Generalized Technical Analysis.
Effects of transaction volume and risk

Marcel Ausloos\(^1\) and Kristinka Ivanova\(^2\)

\(^1\) GRASP, B5, University of Liège, B-4000 Liège, Euroland
\(^2\) Pennsylvania State University, University Park PA 16802, USA

Summary. We generalize the momentum indicator idea taking into account the volume of transactions as a multiplicative factor. We compare returns obtained following strategies based on the classical or the generalized technical analysis, taking into account a sort of risk investor criterion.

Key words. Econophysics; Moving Average; Technical Analysis; Momentum; Investment Strategies

1 Introduction

First we recall classical technical analysis methods of stock evolution. We recall the notion of moving averages and momentum indicators. We present a generalization of momentum indicators based on classical physics principles, taking into account not only the price of a stock but also the volume of transactions. Next we compare the returns obtained following strategies based on the classical technical analysis and the generalized technical analysis. The cases of four stocks quoted on NASDAQ, four stocks traded on NYSE, three major financial indices and the price of Gold will serve as illustrations. We consider the volume of transactions and the daily closing price of these stocks and indices for the period Jan. 01, 1997 to Dec. 31, 2001. Daily closing price signals \(y(t)\) are plotted in Fig.1(a-d) for stocks quoted on NASDAQ, i.e. CSCO, SUNW, AMAT, and MSFT; in Fig.1(e-h) for stocks traded on the NYSE, i.e. GE, AOL, PFE, and GFI; in Fig.1(i-k) are three financial indices: (i) NASDAQ, (j) S&P500), (k) DJIA; the price of Gold is in Fig.1 (l).

2 Classical Technical Analysis

Technical indicators like the moving average and the momentum are part of the classical technical analysis and much used in efforts to predict market
movements \[ \textbf{[1]} \]. One question is whether these techniques provide adequate ways to read the trends.

Consider a time series \( y(t) \) given at \( N \) discrete times \( t \). Let us recall that the series (or signal) moving average \( M_\tau(t) \) over a time interval \( \tau \) is defined by

\[
M_\tau(t) = \frac{1}{\tau} \sum_{i=t}^{t+\tau-1} y(i) \quad t = \tau + 1, \ldots, N
\]

i.e. the average of \( y \) over the last \( \tau \) data points. One can easily show that if the signal \( y(t) \) increases (decreases) with time, \( M_\tau(t) < y(t) \) (\( M_\tau(t) > y(t) \)). Thus, the moving average captures the trend of the signal given the period
of time $\tau$. The intersections of the price signal with a moving average can define so-called lines of resistance or support [1]. The intersections between two moving averages, the so-called "death cross" and "gold cross" in empirical finance [1], are usually used to identify points of drastic changes in the trend of the signal. The cross density characterizes the signal roughness [2].

The so called momentum indicator [1] is another instrument of the technical analysis and we will refer to it here as the classical momentum indicator (CMI). The classical momentum indicator of a stock is a moving average of the momentum defined over a time interval $\tau$ as

$$R^\Sigma_\tau(t) = \sum_{i=t}^{t+\tau-1} \frac{y(i) - y(i-\tau)}{\tau} \quad t = \tau + 1, \ldots, N$$

(2)

The classical momentum indicator (CMI) $R^\Sigma_\tau$ for time interval, $\tau = 21$, i.e. one month is shown in Fig. 2(a) for GE.

### 3 Generalized Technical Analysis

Stock markets do have another component beside prices or volatilities. This is the volume of transactions (Fig. 2 (a) for GE) which we have considered as the "physical mass" of stocks, in a generalized technical analysis scheme [3]. Remember that the number of shares is constant over rather long time intervals, usually like the mass of an object.

Consider $V(t)$ to be the volume of transactions of a stock with price $y(t)$ at time $t$. A generalized momentum $\tilde{R}_\tau$ over a time interval $\tau$ can be

![Fig. 2.](image-url)
Fig. 3. Difference between classical momentum indicator (CMI) $R^C(t)$ and generalized momentum indicator (GMI) $\tilde{R}^G(t)$ with $\tau=21$ days from Jan. 1, 1997 to Dec. 31, 2001 for stocks traded on NASDAQ – (a) CSCO, (b) SUNW, (c) AMAT, (d) MSFT; stocks traded on NYSE – (e) GE, (f) AOL, (g) PFE, (h) GFI; three financial indices – (i) NASDAQ, (j) S&P500, (k) DJIA, and Gold (l)

$$\tilde{R}_\tau(t) = \frac{V(t)}{<V(t)>_\tau} \cdot \frac{y(t) - y(t-\tau)}{\tau} = m(t) \frac{\Delta x}{\Delta t}, \quad t = \tau + 1, \ldots, N \quad (3)$$

where the total volume of transactions over the interval $\tau$ is $<V>_\tau = \sum_{i=1}^\tau V(i)$. In so doing, we introduce some analogy to a generalized time dependent mass $m(t)$ that contains some sort of history of the intercorrelations between price and volume of transactions of a stock during the $\tau$ interval. The total volume in the denominator is introduced for a normalization purpose. The transaction volume can also be represented as a rescaled volume of transactions $V_r(t)$

$$V_r(t) = \frac{V(t)}{<V>_\tau} \quad (4)$$
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which is plotted in Fig. 2 (b) for GE.

We further consider a moving average of the generalized momentum which is called the generalized momentum indicator (GMI)

\[
\overline{R}^\Sigma_t(t) = \sum_{i=t}^{t+\tau-1} \frac{V(t)}{<V>_{\tau}} \cdot \frac{y(i) - y(i-\tau)}{\tau}
\]

\(t = \tau + 1, \ldots, N\) \hspace{1cm} (5)

The difference CMI minus GMI for all data of interest is plotted in Fig. 3.

4 Investment strategy

A simple investment strategy can be suggested based on the trends of the market and using both the price per share and the volume of transactions incorporated in the generalized momentum indicator.

Following basic logics we buy at the minima of the GMI and sell at the maxima of GMI. We assume that we owe one share of a given stock at time
which is the first sell signal of a stock $y(t_0)$. The accumulated return that one can obtain during a certain period of time can be defined as

$$Z(t) = \sum_{i=1}^{N_c} I(i) y(i)/y(t_0)$$

where $N_c$ is the total number of transactions suggested by the strategy during the period of interest; $I(i) = -1$ at the minima of $R^C_{\tau}(t)$ or $R^\Sigma_{\tau}(t)$ is producing a buy signal to investors, and $I(i) = +1$ at the maxima of $R^C_{\tau}(t)$ or $R^\Sigma_{\tau}(t)$ is communicating a sell signal. Results of investments are plotted in Fig. 4 (a,c) for Gold and GE stocks following GMI- (full diamond) and CMI-strategy (open diamond).

In order to take advantage of the knowledge of the dynamics of the market represented by the volume of transactions and included in the GMI we introduce a criterion that will prevent from investment activity (and thus monitor the risk) when the change of the momentum indicator at the local extremum is smaller than a certain percentage of the momentum indicator value at the
Fig. 6. Returns obtained following (GMI)-strategy (full diamonds and solid line) and CMI-strategy (open diamonds and dotted line) for $\tau=21$ days and restriction policy parameter $m=0.01$ for the period Jan. 1, 1997 to Dec. 31, 2001 for stocks traded on NYSE – (a) GE, (b) AOL, (c) PFE, (d) GFI

time just before the extremum. Thus we define a $m$-criterion for measuring the relative depth of the local extrema as

$$m = \frac{R^\Sigma(t_{max/min} + 1) - R^\Sigma(t_{max/min})}{R^\Sigma(t_{max/min})}. \quad (7)$$

Different restrictions on the investment activity expressed in the value of the $m$-criterion lead to different returns as it is illustrated in Fig. 4 (a,c) for Gold and GE, respectively. This also results in a different number of transactions suggested by the strategies as shown in Fig. 4 (b,d) for for Gold and GE, respectively. It is interesting to notice that for approximately the same number of transactions, and different $m$-values the GMI-strategy leads to higher returns. Note that an investment strategy should not be excessively defensive, e.g. the returns for GE and Gold (marked with full/open triangles (GMI/CMI)) for a relatively high (defensive) $m=0.02$ are low as compared to the returns for $m=0.01$, marked as full/open squares (GMI/CMI). To illustrate the performance of the GMI-strategy with respect to the CMI-one for the stocks and indices of interest (data in Fig. 1) we chose the $m=0.01$ investment strategy and plot all the results in Figs. 5, 6 and 7.
Fig. 7. Returns obtained following (GMI)-strategy (full diamonds and solid line) and CMI-strategy (open diamonds and dotted line) for $\tau=21$ days and restriction policy parameter $m=0.01$ for the period Jan. 1, 1997 to Dec. 31, 2001 for three major financial indices – (a) NASDAQ, (b) S&P500, (c) DJIA, the price of Gold (d)

5 Conclusions

We present an investment strategy based on a generalized momentum indicator (GMI) that takes into account complete information from the two faceted market - the share price and the volume of transactions. In addition, our GMI-strategy involves restriction policies defined by the value of a hereabove introduced $m$-criterion, describing a more or less risky investor. By doing so we obtain profits with the GMI that are higher than those obtained with the (classical momentum indicator) CMI-strategy with the same restriction policies applied.

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