator**, **Momentum Indicators**, and **Trading Rules**. These nine technical indicators are designed to display different, yet compatible, aspects of the technical state of the stock data. Theoretically, the stock data contains roughly equal mixtures of Fourier components, or “waves”, of all different frequencies (although in some cases there can be cycles of a specific frequency, temporarily). Hence you can choose essentially any **trading time scale** you want, although some time scales will work better than others. After having chosen a time scale, the technical indicators must all be smoothed according to the same **smoothing filter**, with the same time scale for smoothing. Then the **buy/sell points** can be derived from these smoothed indicators, and they should be compatible between the different indicators. This is the purpose of the nine indicators – to arrive at a set of compatible **buy/sell points** and **trading rules**. The **Trading Rules indicator** is built directly from the **Momentum Indicators**, which in turn are designed by you, the trader, to show a peak in correlation with the future returns on some specified time scale and holding period. Then the actual trading rules are derived directly from this indicator, so in this way you have the best chance of arriving at a set of effective short-term trading rules.

Momentum Indicators Splitter Window

In the **Momentum Indicators** splitter window, you can display three technical indicators of your choice in the three panes of this window. To do this you use the **Correlation Test** and a **Technical Indicators** dialog box to design and test a wide variety of oscillator-type indicators using the stock returns data. These three **Momentum Indicators** are denoted **Momentum 0**, **Momentum 1**, and **Momentum 2**. These oscillators are constructed from smoothings of the past stock data, using the **Savitzky-Golay smoothing filter**, with either *acausal* or *causal* smoothing, or *exponential MA's*. These indicators encompass most of the usual oscillator-type technical indicators. These three technical indicators in the **Momentum Indicators** splitter window are adjusted in phase so that they show a correlation peak in the **Correlation Test**. Then the three indicators may be added together in any relative proportions using three slider bars in the **Trading Rules Settings** dialog box (for each stock), to yield the **Trading Rules** indicator, which is displayed in the **Trading Rules** splitter window (bottom pane). This **Trading Rules** indicator has been designed (by you!) to show the maximum correlation with the *future N-day returns*, where *N* is your chosen trading time scale.

As explained in the article on [Correlation and Technical Indicators](#), this means that the **Trading Rules** indicator should show a positive going zero crossing at the present time corresponding to a **buy signal**, and a negative going zero crossing at the present time

corresponding to a **sell signal**. In other words, the **Trading Rules** indicator is what we call a **Momentum** indicator, which means that it behaves the same way as a **Velocity** indicator. The **Trading Rules** indicator is supposed to be representative of the *projected N-day returns (velocity)*. This indicates that the proper **buy/sell points** are at the *positive/negative zero crossings* of the **Trading Rules** indicator, so that you can buy/sell *before* the move in prices occurs. Hence, the zero crossings (and peaks and troughs) of the three **Momentum** indicators should (roughly) line up, and the **positive going zero crossings** signal a *buy point*, and the **negative going zero crossings** signal a *sell point*. These *buy/sell points* are then indicated on all the graphs by vertical green/red lines, or by green/red arrows on the **Main Graph**.

All of the nine indicators must use the same kind of **smoothing**, for compatibility of the **buy/sell points**. This is because the stock returns data consist of a sum of all different Fourier frequencies, in roughly equal amounts. Sometimes, in the correlation graphs, a definite **cycle** in the correlation with a fixed period can be made out, which indicates that trading on this time scale will produce superior results compared to other time scales. You should try to take advantage of any such cycles that are apparent. However, for the most part, the returns data consist of a roughly equal mixture of all different frequencies. This means that you must choose one trading time scale, and then all the technical indicators must be smoothed to this same time scale, using the same kind of smoothing filter. Otherwise, the **buy/sell points** from the different indicators will not line up, since they are based on different frequency components. After smoothing, the **dominant frequency** component that is left will be the highest remaining frequency component, which is the one that has a half-period equal roughly to two **trading time scale** periods. Thus, the period of this dominant cycle is *roughly* equal to four trading time scales, and one trading time scale corresponds to a *quarter cycle*. I say *roughly*, because it depends on the details of the amplitude response of the smoothing filter. Also, for the *causal Savitzky-Golay* filter and the **Exponential Moving Average** filter (which is also causal), the phase response must also be taken into account. Each frequency of wave will have its phase *shifted* by a different amount by these causal filters. If using the causal filters for smoothing, you thus have to adjust for this phase shift by introducing the proper **lead time** when designing your technical indicators in the **Technical Indicators** dialog box. The **lead time** is adjusted for maximum **correlation** of the technical indicator with the future returns, for a given trading time scale. For *acausal* Savitzky-Golay smoothing, on the other hand, there should be no phase shift since the filter is symmetrical with time. The fact that there is no phase distortion with the *acausal* smoothing makes it preferable from our point of view. However, some people are bothered by the idea that the technical indicator is not causal, so that the past values of the indicator will be modified by future data, which is why the *causal* filters are also available as an option. Also, with the causal filters, the past values of the indicator depend only on the past data (with zero or negative *lead time*), and not on the future projection from the **Price Projection** filter, so they are independent of these future projections. (Of course, the future projections themselves depend only on *past* data, not on any actual *future* data. But in some cases it might be preferable to leave the prediction filters out of the loop entirely, and base the technical indicator only on the causal smoothing filters.)

Harmonic Oscillator Splitter Window

On the **Harmonic Oscillator** splitter window are three technical indicators that are fixed. The main purpose of these three indicators is to provide confirmation of the validity of the **buy/sell points**. These three indicators are called the **Relative Price**, the **Velocity**, and the **Acceleration**. The **Relative Price** is the (logarithmic) price, smoothed according to the chosen smoothing filter, minus the log price smoothed with a long time scale of 320 days (over one year). Thus it is, in essence, a smoothed and detrended price. As is well known, the buy points are supposed to be price minima and the sell points should be price maxima (“Buy Low – Sell High”!). Hence the indicated **buy points** should pass through the **minima** of this indicator, and the **sell points** should pass through the **maxima**. (Note this is only true for *acausal* smoothing. *Causal* smoothing will introduce a time lag.) The **Velocity** indicator is obtained by computing the smoothed *first derivative* of the log prices using the **Savitzky-Golay** smoothing filter. In the case of the **Exponential MA** filter, it is the exponential MA of the *returns*. At price minima and maxima, the first derivative is zero, and hence the **Velocity** indicator should also be zero. At price minima, corresponding to buy points, the first derivative will be *increasing* through zero, and at price maxima, corresponding to sell points, the first derivative will be *decreasing* through zero. Thus for the **Velocity** indicator, the **buy points** should line up with the **zero-crossings moving upwards**, while the **sell points** should line up with the **zero-crossings moving downwards**. The **Acceleration** is obtained by computing the *second derivative* of the log prices using the **Savitzky-Golay** smoothing filter, or the exponential MA of the second difference of the prices using the **Exponential MA** filter. At price minima, the **Acceleration** should reach a positive peak, because the upward curvature of the prices is maximum. At a price maximum, the **Acceleration** should reach a negative peak because the downward curvature of the prices is maximum. Hence the **buy points** should line up with the **maxima** of the **Acceleration** indicator, while the **sell points** should line up with the **minima** of the **Acceleration** indicator. These three indicators thus provide confirmation for the three **Momentum** indicators, for which the **buy/sell points** should line up with the **positive/negative zero crossings** of these indicators (same as **Velocity**).

The buy/sell points should all line up nicely using *acausal* smoothing, and should also line up with the low/high points of the smoothed prices on the Main Graph. However, using *causal* smoothing the situation is not quite so straightforward. It is well known that, using a simple MA, there is a *time lag* equal to about half the window length of the moving average. This corresponds in our case to one smoothing time period, since the window length is actually two smoothing time periods. Actually, the *zero-order* (causal) **Savitzky-Golay** smoothing filter is equivalent to a **simple MA**, so it will also display a time lag of one smoothing time period. The zero-order filter fits the past block of $2N$ data points by the best-fit *average* value and takes this value as the *present* smoothed value, which is just what the simple MA does. The second-order filter, on the other hand, fits the past $2N$ data values with the best-fit *quadratic* polynomial (second-order polynomial), and takes the right-hand value of this fitted polynomial as the smoothed value. Hence, this will effectively eliminate the time lag from the simple MA, *mostly*. Actually, this causal filter will introduce a phase delay, which is frequency-dependent, so there will still be some slight delay and also the phase relationships of the various frequency

components will be modified. For the **fourth-order Savitzky-Golay** filter, which is what we use here, the past block of $2N$ data points are fitted by the best-fit *fourth-order polynomial*, and (for the *causal* filter) the right-hand value of this polynomial is taken as the smoothed value. In this case the time lag will be very small, but there will still be a little lag, and the phase relationships between the various frequency components will still be modified. So, the point is that when using the *causal* smoothing, the buy/sell points may not line up quite as nicely as with **acausal Savitzky-Golay smoothing**. The **Momentum** indicator will still be adjusted for the correct **phase**, but the **Harmonic oscillator** indicators will have their phase relationships with the buy/sell points modified.

Trading Rules Splitter Window

The bottom pane of the **Trading Rules** splitter window displays the **Trading Rules Indicator**, which as we have stated previously, is a weighted sum of the three **Momentum Indicators** displayed on the *Momentum Indicators Splitter Window*. The relative weights of the three Momentum indicators are adjusted using three slider bars on the **Trading Rules Settings** dialog box, for each stock. These three Momentum indicators are ones you have designed yourself using the **Technical Indicators** dialog box and the **Correlation Test**. They are designed to have maximum correlation with the *future returns*. From this **Trading Rules Indicator** are derived the **buy/sell signals**, which display an optimum range of buy or sell limit orders, and the **buy/sell points**, which are the optimum points in the range of buy/sell signals. The level and range of the buy/sell signals are controlled by the **Threshold** and **Range** controls on the **Trading and Portfolio Parameters** dialog box. The **buy/sell points** are denoted by the vertical green and red lines, and you can see that these line up exactly with the **positive/negative zero crossings** of the **Trading Rules Indicator**. This **Trading Rules Indicator** is evidently the single most important technical indicator of all. The relative value of this indicator is also displayed in the **Short-Term Trades** dialog box (to see this modeless dialog box, just right-click anywhere). This relative number ranges from -100% to $+100\%$, and denotes the optimum relative position for short-term trading for the given time scale.

The remaining two indicators on the **Trading Rules** splitter window should also be mentioned. One of the other panes on this window is a **Volatility** indicator, which is the smoothed absolute value of the returns. The last indicator (actually the middle pane) is a little different from the preceding ones. It is simply the output of the **Fractional Difference** filter, with a *negative* fractional difference of -0.25 , appropriate for the anti-persistence of 1 to 3 day returns. This filter, for each data day, is the output of the filter estimating that day's return, given all the past returns up to the previous day in the past. This is by contrast with the other indicators, for which the past values of the indicators are simply various smoothings of the past values of the data. So the **Fractional Difference** indicator is simply the past and projected **Day Trading Rules**. Since the 1 to 3 day returns are *anti-persistent*, these trading rules are opposite to the long-term trading rules, and the **Fractional Difference** indicator shows what amounts to the *negative* of the long-term **Velocity** indicator. Thus, the buy/sell points will tend to line up with negative/positive zero crossings of this indicator. This **Fractional Difference** indicator is not smoothed, since it is a day-trading indicator only.

Trading and Portfolio Parameters Settings

There are two groups of slider bars in the **Trading and Portfolio Parameters** dialog box. These control the settings for the **buy/sell signals** and the **Portfolio Optimization** calculation. At the bottom of this dialog box is a checkbox to specify the method of calculation of the **Portfolio Optimization (Markowitz Method)** yes or no).

Trading Parameters

The left-hand group of two slider bars controls the display of the **buy/sell signals**. These buy/sell signals are displayed on scale 4 of the **Main Graph**. The buy/sell signals that are actually “triggered” are displayed on scale 8 of the **Main Graph**.

Threshold: This slider bar determines how high or low the price has to be to trigger a buy/sell limit order. The slider bar ranges from “high” to “low”. The threshold price is measured from the N -day smoothing curve of the prices on the **Main Graph**, and is determined from the standard deviation of the prices from this smoothing curve. The “high” setting corresponds to two standard deviations, so the limit order will be triggered very infrequently. The “low” setting corresponds to zero standard deviations, so a buy or sell order will be triggered almost every day. The “high” setting corresponds to less frequent trading, and the “low” setting corresponds to more frequent trading.

Range: This slider bar controls the range of the **Trading Rules** indicator over which a buy/sell signal is triggered. The range is from “high” to “low”. The “high” setting corresponds to two standard deviations of the **Trading Rules** indicator (displayed in the bottom pane of the **Trading Rules** splitter window) from the zero line, and the “low” setting corresponds to zero standard deviations. On the “high” range setting, a buy/sell signal will be displayed for practically every trading day. On the “low” range setting, a buy/sell signal will be displayed only when the price is very near the optimum buy/sell points.

Portfolio Parameters

The right-hand group of two slider bars controls the settings for the **Portfolio Optimization** calculation. This calculation uses the estimated **expected return** and the measured volatility or **risk** (for each stock in the portfolio) to compute an optimal portfolio that *maximizes returns* and *minimizes risk*. Then the recommended number of shares and percentage of the equity is displayed in the **Day Trades** dialog (along with the actual number of shares in the Core Portfolio, and the expected return.)

Percent Margin: This specifies the (average) *percent margin*, given the total equity, that you wish to be invested in the portfolio. By *percent margin*, we mean the amount of money invested as a fraction of the equity in the portfolio. Then the optimal number of shares of each stock is computed based on the percent margin. Generally, due to the way the optimization is performed, the actual percent margin invested will be a little less than that specified. It should be equal to that specified if the percentage of equity invested in each stock turned out to be equal. If a large percentage of the equity were invested in one stock, then the total percent margin would be substantially less than that specified. (See the article [Portfolio Optimization](#).)

Risk Tolerance: This is the other parameter in the **Portfolio Optimization** calculation. In order to know what relative weight to give to the **expected return** versus the **risk**, the portfolio optimization routine needs to know your degree of **risk aversion**. The opposite of this is your **risk tolerance**, which is your willingness to tolerate **risk** for the sake of greater **returns**. Setting the slider on “min” results in the least possible variance in the total portfolio return, at the expense of the mean value of the return. Setting the slider on “max” basically results in the variance of returns being ignored, and the proportion of the portfolio invested in each stock is essentially equal to the expected returns alone (relative to the other stocks in the portfolio).

Use Markowitz Model: This checkbox at the bottom of the dialog is used to specify whether to use the **Markowitz Model** or a **Factor Model**. Supposedly, the Markowitz method is too slow for a portfolio with more than a few stocks, although we have not found any such problem. Normally, the Factor Model is used as an approximation to the Markowitz Model, because it is faster to compute. However, we see no real reason not to use the Markowitz Model for the portfolio optimization.

Trading Rules Parameters Settings

The **Trading Rules Parameters** dialog box is available in the **Main Graph** toolbar for each stock data file. It has three slider bars that control the proportion of the three **Momentum** indicators that make up the **Trading Rules** indicator for each stock. The three **Momentum** indicators are displayed in the **Momentum Indicators** splitter window, and the **Trading Rules** indicator is displayed in the bottom pane of the **Trading Rules** splitter window.

Momentum 0: This controls the proportion of the Momentum 0 indicator in the Trading Rules indicator. In the default settings, the Momentum 0 indicator is a **Relative Price** indicator.

Momentum 1: This controls the proportion of the Momentum 1 indicator in the Trading Rules indicator. In the default settings, the Momentum 1 indicator is a **Velocity** indicator.

Momentum 2: This controls the proportion of the Momentum 2 indicator in the Trading Rules indicator. In the default settings, the Momentum 2 indicator is an **Acceleration** indicator.

Short-Term Trading Using *QuanTek*

The **Trading Rules** indicator, constructed as a weighted sum of the three **Momentum** indicators, is supposed to be a function of the *past* data, which has the maximum positive **correlation** with the *future returns* over the trading time scale that you have chosen. The indicator is constructed in such a way that it serves as an *estimate* of the returns, and

should be *in phase* with the returns (or *Velocity*). Hence, day-by-day, the optimum N -day position (assuming a smoothing time scale of N days) is simply to vary the position in proportion to the **Trade Rules** indicator. Then the position will be directly in proportion to the expected 1-day return for the next day, and this position can be adjusted each morning at the open to maintain the optimum position. This relative N -day position, as given by the **Trading Rules** indicator, is shown in the right-most column of the left-hand list box of the **Day Trades** dialog.

Changing the position every day might be a practical trading strategy for some short-term traders. This strategy might actually reduce risk, because the position held in the stock is varied slowly and smoothly, rather than suddenly. In other words, this is the trading strategy which will result in the minimum variance of the position held, and hence the minimum variance of the return (risk) from the trading strategy. If the trading time scale is $2N$ days, then the position can be varied smoothly each day, corresponding to the smoothing time scale of N . However, most traders would probably want to buy or sell roughly every $2N$ days, if the trading time scale is $2N$. Then, the indicated **buy/sell points** may be used to set the long/short position over the holding period all at once, rather than smoothly on a daily basis. The amount to buy/sell will then be proportional to the value of the **Trading Rules** indicator in between the buy/sell points, which can only be estimated from the future projection. To simplify things, many traders will want to just buy or sell a constant amount at each buy/sell point.

It is nice to have quick access to the buy/sell signals and other numbers for trading purposes. This information can be found in the **Day Trades** dialog box, which can be viewed at any time, from anywhere in the *QuanTek* program, just by **right-clicking**. This dialog box displays the current long-term investment position, in **shares held**, for each stock in the portfolio. Then the recommended number of shares, or **Core Position**, based on the **portfolio allocation** routine, is displayed. Next the **recommended position** as a percentage of portfolio equity is displayed. After that, the estimated (long term) **expected return** over the next 100 day time interval is shown. This is based on the extrapolation from the **Fractional Difference** prediction filter, 100 days in the future, and is expressed as an annual compounded gain or loss, in percent. The computations in the **portfolio allocation** routine are based directly on these estimates of future return. You may modify these estimates if you wish, based on some further information, such as **fundamental or economic data**, that you might have for each stock. This is done using **Adjust Expected Return** on the Toolbar for each stock, and the result is simultaneously displayed on the Main Graph. Then, this correction to the estimated expected return is taken into account in the portfolio allocation calculation. After this information, the current **buy/sell/hold** recommendation for each stock is displayed, along with the recommended price. The *buy* and *sell* prices are set at a certain **threshold** below or above the **smoothed price** (at future day 1), and the price for the *hold* recommendation is just the smoothed price itself (at future day 1). The **buy/sell signals** depend on the settings for the **Threshold** and **Range** trading controls. The current ranges of the buy and sell points are displayed on the Main Graph, on scale 4. Finally, as discussed above, the relative value of the **Trading Rules** indicator is displayed (labeled **N -day**, where N is the current setting of the **smoothing time scale**). The value of this should be interpreted

as the relative amount of trading equity that should be invested in that stock at that particular time. As stated before, this indicator ranges from -100% to +100%.

Day Trading Using *QuanTek*

On the right-hand side of the **Day Trades** dialog, there is a list box showing a set of prices and a set of percentages. In the middle row of the list box, a price is highlighted. This is the *estimated* or **projected closing price** for next-day's close, based on the **Fractional Difference** filter with a *negative* fractional difference. As can be seen in the **Correlation Test**, the output of this filter with a *negative* fractional difference shows a good correlation with the daily *future returns*, and this can be corroborated by looking at the autocorrelation indicator, which almost invariably shows an *anti-correlation* for 1, 2, and 3-day lags, with the 1-day future returns. This filter is thus used to estimate the 1-day return from the most recent closing price to the next close, and the resulting estimated closing price is highlighted in the center row of this **day-trades** window. In order to accommodate the widest possible variety of day-traders and their trading methods, this window has not incorporated any specific trading rules. Rather, a list of prices surrounding the center price (estimated closing price) is given, and to the right of it is a list of percentages. These percentages are multiples of 0.1%, and correspond to the prices on the left, which differ from each other by 0.1%. (Actually, the prices on the left are constant multiples of each preceding price, starting from the center, and the percentage difference is 0.1%. Thus the right-hand scale is really a *logarithmic* scale, for the prices listed on the left.) However, the percentages increase downward rather than upward, indicating the *percentage price difference* between the selected price and the estimated closing price. The way to use this scale is simple. The percentages indicated should be (roughly) proportional to the amount invested in a day-trading strategy. The amount to invest for each percentage change in price is up to you, the trader. All you do is invest more when the price goes down, and less when the price goes up, in some proportion to the percentage scale on the right. This should lead to net gains, as indicated by the **Correlation Test** of the estimated returns from the **Fractional Difference** filter.

Also note that the prices can be updated throughout the day using the **Intra-day Update** toolbar button. These updated prices are listed underneath the **day-trades** window. The **Last Close** is the closing price from the previous day. Then, if the prices are updated in the middle of the trading day, the **Last Open** is the opening price for the day, the **Last High** and **Last Low** are the high and low prices so far for the current trading day, and the **Last Price** is the latest price (usually 15 minutes delayed). If the **Intra-day Update** has not been performed, but only a **Daily Update**, then the **Last Price** is the same as the **Last Close**, and the **Last High** and **Last Low** are the high and low prices for the day. The date and time of the last **Daily Update** or **Intra-day Update** are listed at the top right corner of the dialog box.

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