

A Wilder Variation

Reverse Engineering RSI

Can the inverse of an oscillator help you to forecast closing prices?

by Giorgos Siligardos, Ph.D.



Reverse engineering is a mathematical procedure that takes the inverse of an oscillator. In this article I will illustrate this process using J. Welles Wilder's relative strength index (RSI). The reverse-engineered RSI, or RevEngRSI for short, can help determine the following time period's closing price using the value of the oscillator.

RSI REVISITED

To define the RSI of k periods for a daily graph, it is necessary to first define the up-close and down-close indicators (UC and DC) for the day n . These are as follows:

$$UC_n = \begin{cases} C_n - C_{n-1} & \text{if } C_n > C_{n-1} \\ 0 & \text{if } C_n \leq C_{n-1} \end{cases}$$

$$DC_n = \begin{cases} C_{n-1} - C_n & \text{if } C_{n-1} > C_n \\ 0 & \text{if } C_{n-1} \leq C_n \end{cases}$$

where C_n and C_{n-1} are the closing prices for the days n and $n-1$.

In the sequence, the average up close of k periods [AUC(k)] is defined to be the $(2k-1)$ -period exponential moving average of UC. The average down close of k periods [ADC(k)] is the $(2k-1)$ -period exponential moving average of DC. The RSI of k periods for day n then is:

$$RSI(k)_n = \left(1 - \frac{1}{1 + \frac{AUC(k)_n}{ADC(k)_n}} \right)$$

The RSI of k periods may be defined for weekly, monthly, or annual graphs by substituting the daily closing prices with weekly, monthly, and annual closing prices. Wilder favored a 14-period RSI. In her book *Technical Analysis For The Trading Professional*, Constance Brown states that she also prefers a 14-period RSI because of specific forecasting capabilities. However, while Brown spends an entire chapter in her book on reverse engineering, she does not give the formula for reverse-engineering the RSI.

PRELIMINARIES

Before moving on to the formula, I should note that the possible values of one-day closing prices and the corresponding RSI values are in one-to-one correspondence. Suppose that today's closing price for an equity is C_0 and the value of RSI for today is RSI_0 . If you know *a priori* the value of RSI for tomorrow (and this value is RSI_1), then you are able to find the closing price for tomorrow. Moreover, if $RSI_1 > RSI_0$ you can expect $C_1 > C_0$, and if $RSI_1 < RSI_0$, you can expect $C_1 < C_0$. The reverse engineering tactic can be applied to all oscillators if the value depends upon one and only one parameter (high, low, close, open, or volume). For the highest accuracy, it should only be used for the next price projection.

FORMULA FOR A K-PERIOD RSI

Let C_0 , RSI_0 , AUC_0 , and ADC_0 be the values of today's closing price, RSI, AUC, and ADC. Let C_1 and RSI_1 be the values of tomorrow's closing price and RSI. All of these values are known except C_1 , which is what you are seeking.

X is defined to be:

$$X = (k - 1) \left[ADC_0 \left(\frac{RSI_1}{100 - RSI_1} \right) - AUC_0 \right]$$

The value of C_1 is:

$$C_1 = \begin{cases} C_0 + X & \text{if } X \geq 0 \\ C_0 + X \left(\frac{100 - RSI_1}{RSI_1} \right) & \text{if } X < 0 \end{cases}$$

The RevEngRSI for today is equal to C_1 .

The MetaStock code for the RevEngRSI indicator is provided in the sidebar.

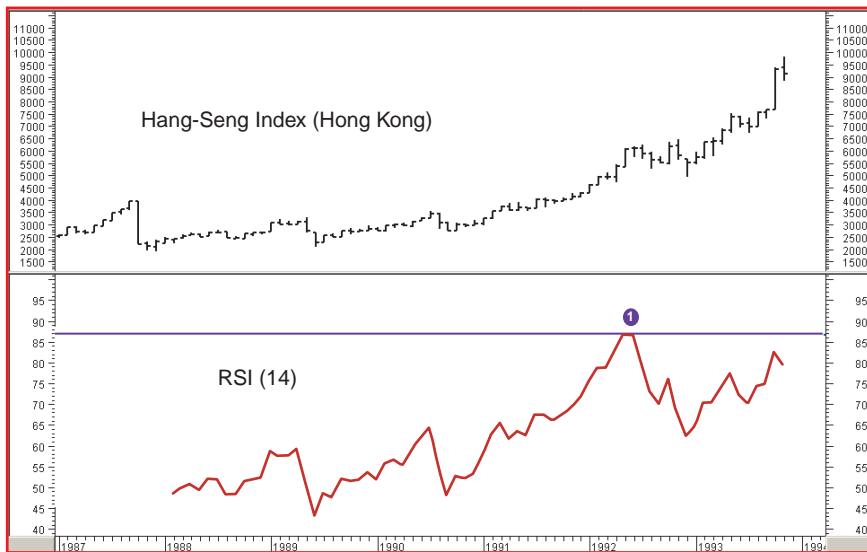
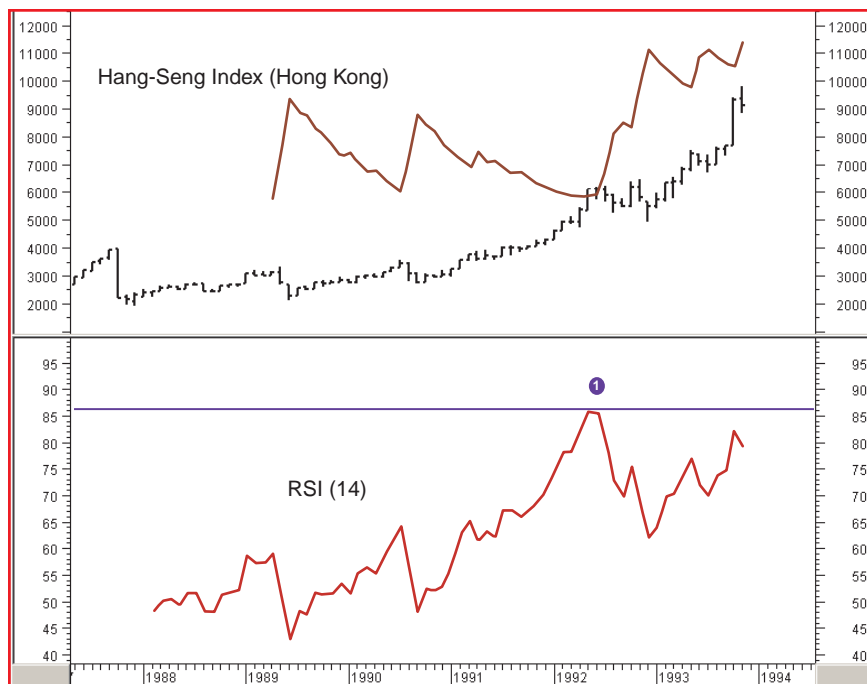


FIGURE 1: MONTHLY CHART OF THE HANG-SENG INDEX. From the RSI(14) you can see that there is strong resistance at the 86.52 level. This means that if the market advances, the RSI may stall at that level.



Date	-	11/30/1993	High	-	9,825.50	Price Chg.	-	-203.90
Value	-	10,513.72	Low	-	8,834.70	RevEng R	-	11,635.58
Open	-	9,378.80	Close	-	9,125.20	RSI	-	79.3864

FIGURE 2: HANG-SENG INDEX WITH REVENGRSI OVERLAID. Using 14 as the parameter for RSI and 86.52 as the RSI value, you can see that 11,635 is the projection for the following month.

APPLYING IT

In Figure 1 you see the monthly graph of the Hang-Seng index from 1987, to November 30, 1993. A subchart displays a 14-period RSI. If a sudden advance occurs, you would like to know a possible closing price for the following month. As there is strong resistance at 86.52 for the RSI (point 1) it is quite likely that the RSI will find resistance at 86.52. Overlay the RevEngRSI indicator on the Hang-Seng index using 14 as the parameter for the RSI and an RSI value of 86.52. The result is displayed in Figure 2. The value for the RevEngRSI for that date, which in this case is 11,635, is the projection for the following month. In Figure 3 you can see what actually happened the following month.

The index did advance, and closed at 11,888 on December 31, 1993. The RSI stalled at 86.91, not 86.52. Even if you had accurately projected that the RSI value would be 86.91, the RevEngRSI indicator would have given you a price projection of 11,856. This is of course incorrect due to errors in the computer's calculations.

Consider that at the time the projection was made, the Hang-Seng index was at an all-time high. No classical support-resistance projection methods could be used on the Hang-Seng itself, since it had never been at that value before. On the contrary, RSI is an overbought-oversold indicator, and even in prolonged bull (or bear) markets, it can give future resistance-support levels if extreme values are discounted. The tendency of RSI to stall at its past pivots enables us to project the next possible resistance level for the closing value of Hang-Seng.

RevEngRSI projected a significant resistance after a 27.5% advance for the closing value (from 9,125 to 11,635), while the actual advance for the closing value reached up to 30.2%. This was because the 86.52 is an overbought level for the RSI. When RSI is in overbought or over-sold levels, small changes in its value correspond to large changes in the closing value for the equity.

DOW JONES INDUSTRIAL AVERAGE

In Figure 4 you see a weekly graph of the Dow Jones Industrial Average (DJIA) from 1990 to March 25, 1994, along with the corresponding graph of the 14-period RSI. A support trendline is plotted on the RSI, defined by the dates October 12, 1990, and October 9, 1992 (marked by black arrows). If you expect the index to decline, you should project where the market will close the following week. The decline might force the RSI to test the trendline levels.

The next week's close will be on March 31, 1994, so I moved the crosshairs and had the trendline touch that date. Look at the level of the y-axis at the point where the trendline intersects the vertical line marking March 31, 1994. If you are using MetaStock, do not use the value of the trendline on that date as the projection. You will often find that the values of the trendlines will conflict with the values of the y-axis at many levels. The level of the y-axis at the intersection point is 39.82 (see the red circle in Figure 4).

I plotted the RevEngRSI indicator for a time period of 14 and an RSI value of 39.82. The result is displayed in Figure 5. If you are using MetaStock, move the pointer to March 25, 1994, and the RevEngRSI indicator gives you a projection for the following week's closing price of 3,647. In Figure 6 you can see what *really* happened. The market declined to 3,636 and the RSI fell to 39.09, which is slightly below the 39.82 level. If you had made the projection using an RSI value of 39.09, you would have projected the exact closing price of 3,636.

The closing price projections with RSI are valuable since they give a sense of where the market is likely to close, especially in emotional market situations. As you can see in Figure 6, the market went below 3,636 during the week, but closed at a level that allowed the RSI to test its trendline. Later, the market tested the same trendline more than once, as you can see in Figure 7.

THE NIKKEI INDEX

Before moving to the next example, I am going to state the following rules, which can be proved using simple mathematics:

- If P is an indicator (such as the closing price of an equity, or an oscillator, and so on), then the value of tomorrow's P

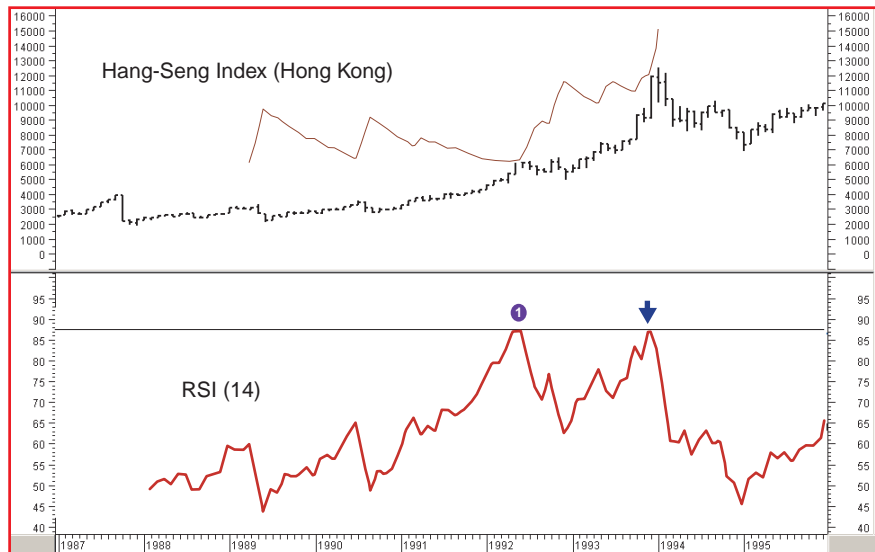


FIGURE 3: WAS THE PROJECTION ACCURATE? The index advanced and closed at 11,888, and the RSI stalled at 86.91.

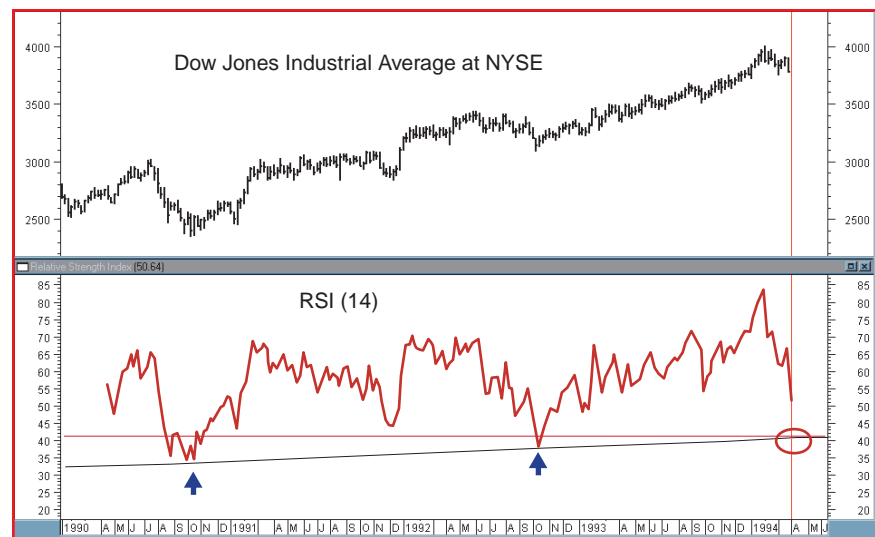


FIGURE 4: WEEKLY CHART OF THE DOW JONES INDUSTRIAL AVERAGE. A trendline support is drawn on the RSI(14) chart to determine the price projection for the following week.

that touches tomorrow's k -period EMA (exponential moving average) of P is the value of today's k -period EMA of P.

- If P is an indicator, then the value of tomorrow's P that touches tomorrow's k -period SMA (simple moving average) of P is the value of today's $(k-1)$ -period SMA of P.

This rule may be used for any periodicity. Now, let's look at the weekly chart of the Nikkei 225 index in Figure 8, which is plotted along with the 14-period RSI November 2, 1990 to February 10, 1994. A 65-period exponential moving average [EMA(65)] of this RSI is also plotted. This specific moving average was selected because it acted as a good measure of support and resistance levels for the RSI (see the black arrows).

Suppose you project a decline on the Nikkei for the next week. The advance is very likely to push the RSI to test its moving average levels. You want to project a value for the Nikkei for the next week's close, which will be on February 18, 1994. The Nikkei's close for the current week (February 10, 1990) is 19,990 and the EMA(65)'s value for the current week is 49.35. According to the rules stated earlier, the RSI(14) will touch its EMA the next week if the RSI of the next week is 49.35, and so I use the 49.35 value for reverse-engineering the RSI.

In Figure 9 I added the RevEngRSI indicator using an RSI value of 49.35. The value of RevEngRSI for February 18, 1994, gives the projection of the next week's close, which is 18,914. In Figure 10 you see what happened during the following weeks. The RSI value for February 18, 1994, was 49.62 (slightly higher than 49.35, so RSI didn't quite touch its EMA), which produced a close of 18,960 for the Nikkei 225 index, which is near enough to the projected 18,914. If you use a simple moving average, you may want to consider using the value of the 64-day SMA for February 3 to find at what closing value the RSI would test the levels of its 65-day SMA on February 18, 1994.

THE REVENGRSI AS A LEVEL CURVE

The RevEngRSI indicator may be used to graphically show support and resistance levels for the market defined by support/resistance horizontal levels of the RSI. The reverse engineering curve, when plotted on the price chart of an equity or index, defines a level curve to use the mathematical terminology. The reverse engineering curve is a transformation of a horizontal line on the RSI graph into a curve in the equity price chart.

In Figure 11 you see the Hang-Seng index plotted along with the RSI(14) on a weekly graph. The blue horizontal line on the graph of RSI is anchored at the 51.31 level, which was an important support-resistance level for the

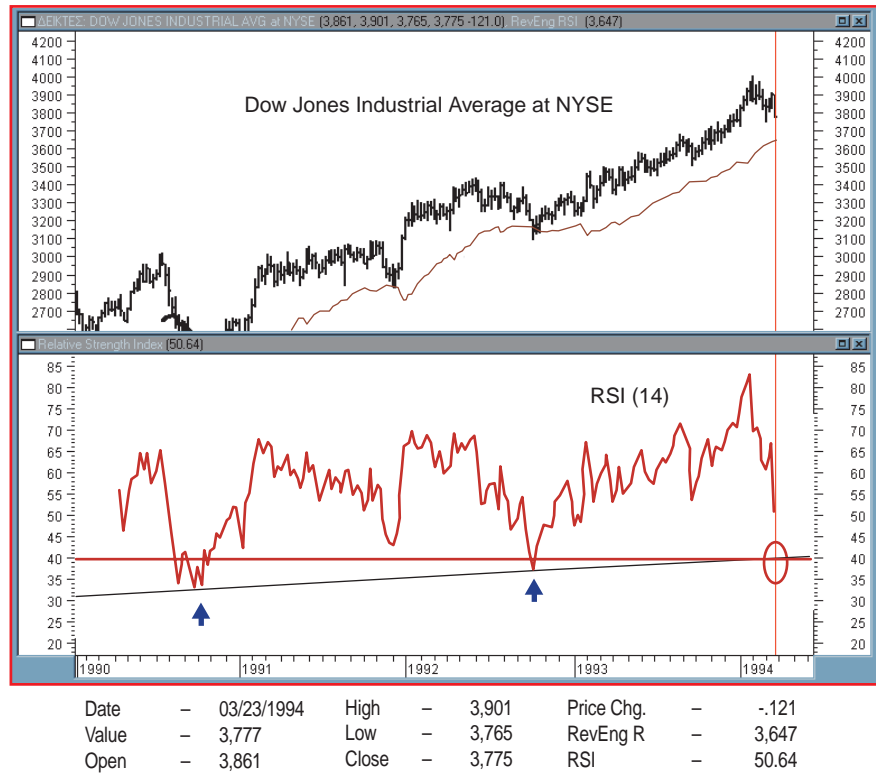


FIGURE 5: DOW JONES INDUSTRIAL AVERAGE WITH RSI(14) AND REVENGRSI. Using 14 as the parameter for the RSI and 39.82 as the RSI value, you see that the projection for the following week is 3,647.

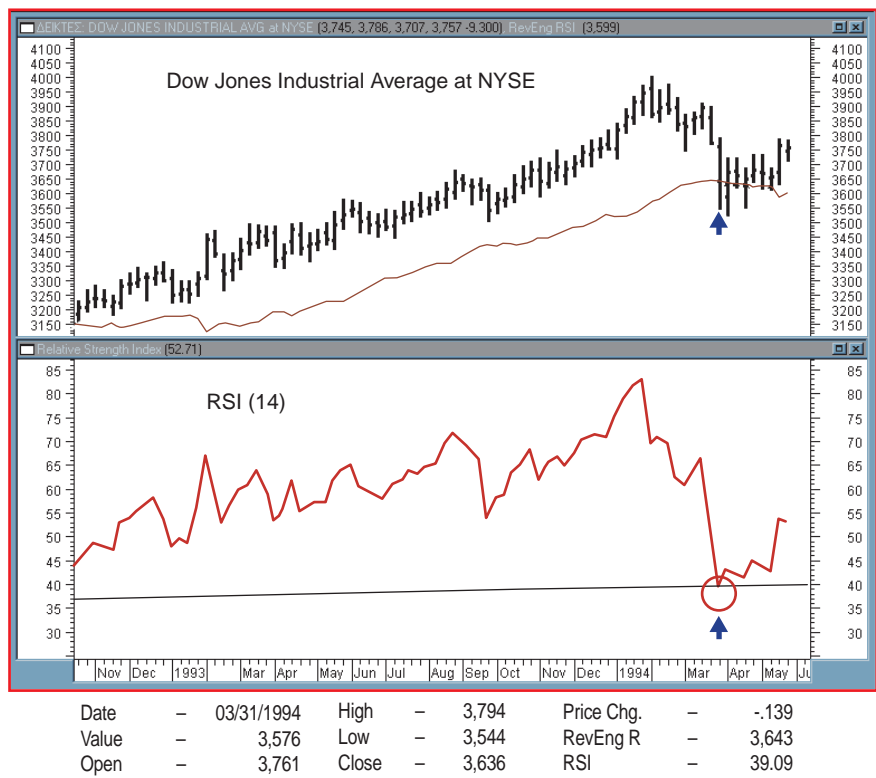


FIGURE 6: WAS THE PROJECTION ACCURATE? The market declined to 3,636 and the RSI fell to 39.09, slightly below the 39.82 level.

RSI. The blue curve on the graph of the Hang-Seng index is the RevEngRSI indicator for an RSI value of 51.31. You may see that when the RSI value is greater than 51.31, the index is above the RevEngRSI, and when the RSI value is lower than 51.31, the index is below the RevEngRSI. In addition, when the RSI touches the 51.31 levels, the Hang-Seng touches the RevEngRSI (see the black arrows). So, the RevEngRSI indicator is a transformation of the support-resistance horizontal line at the 51.31 level for the RSI into a support-resistance curve for the Hang-Seng index.

On the Nasdaq index in Figure 12 you can see how the RevEngRSI could be used in conjunction with other methods to visually enhance the support/resistance levels of the market. Notice the two horizontal lines plotted on the subchart of the RSI(14). The green line is at the 64 level and the pink line is at the 67.11 level. The two diverging black lines plotted on the price chart and the RSI(14) show a positive reversal well above the 40 level. This forecasts a bullish movement with a price projection, which is visually illustrated by the red lines on the price chart.

After the decline of the Nasdaq during the first days of 2000, you expect to see an advance with a price target. As the market starts to advance, the RSI finds resistance at the important level of 64. After the decline of the RSI that follows, it is likely that the RSI will not

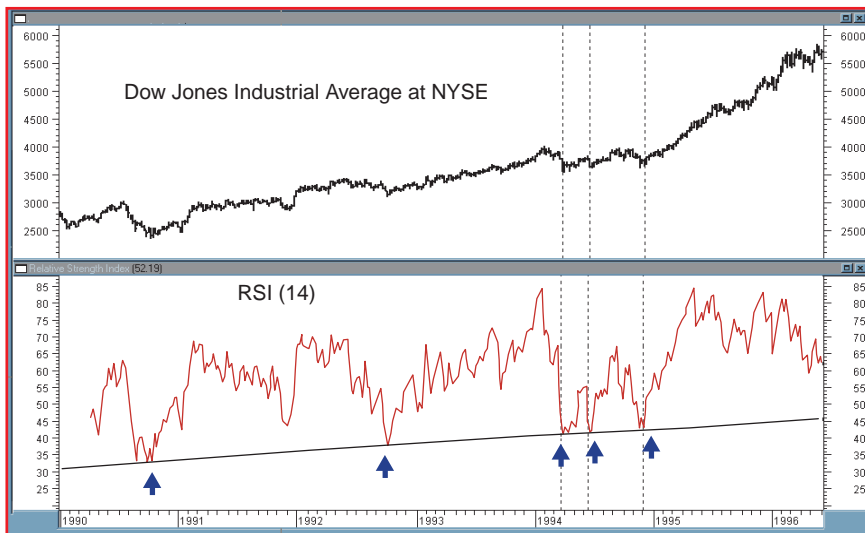


FIGURE 7: TESTING THE TRENDLINE. Notice that the Dow Jones Industrial Average tested the trendline several times.

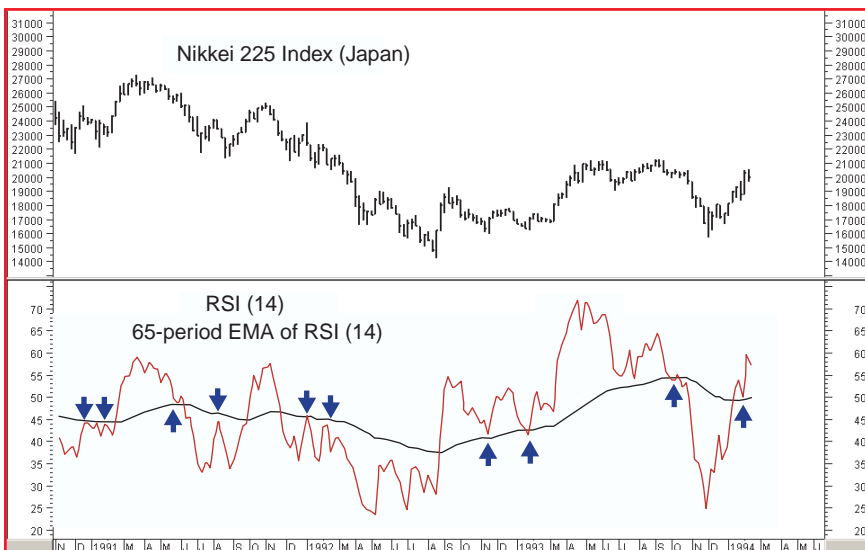


FIGURE 8: WEEKLY CHART OF THE NIKKEI 225 INDEX. Here you see the RSI(14) with its 65-period EMA plotted. Notice the significance of the EMA for determining support and resistance levels.

METASTOCK CODE FOR REVENGRSI

The following program for MetaStock computes the closing price at which the RSI of the previous day will attain a specific level for the next day.

{ Reverse Engineered RSI }

value:=Input("RSI value", 1, 100,50);
 WildPer:=Input("Wilder Time Periods", 1, 100,14);
 ExpPer:=2*WildPer-1;

{ Average Up Close }
 AUC:=Mov(If(C>Ref(C,-1), C-Ref(C,-1), 0), ExpPer, E);
 { Average Down Close }
 ADC:=Mov(If(Ref(C,-1)>C, Ref(C,-1)-C, 0), ExpPer, E);

x:=(WildPer-1)*(ADC*value/(100-value)-AUC);
 RevEngRSI:=If(x>=0, C+x, C+x*(100-value)/value);
 RevEngRSI

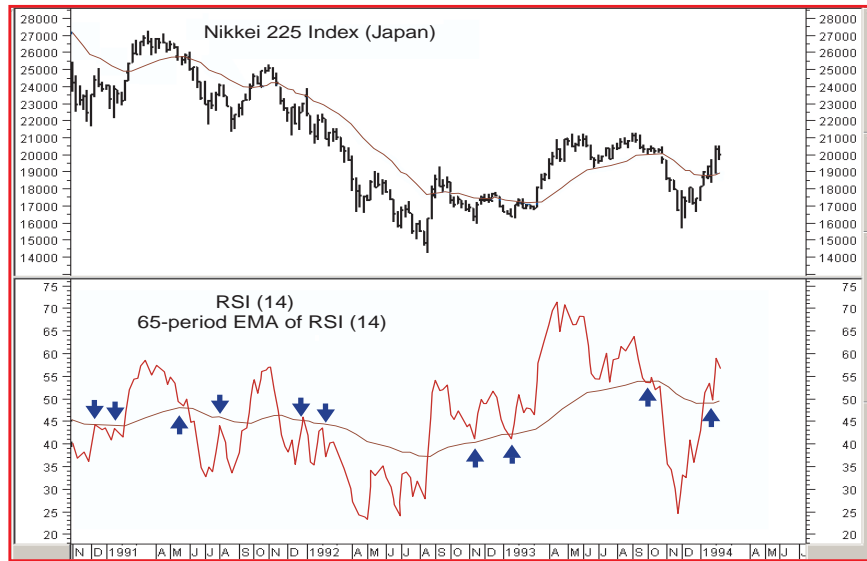
Note: The smoothing method of *k* periods provided by Wilder for smoothing the up and down closes was indeed a (2*k*-1)-period exponential moving average of UC and DC, respectively. For example, Wilder calculates the AUC as:

$$AUC_{today} = \frac{(k-1)*AUC_{yesterday} + UC_{today}}{k} = \frac{1}{k}UC_{today} + \frac{k-1}{k}AUC_{yesterday}$$

which is by definition the (2*k*-1)-period exponential moving average of UC. —GS

have the strength to successfully break — at least on the first attempt — the horizontal line at 67.11, since that line showed its significance and strength by the RSI in the past. A logical interpretation of the graph suggests the market will have a pivot at the point where the RSI reaches 67.11 before moving on to new highs.

On the chart of the Nasdaq you see the RevEngRSI in pink with an RSI value of 67.11. The RevEngRSI transforms the horizontal line at 67.11 into a curve on the Nasdaq chart. The market did find resistance at the RevEngRSI (see the black arrow), and on declining creates a new positive reversal pattern, which confirms both the tendency of the market to attain new highs and that the first price target remains in force. Combining various technical analysis tools makes reversals visually clearer when using the RevEngRSI (see black arrows).



Date	-	02/10/1994	High	-	20,526.00	Price Chg.	-	-311.00
Value	-	18,727.17	Low	-	19,651.00	RevEng R	-	18,914.17
Open	-	20,255.00	Close	-	19,990.00	RSI	-	56.7188
						P-EMA	-	49.3472

FIGURE 9: ADDING THE REVENG RSI INDICATOR. Using 14 as the parameter for the RSI and an RSI value of 49.35, the projection for the following week is for the Nikkei to reach 18,914.

COMMENTS AND COMPLETIONS

The methods presented in this article are supplementary to other methods. After identifying where the market is likely to move, you may want to see which are the possible levels or what the most extreme scenario is for the *next* close. The reverse engineering of RSI should be considered only for the next day's (week's, month's, and so on) movement of the market for highest accuracy, because there are numerous variations of two or more market movements that can push RSI into a specific value. With only one movement, the market can push the RSI to a specific value only by one way, giving you an exact price projection.

The reverse engineering process cannot be used for complex indicators with more than one parameter (such as stochastics) because there would be more than one unknown variable. If you use the reverse engineering method of RSI to project a closing price that needs more than one movement of the market to push the RSI to a specific level, then the accuracy will be low. Moreover, the more movements the market requires to push the RSI to the projected level, the lower the accuracy of the projection for the closing price.

In the case of DJIA, for example, the values of RevEngRSI for an RSI value of 39.09 four, three, and two bars before March 31, 1994, are 3621.4, 3622.9, and 3625.3, respec-

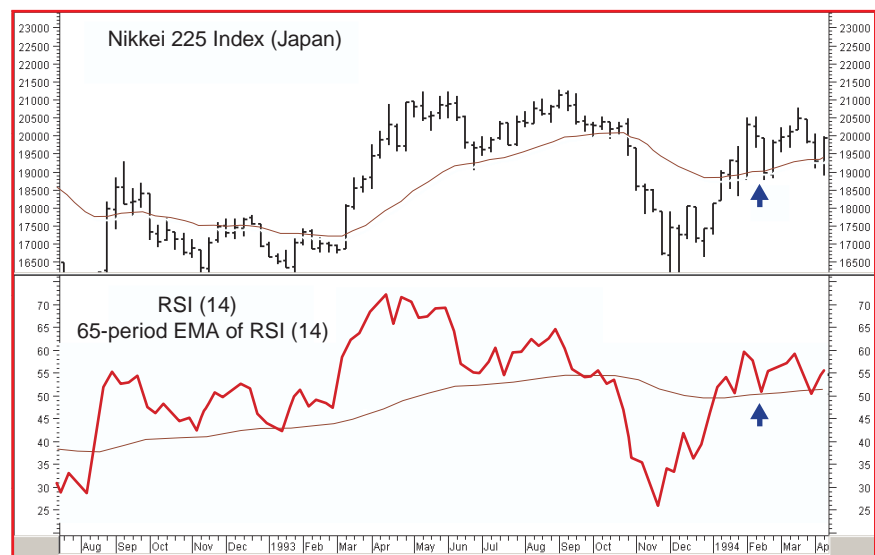


FIGURE 10: WAS THE PROJECTION ACCURATE? You can see that the RSI value was 49.62 and the close was 18,960, which is not too far off from the projection.

tively. On the other hand, as we saw previously, one bar prior to March 31, 1994, the RevEngRSI value for an RSI of 39.09 accurately projects the following close at 3636. Nevertheless, even if the market needs more than one movement to push the RSI to a specific level, it is useful to use the reverse-engineering tactic to get a sense of the next movement, as described in the following example:

In Figure 13 you see a daily graph of the S&P 500 index along with the graph of the corresponding RSI(14). The pink

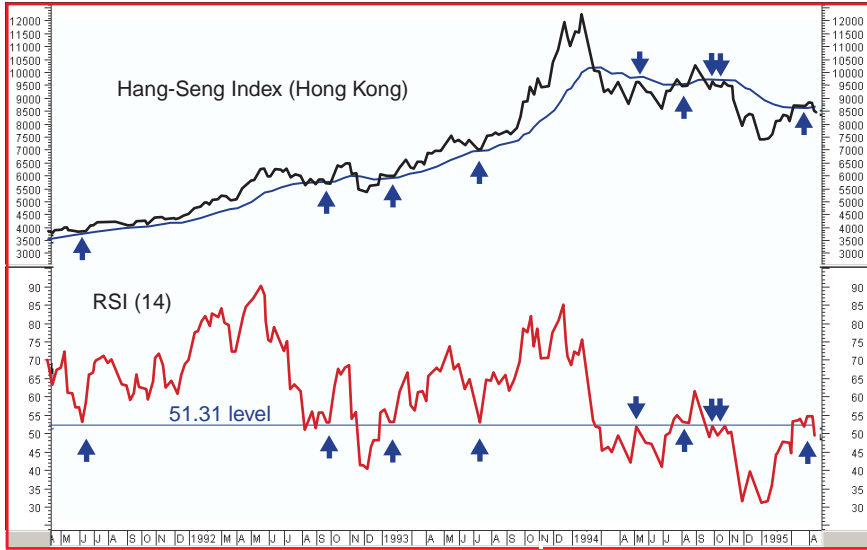


FIGURE 11: SUPPORT AND RESISTANCE LEVELS. The value 51.31 is an important support-resistance level for the RSI(14). The RevEngRSI indicator overlaid on the Hang-Seng index uses 51.31 as the RSI value. When the RSI value is greater than 51.31, the index is above the RevEngRSI, and when the RSI value is lower than 51.31, the index is below the RevEngRSI.

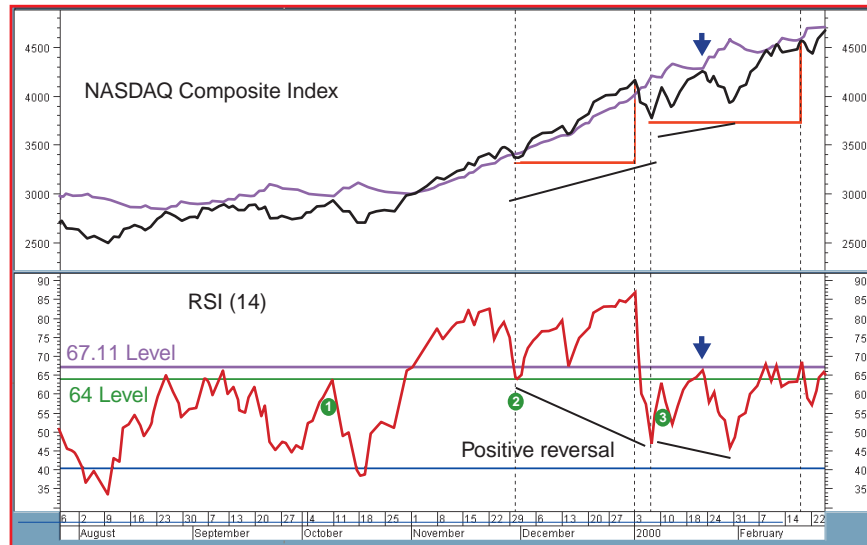


FIGURE 12: USING REVENGRSI WITH OTHER METHODS. Using additional tools such as divergences, horizontal support and resistance levels, and pivots makes reversals visually clearer.

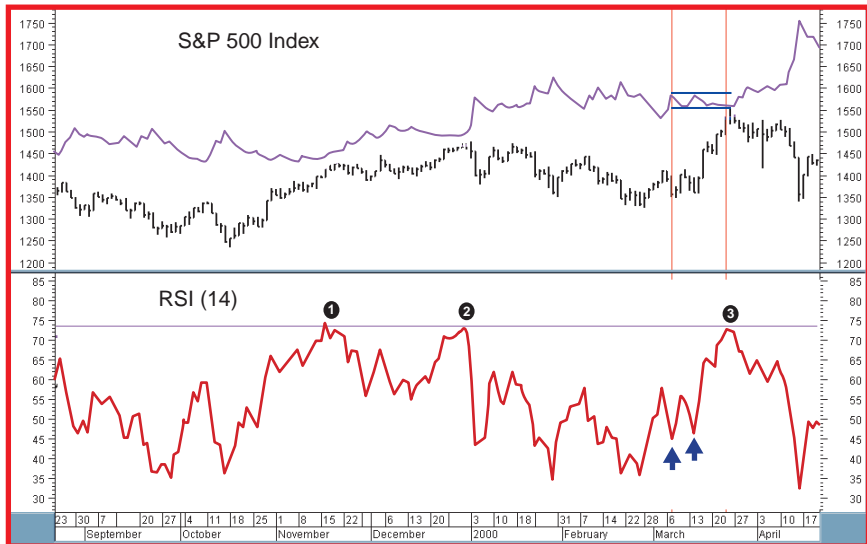


FIGURE 13: S&P 500 INDEX. Here you see the importance of identifying strong support and resistance levels. You can apply this value to create a RevEngRSI indicator to project the next closing price.

horizontal line in the graph of RSI is at the 71 level, which was an extreme resistance level for the RSI in recent months (see points 1 and 2). The pink curve in the graph of the S&P 500 index is the RevEngRSI indicator for the RSI value of 71.

The two vertical red lines represent the dates March 7, 2000, and March 23, 2000. Note that during this period the RevEngRSI was oscillating inside a range of 1,532 to 1,564, defined by the two blue horizontal lines. This indicates that if the market had the strength to push the RSI quickly to the 71 level (after the pivots at the points marked by black arrows, which occur above the 40 level for the RSI), the market would enter the oscillation range of RevEngRSI when the RSI was reaching the 71 level (point 3).

As the RSI was approaching 71, the RevEngRSI curve was approaching the lower blue boundary of the range, forecasting with greater accuracy the close of the market at the pivot 3. Finally, the RSI stalled at 70.32 at point 3; the market closed at 1,527.5 that day with a highest intraday value of 1,552.9. Generally, after you identify an important support or resistance value for the RSI or after you have projected a future value of the RSI, you may create a RevEngRSI indicator for that value. This will follow the price and give you the next closing price at which the RSI will attain that value.

SUGGESTED READING

Brown, Constance [1999]. *Technical Analysis For The Trading Professional*, McGraw-Hill Trade.
 Wilder, J. Welles [1978]. *New Concepts In Technical Trading Systems*, Trend Research.

See our Traders' Tips section this month for strategies implementing Giorgos Siligardos' concepts.

†See Traders' Glossary

