A time-series and cross-sectional momentum strategy: Dual momentum applied from a South African perspective.

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Abstract

Fama and French (2008, p.1654) referred to momentum as a "premier market anomaly". The momentum effect has been nearly universally observed across all asset classes globally (Asness, et al., 2013). This research paper further explores momentum and replicates the dual momentum strategy proposed by Antonacci (2014) within a South African context. Dual momentum combines time-series and cross-sectional momentum in pursuit of enhanced risk adjusted returns. The strategy is constructed using tradeable indices in order to minimise transaction costs. This study investigates the dual momentum strategy applied to the JSE Top 40 index. The strategy also includes two indexes which stay constant, the MSCI ACWI index for offshore exposure and the STeFI index which serves as an alternative proxy investment and acts as a safe haven during economic downturn. In addition, this study investigates two variations of the core strategy which include shortening the look-back period and lowering the strategy's threshold. Furthermore, and supplementary to the core strategy, dual momentum is applied to several South African sector indexes. Followed by a second supplementary section where dual momentum is applied to a pool of indexes where only the top performing index is used over a specific period in time.

The results of the performance analysis of the dual momentum strategy over the sample period illustrates the strategy's ability to generate superior risk adjusted returns, lower standard deviations, lower maximum drawdowns, and yields significant positive alpha. Thus, the core dual momentum strategy and focal point of this study, validates the strategy within a South African context. However, the results of the variations and both supplementary sections display a vast range in underperformance. This highlights the dual momentum strategy's inability to adequately cope with high volatility. During periods of high volatility, the strategy tends to struggle which is also the case with the core strategy and most other momentum strategies. Therefore, the two variations and supplementary strategies do not manage to improve the core dual momentum strategy.

Key words: Dual Momentum, The Momentum Effect, Momentum Investing, Efficient Market Hypothesis.

DECLARATION

I, Michael Fuchsloch, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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1. Introduction

Momentum refers to the persistence in stock price performance and over the past 20 years has been one of the most heavily researched topics in finance. Literature has found momentum effects from as early as the 1800s to the present day spanning across nearly all asset classes. Only now has the academic community accepted momentum as a premier anomaly which has significantly challenged the rational expectations assumption that forms the basis on which the Efficient Market Hypothesis (**EMH**) is built (Antonacci, 2014). Momentum may be gaining greater traction and academic recognition; however, it still remains largely unexplained. Nevertheless, momentum has stood the test of time as a market anomaly. It is also being used in professional practice since it is hard to dismiss the strong results of relative strength momentum investing (Scowcroft & Sefton, 2005). As momentum literature grows in popularity there are still only very few momentum products available professionally, as it mostly gets used as a factor in multi-factor modelling. Thus, can the dual momentum strategy of Antonacci (2016) serve as profitable momentum investment strategy within a South African context and does it challenge the traditional finance's EMH?[1]

1.1 Context

By the mid-1970s the EMH had a strong hold in finance and was vigorously supported by academics and practitioners. The efficient market hypothesis is the theory that all available information is fully reflected in the stock price, which means that no market participants can consistently outperform the market since abnormal profits would be arbitraged away by investors (Clarke, et al., 2001). Momentum still did not receive much professional attention and many academics believed that the stock market returns followed a random walk. The random walk theory supports EMH and suggests that market price movements are random and unpredictable, which meant market participants could not consistently exploit market movements (Antonacci, 2014). However, Shiller (1980) found evidence that stock prices weren't so random and that they had predictable components. Further contradictory evidence was found against the random walk theory when academics started recording stock price persistence due to positive serial correlation (Antonacci, 2014). A long-term reversal effect

[1] Gary Antonacci's research on Dual Momentum was the first-place winner in 2012 and second-place winner in 2011 of the Founders Award for Advances in Active Management, awarded by the National Association of Active Investment Managers (NAAIM) (Optimal Momentum, 2021).

was also identified which further challenged EMH and the random walk theory (De Bondt & Thaler, 1985).

By the 1900s behavioural finance emerged and grew in popularity and started questioning EMH as a way of explaining market anomalies such as price momentum (Tversky, 1995). Behavioural finance exceedingly challenged investor rationality which is the foundation on which EMH is built, meaning that an investor actually can outperform the market because it isn't efficient, since people acting irrationally and emotionally could cause prices to deviate from their fundamental value in predictable ways (Antonacci, 2014). Irrational investors might allow anomalies to persist (Kahneman & Tversky, 1974). For this reason, momentum started to gain some interest from the academic community and behavioural finance could be used to explain some of momentum's characteristics (Sewell, 2010). Behavioural biases helped linked the disconnect growing between theory and finance in practice (De Bondt, et al., 2010). Even the founders of EMH, Fama and French (2008) recognised momentum and referred to it as the "premier anomaly". Momentum is powerful, persistent, and not explained by any of the common risk factors.

The momentum effect research soared after Jegadeesh and Titman (1993) found extensive evidence that over a 6 to 12-month period of past performance, winning stock continued to outperform over the next 6 to 12-months. This led to momentum becoming one of the most researched topics in finance. By 2007 the first momentum-based programmes and products were introduced by Dorsey, Wright & Associates (**DWA**). DWA introduced two mutual funds and four Exchange Traded Funds (**EFT**) that selected stocks using relative strength momentum (Antonacci, 2014). In 2009 AQR Capital Management (**AQR**) introduced three more momentum based mutual funds and in 2013 BlackRock introduced their EFT. All the aforementioned products apply relative strength momentum to individual stocks. Relative strength momentum may provide enhanced returns, however, does nothing to reduce volatility and maximum drawdown (Antonacci, 2014). Furthermore, the use of momentum strategies on individual stocks results in far higher transaction costs than the use of indexes and broad asset classes (Antonacci, 2014). For this reason, the dual momentum strategy of Antonacci (2016) can be a superior strategy because of its use of indexes and most importantly, its inclusion of absolute momentum. Absolute momentum can enhance returns on top of significantly reducing

volatility and downside risk (Antonacci, 2016). The combination of absolute momentum and relative momentum form the valuable dual momentum strategy.

1.2 Overview

This research paper will review the relevant literature on efficient markets and the EMH. Subsequently, contrary literature challenging EMH will be reviewed in the inefficient markets section, which will highlight behavioural finance and market anomalies as well as introduce a major focal point of this paper and key anomaly: momentum. Thus, a comprehensive review on momentum literature to date will follow. The momentum section will review momentum research across the globe before narrowing in on momentum research observed in South Africa. Next, dual momentum will be reviewed as an investment strategy as well as its empirically observed results. The methodology of the dual momentum strategy will be broken down systematically into absolute and relative momentum and applied from a South African investor's perspective. Several South African sector indexes will be included to gain insight on the momentum effect within different sectors in South Africa. In addition, a second variation of the strategy will be included which maximises the profitability of the momentum effect by pooling various indexes together and investing in the strongest index, provided that the index has both absolute and relative momentum. The use of various key performance measures will be used to effectively evaluate the dual momentum strategy. Finally, the results of the strategy will be presented and discussed in detail before final conclusions are drawn in answering the research questions at hand.

1.3 Research Questions

This research paper's intention is to objectively explore dual momentum as strategy and report on the findings within a South African context. The research paper will be guided by two research questions of which the second question is supplementary to the first.

1.3.1 Relevance of Research and its Impact

The rationale of this research paper is to implement Antonacci's (2016) dual momentum strategy from a South African investor's perspective. Momentum is described as the premier anomaly for good reason. The momentum effect has been empirically observed and proven across multiple asset classes in several different countries. However, despite momentum being undeniable, there are no broadly accepted explanations for momentum and still very few

momentum products available in the professional realm (Antonacci, 2014). The dual momentum strategy can help bridge that gap and make an important contribution to the body of knowledge on momentum as well as provide additional momentum research on South African markets. This knowledge may help investors make investment decisions as well as open a door for further momentum research in South Africa and other emerging markets.

This research paper will further investigate the presence of the momentum anomaly. The aim of the paper is to determine the validity of the dual momentum strategy and ask whether the findings corroborate with the findings of Antonacci (2016). The aim is to evaluate whether the dual momentum strategy is a realistic investment strategy in South Africa. In other words, can the dual momentum strategy practically provide a unique strategy to South African markets that is able to generate higher risk-adjusted returns as well as harvest risk premia while at the same time, reducing maximum drawdowns and minimising trading costs. Finally, will the dual momentum's simplistic and universally implementable strategy appeal to South African investors?

1.3.2 Research Question 1

Can a dual momentum strategy implemented in South African achieve higher risk-adjusted returns?

1.3.3 Research Question 2

Do the findings in this thesis support conventional finance's efficient market hypothesis or do the findings support more recent literature contrary to the efficient market hypothesis? Furthermore, does the efficient market hypothesis hold for the South African market?

2. Literature Review

The literature review will entail a detailed review on market efficiency which will explore the EMH, followed by contrasting literature in the inefficient market section. Exploring market inefficiencies will cast a light on behavioural finance and observed market anomalies, which is where momentum will be introduced. Subsequently, an extensive review on momentum literature will follow, building a firm foundation before analysing dual momentum as an investment strategy.

2.1 Market Efficiency

Efficient markets refer to a market's ability to reflect all the available and relevant market information in the market price at a specific moment in time (Boyle, 2020). If markets are efficient then all the prices reflect all the available and relevant market information, which means that there is no way for an investor to outperform the market since none of the securities are over or undervalued (Boyle, 2020). Evidentially, markets cannot be perfectly efficient (Clarke, et al., 2001). Eugene Fama in 1970 argued that markets are efficient on three levels in his EMH theory, which is reviewed in the section to follow. The Efficient Market Hypothesis is fundamentally important to consider from a theoretical perspective when observing market anomalies such as momentum.

2.1.1 The Efficient Market Hypothesis

EMH has been explored substantially since Fama's paper in 1970 on whether markets are efficient or not. EMH states that an investor cannot outperform the market and that market anomalies should not exist because they are instantaneously arbitraged away (Fama, 1970). A market's prices that are fully reflective of the current market information available is referred to as efficient (Fama, 1970). Fama (1970) argued that a market priced by rational and well-informed investors would fully reflect the available information at any point in time. Therefore, the current market price would always be the best estimate of a specific asset. The theory is however subject to the following conditions and assumptions:

- There are no trading costs.
- All information is freely available to all market participates.
- Investors act rationally.
- If investors act irrationally, then arbitrage opportunities are exploited by rational investors, correcting the price deviation.

It is evident that the conditions and assumptions above do not adequately represent the markets in practice (Fama, 1970). However, Fama (1970) argues that the conditions and assumptions are sufficient but not necessary, and therefore, not an issue. The three forms of efficient market hypothesis provided by Fama (1970) are as follows:

i. *Weak Form Efficiency:* The information set, is just historical prices. Technically analysing historical prices cannot be used to predict future prices. Thus, long-run investment strategies based solely on historical prices cannot earn excess returns.

ii. *Semi-strong Form Efficiency:* Excess returns cannot be generated over time with the use of a technical or fundamental analysis using public information. This information includes other information such as stock splits or annual earnings announcements. Therefore, the use of public information can't be used to beat the market.

iii. *Strong Form Efficiency:* Market prices at all times reflect all the available and relevant market information. Not even insider information can be used to generate returns above the market.

EMH is heavily dependent on the assumption that all information is available to investors and that investors act instantaneously on the information which is then accordingly reflected in asset prices (Boyle, 2020). Meaning that prices rapidly adjust to new information, which also means that no investor can have any subsequent advantage since all the market participants receive the same information (Boyle, 2020). Consequently, no investors can outperform in an efficient market without taking on additional risk above the market. Furthermore, competition amongst market participants will drive asset prices to its equilibrium state (Clarke, et al., 2001). However, the momentum effect challenges weak form efficiency, since price momentum is identified by historical prices which in turn is used to predict future prices (Jegadeesh & Titman, 1993).

2.1.2 Random Walk Theory

The EMH was popularised 3 years after Fama's paper in 1973 by Malkiel's book, A Random Walk Down Wall Street. Which popularised the random walk theory, a theory first coined by French mathematician Louise Bachelier. The random walk theory states that investors cannot exploit mispriced stocks consistently because price movements are generally random, since they are driven by unforeseen events and for this reason supported EMH (Malkiel , 1973). The random walk theory suggests that stocks take on a Brownian movement, an unpredicted and random path which means that all methods of calculating future stock prices are ineffective in the long-run and that past movements or trends cannot be used to predict future movements

(Malkiel , 1973).[2] In addition, the random walk theory suggests that it is impossible to outperform the market without taking on additional risk (Malkiel , 1973). Many critics of the theory believe stocks do maintain price trends (i.e., momentum) in the long-term (Shiller, 2003). Mathematically the random walk formula is as follows:

$$Y_t = Y_{t-1} + \varepsilon_t \qquad (1)$$

The mathematical formula is the value Y_t of the time series at time t, which is equal to the value Y_{t-1} of the time series at a pervious time plus an unpredictable event ε_t. Furthermore, stock prices have been empirically observed to increase over time, therefore the inclusion of a trend α term gives us the random walk model with a drift which is mathematically represented below:

$$Y_t = \alpha + Y_{t-1} + \varepsilon_t \qquad (2)$$

The random walk theory does not infer that prices are irrational. Prices can be set rationally by an investor. The random walk theory implies that changes are unpredictable as a result of no one being able to predict the news. Therefore, the reactions of both an irrational and rational investor create a random path of price movements.

2.2 The Inefficiency of Markets

The efficient market hypothesis does however have many challenges, of which will be discussed further. Market inefficiency occurs when a market does not successfully incorporate all the available information into asset pricing, meaning that asset prices in the market do not truly reflect all the available information (Stout, 2002). Empirical observation has led to the discovery of various inefficiencies as a result of market asymmetries (Shiller, 2003). One of these anomalies is momentum, a focal point of this paper.

2.2.1 Behavioural Finance

Behaviour finance has played a major role over the past two decades in questioning EMH. Conventional finance assumes people are rational and that markets are efficient (De Bondt, et

[2] Brownian movement is any various physical phenomena in which some quantity is consistently undergoing small random fluctuation discovered by Robert Brown (Middlemarch, 1827). Robert Brown (1827) studied the random motion of particles suspended in a median.

al., 2010). A second school of thought is that abnormal returns exist not as compensation for additional risk which conventional finance suggests but because investors behave irrationally in predictable and systematic ways (Antonacci, 2014). J.M. Keynes said, "there is nothing so dangerous as the pursuit of a rational investment policy in an irrational world". Thus, behavioural finance has empirically proven that people are normal and not necessarily rational as well as the fact that finance is a social science which contrasts the EMH (De Bondt, et al., 2010). The field of behavioural finance started to gain traction in the 1990s and it questioned the basis on which EMH was built – rationality. Behavioural finance studies demonstrated that psychological influences can affect financial markets as well as explain why and how markets may be inefficient (Sewell, 2010). People are subject to cognitive bias (Tversky, 1995). For this reason, behavioural finance advocates that investors act irrational and as a result, markets are inefficient and do not truly reflect all the available information in asset prices (Shiller, 2003).

Tversky (1995) contrasted the standard notion of economic rationality against empirical psychological observations. The assumption of rational expectations implies that people are logical, unbiased, and accurate which means that people's predictions and forecasts are assumed to fully reflect all the available and relevant information (Kahneman & Tversky, 1974). People's decision-making capabilities fall short of the conventional finance's notion of rationality (Tversky, 1995). Decisions are influenced by cognitive illusions, and expectations are often biases in a predictable manner (De Bondt, et al., 2010).

The reason for such biases is largely explained by the three main heuristics identified in Kahneman & Tversky's paper in 1974, specifically: anchoring, representativeness, and availability (Kahneman & Tversky, 1974). Heuristics can be described as mental shortcuts to ease the cognitive load of decision-making (Kahneman & Tversky, 1974). People tend to display overconfidence in their own judgements and make decisions based on how the problem is framed. This is referred to as anchoring. For example, is the Nile River more or less than 100 miles? How long is it? People tend to anchor their answers around 100 miles because that number is mentioned in the question, which can be a completely arbitrary number selected. Investors are subject to the same bias and can anchor to specific figures and ideas due to the way the information is framed. Secondly, representativeness is when intuitive logic is distorted by mental protocols (De Bondt & Thaler, 1989). For example, if a man is very quiet, shy and

requires order and structure in his life, which occupation is he most likely to choose: sales, pilot, or librarian? Due to stereotypes people mostly say librarian. This approach to judgement can lead to serious errors in judgement. Lastly, availability is the result of more vivid and recent information having a greater impact on your current decision-making (Kahneman & Tversky, 1974). People tend to over-weigh current and more recent information.

Behavioural finance has also called into question the assumption of risk aversion which is apparent in most finance models. It is highlighted that investors are actually loss averse, since investors are more likely to be risk-seeking when losses are involved and resist selling stocks when it is decreasing in value (Tversky, 1995). Risk aversion does however hold true when stock prices increase, meaning that investors will sell increasing stock prematurely to lock-in profits (Tversky, 1995). This well- known cognitive bias is otherly known as the disposition effect and it has a significant impact on momentum in asset prices which will be further discussed in the momentum section.

While substituting mathematical logic for empirical observation is convenient, modern finance demands rational solutions for normative problems which is seen as an adequate basis for understanding actual behaviour (De Bondt, et al., 2010). Behavioural finance will be covered in greater detail in the momentum section.

2.2.2 Cost of Information

Grossman and Stiglitz (1980), attempted to redefine the notion of efficient markets and showed that the EMH is true, information is costly and that competitive markets break down. Therefore, prices do reflect all the information available. It is argued that prices cannot perfectly reflect the available information because information is costly (Grossman & Stiglitz, 1980). In other words, if all the available information is fully reflected in the price, then those who spent resources obtaining such information would receive no compensation for it (Grossman & Stiglitz, 1980). Thus, there would no longer be an incentive to look for new information and for this reason a situation would be created where prices no longer reflect all the available information (Grossman & Stiglitz, 1980). The model built by Grossman and Stiglitz (1980) suggested that searching for new information is profitable because an informed investor could exploit arbitrage opportunities of incorrectly priced securities and as a result drive the market back into equilibrium (Grossman & Stiglitz, 1980). It is evidently clear that information costs;

there are providers of information such as Bloomberg that charge significant fees for access to their information. However, the cost of information is paradoxical, since the more investors seek information due to markets not being efficient, the more efficient markets become as they are driven towards an equilibrium. This leads to fewer arbitrage opportunities being found and more investors feeling that there is no longer a point seeking information due to diminishing marginal opportunities (Grossman & Stiglitz, 1980). As a result, investors stop seeking for information thus, once again creating a less efficient market. In short, the cost of information plays a major role in explaining market inefficiencies.

2.2.3 Market Anomalies

Market participants and academics have uncovered several market anomalies contrary to EMH. One of which is a focal point of this research paper - momentum. Market anomalies are defined as market patterns that lead to abnormal returns with some degree of frequency (Thaler, 1987). These anomalies challenge semi-strong and weak-form EMH (Latif, et al., 2011). Abnormal market returns can occur by learning all the available public information and price momentum is identified by historical prices which in turn is used to predict future prices (Jegadeesh & Titman, 1993). The following bullets highlight the fundamental market anomalies:

- The January effect: This is a case where stock market returns are higher in January comparatively to other months (Thaler, 1987). A process often referred to as "tax-selling" which is when investors often look to sell underperforming stock in order to offset their capital gains tax around year end. As a result, many of these underperforming stocks can become very attractive stocks in January (Thaler, 1987).
- The reversal effect: It was found that due to market over and underreactions when ranking stock returns on a 3 to 5-year horizon, that past winners became losers and past losers become winners (De Bondt & Thaler, 1989). Mean reversion is also found on a short-term basis, one month or less. (De Bondt & Thaler, 1989). Significantly, mean reversion is the opposite of momentum, thus for mean reversion to exist there must be some evidence of momentum (Antonacci, 2014).
- The Size effect: Firms with smaller market capitalizations tend to outperform larger firms (Banz, 1981). Since, smaller firms have a greater potential and ability to rapidly grow in comparison to large mature firms (Banz, 1981) .

- Value effect: Firms that have a high earnings-to-price ratio exhibited higher returns than firms with low earnings-to-price ratio, the same is observed when firms have a higher book-to-market ratio (Brooks & Anderson, 2006).

The aforementioned anomalies shine a light as well as help to explain why there are market inefficiencies contrary to the EMH. Further exploring these anomalies can result in exploitable opportunities. A premier market anomaly due to its strength and persistence as well as subject of this research paper is momentum. Momentum will be explored in extensive detail in the section to follow.

2.3 Momentum

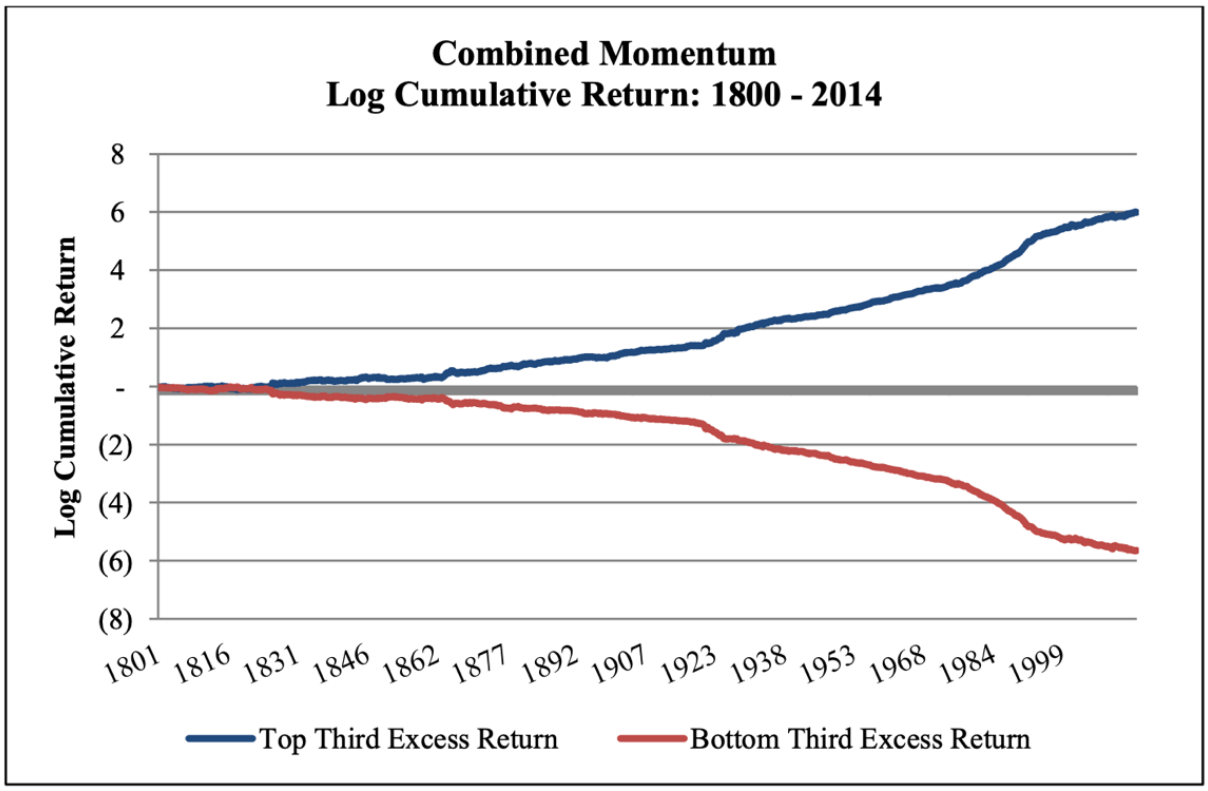
The momentum effect is the core of the dual momentum strategy. The strategy solely harvests returns from the momentum anomaly; thus, it is vital to comprehensively review momentum literature from when momentum was first observed to the present day. The review will include South African momentum literature as well as proposed explanations of momentum before analysing dual momentum as a strategy.

2.3.1 Momentum Overview

Momentum was first observed by Cowles and Jones (1937) when they manually analysed the NYSE stocks from 1920 to 1935. They found that there was a pronounced tendency for stocks that have exceeded the median in one year, to also exceed the median the following year (Cowles & Jones, 1937). Their findings formed the basis of momentum as it is seen and practiced to date, yet there was no further research conducted until the 1990s. Eventually, momentum was first studied by Jegadeesh and Titman in 1993, where they were able to generate excess returns by selecting stocks based on their past 3 to 12-month returns and held them for a further 3 to 12-months. Since then, financial momentum has not only become a common market phenomenon but one of the strongest and most pervasive (Antonacci, 2016). A growing body of literature documents stock return predictability based on a variety of firm specific variables (Jegadeesh & Titman, 2011). Evidence that U.S. stocks perform the best over a 3 to 12-month period tend to continue to perform well over the subsequent 3 to 12-months, and stocks that perform worst over a 3–12-month period tend to continue underperforming (Jegadeesh & Titman, 1993). Researchers have replicated these findings several times in different markets across 40 countries for various time periods as well as testing

various holding periods, the majority of which found momentum present and yielded similar results. In addition, further momentum studies of long and short-term returns find profitable contrarian strategies which all seem to arrive at the same conclusion; that all stock prices overreact to information (Jegadeesh & Titman, 2011). Momentum strategies have proven profitable in most major markets around the world, with some exceptions such as Japan. Furthermore, momentum is not only found across a dozen asset classes but also found in industries (Moskowitz & Grinblatt, 1999). Equally important, a pattern of seasonality is displayed by the momentum effect in the month of January (Jegadeesh & Titman, 2011). The momentum effect earns negative returns in January and positive returns for all the other remaining months (Jegadeesh & Titman, 2011). Thus, the inverse of traditional January effect is present with regards to momentum (Jegadeesh & Titman, 2011).

***Figure 1**: Log Cumulative Global Multi-Asset Momentum Returns (Geczy & Samonov, 2015).*



A study by Geczy and Samonov (2015) documented momentum returns from 1800 through to 2014. **Figure 1** displays the top and bottom third excess returns of momentum which evidently demonstrates the strength of momentum over an extensive time-period (Geczy & Samonov, 2015). Not only is momentum found to be strong but also consistent (Antonacci, 2014). In

short, research shows that systematic momentum has high and consistent returns, it is robust and universally applicable, and persists over time.

2.3.2 Momentum in South Africa

Van Rensburg (2000) documented a cluster of momentum effects over a 6 to 12-month period on the Johannesburg Stock Exchange (**JSE**). At the same time, significant momentum profits over the period 1981 to 2003 were found on the JSE (Chui, et al., 2010). Nnadi and Tanna (2019) found evidence of short-term momentum profits in South Africa. Similarly, La Grange and Krige (2015) found that momentum strategies could achieve annualised abnormal returns of up to 8.7% above the benchmark after adjusting for risk and including transaction costs with the JSE's ALSI40 from January 1998 to May 2013. La Grange and Krige (2015) were able to improve their momentum strategies which resulted in annualised risk-adjusted returns of up to 14.1% above the benchmark by combining other financial ratios to their strategy. Momentum strategies in South Africa continue to provide robust returns. However, medium to long-term contrarian effects are found in the South African market (Nnadi & Tanna, 2019). Contrarian investing is buying a poorly performing stock (undervalued) and selling good performing stock (overvalued), which is contrary to momentum investing; the buying of good performing stock and selling of poor performing stock based on its recent history. In other words, contrarian investors believe the stock is over or underestimated while momentum investors believe the stock is still far from its intrinsic value (Nnadi & Tanna, 2019). Contrarian profits in South Africa are caused by relatively high loser returns and seem to be treated as a safe haven during financial market turmoil (Hsieh & Hodnett, 2011). Nevertheless, Nnadi and Tanna (2019) found that the trend of winner portfolios lasts longer and was much smoother than the loser portfolios. It was also found that the majority of momentum portfolios showed reversal profits and the portfolio's returns are strong and high, meaning that South African investors can earn abnormal profits (Nnadi & Tanna, 2019). Thus, weak-form EMH does not hold since there are arbitrage opportunities that yield abnormal returns. Mean reversals due to overreactions were found to be considerably strong for past loser and winner portfolios with longer formation periods similar to the results of De Bondt and Thaler (Hsieh & Hodnett, 2011).

Recent literature provides evidence of idiosyncratic momentum's superiority over price momentum on the JSE, since it is less prone to long-term price reversal (McClelland & Auret, 2020). Idiosyncratic momentum exists alongside price momentum and is very similar as it

considers a share's recent relative performance over a short to medium horizon but only after being adjusted for asset pricing factors. There is also evidence suggesting that idiosyncratic risk is driven by market underreactions, contrary to EMH (McClelland & Auret, 2020).

2.3.3 Proposed Explanations of Momentum

Literature on the momentum effect has grown substantially over recent decades and led to empirical evidence of its existence. However, the driving factor of the momentum effect has yet to be determined and no consensus has been reached by practitioners and academics. From this stems two streams of argument; that of conventional finance, and that of behavioural finance. Conventional finance argues that EMH holds and that investors are rational. The rationalists focus on how "barely" rational investors react to unpredictable market changes which may result in momentum anomalies (Scowcroft & Sefton, 2005). Whereas behavioural finance argues that investors are irrational as they fall victim to cognitive biases and heuristics when processing new market information.

2.3.3.1 Behavioural Explanations

Empirically observed momentum profits are exceedingly difficult to explain with a risk-based model, which is why researchers have looked towards behavioural models. The majority of the models assume that the momentum effect is caused by the autocorrelation of individual stock returns which seems to be consistent with the evidence (Jegadeesh & Titman, 2011). Significantly, researcher's opinions differ as to whether the autocorrelation is caused by a delayed overreaction or an underreaction (Jegadeesh & Titman, 2011). In short, if abnormal returns are a result of a delayed overreaction, one would expect a subsequent reversal of the overreaction meaning that the momentum returns in the holding period would be followed by negative returns. Whereas, if the autocorrelation is caused by an underreaction, one would expect normal returns in the subsequent period after the abnormal returns during the holding period (Jegadeesh & Titman, 2011). For this reason, behavioural finance has had the most explanatory power with regards to the momentum effect, which is why it will be discussed in greater detail bellow.

Greg Fisher said, "we don't have people with investment problems, we have investments with people problems". Behavioural economics pioneers Tversky and Kahneman (1974) identified three key heuristics that influence investor decision-making, namely: availability, anchoring

and adjustment, and representativeness. Heuristics are the mental shortcuts that guide decision making based on a limited subset of information and facilitate a quicker decision-making process (Kahneman & Tversky, 1974). Investors tend to overweigh more vivid and current information in their decision-making process which can lead to overreactions in the market (Kahneman & Tversky, 1974). This is what Tversky and Kahneman (1974) refer to as the availability heuristic. Whereas, anchoring and adjustments can lead to underreactions since investors anchor their views to past data and are reluctant to change their views, and therefore the market is slow to react (Kahneman & Tversky, 1974). The gradual way people process and absorb information caused by the anchoring can lead to underreactions due to the price friction. It was also argued that price momentum is a result of investor underreacting because of their limited ability to gather, process and conclude the information (Barberis, et al., 1998). Conversely, the momentum effect is also argued to be caused by an overreaction due to high investor confidence as a result of an overestimation in their abilities and the available information (De Bondt, et al., 2010). Investor confidence can also be exacerbated by a confirmation bias due to a positive outcome in the market (Kahneman & Tversky, 1974). Lastly, the representativeness heuristic is a mental shortcut investors take, accessing the likelihood of an event by assessing how similar it is to a generalized mental protocol (De Bondt, et al., 2010; De Bondt & Thaler, 1985). A representativeness bias is a fundamentally flawed way of thinking and can lead to poor decision-making and ultimately lead to prices overshooting their fundamental value (Kahneman & Tversky, 1974).

More recently the disposition effect has been used to better explain underreactions (Grinblatt & Han, 2002). The disposition effect is when investors delay selling stocks which are decreasing in value in hope that the stock will recover and sell stocks that are gaining in value too quickly to lock in the profits (Grinblatt & Han, 2002). The disposition effect can also be seen as a form of mental accounting as investors find loss less painful than a realised loss (Antonacci, 2014). A realised loss refers to a stock that has been sold at a loss where a loss can be temporary drawdown, but the stock isn't sold and therefore the loss isn't realised. The disposition effect supports Tversky's (1995) research indicating that investors are loss averse, since they are risk seeking on the downside but not on the upside (Tversky, 1995). Furthermore, underreactions to information are also argued to be caused by a conservative bias, which gives rise to momentum profits (Barberis, et al., 1998). De Long et al. (1990) introduced the idea of delayed overreaction and documented how investment strategies that buy past winners and sell

past losers, results in market prices deviating from their fundamental values. Further models were proposed that were consistent with long-term reversion and medium-term momentum (Hong & Stein, 1999). As a result, the market would overreact and often the momentum effect would be perpetuated by representative bias, confirmation bias and the herding effect (De Bondt & Forbes, 1999). The herding effect refers to a phenomenon where investors follow the actions and join others under the assumption that they have done their research and due diligence (Spyrou, 2013). Whereas confirmation bias is when investors tend to pay more attention to information that confirms their views and beliefs (Cipriano & Gruca, 2014).

In short, behavioural finance's explanation for the momentum effect is that there is an initial market underreaction caused by anchoring, conservatism bias, slow diffusion of information and the disposition effect. Following the initial underreaction there is a catch-up process which results in a subsequent overreaction due to herding, representativeness, confirmation bias, and over-confidence all of which intensify momentum.

EMH states that an investor cannot outperform the market and that market anomalies should not exist because they are instantaneously arbitraged away. However, this does not seem to be the case for stock return momentum strategies as they continue to generate excess returns (Jegadeesh & Titman, 2011). Jegadeesh and Titman (2011) also argued that perhaps the momentum effect is the strongest evidence against EMH. For this reason, the momentum anomaly has attracted substantial research, where academics are even looking towards behavioural explanations of this phenomenon, making momentum an interesting future area of research. Since, there in still no broad consensus to what is the driving force behind momentum. Behavioural finance has compellingly linked the momentum effect to cognitive bias and irrational behaviour, contrasting traditional finance and the assumption of rationality.

2.3.3.2 Industry Momentum

Moskowitz and Grinblatt (1999) documented that industry momentum plays a major role in individual stock momentum. Industry momentum appears to drive and contribute substantially to the profitability of individual stock momentum strategies (Scowcroft & Sefton, 2005). Significantly, industry momentum captured almost the entirety of the 12-month individual stock momentum profits (Moskowitz & Grinblatt, 1999). It was found that momentum strategies are quite poorly diversified since the losers and winners tend to be from the same

industry, however industry momentum strategies do appear to be more profitable and implementable (Moskowitz & Grinblatt, 1999). Industry momentum is very robust and remains strong among the largest and most liquid stocks unlike individual stock momentum and consistently absorbs stock momentum at every horizon but never the inverse (Moskowitz & Grinblatt, 1999). Furthermore, Moskowitz and Grinblatt (1999) claim that most of the 12-month individual stock momentum strategies are a result of tax-loss selling around year end. Thus, industry momentum may be a key factor in understanding return persistence anomalies (Moskowitz & Grinblatt, 1999). The questions still remain; what is the driving force behind industry momentum? Are behavioural explanations the closest link? Researchers were able to conclude that return momentum is not a result of differing industry exposures to systematic risk or cross-sectional dispersion in industry mean returns (Scowcroft & Sefton, 2005).

2.3.3.3 Risk

Risk is a crucial factor when it comes to momentum and a key source of debate among academics. The EMH supporters argue that all investors are rational and that momentum profits are compensation for taking on additional risks. However, linear rational pricing models fail to capture the momentum effect such as Fama and French's (1970) three factor risk model and the CAPM (Scowcroft & Sefton, 2005). Researchers looked at a vast range of risk factors to account for the momentum effect but had little success. However, researchers did document that in a large-cap context, price return momentum is driven by industry momentum, but in a small-cap context individual stock momentum is the driving force (Scowcroft & Sefton, 2005).

2.3.3.4 Other Explanations

Trading costs lead to market asymmetries and give rise to anomalies such as momentum. Most momentum research has been conducted without realistic transaction costs while the implementation of a momentum strategy is likely to experience significant trading costs. (Li, et al., 2009). The reason being, momentum strategies heavily weight small stocks with low prices as well as low trading volumes, all of which add to the increased transaction costs. Furthermore, momentum trading is high frequency trading as investors must continually buy winners and sell losers (Antonacci, 2014). Lower trading volume and large bid-ask spreads result in increased liquidity risk (Li, et al., 2009). Liquidity risk is a key reason for large bid-ask spreads. Li, et al., (2009) found round trip transaction costs can average as high as 3.77% for winners and 6.71% for losers. Loser's high trading costs were a result of low market

capitalization, lower trading volume and a lower price than the winners. Accordingly, the average round trip quoted spreads are 3.76% for losers and 2.21% for winners, which suggest that trading costs are asymmetric (Li, et al., 2009). In other words, the practice of selling losers is predominantly responsible for the high trading costs associated with momentum strategies. The costs come down to the size and trading volume of winners and losers. Selling small capitalisation loser stocks with low trading volumes attracts significantly high transaction costs while the cost of buying them is significantly less (Li, et al., 2009). In addition to the above trading costs, brokerage commission and taxes further decrease the profitability of momentum strategies. Some researchers such as Carhart (1997) found the impact of transaction cost to be severe on profitability and too great for momentum strategies to be exploitable (Clare, et al., 2010). It is evident that transaction costs play a major role in momentum strategies' profitability. However, different momentum strategies have vastly different transaction costs. For instance, many momentum portfolio strategies were criticised because they used only the top 10% best performing momentum stocks that suffered from large spreads, illiquidity, and high frequency trading which in turn drove up transaction costs (Clare, et al., 2010). On the other hand, momentum strategies with lower trading frequency such as monthly portfolio rebalancing and use of larger indexes with small spreads and a greater liquidity yield far superior returns just by changing the cost structure (Clare, et al., 2010). For example, some that shortlisted the 10%, 20% and 50% of losers and winners which focused on reducing total transaction costs generated net average returns of 18.24%, 15.84% and 12.49% respectively (Li, et al., 2009). Thus, momentum-based strategies that adopt a low-cost attitude can enhance returns significantly which is what Antonacci (2014) did by low frequency trading in large indexes with low costs that characteristically had small spreads and high liquidity.

2.3.4 Problems with Momentum Investing

There are significant problems with regards to momentum investing. Similarly, to most other investment strategies, there are shortfalls and momentum investing is no different. To follow are the key problems associated with momentum investing:

2.3.4.1 Scalability

Momentum is a high turnover strategy, which can be expensive for the funds that are trading the relevant stocks, which can also lead to poor tax efficiency (Antonacci, 2014). The trading cost associated with buying and selling shares on a frequent basis can significantly accumulate

over a year. Momentum stocks tend to have wide bid-ask spread due to their increased volatility. For this reason, trading cost can completely dimmish momentum returns since it is a high turnover strategy (Clare, et al., 2010). As highlighted in section 2.3.3.4 trading costs can largely differ depending on trading frequency, trading volume, spreads, or whether the strategy uses individual stocks or indexes.

Momentum works best when an investor is focused on a few top performing momentum stocks. In other words, the more selective and concentrated an investor is when selecting momentum stock, the more profitable the strategy will be (Antonacci, 2014). Conversely, if an investor has a larger portfolio and isn't very selective then returns will diminish. Similarly, the holding period has the same impact on momentum returns (Jegadeesh & Titman, 1993). The longer the holding period before rebalancing the greater the decrease in returns. Thus, for more optimal returns a momentum investor would aim to have a focused and concentrated portfolio with frequent rebalancing, such as monthly rebalancing no more than quarterly rebalancing. Another issue of scalability is that all momentum investors flock to the same top performing momentum stocks (Antonacci, 2014). The problem arises when several billions of dollars flood the same small selection of stocks every month as investors try to enter and exit their positions (Antonacci, 2014). Meaning that momentum investing would become less, and less profitable as exorbitant amounts of dollars enter and exit the same few selected top performing momentum stocks.

2.3.4.2 Duration and Market Timing

Momentum is an intermediate term phenomenon, meaning that the strategy should have a look-back period of no longer than 12 months and no less than 3 months (Jegadeesh & Titman, 2011). The momentum effect is especially strong over a 6 to 12-month interval (Antonacci, 2014). Stocks are found to be mean reverting over a 3 to 5-year period as well as on a short-term interval of 1 month or less (De Bondt & Thaler, 1989). Shorter look-back periods tend to have a lot more whipsaws (Antonacci, 2014).[3] Therefore, longer look-back (i.e., less than 12 months) periods minimise whipsaws and trading costs. In conclusion, the issue with momentum investing is that it is temporary since the momentum effect is strongest over a 3 to 12-month interval. Meaning that the portfolio will require frequent rebalancing and cannot hold

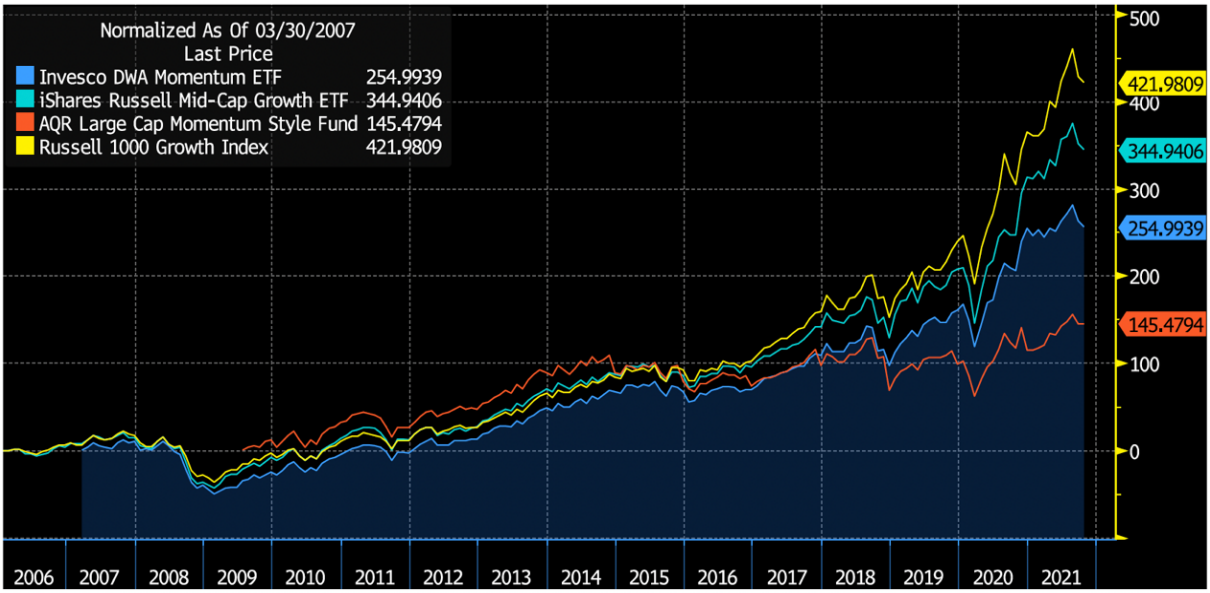
[3] A whipsaw describes a sharp fluctuation in asset price contrary to the prevailing trend (Banton, 2020)

over the long-term. Furthermore, Antonacci (2014) found that momentum strategies tend to struggle during periods of high market volatility. This is because in the late stages of market rally, momentum strategies often overweigh more cyclical stocks (Antonacci, 2014). These cyclical stocks are the same stocks that get negatively impacted the most during a stage of market corrections as momentum strategies tend to overweigh the more defensive stocks and miss out on early market recovery stages (Antonacci, 2014).

2.3.4.3 Benchmark Performance

Momentum investing can be a very profitable strategy, but how have momentum funds performed against their benchmarks? More specifically, consider the performance of the two oldest momentum funds illustrated in **Figure 2**. The first fund is the Invesco DWA Momentum ETF (blue) started in March 2007. It is a focused portfolio of 100 stocks. The benchmark for this fund is the Russell Mid-Cap Growth Index (turquoise) which also has an ETF.

***Figure 2**: Momentum Funds versus their Appropriate Benchmarks (Bloomberg, 2021)*



From inception in 2007, the benchmark has convincingly outperformed the DWA Momentum ETF. Moreover, compare the second oldest momentum fund is the AQR Large-Cap Momentum Mutual Fund (orange) which began in 2009 and its benchmark is the Russell 1000 Growth Index (yellow). The AQR Large-Cap Momentum Mutual Fund is tremendously outperformed by the benchmark. It should not be forgotten that both these outperformances are before factoring an issue of scalability which is slowly becoming a major problem (Antonacci,

2014). In short, the two oldest momentum funds are both being overperformed by their benchmarks, which begs the question is momentum investing a worthwhile investment?

The aforementioned problems associated with momentum investing are considerably severe. When comparing the performance of the two oldest momentum funds to their benchmarks, momentum investing doesn't even seem rational. There are fundamental problems with this style of investing. However, literature has shown that momentum is robust and universally applicable. Antonacci (2016) proved that momentum works better with indices than it does with individual stock, indicating that stock index momentum outperforms other assets. For this reason, the dual momentum strategy can solve much of the aforementioned issues and will be discussed in greater detail in section to follow.

2.3.5 Dual Momentum

Momentum is the empirically observed tendency of asset prices to persist in their performance resulting in positive autocorrelation (Jegadeesh & Titman, 2011). In other words, falling asset prices deteriorate further and rising asset prices ascend even further. This market anomaly in finance theory is largely unexplained since a rise in asset price should not warrant any further increase by itself. A loose interpretation of momentum profits is the lagged reaction to information (Lewellen, 2000). Evidence suggests that momentum profits arise as a result of delayed reactions to firm specific information (Jegadeesh & Titman, 2011). The following two types of momentum are the foundation of which the dual momentum strategy is built.

2.3.5.1 Relative Momentum

Antonacci (2016) refers to cross-sectional momentum as relative momentum. Cross-sectional momentum is a relative strength measure of stocks or asset classes to determine past winners and losers. It is based on price trends between different securities or markets in the cross-section and looks at the relative strength of the cross-section (Shell, 2021). Once the relative strength of the stocks or markets has been determined, they are then ranked to see where performance has been gained or lost. Cross-sectional momentum is the method used by Jagadeesh and Titman (1993).

2.3.5.2 Absolute Momentum

Time-series momentum otherly known as absolute momentum, is the rate of change of stocks or markets over a period (Shell, 2021). Time-series is the price trend of an assets own price return to determine future performance (Antonacci, 2016). Thus, absolute momentum can be used as a trend following strategy. In addition, absolute momentum appears to be as universally applicable and robust as relative momentum (Antonacci, 2016).

2.3.5.3 Dual Momentum as a Strategy

Researchers of relative momentum simultaneously use short and long positions to both the short and long side of the market since long momentum positions hedge short ones, and vice versa. However, when applying dual momentum, Antonacci (2016) specifies it is desirable to be long only over the long term. Antonacci (2016) used the term dual momentum to describe a momentum strategy where he combined absolute and relative momentum. The strategy worked by selecting an asset with a positive momentum on a relative basis, meaning that if an asset had appreciated more than another asset it has relative positive momentum. After which the same asset would be analysed for positive absolute momentum, thus checking for excess return of the asset over its look back period. Absolute momentum of an asset can also be determined by subtracting the risk-free rate and if the asset has excess returns, it has positive absolute momentum. Importantly, absolute momentum is analysed regardless of its relative performance. Therefore, it is possible for an asset to have negative absolute momentum but positive relative momentum. In short, the strategy combines the relative strength price momentum with trend following absolute momentum (Antonacci, 2016).

The dual momentum strategy is better illustrated by Antonacci's (2016) implementation and reasoning. In a globalised world, large conglomerates have operations across the globe, meaning that there may not be as much value to international diversification on a company level. However, with respect to where profits are derived from that is not what is really going on. Antonacci (2016) found that when the dollar is strong, U.S. stocks tend to underperform to non-U.S. stocks, thus it is irrational for an investor to be long and short the U.S. dollar. Yet, the majority of investors with global portfolios, long U.S. and non-U.S. stocks simultaneously which Antonacci (2014) refers to as vertical diversification. If a strategy is always divided 60% in the S&P 500 Index and 40% in the MSCI ACWI ex U.S. (**All Country World Index excluding U.S)**, a drag on the portfolio's performance will be created by whichever asset is

underperforming**.** What relative momentum does when it is applied to the S&P 500 and MSCI ACWI ex U.S., is it provides the investor with horizontal diversification which is a temporal diversification (Antonacci, 2014). In other words, the investor is able to invest dynamically by investing in which ever asset is strongest over time which also means the portfolio diversifies over time. Despite this, the portfolio can still experience downsides as a result of bear markets. In bear markets investors typically reduce equity risk by investing in bonds (Antonacci, 2014).[4] However, by investing in bonds an investor isn't able to generate as high a return as equity, which is where Antonacci (2016) applies absolute momentum, a strategy that enables the investor to invest in equity when it is the strongest or invest in bonds when they are strongest. Therefore, the absolute momentum model switches between the S&P 500 Index and the Barclays US Aggregate Bond Index (monthly rebalancing and 12-month look back period).[5] Like relative momentum, absolute momentum will not enter and exit trades at peaks and troughs since it is trend following and reacts in a way similar to moving average, but with better results (Antonacci, 2014).

Therefore, the two types of momentum, relative momentum, and absolute momentum are combined to form dual momentum. Relative momentum compares performance to it peers and absolute momentum compares performance to itself over the past 12-months. Antonacci's (2016) dual momentum strategy first analyses absolute momentum to see whether the investor wants to be invested in stocks or bonds; if the investor is going to be in stocks, then he uses relative momentum to tell whether to be in U.S stocks (i.e., S&P 500) or non-U. S stocks (i.e., MSCI ACWI ex U.S). If the S&P 500 has increased over the past 12-months it has absolute momentum and then investors will analyse the S&P500 for positive relative momentum against the ACWI ex U.S and invest in whichever of the two assets has positive relative momentum. However, if the S&P500 has negative absolute momentum the investor will switch to the Barclays U.S. Aggregate Bonds Index. All of which is re-evaluated monthly. By performing the above strategy, Antonacci (2014) found the following.

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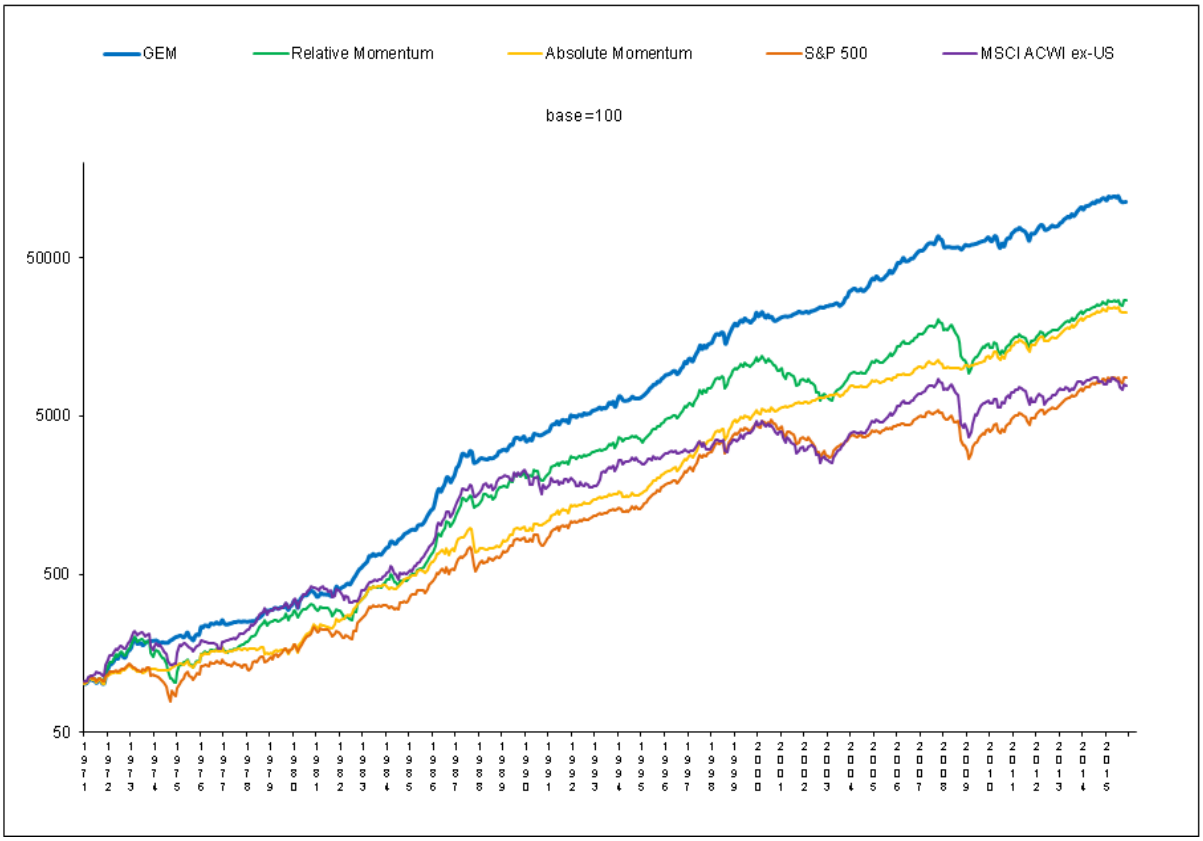
[4] The stock market is a leading indicator. Thus, when stocks start to weaken it is a leading indicator of an approaching recession. As a result, the Federal Reserve will begin to lower interest rates to stimulate the economy which is good for bonds holders as they capture higher returns from rising bond interest rates (Antonacci, 2016).

[5] Barclays U.S Aggregate Bond Index holds high investment grade bonds, 78% of the bonds held are AAA-rated (Bloomberg, 2021).

Figure 3 illustrates the dual momentum strategy labelled as Global Equity Momentum (**GEM**). GEM is the dual momentum strategy but more specifically represents the rotation between U.S. indexes (i.e., S&P 500) and foreign indexes (i.e., MSCI ACWI ex-U.S.), to gain offshore exposure instead of just applying the dual momentum strategy confined to U.S. indexes only. **Figure 3** importantly highlights the superior outperformance of the dual momentum strategy (blue). Both absolute momentum (yellow) and relative momentum (green) were able to outperform the two indexes, specifically the S&P500 (orange) and the MSCI ACWI ex-U.S. (purple). Note, both relative and absolute momentum are completely dwarfed by the outperformance of the combined dual momentum strategy.

***Figure 3**: Dual Momentum (Antonacci, 2016).*



The dual momentum strategy (GEM) avoided all significant bear markets while still capturing upside return (Antonacci, 2016). This is due to the inclusion of absolute momentum. Absolute momentum (yellow) avoided all significant bear markets which limited the strategy's drawdown while still managed to capture the upside returns. The dual momentum strategy captured the significant upward spikes in relative momentum which is illustrated in **Figure 3** as the dual momentum moves with relative momentum. However, most importantly the dual

momentum strategy did not follow relative momentum in bear markets but switched to absolute momentum and therefore started to outperform. **Figure 3** represents quantitatively **Table 1** below:

***Table 1**: The Dual Momentum Strategy's Performance Results (Antonacci, 2016)*

Dual Momentum				
(Jan 1971 - Feb 2016)	CAGR	Standard Deviation	Sharpe Ratio	Worst Drawdown
Dual Momentum	16.7%	12.6%	0.87	-17.8%
Absolute Momentum	12.6%	12%	0.60	-29.6%
Relative Momentum	13%	16%	0.51	-54.6%
S&P500 Index	10.2%	15.2%	0.36	-51.0%
MSCI ACWI ex-U.S.	9.8%	17.3%	0.32	-57.4%
Results are hypothetical and do not represent returns that any investor actually attained. Furthermore, the indexes do not reflect any management or trading fees.				

Table 1 quantitatively displays the dual momentum strategy's results from January 1971 to February 2016. The Compound Annual Growth Rates (**CAGR)** of the MSCI ACWI ex U.S and S&P500 index are around 10% per year and a standard deviation of 17.3% and 15.2% respectively. Moreover, the worse drawdowns on a month end basis were both over 50%. Moving on to relative momentum the return increases by 300 basis points up to 13%. However, standard deviation remains high at 16% as well as a worst drawdown of -54.6%, similar to the indexes. Looking at absolute momentum, which also displays an increase in return just shy of 300 basis points from the indexes, resulting in a fall of its standard deviation to 12% as well as its worst drawdown dips below 30%, as a result of switching to Barclays aggregate bonds. Lastly, looking at the performance of dual momentum, returns soar to 16.7%. This return is similar to the returns that stock momentum generates, however, dual momentum does not have the same issues associated with stock momentum (Antonacci, 2014). These issues were disclosed in section 2.3.4. The issue of scalability is no longer an issue since investing in indexes enables the investors to invest as much as they want. Furthermore, index investing significantly reduces transaction costs and on average the dual momentum strategy only has 1.3 trades per year (Antonacci, 2016). Trading highly liquid indexes with large market capitalisations as well as ETF's offer even lower trading costs (Antonacci, 2016). Nevertheless,

the most significant figure displayed by **Table 1** is dual momentum's ability to avoid bear markets with a standard deviation of 12.6% and worst drawdown of sub 20%. Therefore, dual momentum exhibited a strong comparative performance which can be further explained by separating the strategy's results according to bear and bull markets as done in **Table 2**.

***Table 2**: Bear and Bull Performance Results (Antonacci, 2016)*

Bull Markets			**Bear Markets**		
Date	S&P 500	Dual Momentum	**Date**	S&P 500	Dual Momentum
Jan 71 – Dec 72	36.0%	65.6%	**-**	-	-
Oct 74 – Nov 80	198.3%	103.3%	**Jan 73 – Sep 74**	-42.6%	15.1%
Aug 82 – Aug 87	279.7%	569.2%	**Dec 80 – Jul 82**	-16.5%	16%
Dec 87 – Aug 00	816.6%	730.5%	**Sep 87 – Nov 87**	-29.6%	-15.1%
Oct 02 – Oct 07	108.3%	181.6%	**Sep 00 – Sep 02**	-44.7%	14.9%
Mar 09 – Nov 15	225.7%	89.4%	**Nov 07 – Feb 09**	-50.9%	-13.1%
Average Return	277.4%	289.9%	**Average Return**	-36.9%	3.6%

Table 2 expresses why the dual momentum strategy outperformed the indexes so significantly. Dual momentum is far superior within bear markets. The S&P500 returned an average of -36.9% in bear markets while the dual momentum strategy returned an average of positive 3.6%. The strategy not only outperformed in bull markets but generated positive returns in bear markets, thus achieving crises alpha. Due to absolute momentum, a rising interest rate environment is actually good for the strategy since it shifts to bonds, the strategy is in bonds roughly 30% of the time. In other words, dual momentum does well to eliminate left tail risk as well as extend right tail returns as a result of its positive skew. Therefore, the strategy advantageously has higher returns, high scalability, low trading costs and low downside risk. The strategy does, however, come with risks.

One of the major risks of the dual momentum strategy is that there is significant tracking error (Antonacci, 2014). Most investment professionals cannot have such a high tracking error due to their investment mandates. The reason for the tracking error is that it follows bear markets, where dual momentum dramatically outperforms (Antonacci, 2014). The second risk is that in bull markets the strategy experiences whipsaws and lags due to the inclusion of absolute momentum. The strategy is trend following so things can go temporarily wrong. The last major

risk is that there is short term volatility. Momentum's extraordinary returns are enhanced by short-term volatility which needs to be embraced by the investor when using dual momentum.

2.3.5.4 Empirical Findings Overview

The dual momentum strategy yielded significant performance improvements using 38 years of past performance data without the use of smart betas, risk parity or finding models that over fit the data (Antonacci, 2016). These improvements were found in all four areas examined by Antonacci (2016), specifically equities, real estate, credit risk and economic stress. The empirical findings of Antonacci (2016) are as follows:

I. Dual momentum's combination of absolute and relative momentum works best for long-side momentum, since both relative and absolute momentum can enhance expected return. Absolute momentum's trend determination can significantly mitigate downside risk as well as take advantage of upside persistence. Furthermore, portfolios that employ dual momentum can benefit from low correlations, thus making multi-asset portfolios attractive to investors.

II. Investors can avoid high volatility yet still enjoy decent returns. Portfolio managers are more concerned about downside variability than total volatility. For this reason, absolute momentum is significantly valuable as it reduces the potential drawdown, which is associated with high downside volatility, while helping investors harvest upside volatility and converting it into abnormal returns.

III. Modules can isolate and target specific risk factors and be used as an effective hurdle rate.[6] Modules also impose diversification and flexibility on a momentum portfolio making the implementation of the dual momentum strategy simple.

In short, absolute momentum acts as a better asset filtration system which significantly reduces drawdowns, lowering the strategy's downside volatility (i.e., left tail risk). Thus, absolute momentum plays a key adaptable defensive role in the strategy as it acts as a hurdle rate yet allows market risk when it makes the most sense (i.e., positive absolute momentum), while the

[6] Antonacci's (2016) module approach splits the strategy into two parts (i.e., absolute momentum and relative momentum) making the execution of the strategy much easier.

combination of relative and absolute momentum captures upside volatility and converts it into abnormal returns. Meaning that the strategy is effective at capturing risk premia from volatile assets. At the same time, dual momentum increases diversification and adaptability by selecting assets only when both relative and absolute momentum are positive. These are the assets that are more likely to persistently appreciate.

3. Methodology

The dual momentum strategy proposed by Antonacci (2014) is praised for its simplicity, practicality, and robustness. The model provides economically and statistically significant risk-adjusted excess returns, while also being parsimonious without the use of any smart betas or advanced modelling (Antonacci, 2014).

3.1 The Look-back Period

The look-back period is a crucial part of the dual momentum strategy since momentum is an intermediate-term phenomenon as well as it is modelled off historical price changes. The look-back period is key when it comes to implementing the dual momentum strategy since it can greatly affect the profitability of the strategy. A look-back period too long can include irrelevant data and a look-back period too short cannot be relevant enough. As in the aforementioned Section 2.3.1, the momentum effect has been studied and researched over various look-back periods. As a result, the majority of academic literature uses 12-months. A 12-month look-back period is observed to have a significantly strong momentum effect (Antonacci, 2016). In short, literature suggests that a look-back period of 12-months is most optimal, particularly with long-term strategies. The look-back period is also the same used by Antonacci (2016) and avoids data snooping. Therefore, a 12-month look-back period will be used in this research paper.

It is also important to mention that when it comes to equity returns, it is often common practice to skip the most recent month of the look-back period (Antonacci, 2016). This is to disentangle short-term reversal effect from the momentum effect (Antonacci, 2016). The short-term reversal effect is related to microstructure issues and liquidity, and non-equity assets suffer less from liquidity issues (Antonacci, 2016). However, for consistency reasons since various asset

classes including equities will be used, rebalancing will be done monthly without skipping any months.

3.2 Absolute Momentum

In order to calculate absolute momentum (time-series momentum), the following formula is used:

$$AM_{it} = R_{it=k} - Rf_{rt=k} \quad (3)$$

AM_{it} represents absolute momentum for asset i at time t. Where, $R_{it=k}$ is the return of asset i over the look-back period k (i.e., 12-months) and $Rf_{rt=k}$ is the return of the risk-free asset over the look-back period k. Therefore, the absolute momentum of asset i is calculated by subtracting the return of the risk-free asset from the return of asset i over the look-back period k, which is set to 12-months. Should asset i have positive excess returns by outperforming the risk-free asset over the 12-months look-back period, then asset i exhibits positive absolute momentum. Conversely, should asset i have negative excess return by underperforming the risk-free asset over the 12-month look-back period, then asset i exhibits negative absolute momentum.

$$Positive\ absolute\ momentum:\ AM_i > 0 \quad (4)$$

$$Negative\ absolute\ momentum:\ AM_i < 0 \quad (5)$$

3.3 Relative Momentum

In order to calculate relative momentum (cross-sectional momentum), the following formula is used:

$$RM_{it=k} = \frac{P_{it=0} - P_{it-k}}{P_{it-k}} \quad (6)$$

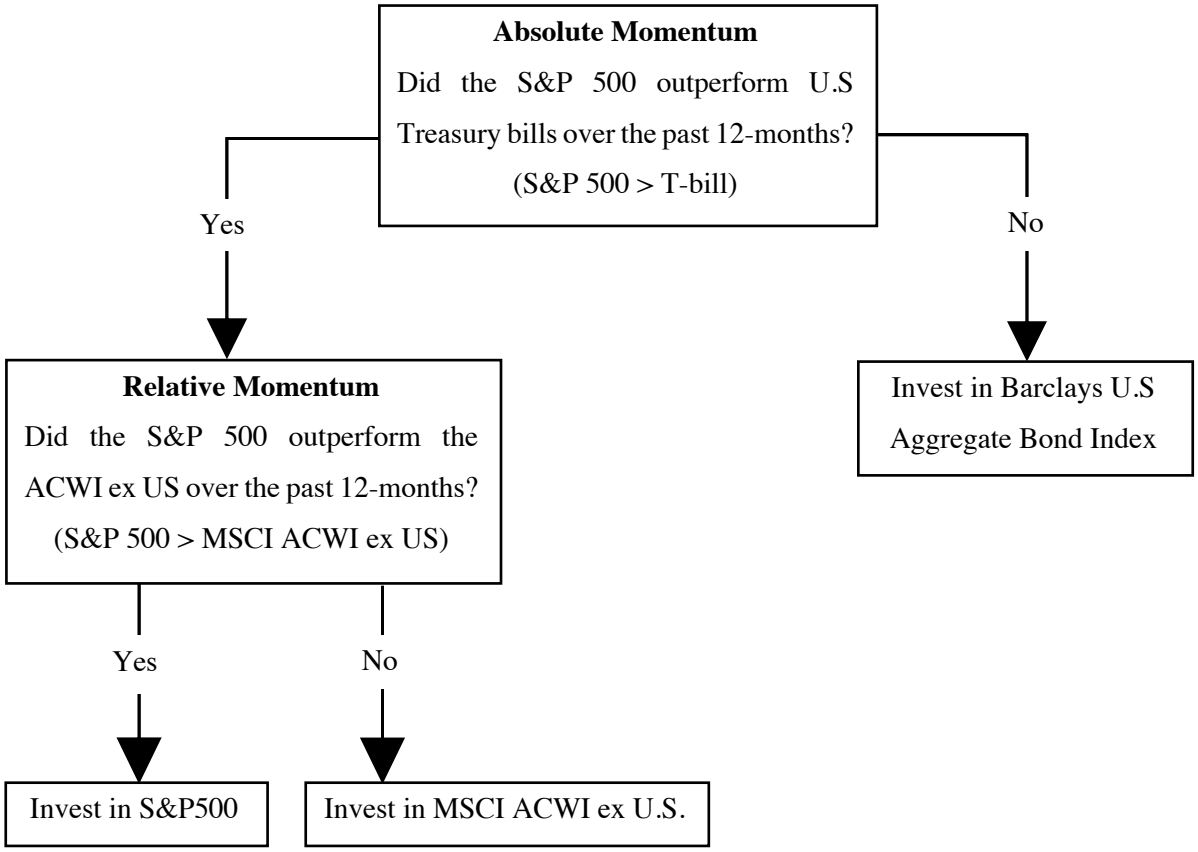
$RM_{it=k}$ is the relative momentum of asset i over the look-back period k. Where, $P_{it=0}$ is current price P of asset i and P_{it-k} is price P of asset i at time $t-k$. Therefore, the current price P of asset i less the price P of asset i at time $t-k$, divided by price P of asset i at time $t-k$ calculates asset i's relative momentum. In other words, relative momentum is equal to the percentage change of asset i's price over a 12-month look-back period.

3.4 Implementation of Dual Momentum

The dual momentum strategy described by Antonacci (2016) combines the relative strength price momentum with trend following absolute momentum. Antonacci (2016) begins by checking whether the S&P 500 Index has positive or negative absolute momentum with respect to the risk-free asset over the 12-month look-back period. The 90-day U.S Treasury bill is used as the risk-free asset. Therefore, Treasury bills are used as a hurdle rate before the investor can invest in other assets, since an investor can only invest in an asset if it has both absolute and relative momentum with regards to a dual momentum strategy. If the S&P 500 does not have positive absolute momentum, then Antonacci (2016) invests in an alternative proxy investment until the selected asset is stronger. The alternative proxy investment used is the Barclays U.S Aggregate Bond Index which also serves as a safe haven during economic downturn. If the S&P500 has positive absolute momentum the investor will then analyse the S&P 500 for positive relative momentum.

The second stage of the implementing the dual momentum strategy is the inclusion of relative momentum, where a second asset is considered. Thus, the asset which has appreciated the most on a relative basis has positive relative momentum. Antonacci (2016) uses the MSCI ACWI ex US as the second asset which is compared on a relative basis to the S&P 500. The ACWI ex US provides the strategy with rotational abilities between the U.S market (i.e., S&P 500) and the offshore exposure of the ACWI ex U.S, which also offers protection from bear markets in the US (Antonacci, 2016). If the S&P500 appreciated more than the ACWI ex US, then the S&P500 has positive relative momentum. The investor will buy/hold their position in the S&P500. On the other hand, if the ACWI ex US has positive relative momentum then the investor will buy/hold their position in the ACWI ex US. Thereafter, the 2-stage process is repeated monthly with a 12-month look-back period. The dual momentum strategy is illustrated below in **Figure 4**.

***Figure 4**: Dual Momentum Strategy Flow Diagram.*



Antonacci (2014) highlights that the dual momentum strategy can also be implemented with the use of EFT's. EFT's closely track indexes that Antonacci (2014) uses in his dual momentum strategy. EFTs are a marketable security meaning that they are highly liquid and can be bought and sold very easily by investors. This is important for momentum strategies since they require frequent rebalancing. Lastly, EFTs tend to come with lower transaction costs.

3.5 The Implementation of Dual Momentum from a South African Perspective

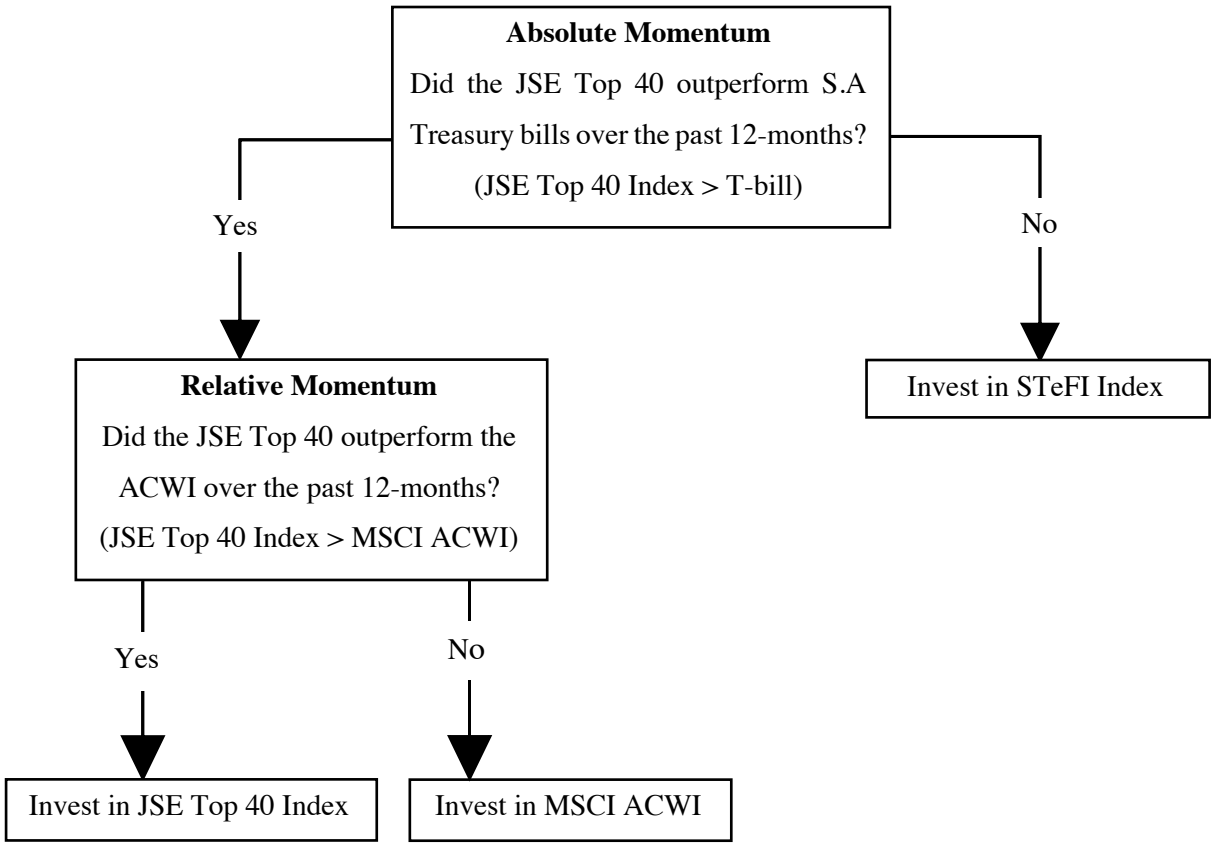
The dual momentum strategy will be applied from a South African perspective. The same two-stage process described in section 3.4 will be implemented, however within a South African context. The first stage will assess the JSE Top 40 index for positive absolute momentum by subtracting the risk-free asset. The risk-free rate used will be the South African 91-day Treasury bill and will serve as the hurdle rate. If the JSE Top 40 index has negative absolute momentum the investor will invest in the Short-term Fixed-interest index (**STeFI**) which will serve as the

alternative proxy investment and acts as a safe haven during economic downturn.[7] The STeFI is used over a South African bond index due to South African government bonds baring additional risk, as a result of higher duration risk and default risk. Higher duration risk is due to large swings in interest rates and inflation, and higher default risk is due to growing debt concerns as well as the mismanaged and financially burdening State-Owned Enterprises (**SOE)** such as Eskom and South African Airways (**SAA)** (Moody's, 2020)**.** Therefore, investing into the STeFI will avoid increased volatility and credit risk. If the JSE Top 40 Index has positive absolute momentum the investor will then analyse the JSE Top 40 for positive relative momentum in the second stage of the dual momentum strategy.

The second stage will assess the JSE Top 40 for positive relative momentum on a relative basis against a second asset. The second asset will be the MSCI ACWI and the asset which has appreciated the most has positive relative momentum. The MSCI ACWI will provide offshore exposure and rotational ability from a bear South African market. Therefore, if the JSE Top 40 has positive relative momentum the investor will buy/hold the JSE Top 40 and if the ACWI has positive relative momentum the investor will buy/hold the ACWI. Thereafter, the strategy will undergo monthly rebalancing and have a look-back period of 12 months as mentioned in section 3.1. The dual momentum strategy from a South African perspective is illustrated below in **Figure 5**.

[7] The STeFI Index is highly liquid and includes instruments that cover all maturities in the short-term market up to one year (Forbes, 2001)

***Figure 5**: South African Dual Momentum Strategy Flow Diagram.*



The dual momentum strategy will also be applied to different sectors across the South African market and not only look at JSE Top 40 Index. The same dual momentum strategy above will be applied to several sectors individually, where the JSE Top 40 Index will essentially be substituted with a bond index (ALBI), a resource index (RESI), a financial index (FINI), an industrial index (INDI), and lastly a property index (SAPY). This will provide greater insight to whether the momentum effect is present across different South African sectors as well as its relative strength. Furthermore, a second variation of the dual momentum strategy will be applied to the above-mentioned indexes including the JSE Top 40, however all the indexes will be pooled together where only the top performing index gets invested in, given that the index exhibits both positive absolute momentum and positive relative momentum.

3.6 Performance Measures

The model in section 3.5 is to be evaluated using a group of quantitative tools to better analyse the results. These measures will adequately indicate whether the dual momentum strategy is viable from a South African perspective. The dual momentum strategy's performance will be evaluated using the following performance measures in accordance with Antonacci (2016):

3.6.1 Return

Return is a key measure of performance and will be used to compare the strategy to that of the benchmark. The returns of the strategy will be measured as an annual average return as well as the total cumulative returns over the entire sample period.

$$R = \frac{V_E - V_I}{V_I} \tag{7}$$

Where, V_E is the value of the investment at the end of the investment period and V_I is the value of the investment at inception.

3.6.2 Standard Deviation

Standard deviation is a measure of dispersion and when applied to an investment's rate of return it shows the historical volatility. One drawback of the statistical measure is that it is impacted by outliers as well as standard deviation assumes price movement in either direction equally as risky. Nevertheless, standard deviation will measure the volatility of returns indicating the strategy's associated risk level and is calculated as follows:

$$SD(\sigma) = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} \tag{8}$$

Where, x_i is the value of the i^{th} data point, $\bar{x}$ is the mean value of the data set, n is the number of data points in the data set. In other words, standard deviation (σ) is the square root of variance which is calculated by determining each data point's deviation from the relative mean.

3.6.3 Sharpe Ratio

The Sharpe ratio is a widely used financial risk metric. It is a useful metric because it describes how much excess return is received by an investor for its given volatility. Furthermore, the ratio does have vulnerabilities. For instance, it assumes investment returns are normally distributed and makes no distinction between downside and upside volatility. Thus, it equally penalises downside risk and upside return potential. In short, the metric is a measure of risk adjusted return and formulated as:

$$Sharpe\ Ratio = \frac{R_i - R_f}{\sigma_i} \tag{9}$$

Where, R_i is the return of asset i, less the risk-free rate R_f divided by the standard deviation σ_i of asset i. Therefore, the ratio is the excess average return after the risk-free rate, divided by the standard deviation which provides the performance of an asset per unit of volatility.

3.6.4 Maximum Drawdown

An important measure for dual momentum strategy is maximum drawdown which is a simple and intuitive indicator of tail risk. It is the maximum fall in value of an investment which is an indicator of downside risk. It is however important to take note that it only measures the largest loss and not the frequency of the losses. In short it is the maximum observed loss from a peak to a trough and is calculated as the following:

$$Maximum\ Drawdown\ (MDD_i) = \frac{TV_i - PV_i}{PV_i} \tag{10}$$

Where, TV_i is the trough value of asset i, and PV_i is the peak value of asset i. Thus, MDD_i is the maximised observed percentage that price moves down from a new high.

3.6.5 Jensen's Alpha

Jensen's Alpha is a key measure in determining abnormal returns of a security or portfolio. It is a measure of the marginal risk associated with an additional strategy that is not explained by the existing factors. Therefore, if the Jensen's alpha is significant and positive, then the dual

momentum strategy has a history of generating excess returns on the expected returns based on other factors. Jensen's measure is expressed as:

$$\alpha_i = R_i - [R_f + \beta_i(R_M - R_f)] \quad (11)$$

Where, α_i is the alpha for asset i, R_i is the realised return of asset i, R_f is the return of the risk-free rate, β_i is the beta of asset i, and R_M is the market return.

3.6.6 Additional Measures

Further descriptive statistics will assist in analysing and explaining the results of the dual momentum strategy as well as provide insight on the distribution of returns. Therefore, measures such as kurtosis and skewness will form part of the performance measure used to analyse the dual momentum strategy.

These performance measures form a framework to effectively evaluate the dual momentum model illustrated in section 3.5. These useful tools will produce comparative returns, standard deviations, alphas, profits, Sharpe ratios and maximum drawdowns.

4. Data

All the indices' price data will be obtained from the Bloomberg terminal. The sample period will go as far back as possible, to when the indexes were commenced. The data collected will be the historical monthly total returns of eight indexes specifically the JSE Top 40 Index, STeFI Index, ALBI Index, RESI 20 Index, FINI 15 Index, INDI 25 Index, SAPY Index, MSCI ACWI, all of which is inclusive of interest and dividends. The data used will span over the 2008 financial crises and the Covid-19 pandemic in 2020. The data will then be processed and analysed and will not be adjusted for trading costs. Since trading costs tend to be marginal with the use of indexes and ETF's. In addition, the use of large-capitalisation and highly liquid indexes would further reduce trading costs.

Data selection plays a significant role in the dual momentum strategy. The strategy is not effective when trading costs are too high which is why the strategy is not applied to stocks. Key to the dual momentum strategy is selecting indexes with enough market capitalisation and

liquidity to exit and enter positions while keeping transaction costs down. This is the reason for the JSE top 40 index being selected and it will perform the same role as the S&P 500 does for Antonacci (2016).

5. Results

This section reports an overview of the study's results which is illustrated and analysed with key graphs and tables. The results section is separated into three categories beginning with the most important and focal point of this study, the dual momentum strategy which is constructed using the JSE Top 40 index. It is then followed by a supplementary section where the dual momentum strategy is applied to several South African indices across different sectors. Lastly, the third and second supplementary section displays the results of the dual momentum strategy applied to a pool of indexes made up from the previous section's indexes. The only constants in all three sections are the South African 91-day Treasury bill which serves as the hurdle rate, the STeFI as the safe haven for when the indexes do not achieve absolute momentum, and the MSCI AWCI for offshore exposure when the indexes are not able to achieve relative momentum.

5.1 The Dual Momentum Strategy

The results presented in section 5.1 is the core dual momentum strategy and focal point of this study, thus it will be analysed in greater detail. The model uses the JSE Top 40 as its key input and the results are as follows.

5.1.1 Presentation of the Results

First the results look at the performance of the strategy relative to its input indexes the JSE Top 40 index, MSCI AWCI index and the STeFI index. The data used is over a 17.5-year (210 months) time horizon from when the STeFI index commenced in back 2004.

***Figure 6**: The Dual Momentum Strategy's Performance (2004-2021)*

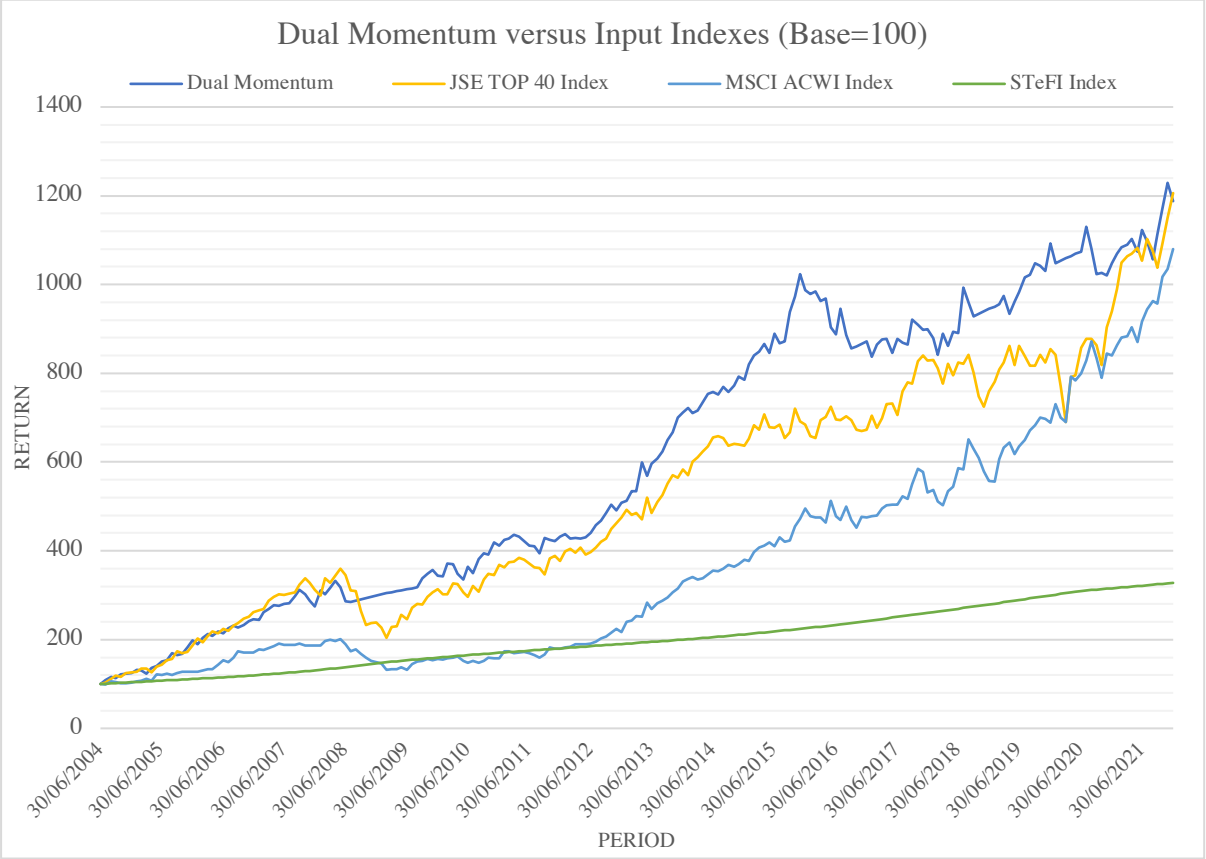


Figure 6 illustrates the dual momentum strategy's (dark blue) performance from mid 2004 to the end of 2021. The strategy performs well and grew substantially, providing superior returns over the MSCI ACWI index (light blue) and the STeFI index (green). The strategy generated an overall return in line to that of the JSE Top 40 index (yellow). Since, the dual momentum strategy gave up a considerable amount of its excess return back to the JSE Top 40 over the late stages of 2015 and the first 6 months of 2016 as well as the second 6-months of 2020. The JSE Top 40 was able to slowly siphon away the excess returns earned by the dual momentum strategy over these two noticeable periods. The first period that occurred from late 2015 to early 2016 was as result of growing investor concerns about the slowing of global growth and the potential of rising interest rates (Renick, 2015). Markets were experiencing rapid whipsaws subject to sudden shifts in investor sentiment. A measure of market turbulence based on the S&P 500, the Chicago Board Options Exchange Volatility index (**VIX**), recorded a record monthly jump at the time of 135% (Renick, 2015). The strategy struggles during periods of high market volatility due to its inherent lag, a key characteristic of momentum and trend following strategies (Antonacci, 2016). In other words, the JSE Top 40's returns over a 12-

month look-back period were often indicated as positive in 2016, while the current returns were actually falling, thus failing to switch to the safety of the STeFI.[8] Consequently, the strategy often switched to the MSCI ACWI due to its positive returns over a 12-month look-back period but was also experiencing a bear market currently yielding negative returns. Thus, exacerbating its previous market timing error resulting in the dual momentum strategy realising further negative returns and underperforming during 2016. The second period in which the strategy gave back outperformance to its benchmark occurred during early 2020 which is seen by the JSE Top 40's sharp decline due to the COVID-19 pandemic. Where shortly after the initial drop, the JSE Top 40 responded very positively and rebounded too quickly for the strategy to mimic its performance. Ultimately, the dual momentum strategy is trend following so things can go temporarily wrong primarily in bull markets when the strategy experiences whipsaws and lags due to the inclusion of absolute momentum. Furthermore, as a result of high market volatility, during the late stages of market rally the strategy overweighs more defensive indexes and can miss out on the early stages of market correction, which can be seen in **Figure 6** during 2017 and mid 2020 to early 2021.

Nonetheless, the dual momentum strategy displays its ability to closely track the superior performing index at a specific point in time.[9] The strategy tracks the JSE Top 40 until there is a major drawdown and the model switches to the STeFI, limiting the strategy's downside. This can be seen during both the 2008 and 2020 crises as well as the 2018 market crash. Over all three periods dual momentum was able to circumvent the drawdowns experienced by the JSE Top 40 and MSCI ACWI. Therefore, dual momentum was able to avoid all significant bear markets while still capturing upside return.

[8] The STeFI serves as the alternative proxy investment which acts as a safe haven during economic downturn.
[9] Returns are calculated over a 12-month look-back period.

***Figure 7**: Dual Momentum versus Absolute and Relative Momentum (2004-2021)*

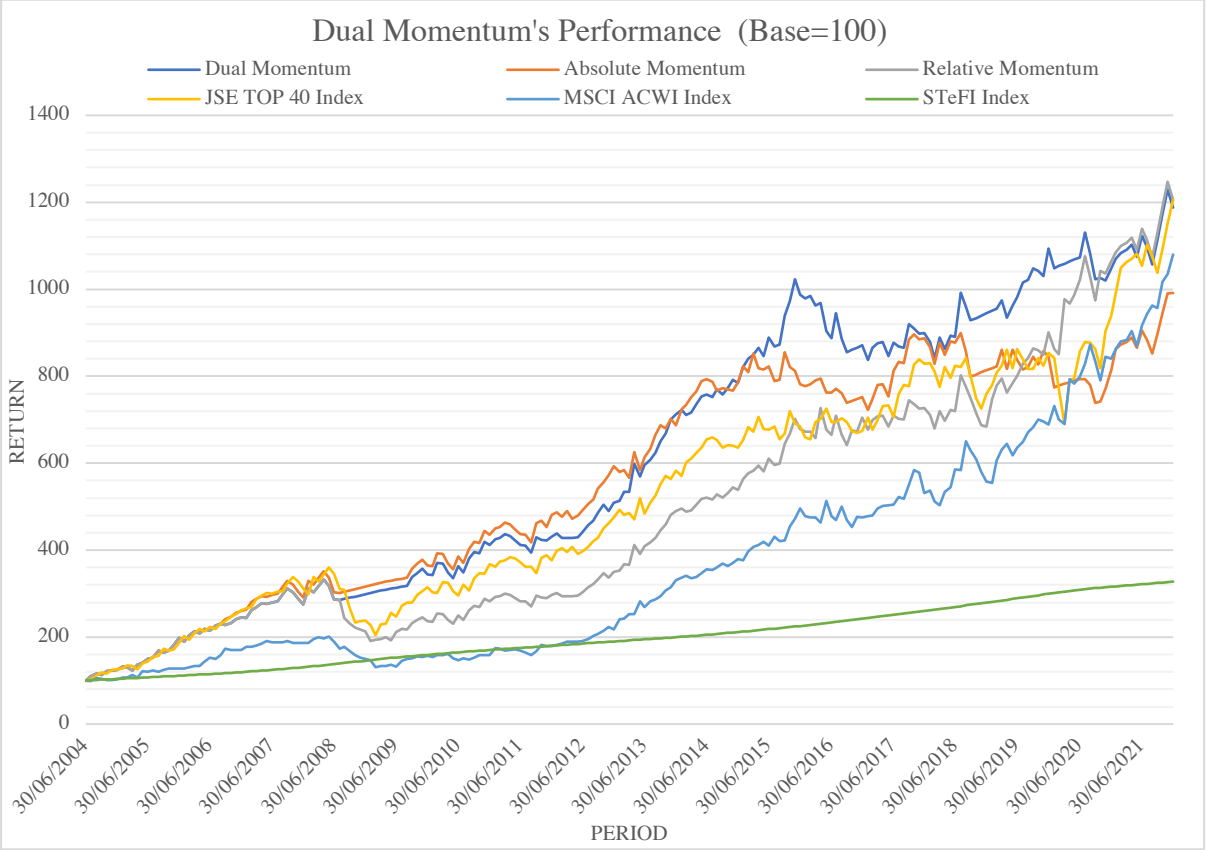


Figure 7 includes the performance of absolute and relative momentum. Here it can be seen that relative momentum performed a finer job at tracking the JSE Top 40 then dual momentum and achieved a greater return as a result, but at the expense of greater volatility. While absolute momentum looked to minimise its drawdowns and compared to relative momentum did exactly that. Significantly, absolute momentum did not cope well during periods of high volatility as seen in 2016, 2018 and early 2020. In addition, **Figure 7** illustrates dual momentum moving with relative momentum on bullish runs however importantly not following relative momentum into bear markets. In bear markets dual momentum switches to absolute momentum in order to mitigate its downside. Therefore, the strategy uses the strengths of absolute and relative momentum to generate a superior risk adjusted return. In order to gain greater insight and a clearer picture one would have to look at the results quantitatively.

***Table 3**: The Dual Momentum Strategy's Performance (2004-2021)*

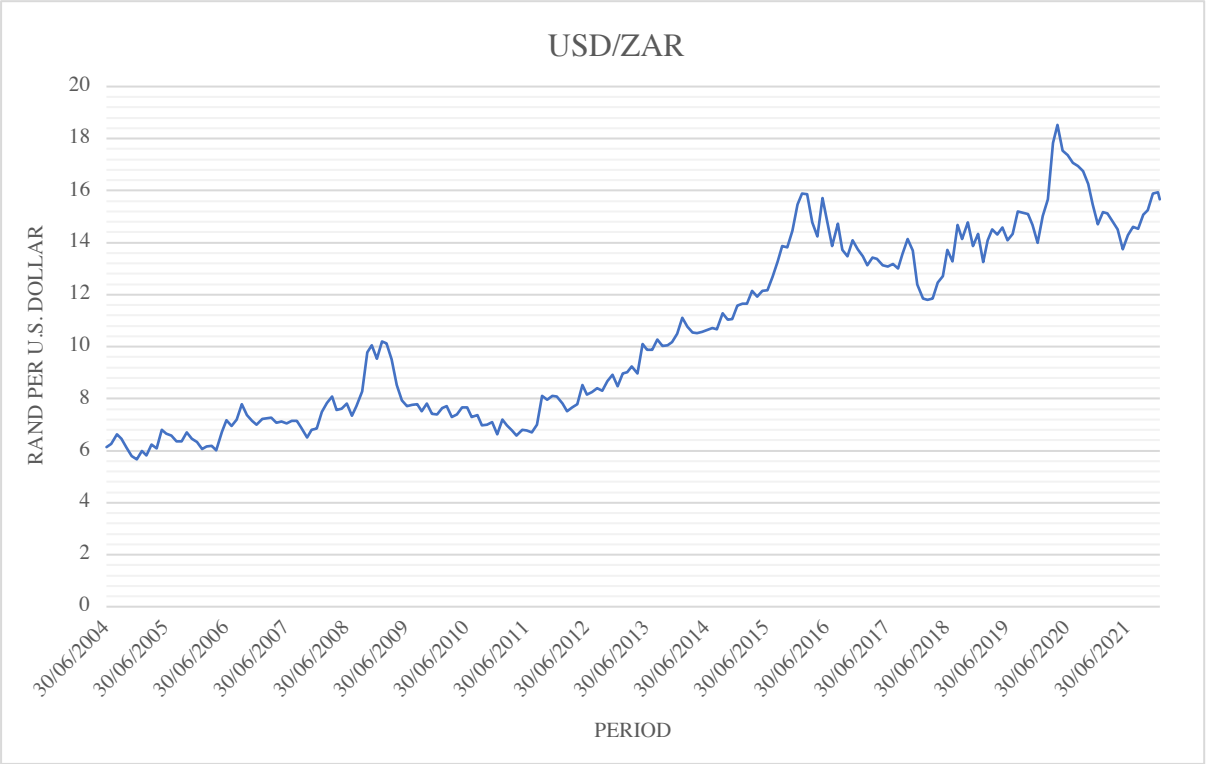
	Annual Return (CAGR)	Annual STDEV	Annual Sharpe	Max Drawdown	Avg Trades per Year	Jensen's Alpha
Dual Momentum	15,19%	13,09%	0,65	-18,13%	2,5	9,12%
Absolute Momentum	14,01%	13,34%	0,55	-17,72%	1,1	7,93%
Relative Momentum	15,28%	15,25%	0,56	-42,42%	1,8	9,13%
JSE Top 40 Index	15,29%	16,17%	0,53	-43,42%	-	-
MSCI ACWI Index	14,56%	13,87%	0,57	-34,83%	-	-

**Sample period 2004-2021.*
**Dual momentum's input indexes include the JSE Top 40, MSCI ACWI and STeFI.*
**Absolute momentum's input indexes include the JSE Top 40 and STeFI.*
**Relative momentum's input indexes include the JSE Top 40 and MSCI ACWI.*
**The Beta for Jensen's alpha is calculated using a regression, benchmarked against the JSE Top 40 Index.*
**Excess return over the risk-free rate is used in the regression calculation.*

The strategy's results are displayed quantitatively by **Table 3**. Analysing **Table 3** from the bottom up presents the results in an insightful manner. The MSCI ACWI had a compound annual growth rate of 14.56% and a standard deviation of 13.87% which generated a Sharpe ratio of 0.57. Meaning that the MSCI AWCI produced the second highest risk adjusted returns. Whereas the JSE Top 40 had the highest annualised return over the subsequent time horizon at 15.29% but the lowest risk adjusted returns illustrated by its Sharpe ratio of 0.53 due to its poor risk metrics. Since the index had the highest standard deviation at 16.17% as well as the highest maximum drawdown of -43.42%. These results were closely aligned with the results of relative momentum. However, relative momentum was able to reduce its risks at the expense of only 1 basis point in upside return relative the JSE Top 40. Relative momentum's standard deviation may have decreased by 0.92% to 15.25% but its maximum drawdown still remained high at -42.43%. Notably, relative momentum achieved the highest alpha at 9.13%. Moving on to absolute momentum, the crux of the dual momentum strategy begins to rear its head. Absolute momentum was able to significantly reduce its standard deviation and maximum drawdown to 13.34% and -17.72% respectively, as a result of switching to the STeFI during bear markets. While, capturing upside returns only 55 basis points below the MSCI ACWI's annualised return and averaged only 1.1 trades per year. Thus, absolute momentum was able to

significantly reduce risk while still capturing upside returns. Finally, looking at the dual momentum strategy's results it can be seen that the strategy harnesses the best of absolute and relative momentum to achieve greater risk adjusted returns - as illustrated by its sharp ratio of 0.65, the highest of them all. Dual momentum was able to reduce its standard deviation and maximum drawdown to 13.09% and -18.13% respectively. Its standard deviation is the lowest and its maximum drawdown is the second lowest after absolute momentum. Not only did the strategy significantly reduce its volatility but generated a very respectable annualised return of 15.19%. The JSE Top 40 may have returned a marginal 10 basis points more than dual momentum, however, the dual momentum strategy was able to achieve far superior risk adjusted returns illustrated by its Sharpe ratio of 0.65 due to its enhanced risk metrics. Although the average trades per year more than doubled when compared to absolute momentum's average trades per year. In spite of this, the average trades per years is still relatively low in the grand scheme of things, since roughly only 2.5 trades occur per year. Which is still aligned with the strategy's key advantage of adopting its low trading cost approach. It is also important to note the strategy's ability to generate an alpha of 9.12%, most of which comes from crises alpha as the strategy circumvents bear markets. Appendix A contains the regression analysis used to calculate beta in the Jensen's alpha calculation, benchmarked against the JSE Top 40. Dual momentum's beta is in fact negative, meaning that the strategy has an inverse relationship to the JSE Top 40 (see Appendix A). The negative beta is a result of the model constantly switching out of the JSE Top 40 and into either the STeFI or MSCI ACWI. This beta value is also explained by the model's notoriously high tracking error.

***Figure 8**: USD/ZAR Monthly Exchange Rate (2004-2021)*



The MSCI ACWI is an offshore dollar denominated investment, meaning that the inclusion of the MSCI ACWI in the dual momentum strategy results in foreign exchange risk.[10] **Figure 8** illustrates the currency devaluation of the Rand against the U.S. Dollar over the strategy's subsequent time horizon. However, the Rand did strengthen from the beginning of 2016 to the end of 2017 mostly due to South Africa avoiding a looming credit rating downgrade to junk. While globally there were growing investor concerns about the slowing of global growth and the potential of the U.S. Federal Reserve raising interest rates which saw the U.S. Dollar weaken. For these reasons, the rand strengthened to record lows in late 2017 where shortly after South Africa was downgraded to junk status which saw the rand begin to weaken once again. The impact of currency devaluation on the dual momentum strategy is quantitatively presented below in **Table 4**.

[10] This study implements the dual momentum strategy from a South African perspective. Thus, all the indexes are denominated in Rands.

***Table 4**: Exchange Rate Risk (2004-2021)*

	Annual Return (CAGR)	Annual STDEV	Annual Sharpe	Max Drawdown
MSCI ACWI Index (R)	14,56%	13,87%	0,57	-34,83%
MSCI ACWI Index (USD)	8,48%	15,42%	0,12	-54,92%

**R denotes the South African Rand.*
**USD denotes the United States Dollar.*

Table 4 displays the dual momentum strategy's direct benefit from the Rand devaluing against the U.S. Dollar. Over the subsequent time horizon, the Rand fell in value relative to the U.S. Dollar which led to the strategy's position in the MSCI ACWI to increase tremendously in value over specific periods in time. The MSCI ACWI's annualised return went from 8.48% to 14.56%. The currency devaluation also led to a reduced standard deviation of 13.87% from 15.42%, which generated a vastly improved Sharpe ratio of 0.57. Furthermore, the devaluation reduced the maximum drawdown to -34.83% from -54.92%. Therefore, the sustained currency devaluation of the Rand against the U.S Dollar immensely benefited dual momentum's position in the MSCI ACWI over specific periods in time. However, it is imperative to acknowledge that the Rand strengthening would move against the dual momentum strategy and reduce the returns of the strategy's position in the MSCI ACWI as seen during 2016 through to 2017 in **Figure 8**.

***Figure 9**: Monthly Returns Distribution of the Benchmark (2004-2021)*

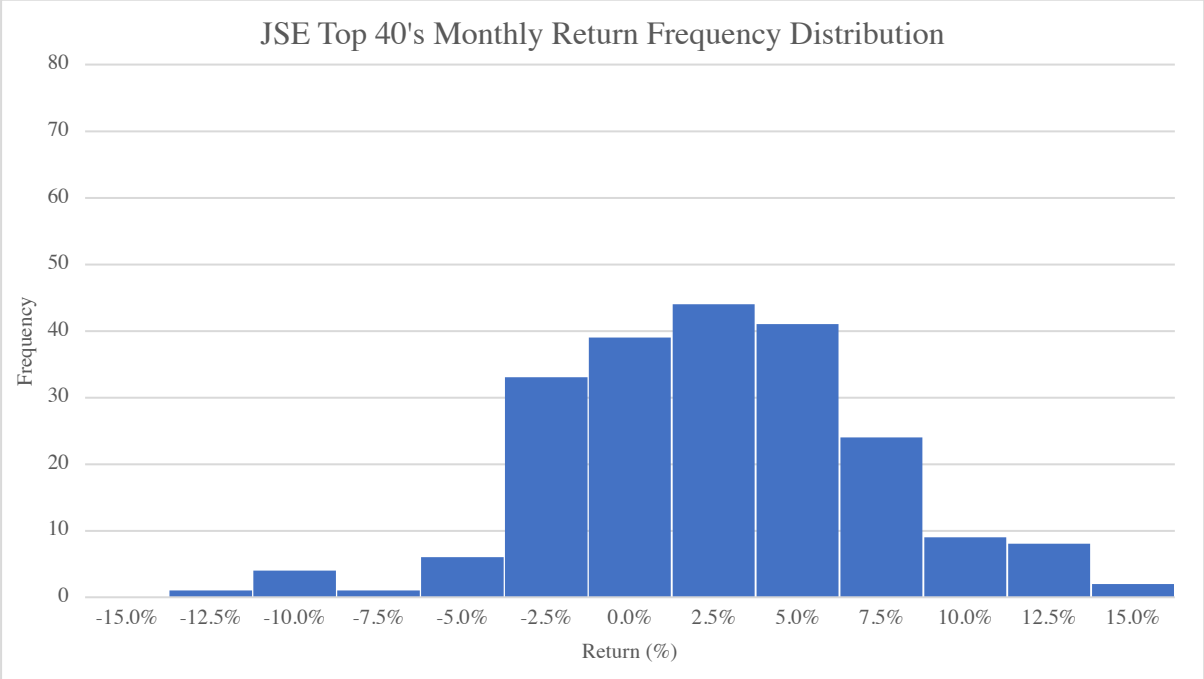


***Figure 10**: Monthly Returns Distribution of Dual Momentum (2004-2021)*

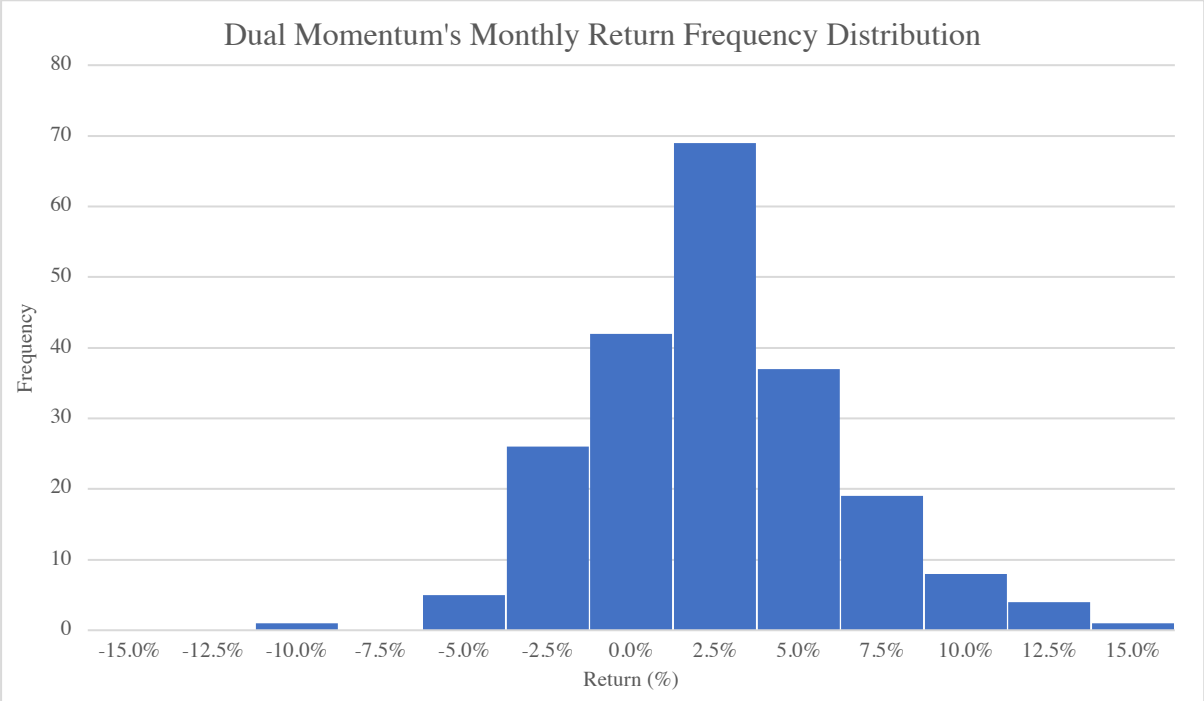


Figure 9 illustrates the JSE Top 40's monthly return frequency distribution. The distribution is not symmetrical around the mean. Therefore, the distribution is not perfectly normally distributed. The JSE Top 40 has a moderate negative skew as shown by the concentration of

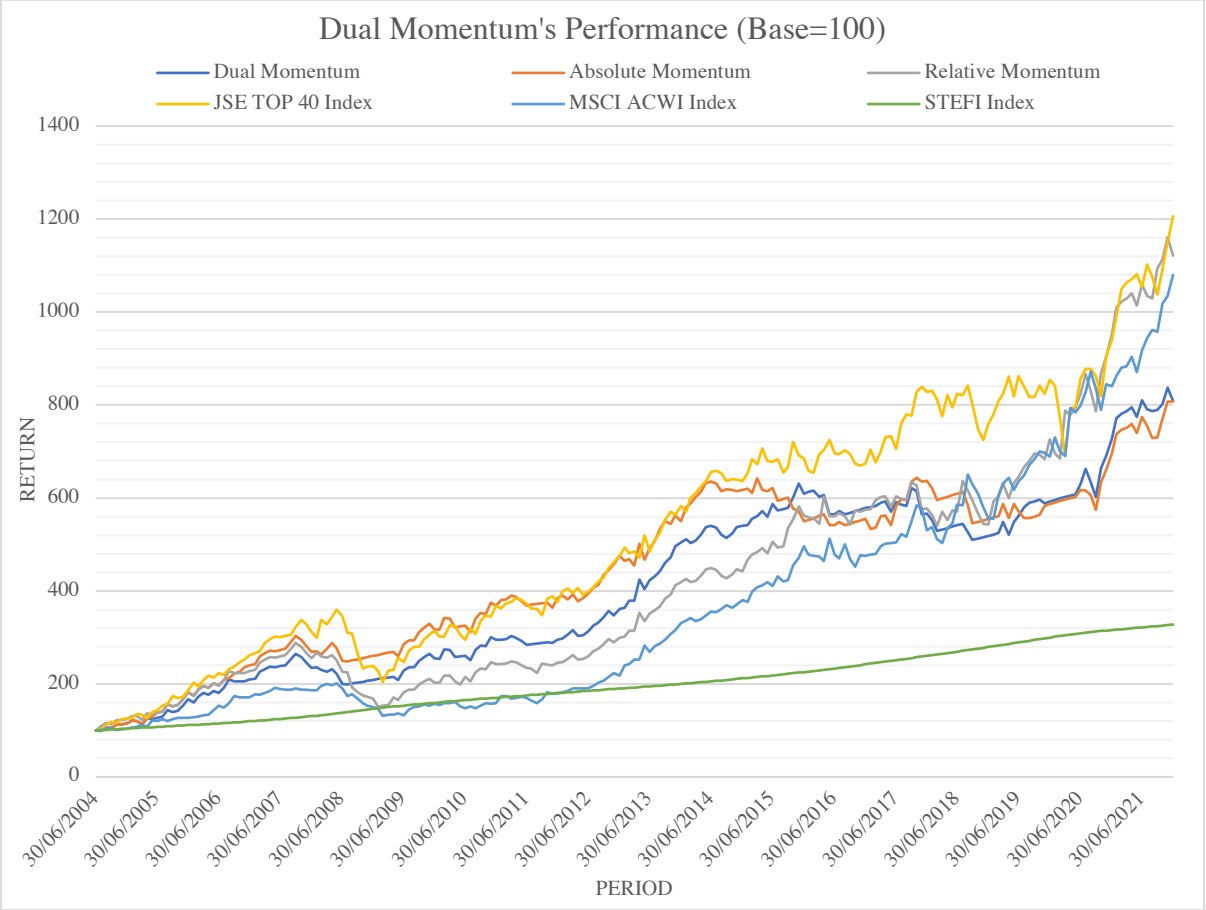
returns to the right-hand side of the distribution and its extended left tail. The JSE Top 40's frequency distribution displays a greater dispersion since the standard deviation and spread in returns around the central tendency is rather significant. In other words, the thicker tails indicate a greater level of risk associated with the JSE Top 40.

Figure 10 indicates dual momentum's monthly return frequency distribution. The dual momentum strategy's return distribution is far more normally distributed when compared to the JSE Top 40's distribution. The distribution is far more symmetrical around the mean with the concentration of returns around positive 2.5%. The distribution displays far less dispersion as the standard deviation and spread in returns around the central tendency has been reduced significantly in comparison to the JSE Top 40's frequency distribution. Meaning that **Figure 10** has thinner tails which means that there are lower levels of associated risk with the dual momentum strategy. The frequency distribution of the dual momentum strategy was able to eliminate most of the left tail risk that the JSE Top 40 had, due to the inclusion of absolute momentum. Notably, some of the right tail returns were also reduced but to a lesser extent. Absolute momentum provides the strategy with tremendous downside protection while still capturing upside return.

5.1.1.1 Dual Momentum Variation 1

The first variation of the dual momentum strategy uses a 6-month look-back period instead of the previous 12-month look-back period. A 6-month look-back period is the second most used momentum look-back period in current literature after the more efficacious 12-month look-back period. Dual momentum variation 1's results are displayed to follow.

***Figure 11**: The Dual Momentum Strategy's Performance (6-Month Look-Back)*



The results of the dual momentum strategy modelled with a 6-month look-back period are illustrated in **Figure 11**. The results display a significant underperformance of the strategy. Absolute momentum also performed poorly relative to the results yielded from the core 12-month look-back period strategy. The strategy did manage to avoid major bear markets as seen over 2008, mid 2018 and early 2020, however the strategy did not adequately capture upside returns and frequently missed out on the early stages of market correction. This can be seen in **Figure 11** from 2004 to mid 2016 and again from 2020 to 2021. Both dual and absolute momentum were too frequently switching between the STeFI and the JSE Top 40. As a result, both dual and absolute momentum lost out on tremendous upside for not holding positions long enough to harvest sufficient price momentum. By lowering the look-back period to 6-months the strategy proved to be more susceptible to volatility, which in turn hinders the dual momentum strategy's performance. Since, the strategy struggles during periods of high volatility, as seen from 2016 to mid-2019. However, Relative momentum was able to perform

as well for the 6-month look-back period as it did for the 12-month look-back period with roughly the same level of volatility.

***Table 5**: The Dual Momentum Strategy's Performance (6-Month Look-Back)*

	Annual Return (CAGR)	Annual STDEV	Annual Sharpe	Max Drawdown	Avg Trades per Year	Jensen's Alpha
Dual Momentum	12,69%	12,14%	0,49	-25,01%	3,2	6,45%
Absolute Momentum	12,68%	12,33%	0,49	-18,43%	1,8	6,50%
Relative Momentum	14,81%	15,40%	0,53	-47,68%	2,1	8,60%
JSE Top 40 Index	15,29%	16,17%	0,53	-43,42%	-	-
MSCI ACWI Index	14,56%	13,87%	0,57	-34,83%	-	-

**Sample period 2004-2021.*
**Dual momentum's input indexes include the JSE Top 40, MSCI ACWI and STeFI.*
**Absolute momentum's input indexes include the JSE Top 40 and STeFI.*
**Relative momentum's input indexes include the JSE Top 40 and MSCI ACWI.*
**The Beta for Jensen's alpha is calculated using a regression, benchmarked against the JSE Top 40 Index.*
******Excess return over the risk-free rate is used in the regression calculation.*

Table 5 presents the results in **Figure 11** quantitatively. As can been seen the results of the JSE Top 40 and the MCSI ACWI remained the same as the core dual momentum strategy with the 12-month look back period. Altering the look-back period does not influence the indexes. The 6-month look-back period negatively impacted absolute momentum, relative momentum and dual momentum. Relative momentum was the least impacted by the formation period alteration. Its risk metrics worsened slightly, displaying a standard deviation of 15.40% and a maximum drawdown of -47.68% while dropping 47 basis points in annualised return to 14.81%. Whereas, absolute momentum and dual momentum were far more severely impacted. The annualised returns of dual momentum and absolute momentum fell by 250 and 133 basis points respectively. The maximum drawdown of dual momentum increased to -25.01% from -18.13% and the maximum drawdown of absolute momentum increased to -18.43% from -17.72%. However, both their standard deviations improved. Dual momentum's standard deviation was reduced by 0.95% to 12.14% and absolute momentums by 1.01% to 12.33%. Both dual and absolute momentum were too frequently switching between the STeFI and the JSE Top 40 due to the shortened formation period. As a result, both dual and absolute

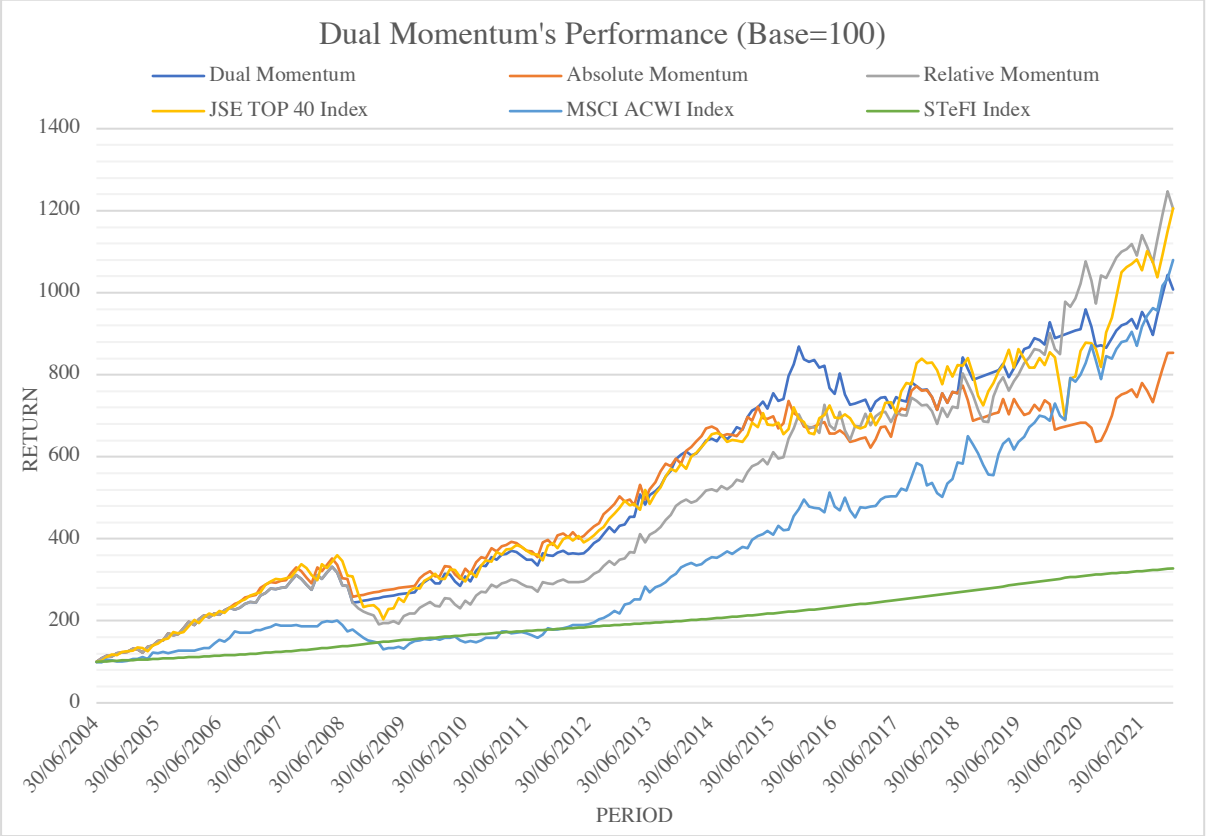
momentum less optimally traded off a greater amount of potential upside for slightly lower levels of risk. Their improved standard deviations weren't enough to offset its significantly reduced returns to increase dual and absolute momentum's Sharpe ratios. Dual momentum's Sharpe ratio fell significantly from 0.65 to 0.49. Thus, the dual momentum strategy modelled with a 6-month look-back period failed to generate improved risk adjusted returns, which is also indicated by its reduced alpha of only 6.45% (see Appendix B for the regression analysis). The strategy also saw its average trades per year increase by 28% to 3.2. Meaning that the strategy often sought the safety of the STeFI during periods of high volatility. Ultimately, by using a 6-month look-back period the strategy failed to adequately cope with the volatility of indexes since the strategy regularly sought the safety of the STeFI during periods of high volatility. For this reason, the strategy frequently missed out on the early stages of market recovery, which is compounded by its inherent lag due to its trend following nature. As a result, the dual momentum strategy using a 6-month look-back period underperformed, yielding reduced risk adjusted returns relative to the core strategy which used a 12-month look-back period.

5.1.1.2 Dual Momentum Variation 2

A second variation of the core strategy was performed which altered the threshold (i.e., the hurdle rate) of positive absolute momentum. Now for an index to have absolute momentum, the return over the 12-month look-back period only had to be greater than zero. Where previously the risk-free asset (i.e., the 91 day South African treasury bill) is subtracted from the return over the 12-month look-back period which had to be greater than zero in order to achieve absolute momentum.[11] Therefore, the hurdle rate is essentially removed and the difference between positive and negative absolute momentum is a positive or negative return over the 12-month look-back period respectively.

[11] The annualised yield of risk-free asset is 6.68%

***Figure 12**: The Dual Momentum Strategy's Performance (Reduced Threshold)*



By reducing the threshold of absolute momentum, **Figure 12** displays the same significant bear market avoiding dual momentum strategy. However, the strategy underperformed its benchmark the JSE Top 40 as well as the MSCI ACWI, where the core strategy with a higher threshold did not. Reducing the threshold only impacts absolute momentum, thus also impacting dual momentum since dual momentum includes absolute momentum in its model. By reducing the threshold, the strategy exposes itself to greater levels of volatility. As previously mentioned, the strategy is trend following so things can go temporarily wrong primarily in bull markets when the strategy experiences whipsaws and lags due to the inclusion of absolute momentum. Therefore, the strategy is less successful at capturing upside returns as a result of poor market timing due to its susceptibility to high volatility. **Figure 12** is represented quantitatively in the table below.

***Table 6**: The Dual Momentum Strategy's Performance (Reduced Threshold)*

	Annual Return (CAGR)	Annual STDEV	Annual Sharpe	Max Drawdown	Avg Trades per Year	Jensen's Alpha
Dual Momentum	14,11%	13,61%	0,55	-26,36%	2,4	7,99%
Absolute Momentum	13,04%	13,84%	0,46	-26,36%	1,0	6,91%
Relative Momentum	15,28%	15,25%	0,56	-42,42%	1,8	9,13%
JSE Top 40 Index	15,29%	16,17%	0,53	-43,42%	-	-
MSCI ACWI Index	14,56%	13,87%	0,57	-34,83%	-	-

**Sample period 2004-2021.*
**Dual momentum's input indexes include the JSE Top 40, MSCI ACWI and STeFI.*
**Absolute momentum's input indexes include the JSE Top 40 and STeFI.*
**Relative momentum's input indexes include the JSE Top 40 and MSCI ACWI.*
**The Beta for Jensen's alpha is calculated using a regression, benchmarked against the JSE Top 40 Index.*
**Excess return over the risk-free rate is used in the regression calculation.*

The results of the core strategy are identical to the results in **Table 6** for relative momentum, the JSE Top 40 index and the MSCI ACWI index. By lowering the strategy's threshold absolute momentum's annualised return was reduced by 97 basis points. Similarly, dual momentum's return fell by 108 basis points. Both absolute and dual momentum's risk metrics marginally increased, and both experienced the same increased maximum drawdown of -26.36%. Where Absolute momentum's standard deviation increased by 0.5% to 13.84% and dual momentums standard deviation increased by 0.52% to 13.61%, as reflected in their considerably reduced Sharpe ratios. Therefore, the risk adjusted return of the dual momentum strategy with a lower threshold fell relative to the core strategy. The dual momentum strategy experienced an increase in risk and a reduction in return, thus negatively impacting its performance. Furthermore, Jensen's alpha fell by roughly a percent for both absolute and dual momentum to 6.91% and 7.99% respectively (see Appendix C for the regression). In short, by reducing the threshold of absolute momentum, the dual momentum strategy's vulnerability to high volatility was amplified, thus yielding lower returns with increased volatility due to poor market timing during periods of high market volatility.

5.2 Dual Momentum Applied to Different South African Sector Indices

The results of the dual momentum strategy applied to various indices across different sectors is presented below. The aim is to analyse whether dual momentum can generate superior risk adjusted returns within specific South African sectors. Notably, the RESI 20 index, FINI 15 index and INDI 25 index have a shorter sample period than that of the ALBI index and SAPY index. The RESI, FINI and INDI indexes only commenced in June 2007. After taking the 12-month look-back period into account the sample period only begins a year later in June 2008. The same applies to the ALBI and SAPY index. However, these indexes were limited by the STeFI Index which only commenced in June 2003, thus their sample period began a year later in June 2004.

5.2.1 ALBI Index

***Figure 13**: The Dual Momentum Strategy's Performance (ALBI Index)*

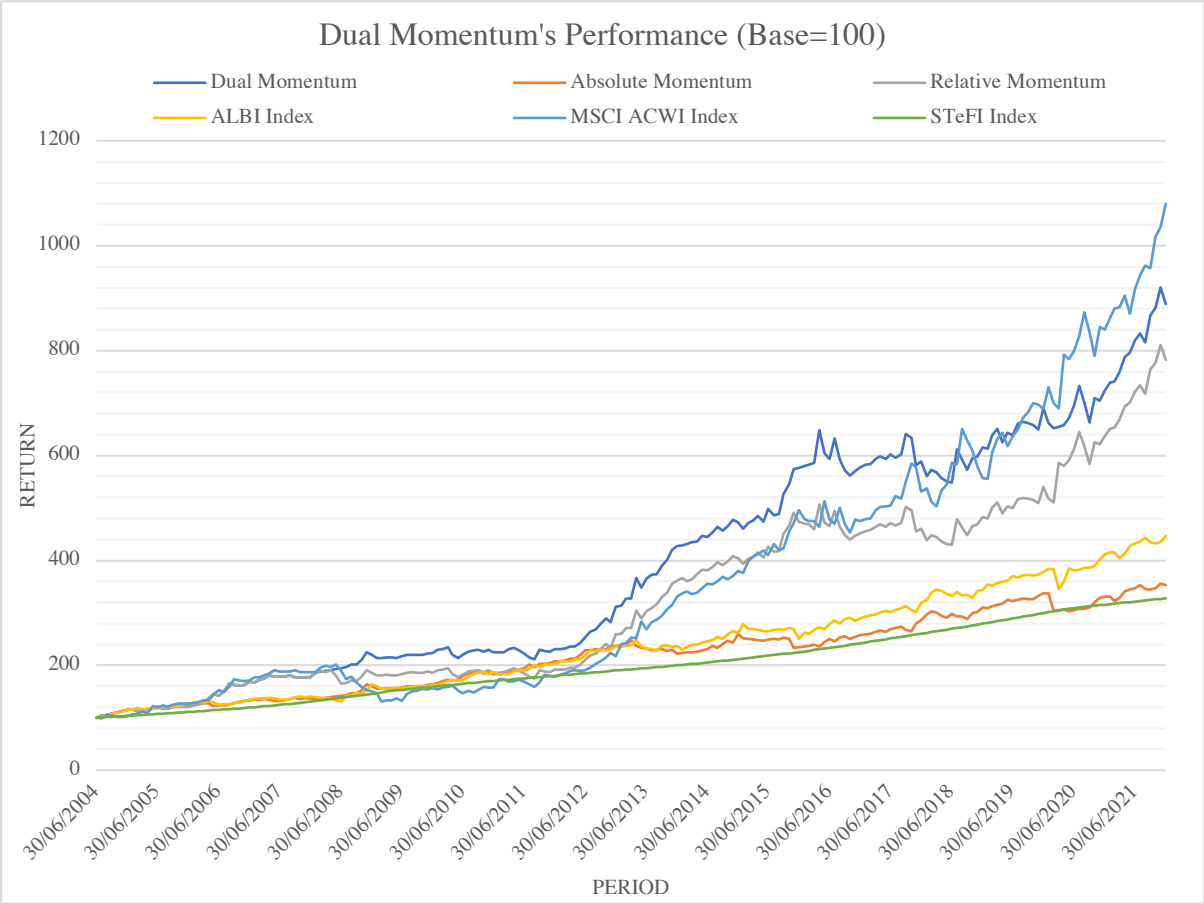


Figure 13 depicts the results of the dual momentum strategy modelled off the ABLI index from mid 2004 to the end of 2021. The strategy performed well considering that its primary input is a bond index which didn't outperform the STeFI by much, keeping in mind the STeFI is a money market index, essentially representing cash. The dual momentum strategy's performance stemmed from its ability to avoid bear markets as well as closely tracking the better performing MSCI ACWI. Illustrated by **Figure 13**, the strategy circumvented both 2008 and 2020 crises, while harvesting tremendous upside from the MSCI ACWI, despite battling to cope during the periods of high volatility experienced over 2016 through to 2018. Which after closer examination roots from poor market timing due to strategy's inherent lag. The strategy received mixed signals during the aforementioned periods of high volatility. Periods where the ALBI and MSCI ACWI's 12-month look-back periods were greater than the STeFI for the initial part of the downdraws. The results show that the returns had surpassed the hurdle rate and achieved absolute momentum over the 12-month look-back period, when in fact current returns were negative and the strategy was realising a loss. Therefore, the strategy reacted to the market's downturns far too late. The dual momentum strategy inadequately tracked and captured returns of the MSCI ACWI during its bullish run which began early 2018 all the way through to 2021, leading to the MSCI ACWI surpassing dual momentum. This is because during bull markets the strategy experiences whipsaws and lags due to the inclusion of absolute momentum. The strategy is trend following and things can go temporarily wrong.

***Table 7**: The Dual Momentum Strategy's Performance (ALBI Index)*

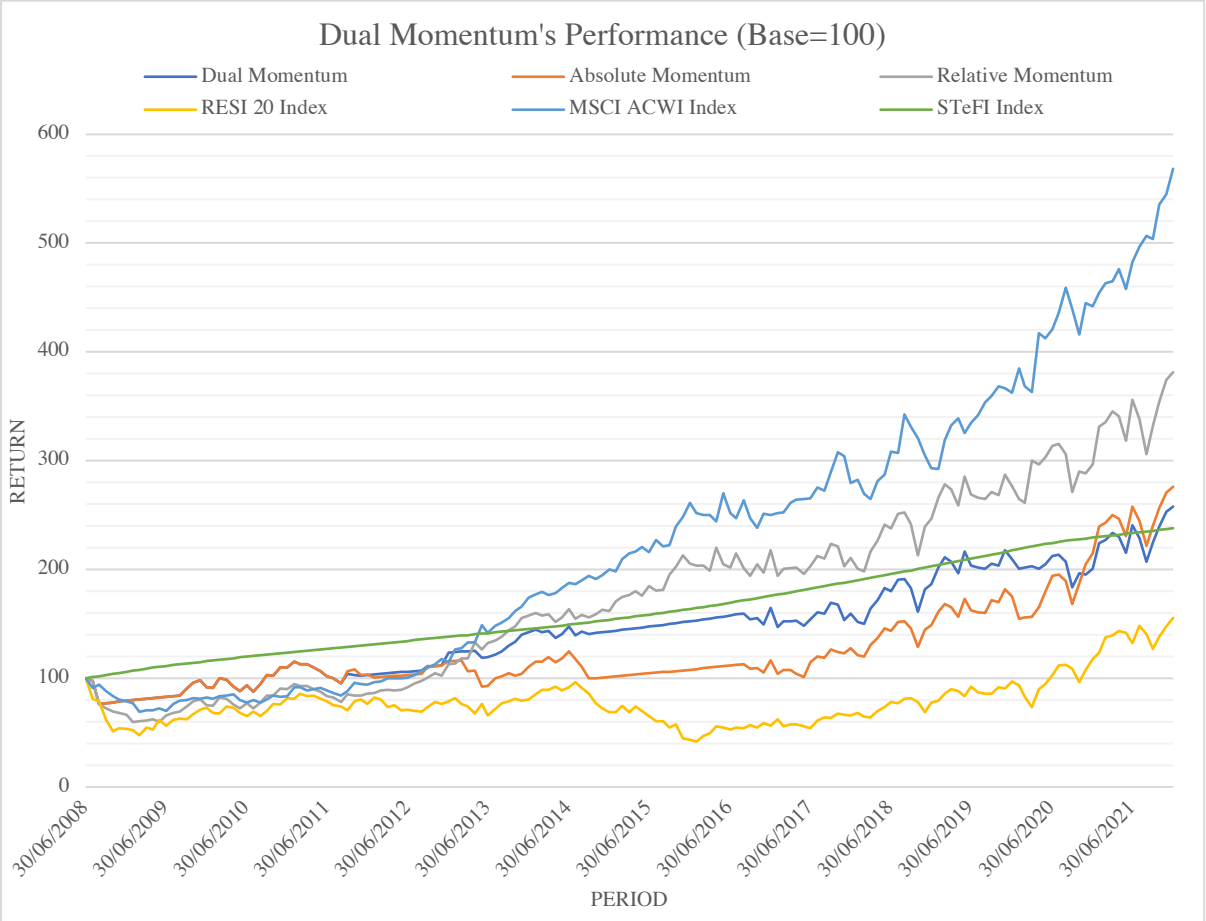
	Annual Return (CAGR)	Annual STDEV	Annual Sharpe	Max Drawdown	Avg Trades per Year	Jensen's Alpha
Dual Momentum	13,30%	10,90%	0,61	-15,31%	2,5	6,33%
Absolute Momentum	7,48%	6,76%	0,12	-10,43%	0,9	0,84%
Relative Momentum	12,48%	11,90%	0,49	-15,31%	1,8	5,74%
ALBI Index	8,93%	7,43%	0,30	-9,79%	-	-
MSCI ACWI Index	14,56%	13,87%	0,57	-34,83%	-	-

**Sample period 2004-2021.*
**Dual momentum's input indexes include the ALBI, MSCI ACWI and STeFI.*
**Absolute momentum's input indexes include the ALBI and STeFI.*
**Relative momentum's input indexes include the ALBI and MSCI ACWI.*
**The Beta for Jensen's alpha is calculated using a regression, benchmarked against the ALBI Index.*
**Excess return over the risk-free rate is used in the regression calculation.*

The quantitative results in **Table 7** illustrates the strength of the dual momentum strategy with regards to the ALBI. The dual momentum strategy demonstrated its key use of the defensive strengths of absolute momentum and combined it with relative momentum's offensive strengths in pursuit of an enhanced risk and return profile. The strategy yielded the second highest annualised return at 13.30% coupled with a low standard deviation of only 10.90%, producing the highest Sharpe ratio at 0.61. The dual momentum strategy, therefore, managed to achieve the highest risk adjusted returns. The strategy traded 126 basis points of upside when compared to the MSCI ACWI, for a 2.97% decrease in standard deviation and a decrease in maximum drawdown just shy of a 20%. In addition, despite the strategy lowering its risk metrics tremendously, it still managed to generate an alpha of 6.33% (see Appendix D for the regression analysis). Ultimately, the strategy performed well by mitigating its downside and extending its upside resulting in the highest risk adjusted returns. Therefore, the dual momentum strategy was able to reduce its risk metrics significantly as a result of its primary input the ALBI index and switch to the superior performing MSCI ACWI index when it most made sense. The MSCI ACWI may have produced the highest annualised return but at the expense of much higher standard deviation and maximum drawdown.

5.2.2 RESI 20 Index

***Figure 14**: The Dual Momentum Strategy's Performance (RESI 20 Index)*



The dual momentum strategy modelled off the RESI index is illustrated in **Figure 14**. The RESI index only commenced in June 2007 and after factoring in the 12-month look-back period, the sample period began during the 2008 financial crises. Where the dual momentum strategy immediately began mitigating its downside and did so again over 2015 when the RESI index fell significantly. Absolute momentum did not allow for dual momentum to follow the RESI into a bear market and demonstrated its ability to avoid bear markets, while relative momentum fell with the RESI. However, dual momentum did not capture sufficient upside and failed to track the MSCI ACWI when it began to climb as can be seen from 2013 onwards. The root of the problem stems from the exceptionally poor performance of the RESI. The dual momentum strategy is structured in such a way that the primary index the RESI has to achieve positive absolute momentum by surpassing the hurdle rate's return over a 12-month look-back

period, before it can be relatively compared to the MSCI ACWI.[12] Thus, only once the RESI has positive absolute momentum can the strategy be invested in the superior performing MSCI ACWI. Consequently, the strategy repeatedly took up defensive positions in the STeFI due to the 12-month formation period's signals from the underperforming RESI, since the RESI more often than not underperformed the hurdle rate. Therefore, due to the underperformance of the RESI index the dual momentum strategy was frequently not able to invest in the superior performing MSCI ACWI. As a result, the strategy was barely able to outperform the STeFI.

The results in **Figure 14** also displayed a key shortcoming of most momentum strategies. Since, Relative momentum is not constrained by a hurdle rate and able to switch to the superior performing index, either the RESI or MSCI ACWI. One would expect the strategy to closely track the superior performing MSCI ACWI, yet the strategy severely underperformed the MSCI ACWI. This is due to the high volatility experienced by the RESI. Cyclical stocks and indexes tend to be more volatile due to their sensitivity to macroeconomic or systematic changes in the overall economy. Significantly, the RESI index is cyclical and often oscillates when experiencing high levels of volatility, which adversely affects price momentum. Meaning that relative momentum would frequently switch out of the superior preforming MSCI ACWI and into the RESI due to positive signals brought on by the RESI's high volatility. For this reason, relative momentum often failed to capture returns from the rapidly rising MSCI ACWI.

[12] The hurdle rate is the 91-day South African Treasury Bill.

***Table 8**: The Dual Momentum Strategy's Performance (RESI 20 Index)*

	Annual Return (CAGR)	Annual STDEV	Annual Sharpe	Max Drawdown	Avg Trades per Year	Jensen's Alpha
Dual Momentum	7,27%	17,18%	0,06	-23,75%	3,0	0,89%
Absolute Momentum	7,81%	19,33%	0,08	-23,75%	1,6	1,55%
Relative Momentum	10,42%	19,52%	0,21	-40,38%	1,7	3,98%
RESI 20 Index	3,32%	25,55%	-0,12	-58,31%	-	-
MSCI ACWI Index	13,74%	14,35%	0,52	-30,90%	-	-

**Sample period 2008-2021.*
**Dual momentum's input indexes include the RESI, MSCI ACWI and STeFI.*
**Absolute momentum's input indexes include the RESI and STeFI.*
**Relative momentum's input indexes include the RESI and MSCI ACWI.*
**The Beta for Jensen's alpha is calculated using a regression, benchmarked against the RESI Index.*
**Excess return over the risk-free rate is used in the regression calculation.*

Table 8 quantitatively displays the results in **Figure 14**. Here the impact of relative momentum's underperformance of the MSCI, attributable to the RESI's extremely high volatility can be highlighted. The RESI had an extraordinarily high standard deviation of 25.55% as well as a substantial maximum drawdown of -58.31% only producing an annualised return of 3.32%, resulting in a negative Sharpe ratio of -0.12. A negative Sharpe ratio indicates that the RESI's return is lower than the risk-free rate. The RESI's underperformance also affected absolute momentum. Despite the defensive abilities of absolute momentum, it only managed to marginally edge the standard deviation of relative momentum to 19.33%. Therefore, the RESI's volatility burdened both absolute and relative momentum which accordingly burdened dual momentum. Dual momentum only had an annualised return of 7.27%, 6.47% short of the MSCI ACWI's annualised return. The strategy had a high standard deviation of 17.18% and a maximum drawdown of 23.75%. For this reason, dual momentum generated the lowest relative Sharpe ratio of 0.06 as well as an alpha of 0.89% (see Appendix E for the regression analysis). In addition, the average annual trades increased to 3 per year. Due to the increased volatility from the RESI's cyclicality. Overall, the structure of the dual momentum strategy constrained the strategy from investing in the superior performing MSCI

ACWI as a result of the severe underperformance of the RESI which was exacerbated by the high volatility of the RESI. High volatility not only breaks down price momentum but sends incorrect signals to the dual momentum strategy causing it to miss out on the early stages of market correction. This lead to the severe underperformance of the dual momentum strategy, yielding the lowest risk adjusted returns.

5.2.3 FINI 15 Index

***Figure 15**: The Dual Momentum Strategy's Performance (FINI 15 Index)*

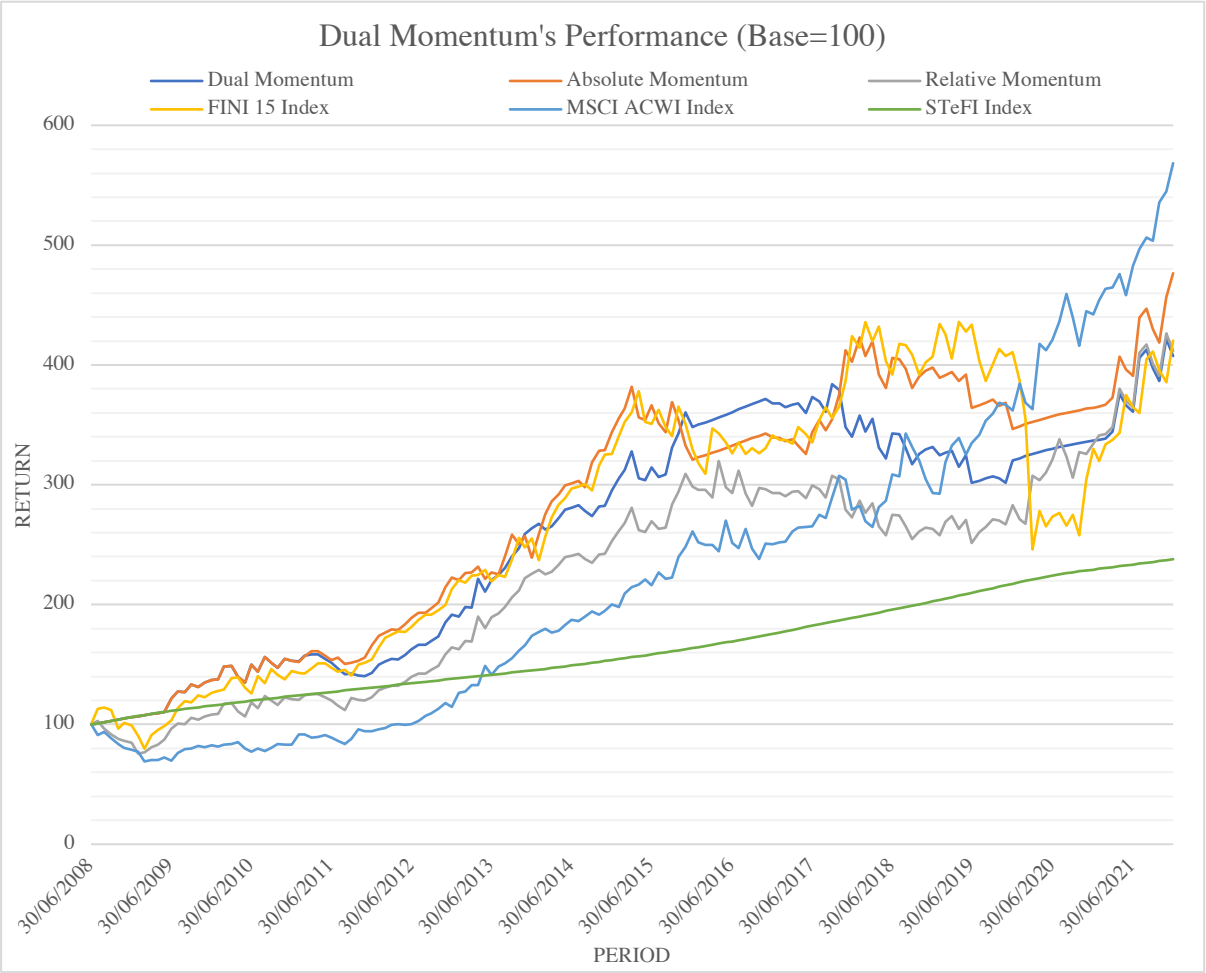


Figure 15 represents the dual momentum strategy constructed from the FINI index, an index similar to the RESI also beginning during the 2008 financial crises. The above Figure shows the strategy's sub-par performance, dual momentum underperformed both absolute and relative momentum as well as the FINI and MSCI ACWI. Its weak performance has much to do with the nature of FINI index. The FINI 15 is an inherently cyclical index made up of the 15 largest

financial companies on the JSE. Cyclical indexes tend to be challenged with periods of high volatility due to its sensitivity to the economic environment. As illustrated in **Figure 15**, the FINI is extremely volatility and during periods of high volatility the FINI index's price oscillates and frequently switches between positive and negative returns which adversely affects price momentum. The dual momentum strategy struggles during periods of high volatility and did not adequately deal with these periods of high volatility, and as a result took on substantial losses which can be seen from 2017 to 2019. High volatility impaired the strategy's trend following ability and caused the strategy to take on further losses as well as miss out on early stages of market correction. This can be seen over the periods mid 2017 to mid 2018 as well as early 2021. Notably, the dual momentum strategy was able to avoid the 2008 financial crises and the significant COVID-19 crash in 2020 yet failed to capture most of the upside post the 2020 crash.

Table 9: *The Dual Momentum Strategy's Performance (FINI 15 Index)*

	Annual Return (CAGR)	**Annual STDEV**	**Annual Sharpe**	**Max Drawdown**	**Avg Trades per Year**	**Jensen's Alpha**
Dual Momentum	10,97%	11,95%	0,39	-21,39%	3,0	5,02%
Absolute Momentum	12,26%	12,44%	0,48	-18,05%	1,2	6,12%
Relative Momentum	11,06%	15,07%	0,32	-26,41%	2,5	5,23%
FINI 15 Index	11,22%	19,54%	0,25	-43,54%	-	-
MSCI ACWI Index	13,74%	14,35%	0,52	-30,90%	-	-

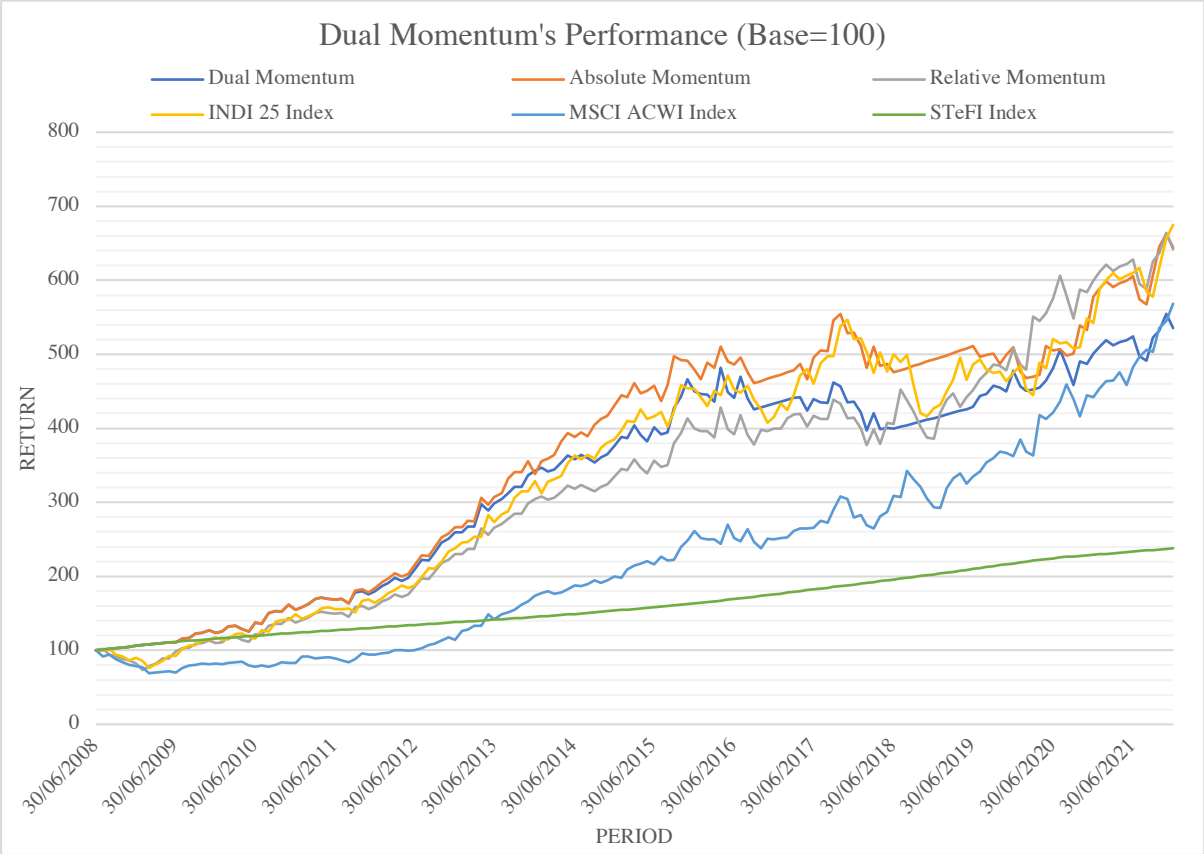
**Sample period 2008-2021.*
**Dual momentum's input indexes include the FINI, MSCI ACWI and STeFI.*
**Absolute momentum's input indexes include the FINI and STeFI.*
**Relative momentum's input indexes include the FINI and MSCI ACWI.*
**The Beta for Jensen's alpha is calculated using a regression, benchmarked against the FINI Index.*
**Excess return over the risk-free rate is used in the regression calculation.*

The results from **Figure 15** presented in the above **Table 9**, illustrate how detrimental high volatility can be for the dual momentum strategy. The strategy had the lowest annualised return at 10.97% below that of both input indexes and returned 25 basis points below the FINI and

277 basis points below the MSCI ACWI. The strategy did manage to achieve the lowest standard deviation of 11.95% and second lowest maximum drawdown of -21.39%. For this reason, the strategy's Sharpe ratio of 0.39 benefited slightly but not enough relative to its peers. The strategy's superior risk metrics did not manage to offset its significantly low annualised return which generated inferior risk adjusted returns. However, the strategy did manage to produce a Jensen's Alpha of 5.02% (see Appendix F for the regression analysis). Notably, the FINI 15 index had an exceptionally high standard deviation just short of 20% which had a major impact on the strategy. Ultimately, the dual momentum strategy struggled during the periods of high volatility and inadequately captured upside as it frequently missed out on the early stages of market correction. Which can also be seen by the increase in average trades per year to 3, as the strategy frequently changed positions due to incorrect signals as a result of high volatility and often led the strategy to yield negative returns. As the strategy is trend following and has an inherent lag, and things can go temporarily wrong.

5.2.4 INDI 25 Index

***Figure 16**: The Dual Momentum Strategy's Performance (INDI 25 Index)*



The INDI 25 index is yet another cyclical index that is highly sensitive to overall market conditions which commenced during the 2008 financial crises. The dual momentum strategy modelled off the INDI 25 Index displayed by **Figure 16** performed well from 2008 through to the end of 2018. The strategy was able to circumvent all major bear markets and closely tracked the INDI and MSCI ACWI harvesting upside returns, until mid 2016. Mid 2016 the INDI began to oscillate experiencing an onslaught of high volatility which did not favour the dual momentum strategy as price momentum began to diminish. Once again, the strategy battled to cope during this period of high volatility, as a result of mixed signals being sent to the strategy from the 12-month look-back period causing the strategy to realise losses in 2017. This guided the strategy to position itself in the more defensive index, namely the STeFI, and therefore frequently miss out on the early stages of market recovery as seen during 2017 and 2020. Here again the strategy's inadequacy of dealing with periods of high volatility hindered its ability to capture upside returns from the MSCI ACWI and INDI. This led to the dual momentum

strategy underperforming both its input indexes as well as remarkably underperforming both absolute and relative momentum by a reasonable way. The reasons why can be better uncovered in the quantitative analysis below.

***Table 10**: The Dual Momentum Strategy's Performance (INDI 25 Index)*

	Annual Return (CAGR)	Annual STDEV	Annual Sharpe	Max Drawdown	Avg Trades per Year	Jensen's Alpha
Dual Momentum	13,24%	11,46%	0,61	-17,57%	2,4	7,24%
Absolute Momentum	14,80%	11,67%	0,73	-15,65%	0,9	9,23%
Relative Momentum	14,76%	14,75%	0,58	-28,30%	1,9	8,44%
INDI 25 Index	15,19%	14,79%	0,60	-25,21%	-	-
MSCI ACWI Index	13,74%	14,35%	0,52	-30,90%	-	-

**Sample period 2008-2021.*
**Dual momentum's input indexes include the INDI, MSCI ACWI and STeFI.*
**Absolute momentum's input indexes include the INDI and STeFI.*
**Relative momentum's input indexes include the INDI and MSCI ACWI.*
**The Beta for Jensen's alpha is calculated using a regression, benchmarked against the INDI Index.*
******Excess return over the risk-free rate is used in the regression calculation.*

Quantitatively **Table 10** exhibits the results of **Figure 16**. Here it can be seen that absolute momentum was able to achieve the greatest risk adjusted returns, producing an annualised Sharpe ratio of 0.73. Since, absolute momentum had the second lowest standard deviation at 11.67% and second highest return at 14.80%, 39 basis points short of the INDI's return. It also had the lowest maximum drawdown of only -15.65%. Absolute momentum's superior performance is a result of its inability to switch to the MSCI ACWI as it was forced to stay in either the INDI or STeFI. Otherwise, it would have made the same error dual momentum made by often switching to the MSCI ACWI in a bear market causing the strategy to incur further losses due to incorrect signals and lagged responses, as a result of not switching to the STeFI sooner. This led to absolute momentum outperforming dual momentum as it was able to avoid making the same market timing errors as dual momentum. The dual momentum strategy's shortfall was favouring more defensive indexes during the late stages of market rally and

missing out on the early stages of market correction. For this reason, the strategy had the lowest annualised returns of 13.24%, which is why relative momentum outperformed dual momentum as it was able to capture significant upside in spite of incurring greater volatility. However, the dual momentum strategy did manage to minimise risk and had the lowest standard deviation of 11.46%, which generated the second highest Sharpe ratio of 0.61. Thus, achieving the second highest risk adjusted returns and generated an alpha of 7.24% despite having severe market timing issues during periods of high volatility (see Appendix G for the regression).

5.2.5 SAPY Index

***Figure 17**: The Dual Momentum Strategy's Performance (SAPY Index)*

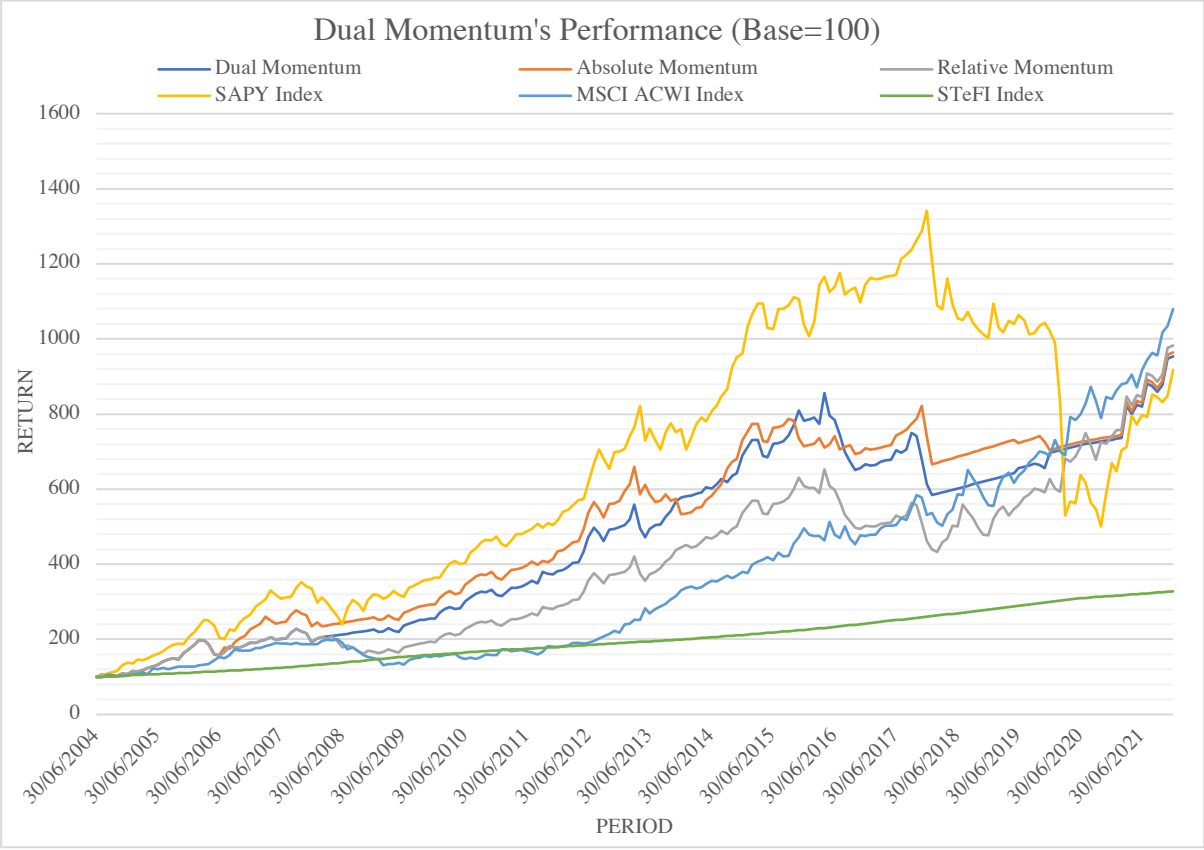


Figure 17 exhibits the dual momentum strategy with regards to the SAPY Index from 2004 to 2021. The SAPY is also highly sensitive to the market and therefore highly volatile due to its cyclicality. The index displayed tremendous growth until late 2017. Then the property index started to gradually fall, which was followed by a severe crash in early 2020 due to the COVID-19 pandemic. Notably, all the momentum strategies performed similarly and slightly outperformed the SAPY but were slightly outperformed by the MSCI ACWI. Moreover, both

absolute and dual momentum displayed their ability to avoid bear markets which can be seen over 2008 and early 2020. However, a period of high volatility led to significant missteps by the strategy due mixed signals which were exacerbated by its inherent lag. Again, the strategy is trend following and things can go temporarily wrong. For this reason, the strategy miss-stepped due to mixed signals and recognised its error but not before the error was compounded by the strategy's lagged response thus realising substantial losses during 2016 and late 2017. Despite being able to limit the strategy's drawdown significantly more during late 2017, which saw the strategy seek the safety of the STeFI and where the strategy waited out the remainder of the high volatility. The dual momentum strategy unsuccessfully captured the significant upside of the SAPY, where once again the strategy missed out on the early stages of market correction due to high volatility. The high volatility brought on by SAPY's cyclicity is significantly detrimental to price momentum's profitability, especially dual and absolute momentum as they constantly focus on limiting their downside in capital preservation. The analysis of the strategy revealed that there are several instances of negative returns over the 12-month look-back period which did not surpass absolute momentum's threshold and therefore the strategy switched to the STeFI. While the following month of rapid market correction was missed due to the strategy being invested in the STeFI and not the SAPY. Fundamentally the strategy was not invested enough into the SAPY in order to capture these rapid market corrections that were being compounded over time, which is made evidently clear in from 2004 to late 2017 and again in 2021.

***Table 11**: The Dual Momentum Strategy's Performance (SAPY Index)*

	Annual Return (CAGR)	Annual STDEV	Annual Sharpe	Max Drawdown	Avg Trades per Year	Jensen's Alpha
Dual Momentum	13,75%	12,70%	0,56	-31,61%	2,6	6,47%
Absolute Momentum	13,83%	12,95%	0,55	-20,29%	1,5	6,72%
Relative Momentum	13,95%	14,95%	0,49	-33,75%	1,7	6,89%
SAPY Index	13,50%	19,84%	0,34	-62,63%	-	-
MSCI ACWI Index	14,56%	13,87%	0,57	-34,83%	-	-

**Sample period 2004-2021.*
**Dual momentum's input indexes include the SAPY, MSCI ACWI and STeFI.*
**Absolute momentum's input indexes include the SAPY and STeFI.*
**Relative momentum's input indexes include the SAPY and MSCI ACWI.*
**The Beta for Jensen's alpha is calculated using a regression, benchmarked against the SAPY Index.*
**Excess return over the risk-free rate is used in the regression calculation.*

The dual momentum strategy with regards to the SAPY Index shown in **Table 11** confirmed dual momentum's inability to manage periods of high volatility. The SAPY's standard deviation is just short of 20% and had a significant maximum drawdown of -62.63%. The superior performing index is the MSCI ACWI as it had the highest annualised return and risk adjusted returns since it is not negatively impacted by the high volatility of the SAPY which severely impacted the momentum strategies. The MSCI ACWI has a slightly high risk adjusted return indicated by its Sharpe ratio of 0.57 than the dual momentum strategy. The dual momentum strategy did not manage harvest enough upside nor lower its standard deviation enough to outperform the MSCI ACWI as a result of the SAPY's high volatility. The strategy also only marginally improved its high maximum drawdown to -31.61% from the MSCI ACWI's at -34.83%. The strategy did however manage to generate an alpha of 6.47% (see Appendix H for the regression). Therefore, dual momentum strategy fell victim once again to high volatility as it inadequately captured upside returns, generously provided by the SAPY and made fatal missteps due to its inherent lag - a tendency seen across almost all of the cyclical indexes analysed in this study that were applied dual momentum.

5.3 Dual Momentum Applied to a Pool of Indexes

A pool of indexes was constructed where only the top performing index over a 12-month look-back period is used in the dual momentum strategy. The pool is made up of the JSE Top 40 Index, ALBI Index, RESI 20 Index, FINI 15 Index, INDI 25 Index and SAPY Index where dual momentum is only applied to the top performing index over a specific period in time. The sample period is limited to 13.5-years (after factoring in the formation period), to when the RESI, FINI and INDI commenced back in mid 2007.

5.3.1 Presentation of Results

***Figure 18**: The Dual Momentum Strategy's Performance (Pooled Indexes)*

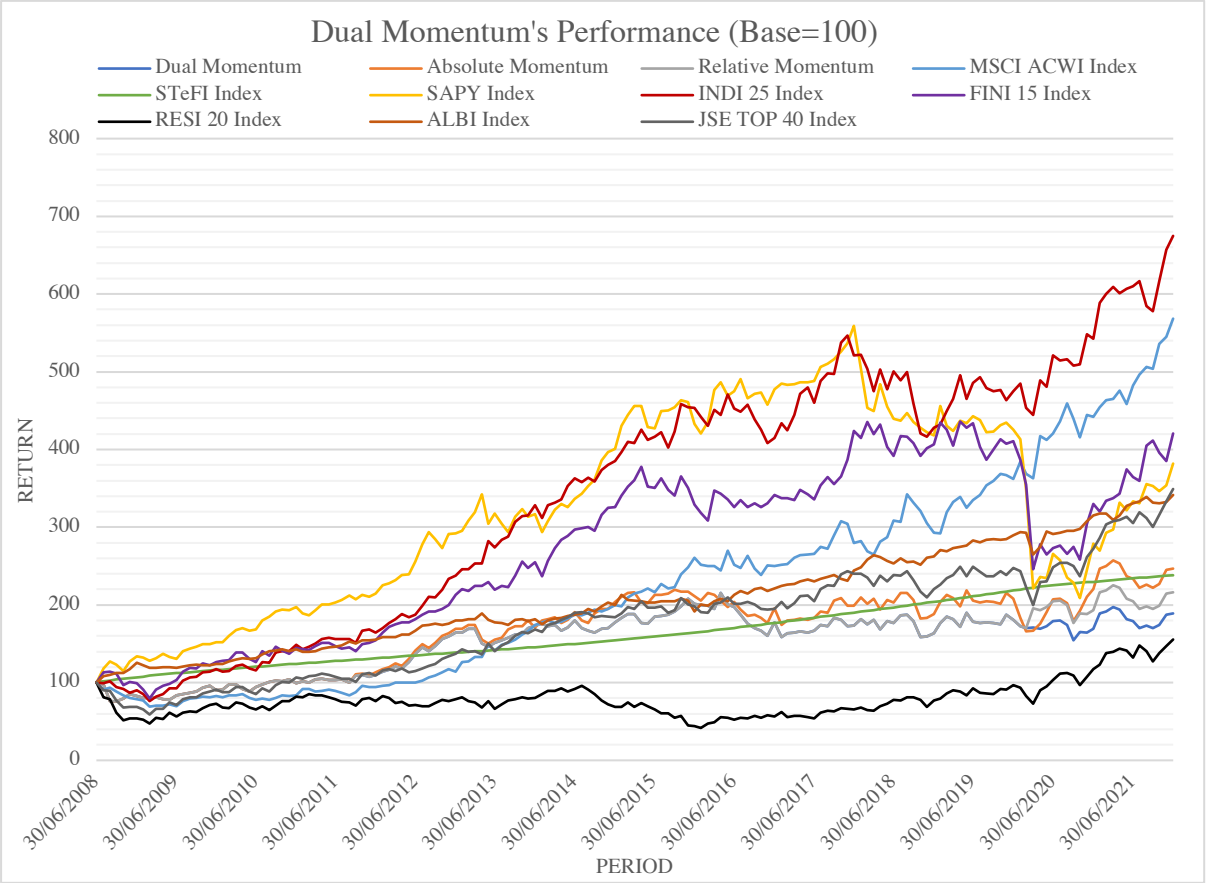


Figure 18 illustrates that the dual momentum strategy applied to a pool of indexes and the strategy underperformed every index except for the RESI, including both absolute and relative momentum. The strategy also failed to outperform the STeFI, a money market index. Similarly, absolute and relative momentum didn't do much better, where only absolute momentum was barely able to outperform the STeFI. The strategy began during the 2008 financial crises and

immediately managed to limit its downside and thereon started to rise until mid 2015. From mid 2015 the dual momentum strategy experienced a decline in return, and then began to oscillate all the way to 2021, unsuccessfully capturing any upside return. While indexes such as the SAPY and INDI were rapidly rising.

***Table 12**: The Dual Momentum Strategy's Performance (Pooled Indexes)*

	Annual Return (CAGR)	Annual STDEV	Annual Sharpe	Max Drawdown	Avg Trades per Year	Jensen's Alpha
Dual Momentum	4,82%	17,01%	-0,09	-28,17%	4,0	-2,16%
Absolute Momentum	6,91%	17,98%	0,04	-24,46%	3,4	-0,31%
Relative Momentum	5,87%	17,47%	-0,02	-26,57%	3,8	-0,95%
MSCI ACWI Index	13,74%	14,35%	0,52	-30,90%	-	-
STeFI Index	6,63%	0,50%	0,71	0,00%	-	-
SAPY Index	10,44%	19,90%	0,21	-62,63%	-	-
INDI 25 Index	15,19%	14,79%	0,60	-25,21%	-	-
FINI 15 Index	11,22%	19,54%	0,25	-43,54%	-	-
RESI 20 Index	3,32%	25,55%	-0,12	-58,31%	-	-
ALBI Index	9,52%	7,90%	0,41	-9,79%	-	-
JSE TOP 40 Index	9,70%	16,14%	0,21	-41,04%	-	-

**Sample period 2008-2021.*
* The pool of indexes is made up of the JSE Top 40 Index, ALBI Index, RESI 20 Index, FINI 15 Index, INDI 25 Index and SAPY Index. Where the momentum strategies are only applied to the top performing index over a specific period.
**Dual momentum's input indexes include the pool of indexes including the STeFI and MSCI ACWI.*
**Absolute momentum's input indexes include the pool of indexes excluding the MSCI ACWI.*
**Relative momentum's input indexes include the pool of indexes excluding the STeFI.*
**The Beta for Jensen's alpha is calculated using a regression, benchmarked against the JSE Top 40 Index.*
*******Excess return over the risk-free rate is used in the regression calculation.*

Table 12 exhibits a dire performance by the dual momentum strategy. The strategy only mustered an annualised return of 4.82% and coupled with one of the high annualised standard

deviations of 17.01%, produced a negative Sharpe ratio of -0.09. A negative Sharpe ratio indicates that the strategy's return is below that of the risk-free rate. The strategy was also not able to avoid significant bear markets as it experienced a maximum drawdown of -28.17%. The extent of the underperformance is captured by the dual momentums strategy's negative alpha of -2.16%, well underperforming the broader market (see Appendix I for the regression analysis). Similarly, absolute and relative momentum exhibited the same underperformance as dual momentum. Both absolute and relative momentum had inferior annualised returns and high standard deviations compared relatively to the input indexes. A key indicator and partial reason for this severe underperformance by the momentum strategies is the average trades per year. Dual momentum had an average of 3.9 trades per year, which is a significantly high number of trades relative to traditional levels established by the core dual momentum strategy in section 5.1.1. Therefore, the number of indexes included in the strategy led to a high frequency of trades being executed as a result of the strategy frequently changing from its invested index to the better performing index over a specific period in time. In other words, the invested indexes were constantly being switched before the strategy could realise any upside returns by harvesting the price momentum effect in the invested index. All of which exacerbated the strategy's failings in capturing early market corrections, due to many of the indexes' inherent cyclicality being burdened with high volatility which adversely affects price momentum and the dual momentum strategy. Keeping in mind that the strategy is trend following so things can go temporarily wrong primarily in bull markets when the strategy experiences whipsaws and lags due to the inclusion of absolute momentum. Ultimately, the dual momentum strategy applied to a pool of indexes significantly underperformed, where the strategy incurred higher levels of risk for immensely low returns which generated inferior risk adjusted returns. As a result of the strategy frequently changing positions before any price momentum profits could be realised due to the bombardment of indexes. Since, no one index could sustainably outperform the remaining indexes long enough for the strategy to remain in the invested index to be able harvest adequate upside returns.

6. Discussion

In this section the results will be reviewed in relation to the theoretical literature, either in support of the findings or contrary to the findings. Furthermore, limitations of the study will be discussed before further research recommendations are made.

6.1 Performance

The discussion surrounding the performance is separated into the same three categories in the results section. Beginning with the most important and focal point of this study the dual momentum strategy, constructed using the JSE Top 40 index, which is accompanied by a discussion on the two variations made to the core strategy. Next the first supplementary section is discussed which entails the dual momentum strategy being applied to several South African indexes across different sectors. Followed by a discussion on the second supplementary section where the dual momentum strategy is applied to a pool of indexes.

6.1.1 The Dual Momentum Strategy

The replication of Antonacci's (2014) dual momentum strategy within a South African context supported the findings of Antonacci (2014) as well as aligned closely with current momentum literature. The dual momentum strategy was able to avoid all significant bear markets due to its inclusion of absolute momentum. The strategy circumvented the 2008 financial crises and the 2020 COVID-19 pandemic which also significantly reduced the strategy's maximum drawdown during severe market stress. The strength of the model is derived from its ability to avoid bear markets. This is well depicted by the frequency distribution analysis illustrating that dual momentum was able to eliminate most of the left tail risk that the JSE Top 40 index had. The strategy was also able to capture significant upside during bullish markets. Therefore, the strategy was able to generate superior risk adjusted returns and harvest risk premia, predominantly from crisis alpha. Despite, substantially giving back excess performance to its benchmark the JSE Top 40 index during 2016 and mid 2020 due to poor market timing as a result of high volatility. The dual momentum strategy did battle during periods of high volatility, which corroborates with the findings of Antonacci (2014) that momentum strategies tend to struggle during periods of high volatility. Bogdanova and Nedev (2019) found evidence that during times of high volatility momentum strategies are highly losing. The strategy is trend following and things can go temporarily wrong, and the strategy can miss out on the early stages of market correction especially during periods of high volatility (Antonacci, 2014). This

primarily occurs in bull markets when the strategy experiences whipsaws and lags due to the inclusion of absolute momentum (Antonacci, 2014). The whipsaws and lags experienced in bull markets may have occurred from the medium to long-term contrarian effects found in the South African market discovered by Nnadi and Tanna (2019), or even reasons stemming from behavioural finance and investor irrationality (Kahneman & Tversky, 1974). However, this study could not assist in explaining the momentum anomaly nor was it intended to do so.

The dual momentum strategy's average trades per year increased relative to Antonacci's (2014) findings. An increase in transaction costs can have a major impact on the strategy's profitability. At the same time, the selection of the JSE Top 40 index played a crucial role in providing increased liquidity and trading volume, key to reducing trading costs from its smaller bid-ask spreads. Meaning that the dual momentum strategy's increase in average number of trades per year has an inconsequential effect on the strategy's profitability. Equally important, relative momentum generated a marginally greater annualised return above that of the dual momentum strategy. However, it closely tracked the JSE Top 40 and experienced a similar risk versus return profile, which means that the use of relative momentum can only marginally increase one's risk adjusted returns over the JSE Top 40 index. Whereas, dual momentum traded off significant risk at the expense of only 10 basis points in annualised return. For this reason, the dual momentum strategy was able to generate the highest risk adjusted returns far above that of its benchmark the JSE Top 40 index as well as relative momentum.

The results of the dual momentum strategy support current momentum literature and for this reason challenges the EMH. This study provides empirical evidence of historical stock price's predictive power which supports Shiller's (1980) findings that stock prices weren't so random and that they have predictable components. The dual momentum strategy's predictive power from historical prices contradicts EMH's weak form efficiency since historical prices can be used to predict future prices. If markets are efficient then all prices reflect all available and relevant market information which means that there is no way for an investor to outperform the market since none of the securities are over or undervalued (Boyle, 2020). Yet the dual momentum strategy was able to generate significant alpha, meaning that current prices did not reflect all the available and relevant market information. Furthermore, the results of this study validate the success of the dual momentum strategy which supports Jegadeesh and Titman's (1993) evidence that over a 6 to 12-month period of past performance, winning stock continued

to outperform over the next 6 to 12-months. As a result, confirms the presence of the momentum anomaly but does not assist in explaining why it occurs. This market anomaly in finance theory remains largely unexplained since a rise in asset price should not warrant any further increase by itself.

Variation 1

The first variation of the dual momentum strategy is modelled using a 6-month look-back period. This is aimed at analysing whether South African markets are better suited for the shorter and second most sort after 6-month look-back period, after the more robust 12-month look-back period which is used in the core strategy. This variation of the dual momentum strategy underperformed significantly, as it too frequently traded in and out of positions before any price momentum could be strengthen and subsequently captured. Shorter look-back periods tend to have a lot more whipsaws and often includes data that is not relevant enough (Antonacci, 2014). The model may have lowered its standard deviation, but its maximum drawdowns increased and its average trades per year increased. Therefore, a 6-month look-back period is not a suitable look-back period for the South African market. South African markets can experience periods of high volatility in which a 6-month look-back period inadequately copes with.

Variation 2

The second variation of the model altered the threshold of absolute momentum. Which indirectly lowers the threshold of dual momentum since it is an amalgamation of absolute and relative momentum. The threshold of the dual momentum strategy within a South African context is high, since the risk-free rate is inherently high due to South Africa's associated risks.[13] By lowering the threshold, the strategy was more susceptible to volatility and the strategy's inability to manage periods of high volatility was compounded which led to poor market timing. For this reason, the strategy experienced an increase in standard deviation and maximum drawdown while achieving a slightly lower annualised return. As a result, the strategy generated lower risk adjusted returns in comparison to the core strategy due to it being more vulnerable to high volatility. Therefore, the hurdle rate used by absolute momentum in

[13] The risk-free asset used is the South African 91-day Treasury bill.

the core dual momentum strategy plays a key defensive role and should not be lowered within a South African context.

6.1.2 The Dual Momentum Strategy Applied to Indexes Across Different Sectors

The dual momentum strategy applied to various indexes across different sectors analysed whether dual momentum could generate superior risk adjusted returns within specific South African sectors. The dual momentum strategy underperformed severely for the most part, when it was applied to the ALBI Index, RESI 20 Index, FINI 15 Index, INDI 25 Index and SAPY Index. The strategy produced the worst risk adjusted returns out of all the indexes across the different sectors except for the RESI 20 Index. The RESI index hugely underperformed of which the dual momentum strategy was able to mitigate its downside and not track the RESI index to extreme lows. Notably, these indexes are particularly cyclical which supports Antoncci's (2014) findings. Cyclical indexes and stocks are heavily influenced by systematic or macroeconomic changes in the overall economy. Antonacci (2014) found that momentum strategies tend to struggle during periods of high market volatility. This is because in the late stages of market rally, momentum strategies often overweigh more cyclical indexes and stocks (Antonacci, 2014). These cyclical indexes are the same indexes that get negatively impacted the most during stages of market correction as momentum strategies tend to overweigh the more defensive indexes and miss out on early market recovery stages (Antonacci, 2014). Therefore, the results support that the use of cyclical indexes and stocks can be severely detrimental to the dual momentum strategy by demonstrating the strategy's inability to generate superior risk adjusted returns.

An additional finding is observed with regards to the structure of the dual momentum strategy. The dual momentum strategy is structured in such a way that the primary index has to achieve positive absolute momentum by surpassing the hurdle rate's returns over a 12-month look-back period, before it can be relatively compared to a peer index. In other words, if the peer index is the superior performing index, the strategy does not consider it until the primary index achieves positive absolute momentum. Therefore, if the primary index constantly underperforms the hurdle rate signalling the strategy to remain defensive, then the strategy prohibits itself from taking up a position in the superior performing peer index. The root of the problem stems from the selection of an underperforming primary index. For this reason, one should select an index that can sustainably generate returns above that of the hurdle rate and

likely to only underperform the hurdle rate during a downturn or high volatility, signalling the strategy to be defensive. The selection of a sustainably strong performing and well diversified primary index is key to the performance of the dual momentum strategy. It is also crucial that the primary index and peer index are not similar in performance. Since the strategy would constantly switch between the two indexes which increases the average number of trades per year. Thus, impacting the strategy's profitability, by driving up transaction costs and by causing the strategy to frequently miss out on the early stages of market correction. To avoid this, one would need to select two indexes that differs slightly in performance, constructing the superior performing index as the primary index.

6.1.3 The Dual Momentum Strategy Applied to a Pool of Indexes

The results from the pool of indexes where the dual momentum strategy is only applied to the top performing index over a 12-month look-back period, were unsatisfactory. The pool was constructed from the JSE Top 40 Index, ALBI Index, RESI 20 Index, FINI 15 Index, INDI 25 Index and SAPY Index. This strategy was not able to circumvent significant bear markets and the extent of the underperformance was captured by its negative alpha, well underperforming the broader market. The number of indexes included in the strategy led to a high frequency of trades being executed as the strategy frequently changed its invested index to a better performing index over a specific period in time. This led to indexes constantly being switched between before the strategy could realise any significant returns by harvesting the momentum effect within the invested index. This was exacerbated by the strategy's inclusion of multiple inherently cyclical indexes which led to further shortfalls in capturing early market corrections during periods of high volatility. Ultimately, the increased number of indexes led to a significant increase in average trades per year as the strategy constantly switched in and out of positions. Resulting in adverse effects to profitability since the strategy didn't allow for the model to remain in the invested index long enough to capture upside returns as well as increased the strategy's transaction costs. Momentum works best when an investor is focused on a few top performing momentum stocks or indexes. In other words, the more selective and concentrated an investor is when selecting momentum stock or indexes, the more profitable the strategy will be (Antonacci, 2014). Conversely, if an investor has a larger portfolio and isn't very selective then returns will diminish which is illustrated by the results of the dual momentum strategy applied to the pool of indexes.

6.1.4 Summary

The dual momentum strategy within a South African context was able to achieve superior risk adjusted returns due to its combination of absolute and relative momentum which supports Antonacci's (2014) findings. Absolute momentum acts as a better asset filtration system which significantly reduces drawdowns, lowering the strategy's downside volatility (i.e., left tail risk). Thus, absolute momentum plays a key adaptable defensive role in the strategy as it acts as a hurdle rate yet allows market risk when it makes the most sense (i.e., positive absolute momentum), while the combination of relative and absolute momentum captures upside volatility and converts it into abnormal returns. This means that the strategy is effective at capturing risk premia from volatile assets. The strategy's ability to capture risk premia by using historical price data challenges EMH's weak form efficiency and supports the presence of the momentum anomaly, despite not being able to explain it.

Furthermore, the strategy does not achieve greater risk adjusted return by lowering the threshold or shortening the look-back period. The results of the sector specific indexes did not fare much better. This is because during the late stages of market rally during periods of high market volatility, the strategy often misses out on early market recovery stages due to the inherent cyclicality of the indexes used in the model. Accordingly, the dual momentum strategy applied to a pool of indexes exhibited the same significant underperformance since the model was constructed with the same cyclical indexes. However, this model was also burdened by the number of indexes included in the pool which in turn led to diminished returns. Momentum strategies benefit from being more selective. Therefore, the selection of a strong performing well-diversified index is far more advantageous to the dual momentum strategy than trying to diversify by including more indexes into the strategy.

6.2 Transaction Costs

Transaction costs can severely affect the profitability of momentum strategies. Importantly, the aim of this study did not include factoring in transaction costs since they can differ significantly depending on the broker and selected investment. Most momentum strategies suffer from large spreads, illiquidity, and high frequency trading which drive up transaction costs (Clare, et al., 2010). Thus, momentum-based strategies that adopt a low-cost attitude can enhance returns significantly. This is what Antonacci (2014) did by employing low frequency trading in large indexes with low costs that characteristically had small spreads and high liquidity. The dual

momentum strategy within a South African context aimed to do exactly that and invest into a large highly traded liquid index with a small spread, the JSE Top 40. The South African JSE Top 40 index is characteristically the strongest and most probable index to succeed when applying the dual momentum strategy. The strategy did manage to achieve superior risk adjusted returns, however, the trading frequency roughly doubled with respect to Antonacci's (2014) findings. In spite of this, the strategy's average trades per year still falls on the lower end of the spectrum, only marginally affecting profitability. The first variation of the strategy increased in average number of transactions per year by just short of 30% which will have a slightly higher impact on the profitability of the strategy, while the second variation was more closely aligned with the core strategy. Furthermore, the sector focused strategies differed in average trades per year ranging from 2.4 to 3 depending on the volatility of the indexes used, which is still low relative to most momentum strategies. Accordingly, the indexes pooled together had an average of 4 trades per year due to the model's bombardment of indexes. Which led to the frequent trading of indexes due to the subsequent volatility of the South African market.

Ultimately, the dual momentum strategy uses a highly liquid index with a high trading volume that maintains a small spread that is only rebalanced monthly to keep trading costs low. A major concern of the strategy is the number of trades per year and unavoidable tax implications due on withdrawal. The core dual momentum strategy has only averaged 2.5 trades per year which is low and still very profitable especially considering its low-cost trading approach. Even the supplementary strategies kept trading frequency low. Despite some of the strategies such as the pooled indexes operating far less optimally incurring 1.6 times more average trades per year than the core strategy. Which is still profitable due to the use of highly traded liquid indexes as well as monthly rebalancing. For instance, daily rebalancing would have a substantial impact on the profitability of the strategy. Which may not even be profitable at all due to the transaction costs incurred by the significant increase in number of trades per year. In short, the average trades per year of the dual momentum strategy are marginal and cost efficient as well as give no reason to believe that the trading costs are high enough to make the strategy unprofitable. Keeping in mind that trading costs can differ vastly depending on the investment. Therefore, before using the dual momentum strategy one would have to investigate the associated costs rigorously.

6.3 Limitations

Dual momentum is considered a long-term strategy and literature suggests that a look-back period of 12-months is most optimal particularly with long-term momentum strategies. The strategy thrives on its ability to generate long-run excess returns by avoiding significant bear markets and thus achieving crises alpha. For this reason, a key limitation of this study is its small sample period. The study goes back as far as the South African indexes used allow and for indexes such as the RESI, FINI and INDI that is only 14.5 years back to mid 2007. Which has yet to include the 12-month look-back period, meaning that the sample period actually starts 12-months later only 13.5 years back to mid 2008. Furthermore, this small sample period then experienced two major financial crises in quick succession, the 2008 financial crises and the 2020 COVID-19 pandemic. Furthermore, the strategy for the RESI, FINI and INDI as well as the strategy applied to the pooled indexes began during the 2008 financial crises. The sample period didn't increase much for the JSE Top 40, ALBI and SAPY since the indexes were limited by the STeFI index which only commenced in mid 2003. When including the 12-month look-back period the sample period starts12-months later only 17.5 years back to mid 2004. Ultimately, due to most South African Indexes only commencing in the 21st century, the sample period is significantly shortened which hindered the dual momentum strategy's ability to outperform, since it is a long-term strategy.

The second key limitation is the exclusion of transaction costs. Transaction costs can play a major role in momentum strategies due to their impact on profitability. The more frequent trades occur the higher the costs. Trading costs are also highly dependent on the investments selected. The third limitation is the unavoidable foreign exchange risk associated with offshore investments. Since, this study makes use of the MSCI ACWI index which provides the strategy with offshore exposure and better diversifies its country specific risks. However, when the strategy switches to the MSCI ACWI there is foreign exchange rate risk attached to the offshore exposure that needs to be taken into consideration. Lastly, this study and subsequent analysis does not explain price momentum and did not aim to. Price momentum continues to remain largely unexplained by current finance literature.

6.4 Recommendations for Further Research

Further dual momentum research could be conducted with the use of ETFs instead of indexes in the pursuit of superior risk adjusted returns. The same principal could also be applied to a

well-diversified portfolio constructed from various ETFs. ETFs can provide a good low transaction cost alternative to indexes. Another recommendation would be to implement the dual momentum strategy inclusive of transaction costs. In doing so one would have to deduct the specific trading costs of the investment associated with every transaction performed in the portfolio and draw conclusions on the dual momentum strategy's profitability. Moreover, further research can be conducted with regards to finding the optimal hurdle rate for the dual momentum strategy, since altering the hurdle rate can have a major impact on the strategy's profitability. Lastly, one could attempt to better explain the momentum anomaly and its persistence with a suitable model built with the sole intention of explaining the momentum effect.

7. Conclusion

This research paper pursued to implement Gary Antonacci's dual momentum strategy from a South African perspective to determine whether the strategy could achieve superior risk adjusted returns and harvest risk prima. While also investigating the presence of the momentum anomaly which challenges the very foundation on which EMH is built.

7.1 Research Question 1

The results of the dual momentum strategy within a South African context corroborate with the findings of Antonacci (2014). The strategy was able to exploit price momentum and achieve superior risk adjusted returns via combining both time-series and cross-sectional momentum over the sample period. The simplistic and universally implementable dual momentum strategy is a viable investment strategy for the South African JSE. The strength of the strategy is derived from the inclusion of absolute momentum. Absolute momentum's trend determination significantly mitigated downside risk, as well as took advantage of upside persistence. For this reason, absolute momentum is considerably valuable as it reduces the potential drawdown, associated with high downside volatility. While both absolute and relative momentum can harvest upside volatility and enhance expected returns, converting it into abnormal returns. The dual momentum strategy avoided high volatility and downside variability yet still enjoys decent returns while minimising trading costs, and as a result generated significant positive alpha and superior risk adjusted returns.

7.2 Research Question 2

The results in this research paper do not support conventional finance's efficient market hypothesis. This study challenges EMH's weak form efficiency since historical prices are successfully used to predict future prices in the dual momentum strategy over the sample period. This confirms the presence of the premier anomaly momentum in the South African market and adds to the growing criticism of the EMH.

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9. Appendices

Appendix A

***Table 13**: Dual Momentum Regressed Against the JSE Top 40 Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0901	0,0315	2,8610	0,0046*
Beta	-0,0714	0,0555	-1,2862	0,1998
Model statistics				
Multiple R	0,088			
R Squared	0,008			
Adjusted R Squared	0,003			
Residual Standard Error	0,453			
F-Statistic	1,654			
Observations	212			

*denote significance at 1% level. F-statistic on 1 degree of freedom.

***Table 14**: Absolute Momentum Regressed Against the JSE Top 40 Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0799	0,0321	2,4922	0,0135*
Beta	-0,0698	0,0566	-1,2341	0,2185
Model statistics				
Multiple R	0,085			
R Squared	0,007			
Adjusted R Squared	0,002			
Residual Standard Error	0,462			
F-Statistic	1,523			
Observations	212			

*denote significance at 5% level. F-statistic on 1 degree of freedom.

***Table 15**: Relative Momentum Regressed Against the JSE Top 40 Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0931	0,0369	2,5249	0,0123*
Beta	-0,0611	0,0650	-0,9410	0,3478
Model statistics				
Multiple R	0,065			
R Squared	0,004			
Adjusted R Squared	-0,001			
Residual Standard Error	0,530			
F-Statistic	0,886			
Observations	212			

*denote significance at 5% level. F-statistic on 1 degree of freedom.

Appendix B

***Table 16**: Dual Momentum Regressed Against the JSE Top 40 (6-Month Look-Back)*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0642	0,0294	2,1863	0,0299*
Beta	-0,0513	0,0518	-0,9910	0,3228
Model statistics				
Multiple R	0,068			
R Squared	0,005			
Adjusted R Squared	0,000			
Residual Standard Error	0,423			
F-Statistic	0,982			
Observations	212			

*denote significance at 5% level. F-statistic on 1 degree of freedom.

***Table 17**: Absolute Momentum Regressed Against the JSE Top 40 (6-Month Look-Back)*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0649	0,0297	2,1823	0,0302*
Beta	-0,0577	0,0525	-1,1001	0,2725
Model statistics				
Multiple R	0,076			
R Squared	0,006			
Adjusted R Squared	0,001			
Residual Standard Error	0,428			
F-Statistic	1,210			
Observations	212			

*denote significance at 5% level. F-statistic on 1 degree of freedom.

***Table 18**: Relative Momentum Regressed Against the JSE Top 40 (6-Month Look-Back)*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0885	0,0373	2,3729	0,0186*
Beta	-0,0538	0,0658	-0,8182	0,4141
Model statistics				
Multiple R	0,056			
R Squared	0,003			
Adjusted R Squared	-0,002			
Residual Standard Error	0,537			
F-Statistic	0,670			
Observations	212			

*denote significance at 5% level. F-statistic on 1 degree of freedom.

Appendix C

***Table 19**: Dual Momentum Regressed Against the JSE Top 40 (Reduced Threshold)*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0808	0,0328	2,4645	0,0145*
Beta	-0,0644	0,0578	-1,1142	0,2665
Model statistics				
Multiple R	0,077			
R Squared	0,006			
Adjusted R Squared	0,001			
Residual Standard Error	0,472			
F-Statistic	1,241			
Observations	212			

*denote significance at 5% level. F-statistic on 1 degree of freedom.

***Table 20**: Absolute Momentum Regressed Against the JSE Top 40 (Reduced Threshold)*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0717	0,0334	2,1482	0,0329*
Beta	-0,0645	0,0588	-1,0971	0,2739
Model statistics				
Multiple R	0,075			
R Squared	0,006			
Adjusted R Squared	0,001			
Residual Standard Error	0,480			
F-Statistic	1,204			
Observations	212			

*denote significance at 5% level. F-statistic on 1 degree of freedom.

***Table 21**: Relative Momentum Regressed Against the JSE Top 40 (Reduced Threshold)*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0931	0,0369	2,5249	0,0123*
Beta	-0,0611	0,0650	-0,9410	0,3478
Model statistics				
Multiple R	0,065			
R Squared	0,004			
Adjusted R Squared	-0,001			
Residual Standard Error	0,530			
F-Statistic	0,886			
Observations	212			

*denote significance at 5% level. F-statistic on 1 degree of freedom.

Appendix D

***Table 22**: Dual Momentum Regressed Against the ALBI Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0618	0,0260	2,3721	0,0186*
Beta	0,1301	0,1010	1,2879	0,1992
Model statistics				
Multiple R	0,089			
R Squared	0,008			
Adjusted R Squared	0,003			
Residual Standard Error	0,378			
F-Statistic	1,659			
Observations	212			

*denote significance at 5% level. F-statistic on 1 degree of freedom.

***Table 23**: Absolute Momentum Regressed Against the ALBI Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0088	0,0161	0,5464	0,5854
Beta	-0,0206	0,0624	-0,3307	0,7412
Model statistics				
Multiple R	0,023			
R Squared	0,001			
Adjusted R Squared	-0,004			
Residual Standard Error	0,234			
F-Statistic	0,109			
Observations	212			

F-statistic on 1 degree of freedom.

***Table 24**: Relative Momentum Regressed Against the ALBI Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0578	0,0286	2,0203	0,0446*
Beta	0,0290	0,1109	0,2611	0,7942
Model statistics				
Multiple R	0,018			
R Squared	0,000			
Adjusted R Squared	-0,004			
Residual Standard Error	0,415			
F-Statistic	0,068			
Observations	212			

*denote significance at 5% level. F-statistic on 1 degree of freedom.

Appendix E

***Table 25**: Dual Momentum Regressed Against the RESI 20 Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0064	0,0467	0,1373	0,8910
Beta	-0,0331	0,0529	-0,6263	0,5320
Model statistics				
Multiple R	0,049			
R Squared	0,002			
Adjusted R Squared	-0,004			
Residual Standard Error	0,598			
F-Statistic	0,392			
Observations	164			

F-statistic on 1 degree of freedom.

***Table 26**: Absolute Momentum Regressed Against the RESI 20 Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0151	0,0526	0,2881	0,7736
Beta	0,0053	0,0595	0,0884	0,9297
Model statistics				
Multiple R	0,007			
R Squared	0,000			
Adjusted R Squared	-0,006			
Residual Standard Error	0,673			
F-Statistic	0,008			
Observations	164			

F-statistic on 1 degree of freedom.

***Table 27**: Relative Momentum Regressed Against the RESI 20 Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0395	0,0530	0,7445	0,4576
Beta	-0,0567	0,0601	-0,9438	0,3467
Model statistics				
Multiple R	0,074			
R Squared	0,005			
Adjusted R Squared	-0,001			
Residual Standard Error	0,679			
F-Statistic	0,891			
Observations	164			

F-statistic on 1 degree of freedom.

Appendix F

***Table 28**: Dual Momentum Regressed Against the FINI 15 Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0521	0,0324	1,6081	0,1098
Beta	-0,0659	0,0477	-1,3817	0,1690
Model statistics				
Multiple R	0,108			
R Squared	0,012			
Adjusted R Squared	0,006			
Residual Standard Error	0,413			
F-Statistic	1,909			
Observations	164			

F-statistic on 1 degree of freedom.

***Table 29**: Absolute Momentum Regressed Against the FINI 15 Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0620	0,0339	1,8310	0,0689*
Beta	-0,0279	0,0499	-0,5601	0,5762
Model statistics				
Multiple R	0,044			
R Squared	0,002			
Adjusted R Squared	-0,004			
Residual Standard Error	0,432			
F-Statistic	0,314			
Observations	164			

*denote significance at 10% level. F-statistic on 1 degree of freedom.

***Table 30**: Relative Momentum Regressed Against the FINI 15 Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0511	0,0409	1,2476	0,2140
Beta	-0,0918	0,0604	-1,5216	0,1301
Model statistics				
Multiple R	0,119			
R Squared	0,014			
Adjusted R Squared	0,008			
Residual Standard Error	0,523			
F-Statistic	2,315			
Observations	164			

F-statistic on 1 degree of freedom.

Appendix G

***Table 31**: Dual Momentum Regressed Against the INDI 25 Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0703	0,0315	2,2338	0,0269*
Beta	-0,0306	0,0604	-0,5069	0,6129
Model statistics				
Multiple R	0,040			
R Squared	0,002			
Adjusted R Squared	-0,005			
Residual Standard Error	0,399			
F-Statistic	0,257			
Observations	164			

*denote significance at 5% level. F-statistic on 1 degree of freedom.

***Table 32**: Absolute Momentum Regressed Against the INDI 25 Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0879	0,0320	2,7513	0,0248*
Beta	-0,0794	0,0614	-1,2934	0,1977
Model statistics				
Multiple R	0,101			
R Squared	0,010			
Adjusted R Squared	0,004			
Residual Standard Error	0,405			
F-Statistic	1,673			
Observations	164			

*denote significance at 5% level. F-statistic on 1 degree of freedom.

***Table 33**: Relative Momentum Regressed Against the INDI 25 Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0777	0,0406	1,9117	0,0577*
Beta	0,0046	0,0780	0,0594	0,9527
Model statistics				
Multiple R	0,005			
R Squared	0,000			
Adjusted R Squared	-0,006			
Residual Standard Error	0,515			
F-Statistic	0,004			
Observations	164			

*denote significance at 10% level. F-statistic on 1 degree of freedom.

Appendix H

***Table 34**: Dual Momentum Regressed Against the SAPY Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0629	0,0303	2,0762	0,0391*
Beta	0,0886	0,0439	2,0197	0,0447*
Model statistics				
Multiple R	0,138			
R Squared	0,019			
Adjusted R Squared	0,014			
Residual Standard Error	0,438			
F-Statistic	4,079			
Observations	212			

*denote significance at 5% level. F-statistic on 1 degree of freedom.

***Table 35**: Absolute Momentum Regressed Against the SAPY Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0659	0,0310	2,1286	0,0344*
Beta	0,0626	0,0449	1,3957	0,1643
Model statistics				
Multiple R	0,096			
R Squared	0,009			
Adjusted R Squared	0,004			
Residual Standard Error	0,448			
F-Statistic	1,948			
Observations	212			

*denote significance at 5% level. F-statistic on 1 degree of freedom.

***Table 36**: Relative Momentum Regressed Against the SAPY Index*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	0,0693	0,0360	1,9276	0,0553*
Beta	0,0550	0,0521	1,0547	0,2928
Model statistics				
Multiple R	0,073			
R Squared	0,005			
Adjusted R Squared	0,001			
Residual Standard Error	0,520			
F-Statistic	1,112			
Observations	212			

*denote significance at 5% level. F-statistic on 1 degree of freedom.

Appendix I

***Table 37**: Dual Momentum Regressed Against the JSE Top 40 (Pooled Indexes)*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	1,3023	0,1741	7,4813	0,0000*
Beta	0,2038	0,3097	0,6580	0,5115
Model statistics				
Multiple R	0,052			
R Squared	0,003			
Adjusted R Squared	-0,003			
Residual Standard Error	2,224			
F-Statistic	0,433			
Observations	164			

*denote significance at 1% level. F-statistic on 1 degree of freedom.

***Table 38**: Absolute Momentum Regressed Against the JSE Top 40 (Pooled Indexes)*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	1,3209	0,1779	7,4261	0,0000*
Beta	0,2739	0,3165	0,8656	0,3880
Model statistics				
Multiple R	0,068			
R Squared	0,005			
Adjusted R Squared	-0,002			
Residual Standard Error	2,272			
F-Statistic	0,749			
Observations	164			

*denote significance at 1% level. F-statistic on 1 degree of freedom.

***Table 39**: Relative Momentum Regressed Against the JSE Top 40 (Pooled Indexes)*

Coefficients	Estimate	std. error	t-stat	p-value
Intercept	1,3147	0,1767	7,4384	0,0000*
Beta	0,1584	0,3145	0,5037	0,6151
Model statistics				
Multiple R	0,040			
R Squared	0,002			
Adjusted R Squared	-0,005			
Residual Standard Error	2,258			
F-Statistic	0,254			
Observations	164			

*denote significance at 1% level. F-statistic on 1 degree of freedom.