

TECHNICAL ANALYSIS: WISDOM OR WIZARDRY

Jorge David da Costa Monteiro

Case study submitted as partial requirement for the conferral of

Master of Science in Finance

Supervisor:

Prof. Pedro Leite Inácio, Assistant Professor, ISCTE Business School,
Department of Finance

October 2014

ABSTRACT

The goal of this case study is to analyze the effectiveness of technical analysis in Portugal, and answer to one of the biggest questions that investors have when they decide to invest, which one of the major theories to use. Through this study we try to clarify if Technical Analysis is a good choice.

Using three indicators, RSI – Relative Strength Index, MACD – Moving Average Convergence Divergence, DMI – Directional Movement Index; four of the biggest Portuguese listed companies, EDP – Energias de Portugal, PT – Portugal Telecom, JMT – Jerónimo Martins, and GALP – Galp Energia; the major Index, PSI20 – Portuguese Stock Index 20; and data from 2008 until 2012, the results of those strategies are computed and compared with the results of buy-and-hold strategy.

The results point to the following conclusion: Technical Analysis works in the majority of the cases and transaction costs do not seem to be so important after all.

Keywords: Technical Analysis, RSI, MACD, DMI.

JEL Classification: G11, G14.

RESUMO

Este estudo de caso tem como objetivo analisar a eficácia da análise técnica em Portugal, e responder a uma das maiores questões que os investidores têm quando decidem investir, que é qual das principais teorias utilizar. Através deste estudo, tenta-se esclarecer se a análise técnica é uma boa escolha.

Utilizando três indicadores, nomeadamente RSI – *Relative Strength Index*, MACD – *Moving Average Convergence Divergence*, e DMI – *Directional Movement Index*; quatro das maiores empresas cotadas nacionais, nomeadamente EDP – Energias de Portugal, PT – Portugal Telecom, JMT – Jerónimo Martins, e GALP – Galp Energia; o principal índice nacional, PSI 20 – *Portuguese Stock Index 20*; e dados do período compreendido entre 2008 e 2012, são calculados os resultados destas estratégias e comparados com a estratégia de *Buy-and-Hold*.

Os resultados apontam para a conclusão de que a análise técnica funciona na maioria dos casos, e que os custos de transação parecem não ser tão determinantes como à partida se poderia pensar.

Palavras-chave: Análise Técnica, RSI, MACD, DMI.

Classificação JEL: G11, G14.

Acknowledgements

I would like to thank my supervisor, Professor Pedro Leite Inácio for his guidance and contributions to this study.

I would also like to thank my parents, without their help and their support, nothing of this would have been possible.

Last, but not least, I would like to thank my friends for their encouragement, specially to Elisabete Santos, Jorge Lopes, and Afonso Lebreiro for the countless hours we spent together working on our thesis.

INDEX

ABSTRACT I

RESUMO II

1. INTRODUCTION 1

2. REVIEW OF LITERATURE 3

 2.1. MARKET EFFICIENCY 5

 2.2. TECHNICAL ANALYSIS 8

3. DATA and METHODOLOGY 16

 3.1. DATA 16

 3.2. METHODOLOGY 18

 3.2.1. RSI..... 19

 3.2.2. MACD..... 22

 3.2.3. DMI..... 26

4. RESULTS..... 30

5. FINAL REMARKS 33

6. REFERENCES 36

APPENDIX 37

Index of Tables

Table 1 - Results for RSI.....	30
Table 2 - Results for MACD Signal.....	30
Table 3 - Results for MACD no signal.....	30
Table 4 - Results for MACD divergence.....	31
Table 5 - Results for DMI no filter.....	31
Table 6 - Results for DMI filter 20.....	32
Table 7 - Results for DMI filter 25.....	32
Table 8 - Weighted Average Excess Return per indicator	33
Table 9 - Difference between Total Return and Net Return in percentage	34

Index of Figures

Figure 1 - Elliot Wave	14
Figure 2 - Elliot Wave decomposed in smaller waves	15
Figure 3 - Example of RSI for EDP	21
Figure 4 - Example of MACD for GALP.....	25
Figure 5 - Example of DMI for PSI20.....	26

LIST OF ABBREVIATIONS

ADX – Average Directional Index
ATR – Average True Range
CAPM – Capital Asset Pricing Model
DI – Directional Indicator
DM – Directional Movement
DMI – Directional Movement Index
DX – Directional Index
EDP – Energias de Portugal
EMA – Exponential Moving Average
EMH – Efficient Market Hypothesis
GALP – Galp Energia
JMT – Jerónimo Martins
MACD – Moving Average Convergence Divergence
MMA – Modified Moving Average
OBV – On Balance Volume
PSI20 – Portuguese Stock Index 20
PT – Portugal Telecom
RS – Relative Strength
RSI – Relative Strength Index
TR – True Range
USA – United States of America

1. INTRODUCTION

In a recent past, technical analysis has been disdained, seen as a poor relative of the Finance World, practiced by wizards instead of chartists, just because their ideas were different from fundamentalists, this rivalry has been responsible for a prolonged discussion that has been fruitful for investment practitioners, not only because it could be an alternative to fundamental analysis, but also because technical analysis could act as a complement and catalyst to fundamental analysis, either investors consider themselves technicians or fundamentalists, it is a good idea to follow the good old principle: “the trend is your friend”. Establishing a comparison with an ordinary life, buying a stock is like a marriage, fundamental analysis indicates who to marry with (the stock to buy), and technical analysis indicates when to marry (when to buy the stock) and when to divorce (when to sell the stock). Meanwhile technical analysis has found its way to the spotlight, and nowadays is considered one of the most important tools in the investment decision process, considering the way it was treated in the past and how it is now, it must have some value, otherwise it would not be worth discussing it.

Considering to invest our savings, there is a world of possibilities available to choose from, we can invest in deposits, bonds, derivatives, stocks, etc., and there is one more choice to make, invest for our own sake and risk or delegate that function to investment professionals, the thing is, we should only choose the second option if they can do better than us, otherwise we would be fools by paying them to do worse than we can do ourselves, but before investing, we have to know ourselves, what kind of investors are we? According to Malkiel (1995) we should only invest in risky assets until our sleeping breakpoint, that is if we cannot sleep well at night thinking on the assets we bought, forget those assets, invest in safer assets, but if we do can sleep, and we are rational and not risk averse investors, the rational choice would be stocks, excluding derivatives that are a more complicated subject, we know from several studies that stocks in the long-term beat the returns of bonds and deposits.

Considering stocks the object of this study, there are two principal schools to choose from, the fundamental school of Graham and Dodd, and the technical school of Dow and Hamilton. From one side fundamental analysis that focuses more in the long-term perspective, it is in a way a more subjective approach due to the assumptions that have to be taken based on the future prospects of the company, and from the other side technical analysis that focuses more in the short-term perspective, it is a more objective

approach because it relies on variations of price and volume, notwithstanding the subjectivity of chart patterns, inputs used for indicators and indicators themselves.

The selected one was technical analysis instead of fundamental analysis for diverse reasons, it is a more controversial theme, and people in general are more suspicious about technical analysis than they are about fundamental analysis, so we try to clarify its usefulness. For example we know that fundamental analysis works, we watch Warren Buffet but if we can apply it ourselves it is a different question. In what relates to Technical Analysis one does not have such a great example of performance, neither we have a general belief that it works, one of its majors criticisms is the argument that considering transaction costs technical analysis is not able to beat the market, so it appears to be a more difficult and exciting challenge to prove that technical analysis works.

The next chapter is the review of literature, which resumes what has been written about Technical Analysis, its origins and some studies about it. After that, the theme of market efficiency is introduced, once it is intrinsically linked with the effectiveness of Technical Analysis. The following topic addresses Technical Analysis, its definition, theories behind the charts, assumptions, principles and main goals. Thereafter the data and methodology used in this study are explained, that is, time frame, indicators, sources, benchmark, constraints, investment amount, transaction costs, etc.

Finally, the results of the different strategies are presented, and subsequently compared with the Buy-and-Hold strategy in order to conclude about the effectiveness of Technical Analysis.

2. REVIEW OF LITERATURE

Technical analysis is the study of past prices and volume used to predict how prices will move in the future; it is not an exact science, but it is instead a tool that can guide investors to what is likely to happen in the future. This theory had its beginnings hundreds of years ago, on Japanese rice markets in the 18th century, what today is known as Japanese candlesticks. Charles Henry Dow, the co-founder of *The Wall Street Journal* and *Dow Jones Industrial Average* is generally considered the father of technical analysis through his theory of price movement, he never called it a theory, and it was instead a group of editorials published in the journal. The ones who called it a theory were Hamilton (1922), and Rhea (1932), after this in 1948, Edwards and Magee published *Technical Analysis of Stock Trends*, one of the most important books in the field. Since then there were dozens of contributions to enrich Technical Analysis, just to quote a few, for example Elliot, John Murphy, John Bollinger, Welles Wilder, Gerard Appel, Martin Pring, Thomas Meyers, George Lane, etc.

Leaving technicians behind and focusing more in studies that had as goal to analyze the effectiveness of Technical Analysis, Brown along with Jennings (1989) demonstrated that technical analysis has importance within a model in which prices are not totally enlightening and traders have rational conjectures about the relation connecting prices and signals. Frankel and Froot (1990) showed support for the increasing importance of chartists. Neftci (1991) showed that only some of the rules used in technical analysis produce precise techniques of forecasting, however even precise rules were revealed to be a waste of time in forecast if the economic time series is Gaussian. Nevertheless, if the processes under reflection are non-linear, subsequently the rules may capture some information. Tests showed that this might really be the case for the moving average rule. Taylor and Allen (1992) report the outcome of a study among chief foreign exchange dealers based in London in November 1988 and discovered that at least 90 per cent of them positioned some weight on technical analysis, and that there was a bias to using technical, instead of fundamental, analysis at shorter time horizons.

Brock, Lakonishok and LeBaron (1992) in a complete and prominent study analyze 26 technical trading rules through 90 years of daily stock prices from the Dow Jones Industrial Average ending in 1987 and found that they all beat the market. Blume, Easley and O'Hara (1994) demonstrate that volume gives valuable information that

cannot be seen from the price. Moreover, they prove that traders that use information enclosed in market statistics do well against traders that do not. Neely (1997) reviews and explains technical analysis in the foreign exchange market. Neely, Weller and Dittmar (1997) employ genetic programming to discover technical trading rules in foreign exchange markets. The system generated reasonably considerable out-of-sample excess returns for all of six exchange rates, during the period 1981–1995. Lui and Mole (1998) state the results of a questionnaire survey conducted in February 1995 on the use by foreign exchange dealers in Hong Kong of fundamental and technical analyses. The result was that over 85% of respondents rely on both methods and, once more, technical analysis was more popular at shorter time horizons.

Neely (1998) reconciles the fact that with technical trading rules to trade against US interference in foreign exchange markets can be profitable, yet, long-term, the intrusion tends to be lucrative. LeBaron (1999) shows that, when using technical analysis in the foreign exchange market, after removing periods in which the Federal Reserve is active, exchange rate predictability is radically reduced. Lo, Mamaysky and Wang (2000) analyze the effectiveness of technical analysis on US stocks from 1962 to 1996 and discover that over the 31-year tested period, a numerous number of technical indicators do offer incremental information and may have some useful value. Fernández-Rodríguez, González-Martel and Sosvilla-Rivero (2000) apply a simulated neural network to the Madrid Stock Market and discover that, in the absence of trading costs, the technical trading rule is always better than a buy- and- hold strategy for both ‘bear’ market and ‘stable’ market episodes, but not in a ‘bull’ market. Defeating the market in the absence of costs seems of small importance except one is involved in finding a signal which will afterward be included into a full method.

Neely and Weller (2001) apply genetic programming to be evidence that technical trading rules can be beneficial during US foreign exchange intervention. Cesari and Cremonini (2003) make a broad simulation comparison of popular dynamic strategies of asset allocation and find that technical analysis only performs well in pacific markets. Cheol-Ho Park and Scott H. Irwin wrote ‘The profitability of technical analysis: A review’ Kavajecz and Odders-White (2004) show that support and resistance levels match with peaks in depth on the limit order book and moving average predictions disclose information about the relative position of depth on the book. They also show that these relationships derive from technical rules locating depth already in place on the limit order book.

2.1. MARKET EFFICIENCY

Analyzing the effectiveness of technical analysis involves a much greater discussion about the efficiency of the market itself, in the sense that if the market is completely efficient, then it is impossible to beat the market and therefore to use either technical analysis or fundamental analysis in the investment decision making process. But it is possible to beat the market, the question is if the ones who did it, were blessed by luck or if they really knew what they were doing, there are a few people that apparently were blessed by the touch of *Midas* like Warren Buffet and George Soros, etc. Those investors passed the most crucial test to one's ability of beating the market, which is the test of time, they were able to have positive returns year after year, most of the times beating their benchmark, they are the living proof that markets are not completely efficient.

Financial markets are now much more efficient than in the past, besides the developments in regulation that nowadays for example suspend the negotiation of a stock if it's variation surpasses certain pre-specified limits or if there is any suspicion of transactions based on inside information, the most important contribute to this increase in efficiency was the access to information. In the past, the only way to get information about stock prices was through newspapers, each day readers had access to the previous day prices, and to know the current prices they would have to wait until the next day. Many things changed from that time, there is a completely new reality, in the past there was lack of information, and today it is possible to get information whenever and wherever people want, with the boom of the internet and nowadays with smartphones and tablets, there is excess of information, if one is not careful, he might lose too much time in the investment decision making process or ending up focusing on less relevant factors that influence stock prices, ignoring the most important ones.

In financial theory, market's efficiency is usually classified according to the efficient market hypothesis (EMH) developed by Eugene Fama in 1970s, according to his theory there are three forms of efficiency: weak, semi-strong and strong. In weak-form efficiency today's prices reflect all past information, so if current prices reflect all the information contained in past prices, it will be worthless to use technical analysis to predict and beat the market. This implies that price movements are only affected by present information, so one can still use fundamental analysis to make money, when there are changes in the "fundamentals" of a company. It also can be deducted that if

past prices do not have an impact in future prices, there is no correlation, and if it is so prices must follow a random-walk and one should use a buy-and-hold strategy. In semi-strong form efficiency current prices reflect all publicly available information, only investors with inside information would be able to get excess returns, the problem is that trading based on inside information is a felony, so neither fundamental or technical analysis can be used to get excess returns, unless one is willing to bear the risk of ending up in jail or paying a big fine. In strong form efficiency, prices reflect all public and inside information, with that being said no one is able to beat the market, and furthermore this form suggests that inside trading laws are ignored, otherwise prices would not reflect private information and this form would be a utopia.

One must have in mind that financial theories are subjective, in the sense that there are no absolute truths in finance, instead there are ideas that try to explain how the market works, and that can contribute to a better understanding of market behavior even though these ideas are just an approximation to the reality (e.g. CAPM model is an approximation to equity returns). In reality there are counter arguments to EMH validity, as referred previously there are investors who have consistently beaten the market basing their investment decisions in undervalued stocks; there are portfolio managers with better performance than others, and research houses with more renowned analysis than others. In response, EMH supporters argue that even if some investors are constantly observed beating the market, EMH is not refuted because with millions of investors worldwide, a normal distribution predicts the existence of a few great performers. This theory, in its strongest forms suggests that all the costs incurred in the investment decision making process are worthless like research costs, advisory costs, information costs, so all the professions related with this process would be a big scam to steel investors' money, this idea it also applies to the fund industry, because if their goal is to beat the market (a benchmark), according to EMH strongest forms that would be an impossible mission.

In addition to these, there are other counter arguments, like the January and the weekend effects, these consistent patterns go against the random walk supported by the EMH, there are also studies in the field of behavioral finance, which is related with the psychology of investors, claiming that investors are influenced by many biases, like loss-aversion, overconfidence, and information biases. Furthermore there are market anomalies like crashes and bubbles that EMH cannot explain and put the theory under serious scrutiny and suspicion. But in fact EMH does not reject the occurrence of

market anomalies that can lead to superior profits, as one may think, instead it states that prices can be over or undervalued in random occurrences, and then return to fair value, the question is how to arrive to fair value, if investors value stocks differently it is impossible to determine the fair value under an efficient market.

As it was referred before, financial markets are increasingly efficient; the fact is that it is the quest to take advantage of market inefficiencies that makes the market more and more efficient, to be efficient a market has to be large, liquid, accessible, with low transaction costs and information must be available to all at the same time, at reasonable costs, without that quest for superior returns the market would be less volatile and a lot more boring.

2.2. TECHNICAL ANALYSIS

Technical analysis can be defined as the study of securities and the market, from the perspective of supply and demand, revealed by series of prices and volumes, that in its purest form ignores stocks' intrinsic value and the state of the economy, what really matters is the dynamic and development of supply and demand and the relationships that can be established between each other, in order to predict future price fluctuations and take the most profit out of it.

With technical analysis, one observes stocks and the market, not the economy and companies, but technical analysis does not reject the value of fundamental analysis, instead it discovers it indirectly, leaving it in the background. Ultimately, prices are formed by the information that reaches the market, which includes all the data available, states of mind, expectations and investors' perceptions. So if a technical analyst shuts himself in a basement, with no TV, no internet, and only has access to a company's price chart, even without knowing that the company exceeded result expectations, the analyst will discover this fact indirectly through price and volume increase, on the other hand each individual investor valuation of the future intrinsic value of a company is too subjective to be of any use, but the consensus of those valuations that are reflected in the price, that is crucial, and consequently, worth to use.

In fundamental analysis the goal is to "buy cheap and sell dear", in Technical Analysis not so much, even if a security is clearly undervalued, it could be in a downtrend, so it would not be the right time to go long, furthermore even if one bought the stock, it is not possible to know how much time the market will take to reach the intrinsic value or if this will happen at all, so a technical analyst will wait for a market reaction, and look to enter as soon as possible, with the trend already in place and ride it until it stands, so the goal is more "buy high sell higher" for long positions. For a technical analyst it does not matter if the company is over or undervalued, there is no cheap or expensive, it is all about going up or down.

Technical Analysis assumes that in the presence of similar circumstances, investors tend to repeat the same behaviors of the past (market action is repetitive); that investors do not act based solely on rationality, but are also influenced by emotions (everything is discounted and reflected in market prices); and that reactions are progressive (prices move in trends and trends persist), that is the information can be received gradually, the interpretation cannot be instantaneous nor unanimous, decisions

are steadily taken and when hesitations are surpassed, information can reach the market very rapidly but without accuracy and unanimity, certain facts take some time to be fully reflected in the market, so as the behavior is repetitive and reactions are gradual, when an up movement starts, it will tend to remain, in return the length of the trend increases the possibilities of reversal.

Technicians know that there are not perfect systems to detect entry or exit signals, for this reason there is always a search for confirmation, using a group of indicators instead of only one, of course it is impossible to use all the indicators available, first because there are too many and by the time the technician ended up seeing them all, the opportunity had already passed, and second because it is difficult to have all the indicators pointing in the same direction. Technical methods are not sensible in many circumstances, so eventually technicians will not take decisions by lack or ambiguity of signals, preferring to wait for the next opportunity in which there is a confirmation, unless the case when supply and demand movement reveals itself as an open book. Furthermore technicians also have the complete perception that it is impossible to be always right and that sometimes there are false signs or misinterpretations that will force them to close or revert their positions, however if an investor gets it right in 60% of the times it is already a strong advantage, if beyond that he knows how to win big in 25% of the times, and loose little in the other 40% of the times, it will be easy to make money on the markets, it is just a matter of “cut the losses, let the profits run”.

“The beauty of Technical Analysis is that it can be applied effectively to virtually any trading medium and investment time horizon” (Meyers, 2002). Everything depends on one’s approach to the market, because everyone is different and has specific characteristics that influence the way one’s invest, such as levels of stress, temperaments, capital, and time availability. Of course one should only use technical analysis if it fits to one’s personality and investment philosophy, the same is valid for fundamental analysis, if one’s capital, time and nerves are limited, maybe short-term opportunities are not a good idea and one should focus in long-term opportunities, bearing this in mind and recognizing one’s strengths and weaknesses, users of technical analysis can find the trading medium and time horizon that better suits them.

Unlike what one may think, the opposite of technical analysis is not fundamental analysis, but rather the random walk theory, which states that it is impossible to predict future price fluctuation using past information, according to this, stock’s price variations

are randomly distributed, this means that the difference between the last transaction's price and the next transaction's price is independent of the past historical return. To get this idea right, consider a drunk on his way home, due to his condition, the direction and length of each step are random and independent from previous steps, so he runs an erratic trajectory, of course that each step starts when the previous one is finished, and consequently his current position depends of the previous steps given, but the next step is unpredictable.

For the random walk to hold there are two conditions, one is that investors are rational and form unbiased expectations based on all available information, if investors are too optimistic or pessimistic, information will be misjudged and prices will not follow a random walk, the other is that price changes are only caused by new information, so if investors can trade, and consequently cause changes in prices without new information, prices will not follow a random walk. In reality, investors are not always rational, price changes themselves can provide information to the market, and as some studies confirm there is evidence of serial correlation between prices and existence of price patterns, so one can predict future prices based on past information and prices do not follow a random walk.

Technical analysis followers argue that prices are influenced by fundamental factors, that are constantly changing, which is reflected in supply and demand, but the important is that what drives price fluctuation, are not the fundamental factors but instead the average of the opinions of all market participants, known as the herd. Initially, fundamental factors are the first responsible for price variation, but for this variation to occur, it is necessary the action of the herd. Only after market participants become aware of fundamental factors, and do their valuation, buy and sell orders reach the market and finally the price will oscillate, thereby, technicians argue that while fundamental analysis studies the fundamentals to know how the herd will interpret them in the future, technical analysis advances a little and studies the way the herd interprets the fundamentals, therefore, is an analysis that studies the behavior of the herd. Technicians believe that if one is studying herd's behavior he will be studying and considering, even indirectly, all the fundamental factors considered by fundamental analysts, and also the psychological factors which are very important, but for which there is no publication or statistic, even though they directly influence herd's behavior.

As referred previously, the founder of technical school was Charles Dow, the Theory of Dow, formulated by William Hamilton started up grounded in investment

behavior and in the process of information dissemination to the market. Dow's theory considers the market from an external point of view, it states that prior to every movement, whether up or down, identifiable formations appear that signal those same movements. It is like weather forecasting, before a hurricane or storm, meteorological coincidences arise related to barometric pressure, temperature, humidity, winds, that allow forecasting the evolution of weather conditions, so meteorologists use past information to anticipate what is likely to happen in the future, just like technicians, none of them is always 100% right, but people in general still believe, or consult the weather forecasts, why not doing the same to technician's forecasts?

According to Dow's theory, the market presents movements of three different ranges: long-term, comprising periods of one year or more; medium-term, lasting from three weeks to a few months; and short-term, lasting from six days to three weeks, these movement are referred to as primary trend, secondary trend and tertiary trend. The primary trend is easy to spot, its direction can be drawn by a straight line that best fits the recorded prices; ex post, secondary trends are also easy to spot, being smaller corrective moments in the opposite direction to the earlier. The problem is, when one is starting the trace of a secondary trend, whether the change of direction is simply a correction of the primary trend or if it is the beginning of a new primary trend in the opposite direction to the earlier. To settle this question, Dow's theory defines that the limit to price variation of a secondary trend relative to the turning point is 66% of the primary trend, and the minimum is 33% of the primary trend, otherwise it would be a tertiary trend.

Dow states that each upward movement consists in 4 stages:

- 1) In first stage, known as accumulation stage, a little group of investors, considered "insiders" with exclusive knowledge of certain relevant good information, position themselves in a discreet manner. In this stage, the quotes are initially barely affected, gradually presenting larger variations, volumes also increase gradually along this stage, in the extent that the "insiders" take positions with more greed;
- 2) In second stage, known as big move stage, other investors attentive to the market also start to participate in "insider's" movement, and initially prices suffer various changes, as well as volume, this stage culminates with a sharp rise in prices and volume;

- 3) In third stage, known as excess stage, a much larger number of investors starts to participate in the process and prices begin to skyrocket, along with a rapid expansion of volume. As time goes by, the trend begins to lose strength due to profit taking;
- 4) In fourth stage, known as distribution stage, those who positioned at the beginning of the movement by buying large quantities of shares, start to operate intensively in the opposite direction, selling with good profits the previously acquired positions. Late buyers, who positioned in excess stage, keep waiting for best prices to try to achieve a reasonable profit. As time passes by and prices walk sideways, or even present some decline, two things can happen: if the “insider’s” group has new information to justify a continuity of the uptrend, one enters into a new accumulation stage, but at higher prices. If no new information emerges, the market keeps walking sideways waiting for a definition, if adverse information emerges, the process enters a new phase, this time in the opposite direction, i.e., a downtrend.

Corresponding to the opposite of the excess stage in an uptrend, the panic stage happens, configured by a fast drop in prices with substantial increase in trading volume. Desperate investors sell their positions at any price, still looking to keep some profits or minimize losses. This increase in supply will not find buyers until that, given the low prices achieved, investors acting rationally begin building or rebuilding their positions, due to new perspectives of trend reversal. This movement ends with a gradual reduction of the downtrend caused by the progressive demand increase.

Usually, the downtrend is always steeper than the uptrend. Regarding volume, the excess stage is always accompanied by an increase in volume, while in panic stage that may not be the case. The identification of an uptrend occurs in big move stage and requires confirmation of rising prices together with increasing volume. Thus, the conscious technical analyst should only take a position upon confirmation of the trend, and should not try to guess such confirmation. The same takes place in a downtrend before the panic stage and confirmation, despite being independent of increasing volume, depends on the extent of the drop from the last high occurred. If the amplitude exceeds 66% of the fall from the last previous high, the downtrend and reversal of the primary trend are confirmed.

The level reached at the end of an uptrend, when its strength runs out and prices stabilize is known as resistance. This resistance does not manifest itself all at once, but

rather progressively by a growing willingness to sell from those satisfied with obtained profits, until the equilibrium of supply and demand, occurring then, the level of resistance. In the downtrend, after the signaling the panic stage occurs, when a great mass of sellers tries to get rid of their positions and, finding no buyers, will offer at lower prices. This process approaches its end when sellers conform themselves with their losses and other investors increase their purchase offers, thinking that the stock is too cheap. Thereby, the downtrend decreases and finally reaches the equilibrium between supply and demand, hitting then, a support level.

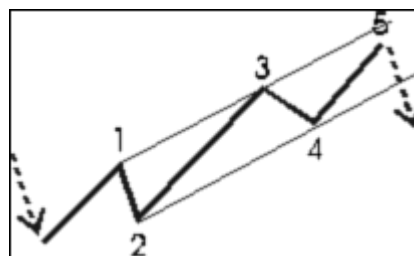
Subsequently to Dow's theory, foundation of all the technical school, arises the wave's theory, which complements Dow's theory and makes more accurate the predictions of both prices and trends, developed by R. N. Elliot and published in 1938 in the work "The Wave Principle". Such a theory, whose goal is to identify more precisely the graphical formations resulting from the application of technical analysis, stems from the observation of the principles and laws extracted from a numerical series – a series of Leonardo Fibonacci, an Italian mathematician from the city of Pisa, in the 13th century. What is important is that the wave's theory attempts to explain the fluctuation of stock prices through Fibonacci's series properties. The Fibonacci series, in turn, is the numerical series, obtained from the result of the sum of two numbers that precede it, in ascending order. Fibonacci series is then: 1, 2, 3, 5, 8, 13, 21, 34, 55..., this series got surprising properties, e.g.: the ratio between two consecutive numbers tends to stabilize in 0.618; the ratio of two consecutive numbers in descending order is 1.618; the ratio of two alternated numbers is 2.618.

The ratio 0.618 found in Fibonacci series is present in most architectural works of antiquity, e.g., in the architecture of Egypt's pyramids, the sculptures of Phidias, and in other monuments of equal importance. Geometers and architects say that this relationship between two segments establishes the most proportional relation to human eyes, so much, that is known as "golden ratio". Fibonacci series is also present in the human body itself, and perhaps even in the dimensions of the Universe. In Giza's Pyramid, of the pre-hieroglyphical phase, the ratio of height to base is 0.618. As it follows, that series discovered by Fibonacci has really surprising properties, even mysterious.

Elliot seized the properties of this series in order to explain the fluctuation of stocks. According to Elliot, stock prices go up or down, reflecting the state of confidence among investors. Defined a primary trend, the price fluctuates upward and

downward along this trend, without each movement annulling the previous one, until the trend runs out. One might say that, by buying a stock at the beginning of an uptrend, until it reaches its end, there will be no fluctuation to annul gains from that purchase. Therefore, if this happens, one shall not have bought in a fluctuation of a primary uptrend, but rather in a fluctuation of a primary downtrend. This principle introduces the concept of “entire wave”, either up or down. The “entire wave” consists of five waves, three impulsive waves in the direction of the trend and two corrective waves, in the opposite direction.

Figure 1 - Elliot Wave

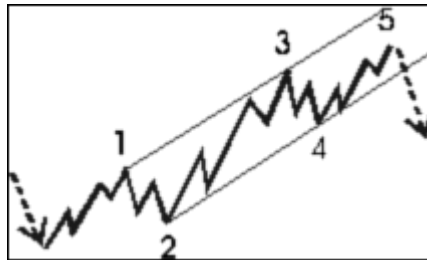


Source: Investopedia

The graph, shows a rising 5-wave sequence with 3 impulsive waves and 2 corrective waves. The first impulsive wave, when the price evolves from P_0 to P_1 , is the steepest, due to the expectation that the stock would rise a lot. The first corrective wave makes the price drop to P_2 , within the limit of $2/3$ of the first high, then, the price goes up again, now with less power, as indicated by the slope of the line P_2 - P_3 , again, the price drops, until P_4 , due to profit taking by some investors, of course that P_4 has to be greater than P_2 , otherwise the trend would have been modified. The third and final impulsive wave takes the price to P_5 , could assume any inclination, and not infrequently occur developments and extensions. Some people interpret the “full wave” as having 7 waves and not 5, however the two waves more than those preconized by Elliot are extensions of the fifth movement. Anyway, the fifth movement leads the share price to reach the resistance line, adjusting it completely to the fundamental factors that are affecting investors’ decisions. From that fifth movement, anything can happen, if a new up wave occurs, this phase will be a new accumulation phase, when a new favorable fundamental factor should occur, or else, when investors once again interpret favorably the previous fundamental factors. In the opposite case, in which a down wave would be next, reverting the previous primary uptrend, certainly a new unfavorable fundamental factor will act on investor causing the subsequent fall. While nothing occurs, prices will be flat, and it is said that the market is walking sideways or undefined.

In general, it can be observed that each “full wave” in the main direction unfolds into five smaller waves, and those of the primary trend correction unfold in 3 smaller waves. And more, within one of the 3 impulsive waves (first, third and fifth movements) of the primary trend, usually occur 3 smaller waves in the main direction and 2 corrective (opposite direction).

Figure 2 - Elliot Wave decomposed in smaller waves



Source: Investopedia

As one can see, in the unfolding of this “full wave” in 5 smaller waves, 3 in trend direction and 2 corrective ones, each of the 3 impulsive waves unfolds itself in 3 smaller impulsive waves and 2 smaller corrective waves, and each two corrective waves, unfolds in 2 smaller waves in correction direction and 1 in reverse. Here it is represented the Fibonacci series: $5 = (3+2)$; $3 = (2+1)$, this harmonic behavior, due to unpredictability of human behavior, may not occur exactly in this way, but this is a general rule and those are exceptions. Interpretation of a price chart requires focus to discover the unfolding of the “full wave”, without which, can be committed projection errors. The strength of the primary trend will be greater the smaller the angle of corrective waves (the second and fourth movements).

3. DATA and METHODOLOGY

3.1. DATA

In the process of picking the data necessary to achieve our goals, a lot of issues were considered, first of all this decision was influenced by the methodology in the sense that depending on the technical indicators that were chosen, there are certain specifications of the type of data that are mandatory, for example some of the indicators just need the daily closing price, other also need the highest and the lowest daily price for their computations. Another thing that was considered very important is one of the major criticisms to Technical Analysis, the idea that in the present with more and more people using technical analysis, its effectiveness is decreasing; this idea is easy to understand bringing up the concept of marginal utility, if everyone was using technical analysis, only the first ones to act would benefit from it, in the sense that when the average person starts to buy or to sell according to indicators, big investors had already taken advantage of that and are already making huge amounts of money, leaving the remaining investors with the end of trend movements.

Considering what was referred above the chosen period to this study starts in January of 2008 and ends in December of 2012, catching the Bear Market of 2008, originated by the subprime mortgage crisis that led to the bankruptcy of Lehman Brothers with nasty repercussions over boundaries, and the recovery that succeeded it, it is important that the chosen period includes a recession and its respective recovery to see if Technical Analysis is effective in bad and good times. After the period chosen, the next step is to choose which financial assets to use; the choice were stocks and an Index, it could have been commodities, forex, etc., but to the extent of this study those seemed to be the most appropriate ones. This choice is based on one of our goals, that is to test the effectiveness of technical analysis in Portugal, for this the chosen index was PSI20 and the chosen stocks were EDP - Energias de Portugal, PT - Portugal Telecom, JMT - Jerónimo Martins, and Galp – Galp Energia, the choice of the Index can seem logical because unlike USA, Portugal and most of the countries have only one major index, the choice of the stocks was not that easy, the touchstone ended up to be market capitalization, these were at the time of the choice four of the biggest companies of PSI20, excluding financials. This allowed us to have a considerable slice of PSI20 using only 4 stocks, and so we can evaluate Technical Analysis at an aggregate and individual level.

The frequency of the data is daily because it is the most commonly used in several studies related to this matter, it would not make sense to use weekly, monthly and yearly data because we would miss a lot of buy and sell signals through the chosen indicators, and in the reverse situation if we choose hourly data, we probably would have too many signals, and one of two things could happen, this could require a constant follow up of the market, that is not the scope of this study, the goal is to analyze if the average person can use technical analysis, or transaction costs would probably make the strategy unprofitable unless huge amounts of money were invested. The data was obtained through Bloomberg.

3.2. METHODOLOGY

The methodology to use was one more fact that contributed to the choice of technical analysis as the subject of this study, in the process of choosing which one of the theories to study, there were some issues with choosing fundamental analysis. The hypothesis founded to be more applicable would be to perform a valuation exercise of the companies referred before with information of 2007, computing a price-target to the end of 2012 and then compare with the market price in the end of 2012, but that would be a little bit strange because the growth rates that would be necessary to assume using a Discounted Cash flow model would already have been known, so even trying to ignore them we would be influenced unconsciously either to use approximated values, or different ones that could not be the best ones just to shy away from the real ones. Another alternative was to use analysts' recommendations computing an average price-target and then compare it with the market price; the problem with this hypothesis is the availability of those reports, because the current reports are pretty easy to have access, but the previous ones are not that easy, furthermore using those price-targets, there would always be a disbelief in the back of the mind, because financial intermediaries profit from commissions, so maybe equity researchers are a little bit influenced by this when projecting and valuing a company to achieve a price-target, so to avoid these problems, the choice felt over technical analysis.

But even this choice had its own issues, the hypothesis considered to analyze the effectiveness of technical analysis were using charts through patterns recognitions, or using technical indicators. The first alternative was a little bit dubious, because what can be an obvious pattern for one person could not be for another, which would generate a lot of subjectivity that would undermine any conclusion of this study. Buy and sell signals could be contradicted in the blink of an eye, and beyond that there is the possibility of failure, that is the incapability of reading the chart, getting wrong signals or missing them, one statement that chartists use to say when they lose is "there was not a problem with the charts, I was the one who was not able to read it properly, I did not believe in what the chart was telling me, so that is why I lost". Considering all the above, all ended up with technical indicators, that appeared to be the most effective and trusty way to analyze the effectiveness of technical analysis, what was necessary then was to define which indicators should be used to achieve the defined goals.

There is a wide range of indicators that could be chosen for this study, which go from simple to more difficult ones, just to quote a few, there are simple moving averages, leading indicators like RSI, volume indicators like OBV, lagging indicators like MACD, a countless number of indicators, variations and combinations that hamper the task of choosing the indicators that are going to be used. The criteria for this choice was indicators' complexity, that is neither the choice felt in too simple indicators, neither it felt in too complex indicators, the goal was to use understandable indicators to the average person, so everyone can read this study and understand what was done. In the end the choice resided over three indicators, which are going to be explained below, the MACD – Moving Average Convergence Divergence, the RSI – Relative Strength Index and the DMI – Directional Movement Index.

It is important to refer, that short-selling will be considered, and so when there is an indication to sell, the long position is closed, and a short position is opened. The amount of the investment will be 100.000 €, and it is necessary to consider transaction cost (5€ per transaction). Furthermore, the return of the strategies involving those indicators referred before will be compared with the return of buy-and-hold strategy, and the transactions will use the daily closing price.

3.2.1. RSI

Recently, technical analysts seem to be shifting their attention from the usual bar charts to interpreting relative strength charts. This method came up with a work of Robert Levy, in 1966, entitled “An evolution of selected applications of stock market timing techniques, trading tactics and trend analysis”. The technique used by him is based on the belief that the stocks that have presented superior performance in the market attract more attention from investors and, therefore, are more likely to continue presenting in the future, better rates of return.

Relative Strength Index (RSI) is an indicator that belongs to the class of price momentum indicators; it was introduced by Wilder (1998) in his book *New Concepts in Technical Trading Systems* and it is now commonly used by technicians, it is a leading indicator in the sense that it was built to give information about the future price movement. The reason for this anticipation, provided by RSI, is the so called relative strength, which derives from the concept of momentum and seeks to measure the acceleration of the trend. To the extent that RSI detects an acceleration of the trend, it can give an indication of reversal of the previous trend, which anticipates the signals of

the chart. RSI was intentionally designed to meet three failures often associated with oscillators. Firstly, sometimes oscillators move erratically due to the drop of old data for its calculation. For example, if someone has an oscillator of 14 days and 14 days ago, the stock price moved up or down frenetically, the current oscillator reading shall be too high or too low, misleading the interpretation. The second issue concerns the vertical scale of an oscillator, how high or low should be the oscillator signal for buying or selling opportunities. The third issue is the need to keep a large amount of data for computing the oscillator. RSI solves these three problems. RSI is a rate of change indicator that measures the velocity at which prices are changing; its formula is given by:

$$RSI = 100 - \frac{100}{1 + RS} \quad (1)$$

Where:

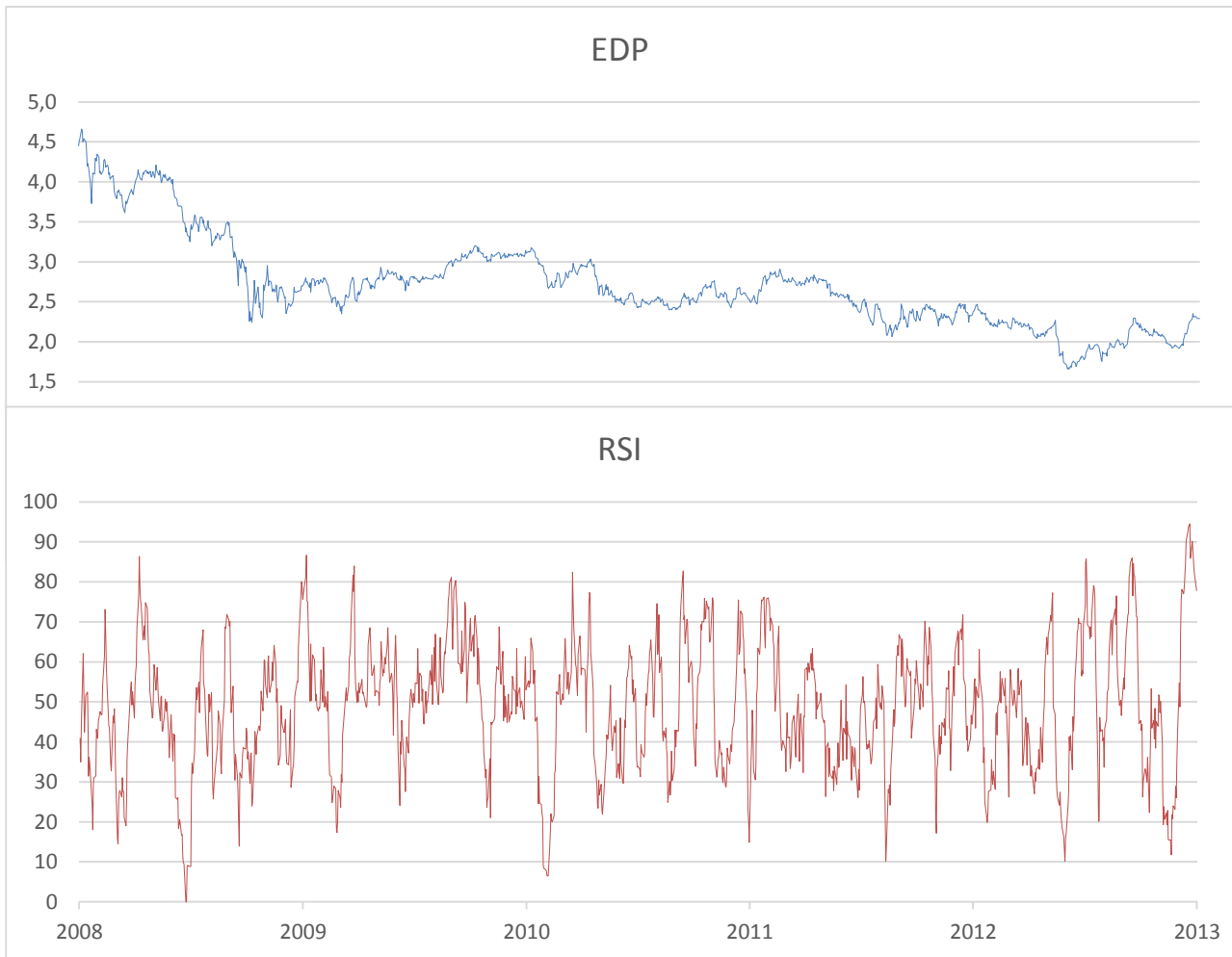
$$RS = \frac{\text{Average of } N \text{ period's up closes}}{\text{Average of } N \text{ period's down closes}}$$

N = number of periods used in the calculation

Using 14 days as example, to get the average of up closes, sum the total points earned in positive days during the past 14 days and divide by 14, the average of down closes is obtained by summing the total points lost in negative days during the past 14 days and divide by 14. Divide the average up by the average down to compute RS and then, insert RS in the formula to compute the RSI value for the first day. To update RSI on a daily basis, multiply the previous positive average by 13, add this result to the positive variation of the day (if zero or negative, sum zero) and divide the result by 14, proceed in the reverse way to find the new average negative, and recalculate RSI with the previous formula. The N period used was 14, because it is the standard for this indicator and, in simple terms if we have a RSI above 70, the stock is overbought, so it should be sold, and when RSI is below 30, the stock is oversold, and it should be bought, of course there are other ways to use this indicator but this seemed the most appropriate one. Wilder suggests the use of 14 days of data to compute RSI, nevertheless, other technical analysts found other time periods also work successfully. Generally, the larger the number of periods used, the RSI is more stable and fewer

signals are generated, shorter RSIs tend to generate more signs than longer RSIs, sometimes false signals. The graphic monitoring of RSI allows checking the points where the index breaks values, indicating that the market is overvalued and therefore a fall is imminent or vice versa.

Figure 3 - Example of RSI for EDP



Source: author

RSI can be interpreted from various perspectives: extreme readings, chart patterns, failure swings, support, resistance and divergence. Extreme RSI values signal the probability of major tops or bottoms, although the exact levels to use are subject to discussion, Wilder recommends using levels of 70 and 30. If RSI rises above 70, a major top in market prices is likely, if RSI goes below 30, a major bottom in market prices is likely. The chart patterns also apply to RSI as they do for usual price charts, many times, chart patterns are also observable in RSI, and once the same rules of breakout apply to RSI as to standard price charts, buy and sell points are frequently

indicated. Failure swings can also be used to interpret RSI, the top swing failure occurs when the index goes above 70, decreases to a lower level (fail point), goes up again but fails to reach the level 70, and then drops below the previous lower level (fail point), one should sell at that point. A bottom failure swing is the opposite of top failure swing. Often, support and resistance lines will appear on RSI before appearing in the bar price chart. The break of support and resistance is interpreted in a similar way to price charts. At last, divergence between prices in a bar chart and RSI strongly suggests that prices will reverse, if prices are going up and RSI is going down, look for a descending curve in prices, if, on the other hand, prices are decreasing or flat and RSI is rising, one expects the reverse and move higher.

3.2.2. MACD

Moving Average Convergence-Divergence (MACD) is one technical indicator that uses multiple moving averages and is also a price momentum indicator introduced by Gerard Appel in the late 70's. As MACD is composed by moving averages, before focusing on this indicator, one will introduce and develop the important concept of moving averages. Trend lines built from moving averages are perhaps the strongest indicators of trend analysis of the market, the most known is the 200 days moving average, its creation was based on the premise of being much safer for investors to be guided by the behavior of the average price of a stock when compared with its daily price, than simply follow the evolution of the daily price alone. Observing levels of daily price fluctuations relative to the average built with previous daily prices, when properly applied, is very useful. The 200 days moving average line is a sequence of points posted daily in a particular stock chart, or index chart, the first point of this line represents the arithmetic mean of the closing prices of the stock, during 200 consecutive trading days. The following points are computed in the same way, with one difference, the closing price of the first day of the series is removed from the sum, the price of the 201st day is added, and so on. The reason to choose the 200 days moving average is that this line seems to be softer than the others of fewer days, by the dilutive effect of sharp fluctuations in daily prices. The daily price fluctuates around the 200 day line, to stand sometimes below and sometimes above it. One can start the line at any chosen point and the price adjustment for stock rights (bonus, dividend, and subscription) can be computed using the usual known formulas, or in alternative, only pointing up the gap in the chart.

The basic rules to use moving average lines are the following:

A buy signal occurs when:

1. the moving average line stabilizes after a period of declining or the stock price penetrates the line from below when the line is rising;
2. the stock price falls below the line, when the line is still rising;
3. the stock price that it is above the line had been declining and turns upwards;
4. the stock price crosses very rapidly the line from above to below, it is natural to expect a return upwards.

A sell signal occurs when:

1. the line stabilizes after a rising period or the stock price penetrates the line from above when the line is descending;
2. the stock price rises above the line while the line is still declining;
3. the stock price comes from below to above the line, not reaching it, and returns declining;
4. the stock price moves too fast from below to above the line, and the line is rising, one should expect a downward shift of the stock price.

There are three types of moving averages, the simple moving average (referred above), the weighted moving average and the exponential moving average. The simple moving average is the most commonly used because it is the easiest to compute, and it is fairly effective, it is equivalent to the moving arithmetic mean. A major criticism to the simple moving average is that it equally weights each period's price instead of weighting recent periods more than older periods, both weighted and exponential moving averages solve that question.

The weighted moving average assigns to each period's price a weight based on its age. The first period's price is given a weight of 1, the second period is given a weight of 2, the third period is given a weight of 3, and so on, the weight increases by 1 until the final current period is assigned a weight. Each period's price is multiplied by the correspondent weight, the products of this computation are summed and divided by the total of the weights (i.e. $1+2+3=6$). One criticism to the simple moving average and the weighted moving average is that both include data only for the number of periods the moving average covers. Many technicians argue that previous data is an important reflection of prices and should be included in a moving average computation, so those technicians often use an exponential moving average to solve that task.

The exponential moving average assigns more weight to recent periods and decreasing weight to older periods, but unlike simple and weighted moving averages, the older period's prices never go away of the computation of exponential moving averages. Before computing the exponential moving average on a daily basis, one must have a beginning moving average value, which will be a simple moving average. Each day one subtracts the previous day's exponential moving average from the current day's closing price. That difference is then multiplied by the exponential moving average exponent, the product of this computations is added to the previous day's exponential moving average, and the result is the current day's exponential moving average. The exponential moving average exponent at any given time is computed dividing 2 by the number of periods in the exponential moving average plus one, for example for 200 periods, the exponent is equal to 2 divided by 201, that is approximately 0.01.

Moving averages of different periods are frequently combined to determine the trend, the goal of using more than one moving average is to reduce whipsaw trades. When one uses two moving averages, a buy signal occurs when the shorter term moving average crosses above the longer term moving average, a sell signal occurs in the opposite situation. The shorter term moving average is much more sensitive to trend changes than the longer term moving average. One can also combine three moving averages in a triple crossover system, in which a buy signal occurs when the two shorter term moving averages cross above the longer term moving average (the shortest moving average acts as a warning and the other acts as a confirmation). A sell signal is generated when the shorter term moving averages cross below the longer term moving average.

MACD is a trend-following indicator because it uses three exponential moving averages in its computation, and it is computed based on the difference between two of them (usually a 26- period and a 12-period exponential moving average), and the third one is used as signal line (usually a 9-period exponential moving average); its formula is given by:

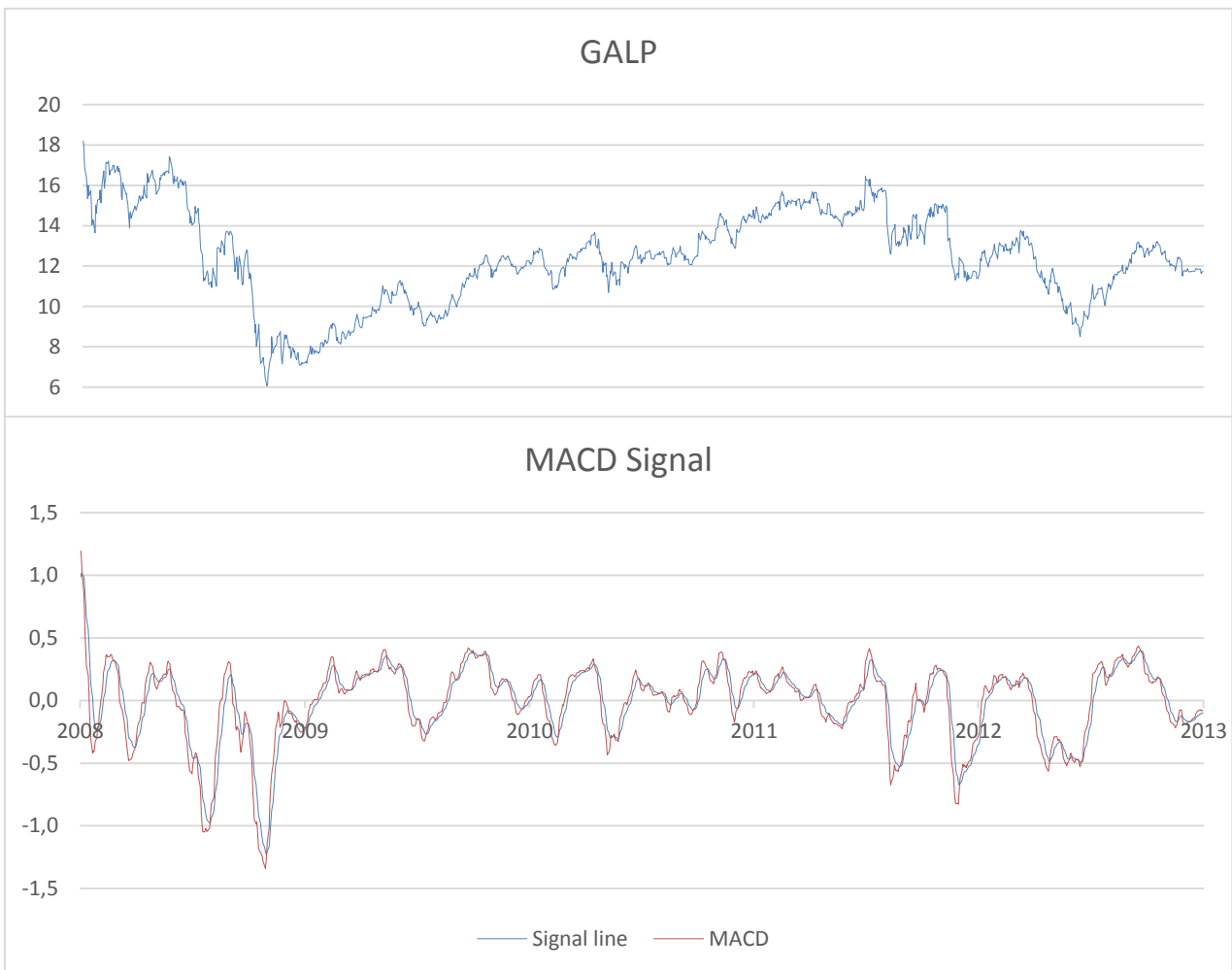
$$MACD\ Line = (12day\ EMA - 26day\ EMA) \quad (2)$$

$$Signal\ Line = 9day\ EMA(MACD\ Line) \quad (3)$$

$$MACD\ Histogram = MACD\ Line - Signal\ Line \quad (4)$$

Even though, 26 and 12 days exponential moving averages are typically used for MACD computation and an exponential moving average of 9 days is usually used to calculate the signal line, other exponential moving averages could be used. There is not a defined number of exponential moving average periods that work best across all markets and investment time horizons. Just by experimenting with a particular stock or market, one can achieve the optimal combination of exponential moving averages periods, to compute MACD.

Figure 4 - Example of MACD for GALP



Source: author

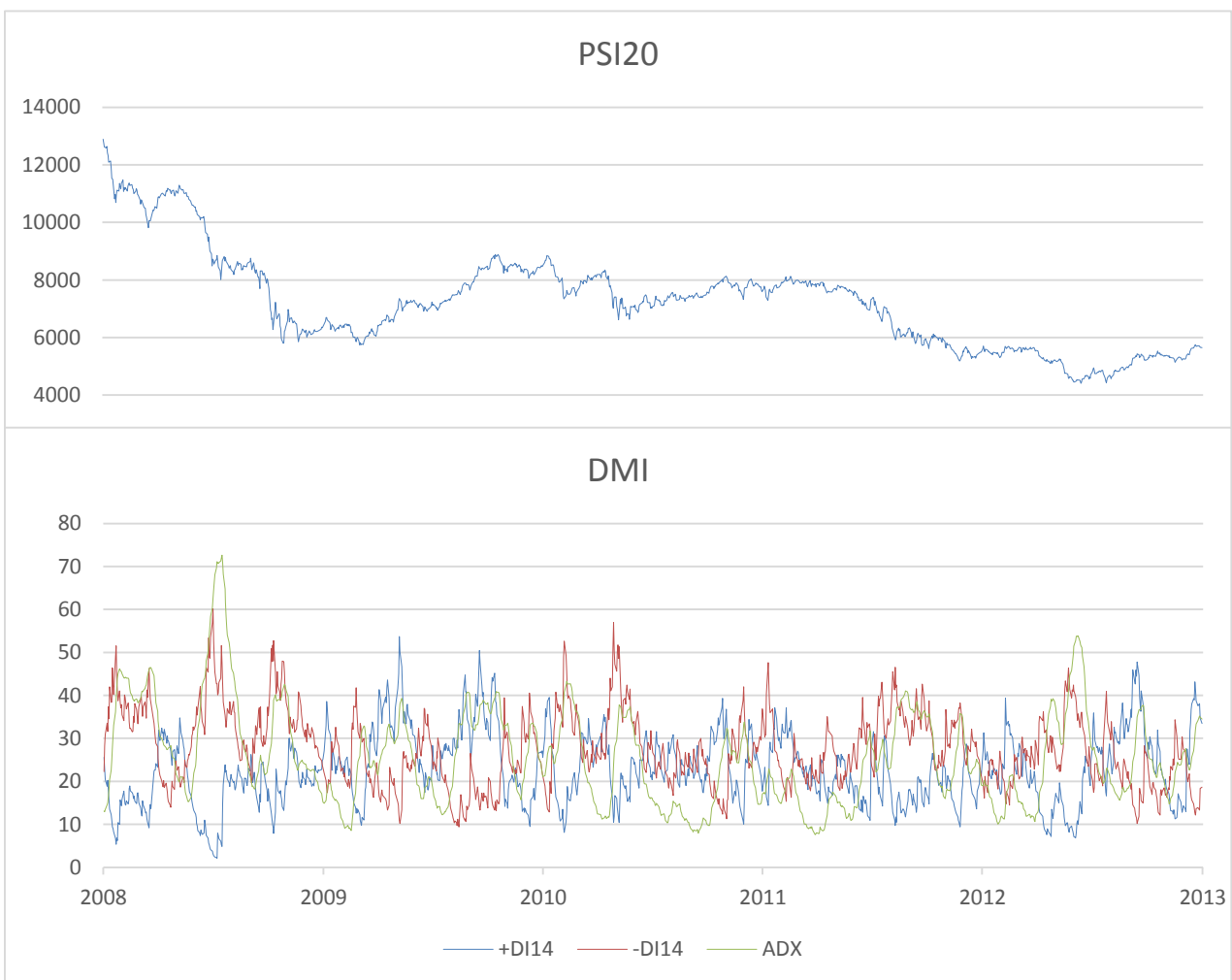
One can interpret this indicator using three perspectives, namely, crossover of MACD by signal line, divergence analysis, and extreme readings. When MACD line crosses from below to above the signal line, the stock should be bought, and when the MACD line crosses the signal line from above to below, it should be sold. One can also use divergence analysis, in which the signs that were referred happen when prices are

moving in the opposite direction or moving sideways, in that situation MACD strongly suggest that prices will be changing direction, that is when there exists a signal to buy, and the prices are decreasing or moving sideways, the stock should be bought because it is likely to occur a reversion of the trend. Analyzing MACD trough extreme readings resembles RSI analysis, extreme MACD readings indicate overbought and oversold conditions, which corresponds to probable tops and bottoms, as this form is similar to RSI, it was not tested, but in return MACD was tested without the signal line, being composed only by the 12 and 26 periods' exponential moving averages.

As all technical indicators, MACD should not be used in isolation and turned into a mechanical system, but rather to confirm or in combination with bullish or bearish evidences from charts and other indicators.

3.2.3. DMI

Figure 5 - Example of DMI for PSI20



Source: author

By last but not least the Directional Movement Index (DMI) was also introduced by Wilder in 1978, it is a momentum indicator that compares the current price with the previous price range and results in an upward movement line and in a downward movement line, respectively (+DI) and (-DI), these can be combined with Average Directional Index (ADX), that shows the strength of the trend. The combination of DMI and ADX results in a trading system that basically consists in buying the stock when +DI is above -DI, and the ADX is above a certain level (usually between 20 and 25), that is when the trend has some strength, when -DI is above +DI, the stock should be sold, we can use DMI with or without ADX, but without ADX the signals could occur in trends with no strength causing bad results.

The formula is a little bit tricky and extensive and involves numerous steps, but it can actually be divided in two parts, first compute the +DI and -DI, and second, compute the ADX. To compute +DI and -DI, one needs price data consisting of high, low, and closing prices each period, first, one computes the directional movement, +DM and -DM. Directional movement is positive if the current high minus the previous high is greater than the previous low minus the current low, this +DM is equal to the current high minus the previous high, if it is positive, if it is negative, the value for +DM is zero. Directional movement is negative if the opposite happens, that is the prior low minus the current low is greater than the current high minus the prior high, -DM equals the prior low minus the current low, if positive, otherwise zero.

$$UPmove = today's\ high - yesterday's\ high \quad (5)$$

$$DOWNmove = yesterday's\ low - today's\ low \quad (6)$$

If $UPmove > DOWNmove$ and $UPmove > 0$, then $+DM = UPmove$, else $+DM = 0$

If $DOWNmove > UPmove$ and $DOWNmove > 0$, then $-DM = DOWNmove$, else $-DM = 0$

To compute +DI and -DI, one needs to compute the True Range (TR) or ATR (Average True Range), TR and ATR (smoothed version of TR) are indicators that measure volatility, their formulas are given by:

$$TR = \max[(high - low), \text{abs}(high - close_{prev}), \text{abs}(low - close_{prev})] \quad (7)$$

$$ATR_t = \frac{ATR_{t-1} \times (n - 1) + TR_t}{n} \quad (8)$$

The first ATR value is given by:

$$ATR = \frac{1}{n} \sum_{i=1}^n TR_i$$

The True Range was used as the measure of price volatility, because it is most commonly used. The idea behind it is to show the commitment or enthusiasm of traders, large or increasing ranges suggest traders prepared to continue bidding up or selling down a stock, decreasing range suggests waning interest.

After this, one needs to smooth these periodic values using Wilder's smoothing techniques, Wilder suggests a modified moving average of 14 days.

$$+DI = 100 \times \frac{14 \text{ day MMA}(+DM)}{14 \text{ day MMA}(TR)} \quad (9)$$

$$-DI = 100 \times \frac{14 \text{ day MMA}(-DM)}{14 \text{ day MMA}(TR)} \quad (10)$$

The results of these formulas are going to be plotted on charts, representing the Plus Direction indicator line and Minus Direction indicator line respectively, to complete the system one needs to compute DX, and subsequently ADX, their formulas are given by:

$$DX = \frac{Abs((+DI) - (-DI))}{(+DI) + (-DI)} \quad (11)$$

$$ADX = 100 \times 14 \text{ day MMA}(DX) \quad (12)$$

ADX was used as a filter to trend's strength, for that purpose 20 and 25 levels were used, Wilder believed that a ADX reading above 25 indicated a strong trend, while a reading below 20 indicated a weak or non-existent trend. A reading between 20 and 25, would be considered indeterminable or a sideways trend. Notwithstanding, these values depend on investor's interpretation, one could use other values depending on the

financial instrument being examined, originally Wilder designed this indicator for commodities and currency market, which tend to be more volatile with short and strong trends. Therefore, stocks with low volatility may not generate signs based on those levels, but historical analysis can work that out.

DMI is another valuable technical indicator provided by Wilder, which respects to the complex theme of trend strength and direction, and computes it down into a very simple and straightforward chart. The key disadvantage of using DMI is that although it can give quality information and trading signs, it is not easy to master, to get the most out of this indicator, a technical analyst has to continuously study and adjust his use of the indicator. Combining the knowledge of how the indicator works and its abilities, with experience and historical analysis, will help investors to make DMI a good, possible addition to their investment strategy.

4. RESULTS

The ultimate goal of this study is to analyze the effectiveness of technical analysis in Portugal, to accomplish this, three indicators were chosen and tested against a buy-and-hold strategy. The results were as follows:

Table 1 - Results for RSI

	RSI				Buy-and-Hold
	Total Return	Net Return	Difference	Excess Return	
EDP	129.085%	128.910%	0.175%	177.624%	-48.539%
GALP	127.575%	127.400%	0.175%	162.959%	-35.385%
JMT	-85.883%	-86.008%	0.125%	-251.821%	165.938%
PT	-37.317%	-37.442%	0.125%	20.795%	-58.112%
PSI20	-70.003%	-70.138%	0.135%	-13.867%	-56.137%

Source: author

As one can see Relative Strength Index performed better than Buy-and-Hold strategy for EDP, GALP, and PT with an excess return of 177.624%, 162.959% and 20.795% respectively. RSI underperformed Buy-and-Hold strategy for JMT and PSI20 with an excess return of -251.821% and -13.867% respectively.

Table 2 - Results for MACD Signal

	MACD signal				Buy-and-Hold
	Total Return	Net Return	Difference	Excess Return	
EDP	-37.126%	-37.701%	0.575%	11.413%	-48.539%
GALP	123.731%	123.221%	0.510%	159.115%	-35.385%
JMT	-66.506%	-67.071%	0.565%	-232.444%	165.938%
PT	-56.470%	-57.055%	0.585%	1.642%	-58.112%
PSI20	-5.905%	-6.410%	0.505%	50.232%	-56.137%

Source: author

The Moving Average Convergence Divergence with signal line performed better than Buy-and-Hold strategy for three stocks and PSI20, with excess returns of 11.413% for EDP, 159.115% for GALP, 1.642% for PT and 50.232% for PSI20. The exception was JMT with a negative excess return of -232.444%.

Table 3 - Results for MACD no signal

	MACD no signal				Buy-and-Hold
	Total Return	Net Return	Difference	Excess Return	
EDP	-33.148%	-33.413%	0.265%	15.392%	-48.539%
GALP	-16.512%	-16.707%	0.195%	18.873%	-35.385%
JMT	-59.416%	-59.686%	0.270%	-225.354%	165.938%
PT	-53.889%	-54.144%	0.255%	4.223%	-58.112%
PSI20	35.636%	35.406%	0.230%	91.773%	-56.137%

Source: author

The MACD without signal line performed better than Buy-and-Hold strategy for EDP, GALP, PT and PSI20 with excess returns of 15.392%, 18.873%, 4.223% and 91.773% respectively. It underperformed Buy-and-Hold strategy for JMT, with excess returns of -225.354% respectively.

Table 4 - Results for MACD divergence

	MACD divergence				Buy-and-Hold
	Total Return	Net Return	Difference	Excess Return	
EDP	-16.722%	-17.207%	0.485%	31.818%	-48.539%
GALP	19.138%	18.613%	0.525%	54.522%	-35.385%
JMT	-79.544%	-80.119%	0.575%	-245.482%	165.938%
PT	-48.768%	-49.323%	0.555%	9.343%	-58.112%
PSI20	1.900%	1.415%	0.485%	58.037%	-56.137%

Source: author

MACD analyzed trough divergence analysis performed better than Buy-and-Hold strategy for all stocks and PSI20, except for JMT. The excess returns were 31.818% for EDP, 54.522% for GALP, 9.343% for PT, 58.037% for PSI20 and -245.482% for JMT.

Table 5 - Results for DMI no filter

	DMI				Buy-and-Hold
	No filter				
	Total Return	Net Return	Difference	Excess Return	
EDP	14.234%	13.659%	0.575%	62.773%	-48.539%
GALP	-17.362%	-17.897%	0.535%	18.023%	-35.385%
JMT	-54.633%	-55.253%	0.620%	-220.571%	165.938%
PT	54.964%	54.509%	0.455%	113.076%	-58.112%
PSI20	110.684%	110.174%	0.510%	166.821%	-56.137%

Source: author

The Directional Movement Index performed better than Buy-and-Hold strategy for all stocks and PSI20 with excess returns of 62.773%, 18.023%, 113.076% and 166.821% respectively. Once again, the exception was JMT with a negative excess return of 220.571%.

Table 6 - Results for DMI filter 20

	DMI				Buy-and-Hold
	Filter 20				
	Total Return	Net Return	Difference	Excess Return	
EDP	7.273%	7.028%	0.245%	55.812%	-48.539%
GALP	-11.456%	-11.711%	0.255%	23.928%	-35.385%
JMT	-39.845%	-40.125%	0.280%	-205.783%	165.938%
PT	-47.829%	-48.134%	0.305%	10.283%	-58.112%
PSI20	75.238%	75.023%	0.215%	131.375%	-56.137%

Source: author

DMI with a filter of 20 for the Average Directional Index outperformed Buy-and-Hold strategy for all stocks and PSI20, once again with the exception of JMT. The excess returns were 55.812% for EDP, 23.928% for GALP, 10.283% for PT, 131.375% for PSI20 and -205.783% for JMT.

Table 7 - Results for DMI filter 25

	DMI				Buy-and-Hold
	Filter 25				
	Total Return	Net Return	Difference	Excess Return	
EDP	-54.702%	-54.877%	0.175%	-6.162%	-48.539%
GALP	-73.015%	-73.160%	0.145%	-37.630%	-35.385%
JMT	-17.750%	-17.890%	0.140%	-183.688%	165.938%
PT	-29.705%	-29.860%	0.155%	28.407%	-58.112%
PSI20	122.741%	122.606%	0.135%	178.877%	-56.137%

Source: author

By last, the DMI with a filter of 25 to the ADX outperformed Buy-and-Hold strategy only for PT and PSI20 with excess returns of 28.407% and 178.877% respectively. It underperformed Buy-and-Hold strategy for EDP, GALP and JMT, with excess returns of -6.162%, -37.630% and -183.668% respectively.

5. FINAL REMARKS

Through the observation of these results one can conclude than none of the indicators and their variations was able to beat the Buy-and-Hold strategy for JMT's stock, curiously this is the only security in the sample that had a positive performance during the time frame of this study, so one can conclude that JMT is an outlier in this study, because it is a very difficult task to beat Buy-and-Hold Strategy when the stock is constantly rising and it almost tripled its price in 5 years. The most common result was the indicators outperforming the Buy-and-Hold strategy for all securities with the exception of JMT's stock, this took place to five of the seven indicators (MACD signal, MACD no signal, MACD divergence, DMI no filter, and DMI filter 20). In one of the other two indicators, the Buy-and-Hold strategy outperformed RSI for JMT and PSI20. The DMI filter 25 underperformed the Buy-and-Hold strategy for EDP, GALP and JMT.

Table 8 - Weighted Average Excess Return per indicator

Weighted Average Excess Return						
RSI	MACD signal	MACD no signal	MACD divergence	DMI No filter	DMI Filter 20	DMI Filter 25
19.138%	-2.008%	-19.019%	-18.352%	28.024%	3.123%	-4.039%

Source: author

In average terms, the indicator with the best performance was DMI no filter with a weighted average excess return of 28.024% and the indicator with the worst weighted average was MACD no signal with -19.019%. At security level, the indicator with the best performance for EDP was RSI with an excess return of 177.624% and the worst was DMI filter 25 with an excess return of -6.162%; for GALP the best indicator was RSI with an excess return of 162.959%, and the worst was DMI filter 25 with an excess return of -37.630%; for JMT the indicator with the best performance was DMI filter 25 with an excess return of -183.688% and the worst indicator was RSI with an excess return of -251.821%; for PT the best indicator was DMI no filter with an excess return of 113.076% and the worst one was MACD signal with an excess return of 1.642%; finally for PSI20 the best one was DMI filter 25 with an excess return of 178.877% and the worst was RSI with an excess of -13.867%.

Table 9 - Difference between Total Return and Net Return in percentage

	Difference between Total Return and Net Return						
	RSI	MACD signal	MACD no signal	MACD divergence	DMI No Filter	DMI Filter 20	DMI Filter 25
EDP	0.175%	0.575%	0.265%	0.485%	0.575%	0.245%	0.175%
GALP	0.175%	0.510%	0.195%	0.525%	0.535%	0.255%	0.145%
JMT	0.125%	0.565%	0.270%	0.575%	0.620%	0.280%	0.140%
PT	0.125%	0.585%	0.255%	0.555%	0.455%	0.305%	0.155%
PSI20	0.135%	0.505%	0.230%	0.485%	0.510%	0.215%	0.135%

Source: Author

As previously referred, one of the biggest criticisms to technical analysis is that it is not able to beat Buy-and-Hold strategy after transaction costs being considered, but as one can see above, the differences between Net Returns (after deducting transaction costs) and Total Returns are small, in this study lower than 1%. So, assuming that the criticism holds, the difference between the absolute return of a technical method and Buy-and-hold strategy would be lower than 1%, but no one uses technical analysis to beat the Buy-and-Hold strategy by 1%, it would not be worth the effort. Furthermore, considering the excess returns presented before, the difference was higher than 1% in all cases, so one can conclude that the transaction costs seem to be not decisive to the effectiveness of Technical Analysis. In addition, transaction costs are increasingly lower due to competition for commissions, and the development of online brokers, this allows investors to trade cheaply, so the slice of profits that goes to commissions is significantly lower. Is important to refer that the transaction cost assumed was of 5€ per transaction, and this is the lower one can get and only for Portuguese market, the subject of this study, but even if we assume twice the cost, the differences between Total Return and Net Return are still approximately 1%.

This study has some limitations, which should be considered to obtain a better understanding of its conclusions, first of all it is crucial to remind that these indicators, and any others of Technical Analysis, are not flawless, neither were constructed to be used individually as mechanical systems. However, those who use various indicators, price, volume and charts at the same time for guidance to buy and sell, will be putting the odds at their favor, and thus, should be able to be winners in the market. What technical analysis intends to achieve is a guideline for investment decision process when buying or selling, meanwhile, investors should not abandon other techniques such as those provided by fundamental analysis and also never forget common sense. Success in the marketplace combines a number of factors, and especially the coldness in the decision, avoiding, whenever possible, external influences such as tips, euphoria and pessimism.

Other limitations of this study are the time frame, which includes 5 years starting with the crisis of 2008, the dimension of the sample, the fact that this study is only for the Portuguese market, which is not one of the most developed ones, the fact that transactions occur at the closing price, which is not the most realistic scenario, and the lack of statistical evidence.

For further research, some suggestions are given in the text, namely in the methodology chapter, regarding the effectiveness of fundamental analysis using price-target estimates, or using Discounted Cash flow to predict the future price of a stock and then compare it with the market price. Another suggestion is to analyze the effectiveness of technical analysis but at the portfolio level, instead of analyzing each stock individually, that is to adjust the weight of each stock in the portfolio according to technical indicators. The last two suggestions are not to consider transactions at the closing price, rather using daily average price, or daily median price, and perform an out-of-sample analysis, with the goal of choosing the best indicator.

6. REFERENCES

Published references:

Appel, G. 2005. *Technical analysis: Power tools for active investors*. Pearson Education.

Damodaran, A. 2003. *Investment philosophies: Successful strategies and the investors who made them work*. Hoboken: John Wiley.

Douglas, M. 2013. *Trading: A attitude mental do trader de sucesso*. Bookout.

Hagstrom, R. G. 2005. *The Warren Buffet way* (2nd edition). New Jersey: John Wiley.

Lacalle, D. 2014. *Nós, os mercados*. Marcador.

Lo, A. W., & MacKinlay, A. C. 1999. *A non-random walk down Wall Street*. Princeton: Princeton University.

Malkiel, B. G. 2003. *A random walk down Wall Street: The time-tested strategy for successful investing* (8th edition). New York: W. W. Norton.

Matos, F. B. 2013. *Ganhar em Bolsa* (9th edition). Dom Quixote.

Meyers, T. A. 2002. *The technical analysis course: A winning program for investors and traders* (3rd edition). New York: McGraw Hill.

Silva, M. G. 2013. *Bolsa – investir nos mercados financeiros*. Bookout.

Other references:

www.investopedia.com

stockcharts.com

APPENDIX

Appendix 1 – Number of trades and general information per security and indicator

		RSI	MACD signal	MACD no signal	MACD divergence	DMI No Filter	DMI Filter 20	DMI Filter 25
EDP	Trades	35	115	53	97	115	49	35
	Percentage profitable	60%	34%	26%	40%	38%	43%	29%
	Average % gain, winners	8%	5%	7%	5%	4%	5%	8%
	Average % loss, losers	-5%	-3%	-4%	-3%	-2%	-4%	-6%
	Annual return	18%	-9%	-8%	-4%	3%	1%	-15%
	Long winners	12	24	10	20	24	15	8
	Short winners	9	15	4	18	20	6	2
GALP	Trades	35	102	39	105	107	51	29
	Percentage profitable	66%	43%	31%	41%	33%	33%	38%
	Average % gain, winners	9%	7%	13%	7%	7%	11%	8%
	Average % loss, losers	-10%	-4%	-6%	-4%	-3%	-5%	-11%
	Annual return	18%	17%	-4%	4%	-4%	-2%	-23%
	Long winners	12	20	5	17	15	6	5
	Short winners	11	24	7	25	20	11	5
JMT	Trades	25	113	54	115	124	56	28
	Percentage profitable	16	29%	17%	36%	26%	27%	29%
	Average % gain, winners	9%	6%	17%	5%	7%	12%	22%
	Average % loss, losers	-23%	-4%	-5%	-5%	-3%	-5%	-8%
	Annual return	-32%	-20%	-17%	-27%	-15%	-10%	-4%
	Long winners	8	14	3	18	12	4	1
	Short winners	8	19	6	22	20	11	7
PT	Trades	25	117	51	111	91	61	31
	Percentage profitable	60%	27%	20%	33%	31%	34%	42%
	Average % gain, winners	7%	7%	15%	6%	8%	8%	10%
	Average % loss, losers	-13%	-3%	-5%	-4%	-2%	-5%	-9%
	Annual return	-9%	-15%	-14%	-13%	9%	-12%	-7%
	Long winners	8	19	6	17	16	12	9
	Short winners	6	13	4	19	12	9	3
PSI20	Trades	27	101	46	97	102	43	27
	Percentage profitable	56%	37%	30%	39%	32%	37%	41%
	Average % gain, winners	4%	5%	10%	5%	6%	10%	13%
	Average % loss, losers	-14%	-3%	-3%	-3%	-2%	-3%	-3%
	Annual return	-21%	-1%	6%	0%	16%	12%	17%
	Long winners	8	20	9	19	20	10	8
	Short winners	7	17	5	18	13	6	3

Source: author