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# How low can you go? How high can you fly?

Exploiting reversals following N-day highs and lows in the Forex- and the Swedish stock market, and the implications of this for the hypothesis of weakly efficient markets


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Abstract

This thesis deals with technical analysis, exploring the profitability of a trading strategy based on buy/sell signals after N-day lows/highs. The strategy is tested on 10 years of data in the Forex market and the Swedish stock market. The results show that significant profit can be made, and this is discussed in light of the hypothesis of weak market efficiency.

# Contents

# Prelude and acknowledgements

It is with great joy yet also with reverence, that I seal and submit this bachelor thesis of mine. The journey hereto has been a long one, encompassing over a decade in time, stretching over two continents and connecting vastly different ways of life that I have pursued.

This thesis has indeed been a learning experience for me. Many of the subjects covered throughout my studies were in fact learnt anew, as putting theory into practice tends to present problems calling into question that which was previously perceived as simple and molding knowledge into craftsmanship. Econometric concepts such as probability distributions, hypothesis testing and measures of central tendencies had to be rehearsed, and certainly also financial concepts such as risk adjustment, performance-measuring and market efficiency. Delving into the academic research of others has also been very enlightening.

Most of all, however, I felt this again corroborated an insight that'd already begun to take root within my mind, namely about the nature of the practical world itself, and that is that it's full of stumbling blocks! There are always small things happening, going wrong, not going smoothly, that could be exceedingly unsettling for the unsuspecting. Formulas in Excel that magically change when copied, cells that refuse to be reformatted and online stock prices allegedly adjusted for splits but that turn out not to be are just a few examples. A main lesson from this work has been fully integrating into myself that this is how real life is, but that it's not such a big deal if you don't make it into one. Much in life is a question of attitude.

I would like to offer my acknowledgements to my supervisor, Dr. Erik Norrman, who has offered wise guidance throughout this work, and who has delivered this with utmost friendliness. There have been others whom I've briefly consulted with over the last few months, and hopefully they know who they are, and to them also I offer my thanks. Moreover, I thank my beloved mother, for without her assistance during the last difficult year, things indeed would've looked a lot grimmer today. Lastly, but certainly not the least, I offer, as is customary among my people, my gratitude to G-d.

# Introduction

## Choice of subject

Enormous time and effort have, over the generations, been invested in the ever-fascinating topic of how to best make money. The idea that, somewhere out there, the Holy Grail waits to be found, has made brave men set out on life-threatening treasure hunts, has bound brilliant minds to the question of how to make gold out of iron and has caused billions to be invested into mining the deepest of waters for the thick, black fluid of fortune. Wherever the sweet scent of money is ever so faintly sensed, rest assured that someone is conniving to exploit this.

Modern capital markets are no exception. Au contraire, there is something spellbinding with these intangible entities, stocks, bonds, currencies and so on, seemingly living a life of their own, being priced, bought and sold at mind-boggling quantities and killer speed by scores of actors who have no interest in the underlying asset but only in selling at a higher price than they bought. Is there a pattern to the way prices evolve? Are there identifiable "signs" hinting what will be in the future?

For this author, interest was sparked through listing to free, online lessons on how so make profit just by glancing a few moments at a Forex chart (this was at a time when I was still prone to give the benefit of a doubt even to what seemed too good to be true). I found it absolutely fascinating, for indeed, patterns seemed to recur every time before the start of a trend, and the trend itself seemed to follow a pattern. True, after a not so long while, I realized it wasn't so simple. The trend-signaling patterns, sure enough, were there *most of the time*, but not always, and they were there even at times when no trend followed. Looking through historical data I saw that the only way you could claim that the strategy worked was if you'd continually change the already vague definitions of the signals as you go along, in the end coming up with definition way too loose to be used. Still, this episode actually sparked an interest in me of capital markets in general; even if the charts are not so easily exploited, those trends still had their allure, crying out to come ride them, and so it came about that when I chose my field of studies the choice was economics, and particularly, financial economics. But this was not all; once I saw, in the course of my studies,

that the subject of technical analysis was actually dealt with by academics, and although the general attitude was skeptic thereto there were also those supportive, I came back to this enfant terrible of mine. Thus, when time came for my bachelor thesis, the choice of subject was just that, to try to find the Holy Grail, for even though I was, to say the least, highly doubtful that I would, I still felt a debt obligating me to at least try, and even a longing, almost as a longing to see an old friend. *Should old acquaintance be forgot and never brought to mind?*

## Purpose

My purpose here is to contribute to answering the delicate question of whether or not pursuing technical analysis is to recommended for the rational investor or if it is be dismissed at hand in light of the hypothesis of weak market efficiency. Put into simple questions: Are markets weakly efficient? If not, can we find rules to exploit the market? Does the profitability of these rules persist even as transaction costs are accounted for? Might we get different results depending on which market we investigate? As the answer for the question of weak market efficiency contra technical analysis is vast and many-facetted my more direct purpose is to investigate this specifically as far as the strategy of going long/short after breaches of N-day lows/highs is concerned, and on the Forex- and Swedish stock market.

## Summary

This thesis revolves around the findings put forth in a 2009 paper by Bruce Mizrach and Susan Weerts (from henceforth: M&W), more specifically around a trading strategy (henceforth "the strategy") implied by this paper, that following a breach of N-day highs/lows reversal tends to occur and positive yields tend to be attained by going short/long. The purpose of this thesis is to further test the findings of M&W and to discuss their implications on the hypothesis of weakly efficient markets. Thus, I will initially explain the concept of technical analysis (from henceforth: TA) under which heading the strategy falls; this will be followed by a presentation of the hypothesis of week market efficiency and by an elaboration of how these two concepts clash. I will then in detail present the results

M&W and present additional research relating to this issue of market efficiency and technical analysis.

In order to either further substantiate these findings, or alternatively, to question them, I ran tests on the strategy on the Swedish stock market and the Forex market respectively. When testing each stock/currency pair (of a randomly chosen group of such) individually, I found that only for a small minority of these assets was the strategy successful (where the meaning of “success” will be clearly defined in the section “Method”). However, for a well-diversified portfolio of stocks/currency pairs, my results show that profit is to be expected in both markets.

I then compare the expected yield from the strategy, in the two investigated markets respectively, with investing in a well-diversified stock index adjusting for risk, and my results were that a higher risk-adjusted yield is to be expected from the strategy.

I also tested the strategy while accounting for transaction costs and found that, indeed, the strategy remains strongly profitable in both markets

I finish off by discussing possible ways of explaining my results, i.e. that the strategy was profitable during the sample period, in light of the questions that arise from the arguments for weak market efficiency and point to interesting issues relating to this work that I believe to be of relevance for further research.

# Theory

## Technical analysis

By technical analysis I refer to the practice of using past data concerning a certain asset, particularly price or volume, to forecast future prices (Malkiel a: p. 105, Byström: p. 82). This is often (ibid.) contrasted with fundamental analysis which looks at the "fundamentals" of an asset, meaning those variables that according to economic theory "should" determine its value. For a company stock, this would include trying to estimate the future size of the market, the competitiveness of the company, the quality of its management, its dividend policy etc., and then using economic theory to determine what the correct value of the stock should be. If actual price differs from what should be according to the conclusions of the analysis then the company is over-/underpriced and is a candidate for buying/selling. Technical analysis is often described as ignoring all these factors, instead focusing on "patterns" in price movements of the past, or how price moved after rising above/dropping below a certain point, or after moving by a certain amount in i certain period of time, or when volume traded was so and so at a time when price was below this or that (Byström: p. 82). This is closely related to the concept of behavioral finance, an approach to finance and pricing that holds that human psychology should be a major determinant in forecasting future prices (Byström: p. 81). It might in fact be said that the foundations of these ideas were laid out in John Maynard Keynes in chapter 12 of his magnum opus *The general theory of employment, interest and money* with his famous analogy of a beauty contest where the readers of a newspaper were presented with a number of pictures of different women and asked to pick *the most beautiful*. Those who picked the face that received the most votes would be eligible for a prize. Thus the rational voter must not vote simply according to *his* perception of esthetics, but according to how he expects the majority to *vote*. In the words of the author himself: "It is not a case of choosing those [faces] that, to the best of one's judgment, are really the prettiest, nor even those that average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligences to anticipating what average opinion expects the average opinion to be. And there are some, I believe, who practice the fourth, fifth and higher degrees." It follows from this that if traders in general indeed do look at charts to determine their investments, it in fact *becomes*

*rational* to do just this, and thus we see that the theoretical groundwork underlying technical analysis is certainly not nonsensical. Whether or not this could lead to persistent gains will be further discussed in the light of implications from the next section.

## The hypothesis of weak market efficiency

Although the concept of market efficiency had been discussed before, the one generally considered to be the father of the concept of market efficiency is Eugene F. “Gene” Fama who in the May, 1960 issue of the journal of finance published his groundbreaking article "Efficient Capital Markets: A Review of Theory and Empirical Work" after which the concept became part of mainstream financial doctrine (from henceforth we will denote the hypothesis of weak market efficiency by HWME), in fact for long being a quite dominant paradigm in the world of academia (Park and Irwing: p. 788, Malkiel b: p. 59). Fama categorized different types of market efficiency but the one relevant to us is what he called “weak market efficiency”, and it is the in fact implied by the other types and thus “more easily accepted” in the sense that less assumptions are required to made in order for it to be true. Weak market efficiency means that at any present moment the price of an asset is already updated to eliminate any mispricing that could give rise to profit based on the analysis of data from the past. To make this clear, we will exemplify. Let’s say an anomaly is noted, that almost every time the price of an asset drops by 5% in one day it than rises the next day by the same amount. If then, on a certain day, price indeed drops by 5%, the rational investor might think that he would therefore have an excellent opportunity for making profit by buying the asset as soon as this happens and selling it again the next day. Weak market efficiency, however, would mean that *enough* investors would try to make the same order, increasing demand and thus driving price up, in order for whatever profit that would be made to be eliminated, alternatively no one would want to sell immediately driving price back up. In other words, at every present moment price is set to eliminate any advantage possible to derive from information of the past so as soon as a phenomenon becomes statistically reliable it would therefore disappear, or at least become statistically unreliable. The arguments for this type of market efficiency are strong, information of past prices is readily available for everyone to analyze, and as long as the amount of investors is large (though how large remains an unsolved question) assuming that enough of them would notice the same anomaly and try to exploit it not an outlandish assumption. On the

other hand, it is important to remember that it is only that, a quite reasonable assumption. It could also be that not enough investors notice the opportunity, or that not enough try to exploit it, and that thus the opportunity remains. Ironically, the hypotheses of weak market efficiency could in fact destroy itself by virtue of becoming accepted, for if enough investors internalize the concept they might cease to analyze passed data for anomalies and thus not notice it and not trying to exploit it, and thus the phenomena might indeed persist. Furthermore, because of the very arbitrariness of technical analysis, there is a myriad of different anomalies to check for, and it is by no means certain that everyone is checking for the same, in fact, I would argue that it certainly not so. Setting this aside, and for the moment accepting the hypothesis of weak market efficiency, prices would be assumed to follow a so called *random walk*, i.e. the future movement of price is completely uninfluenced by previous movements. It might, however, still be influenced by fundamental factors, such as news about a company, or about the market demand etc.

## Previous research

Academics tend to be skeptical about technical analysis (Park and Irwin: p. 787, Malkiel: p. 104, 128-, Byström: p 164). Park and Irwin (ibid.) link this to a general acceptance of the hypothesis of weak market efficiency and to negative empirical findings in several early studies of technical analysis in the stock market. This division, between HWME in the sense of implying that asses prices follow a random walk (which is how I use the term HWME) and TA, is actually important, as it should be noted than even if we don't accept HWME, and even if we were able to point to autocorrelation in asset prices, this would not automatically mean that this phenomena could be profitably exploited, as transaction costs could eliminate this; also it might simply be to too small a profit for the rational investor if f.ex. the profit from a risk-free government bond would be greater (Malkiel b: p. 62). Not accepting HWME, however, is a *necessary* condition for TA to be profitable.

The general academic skepticism towards TA does not, however, mean that there is a lack a research that points to the profitability of TA, as we will see below.

In general, research has on technical analysis has focused has focused on stock markets over the world and on the Forex market, and a smaller number on the futures market (ibid: p.

787). Below is the table of Park and Irwing (ibid: p. 788) summarizing research of TA from the 1960s to the early 2000s, categorizing them according to market investigated:

**Table 1.** Number of Technical Trading Studies, 1960–2004.[a]

| Year | Stock markets | Foreign exchange markets | Futures markets | Total | Relative frequency (%) |
|---|---|---|---|---|---|
| 1960–1964 | 3 | 0 | 3 | 6 | 4.4 |
| 1965–1969 | 6 | 1 | 1 | 8 | 5.8 |
| 1970–1974 | 4 | 0 | 3 | 7 | 5.1 |
| 1975–1979 | 2 | 3 | 2 | 7 | 5.1 |
| 1980–1984 | 2 | 1 | 6 | 9 | 6.6 |
| 1985–1989 | 4 | 3 | 7 | 14 | 10.2 |
| 1990–1994 | 5 | 3 | 2 | 10 | 7.3 |
| 1995–1999 | 18 | 13 | 1 | 32 | 23.4 |
| 2000–2004[b] | 22 | 20 | 2 | 44 | 32.1 |
| Total | 66 | 44 | 27 | 137 | 100.0 |

[a]Studies on equity (index) futures and options and foreign exchange futures are categorized into 'stock markets' and 'foreign exchange markets' studies, respectively. 'Futures markets' studies include studies on other individual futures markets or various groups of futures markets.
[b]Through August 2004.

Park and Irwing note (ibid: p. 787) that the veritable explosion in research on TA in recent years, about half of all empirical studies conducted after 1960 were published in the period of 1995-2004. They speculate that this might be partly due to the increased availability of computer power and electronic databases of prices but also to the fact that in the mid-1980s and early 1990s several seminal papers, in contrast to earlier research, found significant technical trading profits to TA-systems. A quick overview of the treatment of Park and Irwing (ibid: p. 790-) on the results of previous research on the profitability of TA is provided below:

- Early studies on the stock market: The best known work on technical trading rules from the early days was a paper of Fama and Blume (1966) on the "Filter rules" of Alexander (1961). A filter rule generates a buy/sell signal when price moves x% above/below its most recent high/low. Fama and Blume tested this on 30 securities of the DJIA and found that only three small filters of 0.5%, 1.0% and 1.5% generate an annual mean higher than that of a buy-and-hold strategy but conclude that profit might actually be negative once transaction costs are taken into account. Other

studies from this period, e.g. Varn Horne and Parker (1967), James (1968) and Jensen and Benington (1970) also show that that trading rules based on moving average and relative strength are not profitable.

In contrast, early studies on the Forex market and on the futures market found substantial net profit in technical strategies. For example, Leuthold (1972) apply six filter rules to live cattle futures over the period 1965-1970 and found four of them to be profitable after transaction costs, in particular a 3% filter rule generated an annual net return of 115.8%. Another example is Sweeney (1986) who tested small filters of 0.5%, 1.0% and 2.0% across 10 currency pairs and found that long positions based on these rules generate positive risk-adjusted returns on all pairs. Among his results was that a 1.0% filter generates excess returns that average between 3.0%-6.75% per year.

Thus we see conflicting results in early research, suggesting that stock markets are more efficient than the Forex market or the futures market. Still, Park and Irwing (ibid: p. 791) urge caution and list a number of reasons why an attitude of skepticism is proper as to the results of the research of then, as it generally suffers from quite serious problems, all of this beyond the scope of this thesis, yet I encourage the interested reader to look into the paper by Park and Irwing for it is extensive and thorough.

- Modern studies: Park and Irwing state (ibid: p. 792) that modern studies generally improved upon the problems that characterized earlier research, yet have differed considerably with regard to treatment of transaction costs, risk, parameter optimization, out-of-sample tests, statistical tests and data snooping and thus they saw need to treat them in detail categorizing them into 7 groups, the technical details of which is beyond the scope of this thesis. Yet, they (ibid: p. 804, 805) did summarize that out of 95 modern studies on the subject, 56 show positive-, 20 show negative- and 19 show mixed results as illustrated by the table below, imported from the Park and Irwing paper itself (ibid: p. 806, 807):

| Studies | Number of studies | | | Profit range |
|---|---|---|---|---|
| | Positive | Mixed | Negative | |
| **A. Stock markets** | | | | |
| Standard | 2 | 2 | 2 | 4%–17%[b] |
| Model-based bootstrap | 7 | 4 | 3 | (1897–1998) |
| Reality check | 0 | 1 | 1 | |
| Genetic programming | 2 | 1 | 3 | |
| Non-linear | 3 | 2 | 0 | |
| Chart patterns | 4 | 1 | 1 | |
| Others | 8 | 1 | 0 | |
| **Sub-total** | 26 | 12 | 10 | |
| **B. Foreign exchange markets** | | | | |
| Standard | 8 | 2 | 3 | 5%–10%[c] |
| Model-based bootstrap | 4 | 2 | 1 | (1976–1991) |
| Reality check | 1 | 0 | 0 | |
| Genetic programming | 3 | 0 | 1 | |
| Non-linear | 3 | 0 | 0 | |
| Chart patterns | 2 | 1 | 2 | |
| Others | 3 | 1 | 1 | |
| **Sub-total** | 24 | 6 | 8 | |

**Table 3.** *Ca*

| Studies | Number of studies | | | Profit range |
|---|---|---|---|---|
| | Positive | Mixed | Negative | |
| **C. Futures markets** | | | | |
| Standard | 5 | 0 | 0 | 4%–6%[c] |
| Genetic programming | 0 | 1 | 0 | (1976–1986) |
| Non-linear | 0 | 0 | 1 | |
| Others | 1 | 0 | 1 | |
| **Sub-total** | 6 | 1 | 2 | |
| **Total** | 56 | 19 | 20 | |

Still, to conctretize things, we will mention a few key papers of "general" relevance, by Park and Irwing called "standard studies", that are based on a specific performance criteria and out-of-sample testing for parameter optimization, something that is likely to more closely emulate trader-behavior and actually partially adress the problem of data-snooping (ibid: p. 794). Furtermore, these studies incorporate transaciton costs and risk into trading procedures and test risk and returns using conventional statsiticla methods (ibid: p. 794) (these being among the things that were, amazingly enough, often not done in earlier research). *Lukac et al.* (1988) simulate 12 technical trading systems on price series from 12 agricultural,

metal and financial futures markets over the period of 1975–1984 and find that four trading systems, including the dual moving average crossover and channel systems, yield statistically significant monthly portfolio net returns ranging from 1.89% to 2.78% after deducting transaction costs, with Deutschemark, sugar and corn appearing to be especially promising futures contracts. The thus conclude that indeed some futures market were inefficient during the sample period. Using similar methods as Lukac *et al.* Lukac and Brorsen (1990) tested more rules and futures contracts over a longer period and found that 7 out of 23 systems generate a statistically significant positive return after accounting for transaction costs, with Forex futures being the most profitable. Park and Irwing continue to quote a stream of papers on the Forex market from the late 70s to the early 90s pointing to unlevered annual net returns of between 2%-10% not only on futures contracts, but also in the spot market.

What should be noted, though, is the fact that while studies showed TA to yield positive profits in the late 1980's they failed to show so thereafter, while in emerging stock markets several studies show success regardless of time period considered (Park and Irwing: p. 805). Olson (2004) reports that risk-adjusted profits of moving average rules for a portfolio of 18 foreign exchange rates decline from over 3% in the late 1970s and early 1980s to near zero in the late 1990s. Taylor (2000) investigates a wide variety of US and UK stock indices and individual stock prices, finding an average breakeven one-way transaction cost of 0.35% per transaction across all data series, meaning that if the cost was greater than this net loss would occur. This phenomenon of disappearance of TA profitability is important, as it related to the tendency of TA to be self-defeating, something that will be addressed further in the analysis section below.

To explain the possible profitability of TA, or the actual profitability in light of the abundance of research the points to such theoretical explanations to fend of HWME must be provided, and indeed theoretical assaults on the concept of market efficiency as a whole, meaning on all sub-types thereof, began most seriously with the rise of behavioral finance economics in the 90:s (Malkiel b.: p. 61, 62). Incorporating human psychology into asset pricing would allow us to first of all understand deviations from fundamental value but also why trading

opportunities might persist for at least an amount of time that will allow some to benefit from. More on this in the section “Analysis” below.

## The Mizrach/Weerts paper

### MOMENTUM-, CONTRATIAN AND REVERSAL INVESTING

Before getting to M&Ws paper it’s important to note that there has been, and is still, a debate in the world of investors and financial economists regarding strategies that in a sense are quite diametrically opposed. Du Bondt and Thaler (1985) showed that stocks that performed bad over a past period of 3 to 5 years performed better in the next 3 to 5 years than stocks that performed well during the first period. The proposed explanation is that investors consistently overreact to news, driving stocks prices “too much” in a certain direction, which later will be followed by a reversal. Thus, an investing strategy that is *contrarian*, i.e. contrary to what’s been happening up until recently, is to be preferred, as reversal tends to follow trends (ibid: p. 795). On the other hand Jegadeesh and Titman (1993) showed that a strategy that buys the top 10% and sells the bottom 10% of stocks ranked according to performance over the last 6 months and holds them for 6 months achieves a monthly average return of 1%. It should be noted that the results of Jegadeesh and Titman concern an intermediate time period of 6 months while Du Bondt and Thaler dealt with a longer period of 3 to 5 years and this might be the divide.

### M&Ws RESULTS

In the 19:th edition of the journal *Applied financial economics* of 2009 Bruce Mizrach and Susan Weerts published an article titled “Highs and lows: a behavioural and technical analysis”. We will here focus only on the aspect of the article that concerns us. The article comes off a previous article of George and Hwang in 2004 pointing to a momentum effect after the breach of a 52-week high. George and Whang conducted their research on stocks in a so called momentum portfolio, meaning stocks for a certain period of time, in that case focusing of sex months, had been “the best performing”. Mizrach and Weerts on the other hand chose stocks from the US market randomly, not a momentum portfolio (ibid: p. 767), and found that on the contrary, there is a reversal effect on *first day* following the breach of

a N-day high and for up until 10 days following the breach of a N-day low(ibid: p. 767, 777). Values chosen for N were 10-, 25-, 50-, 100-, 150- and 200 days and 52-weeks (ibid: p. 769).

EXPLANATION

To explain their choice of trading rules for which to test for, and thus in retrospect also their positive results, M&W drew upon behavioral finance, among else citing Kahneman and Twersky (1974) that "agents use recent, salient, concrete and personally relevant information, rather than fundamental values as a basis for their decision making" (ibid: p. 768) and Das and Raghubir (2006) "that people perceive local maxima and minima as salient points" (ibid: p. 768) which M&W means "could potentially explain the absence of momentum effect at new highs and lows". Furthermore, M&W cite Menkhoff and Schmidt (2005) that "36% of German fund managers surveyed all allocating funds using alternative strategies including technical analysis", and a survey by Mizrach and Weerts (2007) of semi-professional traders "that suggest that simple rules like moving averages (52%) and chart patterns (56%) are preferred" (ibid: p. 768). Thus M&W mean that "psychological, behavioral, survey and experimental evidence appears to support our choice of simple, widely reported and graphically-oriented rules like the n-day high and low" (ibid: p. 768).

# Method

## Choice of markets, assets and period in time

I chose to check the results of M&W on two markets significantly different than the ones checked by them, the Swedish stock market and the Forex market. The Swedish stock market was chosen in order to remain in the realm of stocks but on a market much smaller than the American, one that thus might be suspected to be less effective. The Forex market was chosen being a market for a completely different asset than stocks, and at that one that is much bigger, the Forex market in fact being the biggest market around, and that thus might be suspected to be all the more effective.

From the Swedish stock market I randomly chose 25 stocks of major companies listed on "Stockholmsbörsen", run by OMX AB. They were the following:

ABB ltd, Assa Abloy B, Astra Zeneca, Atlas Copco B., Castellum , Electrolux B, Elekta B, Ericsson B, Fabege, Getinge, Industrivärden C, Investor B, H&M B, NCC B, Nordea Bank, Ratos B, Scania B, Securitas B, Skanska B, SSAB B, Sv. Handelsbanken B, Swedbank A, Swedish Match, Tieto Oyj och Volvo B.

From the Forex market I randomly chose 11 currency pairs so that each currency appears only in one pair, this in order to decrease correlation. The pairs were the following:

AUD-PLN, CAD-NOK, CNY-MAD, CZK-LVL, DKK-LTL, GBP-NZD, HKD-JPY, HUF-ISK, IDR-INR, RUB-ZAR and SEK-SAR.

For comparison with an alternative strategy of investment I chose the OMX 30 index.

For calculating Sharpe rates I used the a 30 days Swedish treasury bill.

The data was end-of-day quotes between 2000-01-01 and 2009-12-31.

## Choice of method for statistical tests

<u>BASIC FORMULATION OF THE STRATEGY</u>

I checked above data for N-day highs and lows with the same values for N as the ones M&W chose, i.e. 10, 25, 50, 100, 150, 200 and for the 50-week high/low 365 days. As M&W pointed to 1-day up until 10-day effects I decided to test the strategy in two forms, buying/selling after an N-day low/high and holding for 1 day or 10 days respectively. It should be noted that, as stated above, I used only end-of-day quotes. Thus buy/sell signals were based only on end-of-day quotes. Similarly, the price paid/received for entering the trade was that same end-of-day quote. This choice was made primarily for the purpose of simplification, yet should not be dismissed as arbitrary as end-of-day quotes are likely to carry significant psychological weight for decision-making, and due to the high liquidity of todays' markets, entering a trade the day after close to this price is not unrealistic in the aggregate.

TREATING BUY- AND SELL SIGNALS SEPERATELY

Since it's a historical fact that the stock market as a whole exhibits a positive trend over time I saw as a distinct possibility that buy-signals would produce a better outcome than sell-signals, the latter being counter-balanced by traders' general expectation of rising prices. Thus I saw fit, for the stock market, to run my simulations of the strategy for buy- and sell-signals separately as well as together. For the Forex market, however, since the assumption must be the absence of a trend, in other words that the exchange rate follows a random walk, it makes no sense to look at the signals for going long and short.

ESTIMATING THE MEAN YIELD PER TRADE IN 3 WAYS

My simulations of the strategy consisted of identifying each signal, and calculating the yield that would've been earned by acting upon this signal, then calculating the mean revenue.

1. I first did this for each asset, meaning every individual stock and currency pair, and for each value of N separately. For example, I calculated the mean yield for acting upon buy signals in the Assa Abloy data-series for N=10, then another mean yield for N=25 and, and so on for all values of N, each time separately, then repeating this for Astrazeneca, Volvo all other stocks and for the currency pairs. This is illustrated in the table below:

**Table 1**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N=10 | | | | N=25 | | | … | N=365 | | |
| | | | Yield | | | | Yield | | | | Yield | |
| | | Signal | 1 day | 10 days | | Signal | 1 day | 10 days | | Signal | 1 day | 10 days |
| RUB-ZAR | 2000-01-01 | No | | | | No | | | | No | | |
| | | No | | | | No | | | | No | | |
| | | Yes | 0,001 | | | Yes | 0,0005 | | | Yes | -0,0001 | |
| | | … | … | … | | | | | | | | |
| | | | | 0,002 | | | | -0,0001 | | | | 0,0002 |
| | 2009-12-31 | Yes | | | | Yes | | | | Yes | | |
| | Average | | 0,0014 | -0,0016 | | | 0,0014 | -0,0034 | | | 0,0008 | -0,003 |
| | Success | | Yes | No | | | Yes | No | | | No | No |
| | | | | | | | | | | | | |
| … | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| IDR-INR | | N=10 | | | | N=25 | | | … | N=365 | | |
| | | | Yield | | | | Yield | | | | Yield | |
| | | Signal | 1 day | 10 days | | Signal | 1 day | 10 days | | Signal | 1 day | 10 days |
| | 2000-01-01 | No | | | | No | | | | No | | |
| | | No | | | | No | | | | No | | |
| | | Yes | 0,001 | | | Yes | 0,0005 | | | Yes | -0,0001 | |
| | | … | … | … | | | | | | | | |
| | | | | 0,002 | | | | -0,0001 | | | | 0,0002 |
| | 2009-12-31 | Yes | | | | Yes | | | | Yes | | |
| | Average | | 0,0243 | 0,0409 | | | 0,0292 | 0,0498 | | | 0,0281 | 0,0583 |
| | Success | | Yes | Yes | | | Yes | Yes | | | Yes | Yes |

2. Then I calculated the mean yield, again for each value of N separately, but now using all the assets in stock- and Forex market respectively as base. For example, in the stock market, if on a given day there was a buy signal for Assa Abloy, Ericsson and Astra Zeneca, all these breaking a 10-day low, I would calculate the average yield for investing in each of these three assets, and so on for whatever assets, produced signals for N=10 the next day, let's say it was Volvo and H&M, and so on, finally calculating the averages of all these averages. This process would then be repeated for the other values of N. This is illustrated in the table below:

**Table 2**

| | | N=10 | | | | N=25 | | | … | N=365 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Yield | | | | Yield | | | | Yield | |
| | | Signal | 1 day | 10 days | | Signal | 1 day | 10 days | | Signal | 1 day | 10 days |
| RUB-ZAR | 2000-01-01 | No | | | | No | | | | No | | |
| | | No | | | | No | | | | No | | |
| | | Yes | 0,001 | | | Yes | 0,0005 | | | Yes | -0,0001 | |
| | | … | … | … | | | | | | | | |
| | | | | 0,002 | | | | -0,0001 | | | | 0,0002 |
| | 20009-12-31 | Yes | | | | Yes | | | | Yes | | |
| | | | | | | | | | | | | |
| … | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| IDR-INR | 2000-01-01 | No | | | | No | | | | No | | |
| | | No | | | | No | | | | No | | |
| | | Yes | 0,001 | | | Yes | 0,0005 | | | Yes | -0,0001 | |
| | | … | … | … | | | | | | | | |
| | | | | 0,002 | | | | -0,0001 | | | | 0,0002 |
| | 2000-12-31 | Yes | | | | Yes | | | | Yes | | |
| | | | | | | | | | | | | |
| | Average | | 0,0015 | 0,0022 | | | 0,0018 | 0,0021 | | | 0,0019 | 0,0021 |
| | Success | | Yes | Yes | | | Yes | Yes | | | Yes | No |

3. Finally, I calculated mean yield for the stock- and Forex market respectively using all the assets of values of N as base. In other words, if on a given day signals we had Assa Abloy breaking a 10-day low, Ericsson a 100-day low, and Astra Zeneca a 350-day low, the yield for pursuing these three trades would be calculated. This is illustrated in the table below:

**Table 3**

| | | | | | |
|---|---|---|---|---|---|
| RUB-ZAR | N=10 | | | | |
| | | | | Yield | |
| | | | Signal | 1 day | 10 days |
| | | 2000-01-01 | No | | |
| | | | No | | |
| | | | Yes | 0,001 | |
| | | | … | … | … |
| | | | | | 0,002 |
| | | 20009-12-31 | Yes | | |
| | | | | | |
| | N=25 | 2000-01-011 | No | | |
| | | | No | | |
| | | | Yes | 0,0005 | |
| | | | | | |
| | | | | | -0,0001 |
| | | 2009-12-31 | Yes | | |
| | | | | | |
| … | … | … | | | |
| | | | | | |
| IDR-INR | N=10 | 2000-01-01 | No | | |
| | | | No | | |
| | | | Yes | 0,001 | |
| | | | … | … | … |
| | | | | | 0,002 |
| | | 2009-12-31 | Yes | | |
| | | | | | |
| … | … | … | | | |
| | | | | | |
| | | Average | | 0,00195 | 0,00222 |
| | | Success | | Yes | Yes |

TESTING THE ESTIMATIONS FOR STATISTICAL SIGNIFICANCE

For each mean yield I checked if it was significantly different from zero by assuming, as common practice is, that yields are normally distributed and setting as null hypothesis that the mean yield is zero, as HWME would have it.

COMPARING TO AN ALTERNATIVE INVESTMENT

Finally, I compared my means to the mean revenue of investing either 1 or 10 days in a "market portfolio". As my "market portfolio" I chose the "OMX Stockholm 30 index" on Stockholmsbörsen. It should be noted that although the "normal" comparison is with a buy-and-hold strategy in a market portfolio, since here I've calculated not the performance of the strategy over time but rather it's expected yield per trade, the relevant comparison must be the expected yield for investing during the corresponding period in a well-diversified, and thus presumably more secure, portfolio of securities. Therefore, I calculated the expected yield of buying the OMX-30 and holding for 1 or 10 days respectively during the *same period* as the ones which the strategy would mandate investing in the high/low breaking assets.

ADJUSTING FOR RISK

As higher yield might be "payment" for accepting higher risk, there is a need to adjust the expected yields calculated for risk, and for this purpose I've used the Sharpe ratio. This choice is motivated primarily by its widely accepted usage (Park and Irwing: p. 813) and its simplicity.

CONSTRUCTING AN INDEX

Aside from calculating the expected yield per trade I also set out to measure the development of an index managed according to the strategy, one in the Forex market and one in the Swedish stock market each. The idea of an index is to measure the performance of the strategy over time, starting with a unit amount and investing this amount whenever there's a signal, and so on, at each signal reinvesting whatever remains after closing the trade of the previous signal. In order to simplify and avoid overlapping trades I have focused on the implementation of the strategy holding for 1 day only. Furthermore, if multiple signals occurred on a certain day, for example for more than one asset, and/or for more than one value of N, then I've considered as though all of the signals were acted upon and the yield was the average yield from all these trades. From my results for 10 year implementation of the strategy in this way, I calculated an expected yield per year.

It should be noted in this context that I did not account for revenue due to interest, even though during days when there was no signal the money would earn interest being for the

meantime invested in a risk free asset. Thus the results for this implementation of the strategy underestimated.

TWO TYPES OF INVESTORS

The two above mentioned ways of testing the strategy, by estimating the expected yield per trade and by estimating the performance of an index, correspond to two different types of investors, the first someone investing an equal amount at each signal, and the other setting aside an amount for the strategy at the beginning of the period, never to add funds thereto afterwards.

TRANSACTION COSTS

In order to check for the effects of transaction costs for the Swedish stock market I relied upon the price comparing company "Compricer" (www.compricer.se/aktier/) where among the lowest commissions were of 0.03% per trade (Swedbank, Nordnet and Skandiabanken) for large quantities. Thus our results will first of all be relevant for the "big" investor, as costs for "small" quantities are greater. For the Forex market determining a reasonable spread is more difficult as the spread tends to vary a lot between different currency pairs as well as between different brokers. Relying on a price comparison by Oanda Corporation (www.http://fxtrade.oanda.com/why/spreads/comparison) we see that assuming a spread of again, 0.03%, is quite realistic.

SOURCES FOR DATA

The stock prices were taken from the database Datastream (adjusted for splits etc.), the exchange rates from the homepage of the Swedish central bank, Riksbanken (http://www.riksbank.se/templates/stat.aspx?id=15882) and the prices for OMX Stockholm 30 index was collected from the homepage of NASDAQ OMX Nordic (http://www.nasdaqomxnordic.com/index/historiska_kurser/?Instrument=SE0000337842).

# Results

In table 4 we see, for each individual asset, how many of implementations of the strategy that resulted in a mean yield per trade significantly larger than zero (in the tables called a success). For each asset there were 28 implementations, two long- two short and two short strategies (holding for 1 respectively 10 days) for 7 values of N. At the bottom of the table we also display the results of investing in all of the stocks simultaneously.

**Table 4:**

| Asset | Number of successes | In percentage |
|---|---|---|
| **ABB ltd** | 0 | 0.0 |
| **Assa Abloy B** | 16 | 57.1 |
| **Astra Zeneca** | 11 | 39.3 |
| **Atlas Copco B** | 16 | 57.1 |
| **Castellum** | 8 | 28.6 |
| **Electrolux B** | 10 | 35.7 |
| **Ellecta B** | 8 | 28.6 |
| **Ericsson B** | 2 | 7.1 |
| **Fabege** | 0 | 0.0 |
| **Getinge** | 6 | 21.4 |
| **H&M B** | 11 | 39.3 |
| **Industrivärden C** | 1 | 3.6 |
| **Investor B** | 2 | 7.1 |
| **NCC B** | 0 | 0.0 |
| **Nordea Bank** | 13 | 46.4 |
| **Ratos B** | 7 | 25.0 |
| **Scania B** | 0 | 0.0 |
| **Securitas B** | 19 | 67.9 |
| **Skanska B** | 5 | 17.9 |
| **SSAB B** | 3 | 10.7 |
| **Sv. Handelb. B** | 19 | 67.9 |

| | | |
|---|---|---|
| **Swedbank A** | 1 | 3.6 |
| **Swedish Match** | 19 | 67.9 |
| **Tieto Oyj** | 3 | 10.7 |
| **Volvo B** | 6 | 21.4 |
| | | |
| **Average** | 7.4 | 26.6 |
| | | |
| **Investing in all above stocks** | 21 | 75.0 |

In table 5 we find the results for implementing the strategy investing in all the stocks and for all the values of N simultaneously. I have done this pursuing long- and short strategies separately as well as together.

**Table 5**

| | **Short and long together** | | **Short only** | | **Long only** | |
|---|---|---|---|---|---|---|
| | **1 day** | **10 days** | **1 day** | **10 days** | **1 day** | **10 days** |
| **Mean (%)** | 0.165 | 0.509 | 0.112 | 0.330 | 0.246 | 0.779 |
| **Conf. int. (%)** | 0.14-0.19 | 0.47-0.55 | 0.09-0.14 | 0.27-0.39 | 0.20-0.29 | 0.72-0.84 |
| **Success** | Yes | Yes | Yes | Yes | Yes | Yes |
| **Sharpe ratio** | 0.057 | 0.098 | 0.046 | 0.053 | 0.067 | 0.159 |

In table 6 we present our result for the currency individual currency pairs similarly to ones for stocks in table 6. Here, however, only a total of 14 implementations were made for each pair.

**Table 6**

| Asset | Number of successes | In percentage |
|---|---|---|
| **AUD-PLN** | 3 | 21.4 |
| **CAD-NOK** | 3 | 21.4 |
| **CNY-MAD** | 14 | 100.0 |
| **CZK-LVL** | 0 | 0.0 |
| **DKK-LTL** | 8 | 57.1 |
| **GBP-NZD** | 0 | 0.0 |
| **HKD-JPY** | 0 | 0.0 |
| **HUF-ISK** | 1 | 7.1 |
| **IDR-INR** | 14 | 100.0 |
| **SEK-SAR** | 0 | 0.0 |
| **RUB-ZAR** | 2 | 14.3 |
| | | |
| **Average** | 4.1 | 29.2 |
| | | |
| **All pairs** | 13 | 92.9 |

In table 5 I find the results for implementing the strategy investing in all the currency pairs and for all the values of N simultaneously. I have done this pursuing long- and short strategies together, but, unlike my treatment of the stock market, not separately.

**Table 7**

| | **1 day** | **10 days** |
|---|---|---|
| **Mean (%)** | 0.195 | 0.222 |
| **Conf. int. (%)** | 0.19-0.22 | 0.17-0.28 |

| | | |
|---|---|---|
| **Success** | Yes | Yes |
| **Sharpe ratio** | 0.084 | 0.059 |

In table 8 I present the result for pursuing strategies of 1- and 10 day holding strategies in the OMX-index.

**Table 8**

| **OMX-index** | **1 day** | **10 days** |
|---|---|---|
| **Mean (%)** | 0.0052 | 0.028 |
| **Conf. int. (%)** | -0.06-0.07 | -0.16-0.22 |
| **Sharpe ratio** | -0.001 | 0.006 |

In table 9 I present the results for pursuing the strategies as in table 5 and 7, but now adjusted for estimated transaction costs. All results are for pursuing the strategy holding for 1 day only.

**Table 9**

| | **Mean (%)** | **Conf. int. (%)** | **Success** | **Sharpe ratio** |
|---|---|---|---|---|
| **Stocks** | 0.135 | 0.11-0.16 | Yes | 0.046 |
| **Forex** | 0.165 | 0.14-0.19 | Yes | 0.071 |

Below we see the development of a stock index managed according to the strategy from the beginning of 2000 until the end of 2009, for the stock- and the Forex market respectively. The results have been computed after adjusting for transaction costs.

**Table 10**

| | **Date** | **Wealth** | **Exp. yield per year (%)** | |
|---|---|---|---|---|
| Stocks | 2000-01-01 | 1 | 4.6 | |

| | | | | |
|---|---|---|---|---|
| | 2009-12-31 | 1.57 | | |
| Forex | 2000-01-01 | 1 | 20.2 | |
| | 2009-12-31 | 6.31 | | |
| Omx 30 | 2000-01-01 | 1 | -2.39 | |
| | 2009-12-31 | 0.79 | | |

Below follows two diagrams illustrating the performance of the two indexes graphically.

**Diagram 1**

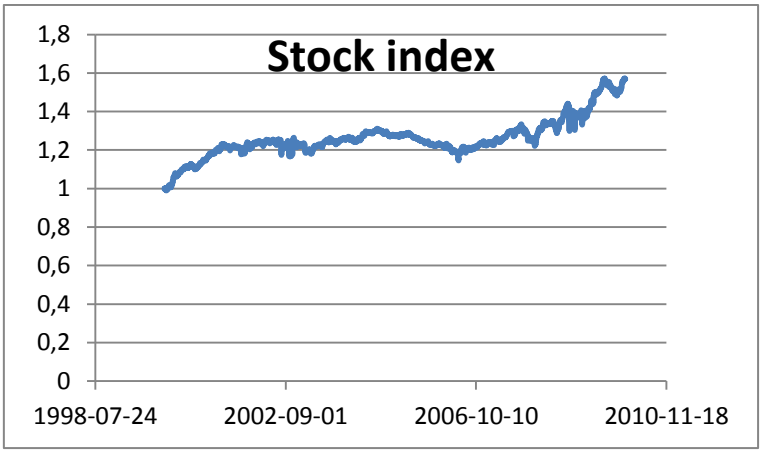
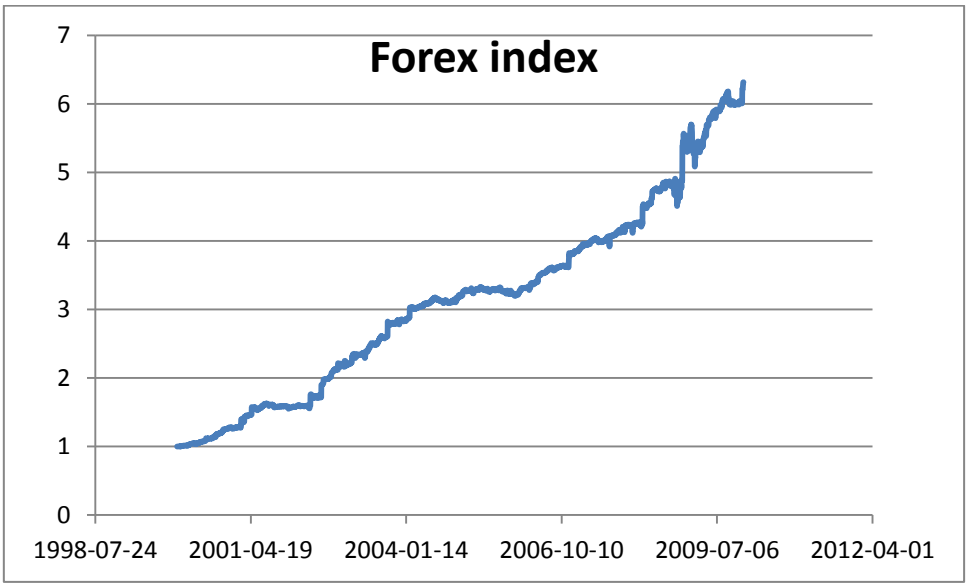



**Diagram 2**



# Analysis

## Comments on the results

DISREGARDING TRANSACTION COSTS

We see (table 4 and 6) that as far as the individual assets are concerned the results are not very encouraging to say the least, with only 26.6% of successes in the stock market and 29.2% in the currency market. However, investing in all stock and currency pairs, respectively, together, still pursuing the strategy separately for different values of N, we see (bottom of tables 4 and 6 respectively) 75% successes in the stocks market and 92.9% in the currency market. Investing again in all individual assets simultaneously, but now also simultaneously for all different values of N we attain (table 5 and 7) success in all cases. Furthermore we see (comparing tables 5 and 7 to table 8) that when spreading the risk, investing in all our assets together, the strategy greatly outperform investing in the OMX-index market portfolio in risk adjusted return measured as measured by the Sharpe ratio.

Furthermore, we see (table 5) that greater risk adjusted revenue would be attained in the stock market holding for 10 days after signals to go long, rather than only holding for 1 day, but that the opposite is true for signals to go short. This confirms the findings of M&W (ibid: p. 11) that the downwards reversal is quicker to pass, something that could be because of traders general belief in the historically positive trend of stocks

As for the Forex market we see (table 7) that it's more profitable to close our position on the day after the signal rather than holding for 10 days. This might be because of the largeness of the currency market, making for greater efficiency and quicker elimination of profit.

TAKING TRANSACTION COSTS INTO ACCOUNT

We see in (table 9) that taking transaction costs into account does not eliminate the profitability of the strategy either market, nor does it eliminate the superiority of the strategy as compared that of investing in a stock index.

THE PERMORMANCE OF AN INDEX

In table 10 we see that the performance of an index managed according the strategy would be expected to be highly profitable, with an expected yearly yield of over 9% for the stock market and over 20& for the Forex market, to be compared with a buy-and-hold strategy in the OMX-30 which would actually result in a net loss.

## Our results and the hypothesis of weakly efficient markets

We thus have results that contradict what ought to be had markets been weakly efficient, that the current price already incorporates all passed information. There were, however, good reasons to assume that weak efficiency would indeed hold; furthermore thy hypothesis also has garnered empirical support, and both these issues have now to be addressed.

### THEORETICAL DEFENCE OF MARKET INEFFICIENCY

As Burton Malkiel (Malkiel, p. 113) notes technical methods must ultimately be self-defeating: “No buy or sell signal can be worthwhile if everyone tries to act on it simultaneously”. In other words, if indeed technical methods would show to be profit generating, surely *enough* investors would act on them to move price enough to eliminate the opportunity, just as profit is eliminated in any perfectly competitive market, and all the more so in the extremely liquid markets of financial securities of today. Park and Irwin (Journal of economic surveys, p. 812, 813) cite research that many well-known market anomalies have disappeared or even reversed once they are documented in academic literature. The question remains, however, how “strong” the reports of possible trade gains have to be in order to induce enough traders in order to eliminate profits. After all, this issue, the profitability and not of technical trading methods, is still very much debated. Differing empirical results are obtained, and thus it would not be inconceivable that reports of a certain strategy being successful could be received with skepticism. Moreover, there is an abundance of different trading strategies, technical or fundamental, around, and the attention span and time of traders might suffice to investigate every possibility reported to be profitable. Therefore, amassing the critical mass of traders to eliminate profit might actually require not one but several reports, perhaps also testing by practitioners, and this might take time.

Another explanation might be that excess profit is in fact compensation for excess risk. In this paper I have measured risk by the Sharpe ratio, a widely used measurement in the context (Park and Irwin, there, p. 813) and we see that the strategy generates a higher ratio than a benchmark buy and hold strategy in a stock index which based on the period in question would actually lead to an expected loss of more than 2%!

EXPLANATION OF DIFFERING IMPERICAL RESULTS

In light of the above analysis it should not be surprising that studies have been made showing the uselessness of technical indicators. In fact, we could well acknowledge the fact the mechanisms assumed by the proponents of the hypothesis of weak market efficiency are at work, just not at every market with full force and instantaneous results. Each study showing this way or that, assuming that they were performed adequately, could therefore only be accepted on the market investigated, and for the relevant period in time, but not on others.

# Conclusions and final remarks

We thus see, aside from the fact that theoretically it's far from inconceivable that market inefficiencies could arise and indeed persist, thus making TA profitable, that this paper lends further support to already existing research that corroborates this. However, to say that the mechanisms assumed by the hypothesis of weakly efficient markets do not exist at all would also be false, for aside from being theatrically convincing, itself a good reason at least not to dismiss it, we do also see research pointing to asset prices following a random walk, or at least, even if there might be some predictability in prices based of movements in the past, that it is often impossible to take advantage of the predictability to make profit. In other words, both theory and empirics point in opposite directions. To this author it seems reasonable that persistent market efficiencies could and do occur, and that room for making profit from technical analysis does arise, but that these phenomena could just as easily disappear or change, necessitating a constant checkup if inefficacies still exist, can be exploited, and if the signals thus far used are still the proper ones.

## IDEAS FOR FUTURE RESEARCH

As noted above, inefficiencies and thus also possibilities for profitable TA, appear and disappear. For the investor it'd crucial to spot a budding disappearance early on and therefore I believe a field of research of interest would be the development of methods that do this.

Furthermore, if we attribute the upcoming and persistence of TA-opportunities to the complex dynamics of the human mind, further research into this is certainly warranted. We've seen how breaches of highs/lows trigger reversals, and previous research points to momentum effects in certain cases. Which other psychological tendencies can be spotted? How do the different tendencies interact when they clash?

The issue of transaction costs is a delicate one. Since these costs differ significantly from market to market and from broker to broker, and since their certainly dependent on the size of the investments, further treatment of the exact influence of transaction costs on TA and

*under which circumstances* we see this influence, and how this influence might vary depending on the circumstances, is warranted.

A point of special interest for me is the subject, mentioned above, of the influence of publishing academic research reporting on TA profitability. How much does this influence depend on where it was published and who the author was? Is it enough to be mentioned once, or does it generally require several recurring reports for influence to be seen? What is the influence of reports corroborating market efficiency?

As we can see, this is indeed a field where much is still left to be done.

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