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Style-based investment strategies for currencies

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A research project submitted to the Gordon Institute of Business Science, University of Pretoria, in partial fulfilment of the requirements for the degree of Master of Business Administration.

7 November 2016

Abstract

In this paper a graphical time-series approach was used to analyse style-based investment strategies for currencies. The styles investigated included momentum, volatility and value, and particular focus was given to understanding whether differences exist in the results between the currencies of developed versus emerging countries. The results showed that differences between emerging and developed currencies were statistically significant for each of the styles studied and that the classification of countries' currencies, as either developed or emerging, was therefore necessary in analyses. Momentum was confirmed to exist in currencies, with a reversion to the mean in the long-term; optimal returns were achieved with the least momentum (quintile five) currencies, using a 10-month look-back period (formation period), three-month look-to period and a two-month holding period. Volatility as a style started out as a particularly good trading strategy, but the results show that the style has been traded-out from around the time of the global financial crisis in 2007 to 2008. Returns from the value style have persisted, with the greatest returns achieved with those currencies most under-valued according to the Big Mac index. The relative strength of the base currency used in the analysis, in this case the U.S. dollar, was found to have a significant impact on the success of the various style-based investment strategies.

Keywords

Currencies; style; time-series; momentum; value; volatility

Declaration

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Masters of Business Administration at the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other University. I further declare that I have obtained the necessary authorisation and consent to carry out his research.

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7 November 2016

Contents

List of Figures

List of Tables

List of Equations

List of Acronyms

AAR	Average Annual Returns
BCTI	Barclay Currency Traders Index
BIS	Bank of International Settlements
BRICS	Brazil, Russia, India, China, South Africa
CAPM	Capital Asset Pricing Model
FOREX	Foreign Exchange
FTSE	Financial Times Stock Exchange
GDP	Gross Domestic Product
JSE	Johannesburg Stock Exchange
IMF	International Monetary Fund
MOM	Momentum
OECD	Organisation for Economic Co-operation and Development
PPP	Purchasing Power Parity
S&P	Standard & Poor's
USD	United States Dollar
VAL	Value
VBA	Visual Basic for Applications
VOL	Volatility

1. Introduction to Research Problem

1.1. Research title

Style-based investment strategies for currencies.

1.2. Research problem

The ability to predict exchange rates is important to market traders, corporates and policy makers (Kenneth, 2013). Market traders use econometric models to discover ways of exploiting market inefficiencies to make excess returns, whilst minimising their exposure to risk. Corporates need to be able to predict exchange rates to allow for the timing of major foreign exchange (forex) transactions. Chung and Hong (2007) note that the ability to predict exchange rates is also important to policy makers, particularly for countries making use of a pegged exchange rate system as they often use exchange rate changes to maintain economic stability or even as a means of monetary policy to achieve certain macroeconomic objectives, such as low inflation, price stability, low unemployment and trade balance. Intervention in the forex market would usually take place when exchange rates are expected to either depreciate or appreciate beyond a pre-determined threshold (Chung & Hong, 2007).

There are two major schools of thought for investment strategies, the first being trading on fundamentals, which typically attempt to predict future trends on the basis of a number of factors believed to affect the exchange rate movement (Kenneth, 2013). The other is technical analysis, which according to Kenneth (2013), make use of past patterns and time-series trends, and are more suitable for predicting short-run trends. Chung and Hong (2007) note that technically oriented forecasts are also usually more accurate than economic structural models in predicting changes in exchange rates.

Academics in the field of behavioural finance have shown that exchange rate and stock momentum are consistent with psychological feedback mechanisms (Gómez-González & García-Suaza, 2012). Typically, when a market is perceived to be depreciating or appreciating, investors tend to believe that the trend will continue. Barraso and Santa-Clara (2015) show that investing in currencies offers exposure to “unknown risk factors” that allow for significantly improved portfolio performance, where portfolios are already

exposed to stocks and bonds, making currency trading an attractive hedge against traditional asset classes.

According to Pojarliev and Levich (2008), currency trading has grown to become a popular asset class since the 1990s, which is assumed to be a result of the abundant literature written in the field of currency trading strategies as potential sources of excess returns. Gómez-González and García-Suaza (2012) argue that if forex markets were completely efficient, currencies would fluctuate randomly after having been controlled for various market factors. They do however state that there is sufficient evidence to suggest that the "random walk hypothesis" in forex markets does not prevail, which allows for the opportunity to exploit markets (Gómez-González & García-Suaza, 2012). "Beating the market" and predicting future trends in currencies has become increasingly difficult with the use of traditional investment strategies. Traders and analysts need to continue to innovate and find ways to generate profitable returns for their investors, with much of this work being left to academics to develop.

There is therefore a need for the development of optimised investment strategies, particularly for more volatile emerging markets, that consider various investment styles to ensure that investors and analysts can provide value and generate returns for their investors. As discussed above, the ability to predict exchange rates will be highly beneficial to those involved in forex transactions to ensure that where possible, value is created rather than eroded through the timing of transactions, as well as to policy makers needing to mitigate risk.

1.3. Research aim

The aim of this research was to explore various technical investment styles used to trade in currencies and determine whether they are useful in creating excess returns for traders and investors. Additionally, investment styles not well covered in the literature were further explored to determine whether there is any merit in trading on such principles. Results were established by developing a theoretical style model for investors to use to "beat the market", thereby yielding positive returns after transaction costs. The research also aimed to further understand the differences (if any) in transacting using

developed currencies versus emerging currencies, enabling the relevance of previous studies done on major currencies to be verified as applicable to emerging currencies.

Furthermore, the research aimed to contribute to the vast literature available on currency investment, documenting empirically optimised results on existing styles, which have not been documented in the literature. Areas for potential future research were also identified, which will allow for the continual development of knowledge in the area of style-based investment strategies for currencies.

1.4. Report outline

The report follows on in chapter two with an overview of the relevant theory and literature concerning style-based currency trading. It begins broadly with an overview of currencies analysed in past literature, covering various methodologies used to “beat the market”, thereafter narrowing down to the most recent literature on isolated styles. This is then followed by the most recent literature on combination style-based trading strategies for currencies. Chapter three highlights the major research objectives and provides an encompassing research question that the project aims at answering. A detailed overview of the research methodology and design is provided in chapter four, which includes a justification for the proposed methodology, the population, unit of analysis, sampling method and size, measurement instrument, analysis approach, and limitations to the research. In chapter five, an overview of results from the empirical analysis is provided, followed by an in-depth discussion of the results in chapter six. Finally, the research report concludes in chapter seven with a summary of the principal findings, implications for management, limitations of the research and finally suggestions for future research in the area of style-based investment strategies for currencies.

2. Literature Review

2.1. Introduction to the literature review

The literature review is divided into three distinct sections: currencies analysed, methodologies used for analysis, and style-basis for investment strategies. Due to the immense literature available on investment in currencies, the literature review is limited to the more recently published, peer-reviewed journal articles, focusing on style-based strategies rather than fundamental types of analyses. Although the literature on currency investment is vast, there is limited material on style-based investment approaches for currencies. Where such shortcomings exist, reference is made to style-based investments in other asset classes, where such investment strategies are more popular.

2.2. Currencies analysed

2.2.1. Developed currencies

Many of the journal articles studied focus on Organisation for Economic Co-operation and Development (OECD) currencies for their analyses. Barroso and Santa-Clara (2015) made use of 27 member countries of the OECD. Their argument for using OECD countries for their sample was that it is difficult to determine when emerging currencies first became suitable assets to invest in, and by using all OECD currencies they were avoiding selection bias. Exchange rate data with a monthly frequency was used for the period November 1960 to December 2011 (Barroso & Santa-Clara, 2015).

Asness, Moskowitz, and Pedersen (2013) made use of 10 major currencies from the following countries: Australia, Canada, Germany (linked to the Euro), Japan, New Zealand, Norway, Sweden, Switzerland, United Kingdom and United States of America. The authors provided no rationale for their choice of currencies, therefore one can assume that judgement or convenience sampling was used for their analysis. The data used covered a period from January 1979 to July 2011, with a minimum of seven currencies available at any point in time and all 10 currencies available after 1980 (Asness et al., 2013). This was the same universe used by Moskowitz, Ooi and Pedersen (2011).

2.2.2. Emerging currencies

Tajaddini and Crack (2012) analysed momentum-based trading strategies on emerging markets, using data from 1985 to 2009. The authors noted that currencies in emerging markets are less liquid than those of major markets, and that limitations of free trade are often created due to interventions and capital controls by their respective central banks. Additionally, these market inefficiencies could present an opportunity to be exploited, as was shown in their analysis of six emerging currencies, namely Mexico, Philippines, South Africa, South Korea, Sri Lanka and Thailand.

Narayan, Mishra, Narayan, and Thuraisamy's (2015) paper considered exchange rate trading in four emerging markets, namely Brazil, India, China, and South Africa. Russia was excluded due to limitations on the availability of high-frequency intra-day data. Their motivation for using the aforementioned currencies was related to an announcement at the 2012 BRICS Summit, whereby the idea of the formation of a BRICS (Brazil, Russia, India, China and South Africa) development bank was tabled, with the purpose of funding development and infrastructure projects in developing countries, making loans during financial crises, and issuing convertible debt (Narayan et al., 2015). According to Express News Service (2012), a master agreement was signed between BRICS nations with the aim of reducing the demand for fully convertible currencies when transacting between BRICS nations, which would reduce transaction costs on intra-BRICS trading. Narayan et al.'s (2015) rationale for selecting BRICS currencies was therefore to understand the profitability of trading BRICS currencies, as these findings would be of interest to policy makers and investors.

2.3. Methodologies used for analysis

A brief overview of methodologies used in recent past literature are discussed below.

Various frequencies have been used when analysing data, with low-frequency data being the norm. Mokowitz et al. (2011), Novy-Marx (2011), Tajaddini and Crack (2012), Asness et al. (2013), and Barroso and Santa-Clara (2015) all made use of low-frequency data, typically using daily spot exchange rates. Narayan et al. (2015) on the other hand made use of high frequency, intra-day trading data for their analysis.

Moskowitz et al. (2011) observed that time-series momentum is different from traditional cross-sectional momentum. Time-series momentum focuses on securities' own past returns to predict future returns, rather than using relative returns in a cross-section of currencies to predict relative outperformance (Moskowitz et al., 2011). By analysing trading activities, Moskowitz et al. (2011) found that speculators profited at the expense of hedgers by using time-series trading strategies.

Muller and Ward (2013), in their study of investment styles on equity markets, argued that the traditional approach used by most researchers doing similar studies was methodologically weak in comparison to cumulative returns on portfolios of assets. Typically, average returns (monthly or quarterly) were used in analyses, with t-tests carried out to test for significant differences in results. According to Muller and Ward (2013), the approach of using average returns has shortcomings in a similar way that average annual returns reveal little in comparison to cumulative abnormal returns in event studies. The averages of small gains and losses reveal very little about the data being studied (Muller & Ward, 2013). The graphical time-series approach developed by Muller and Ward (2013), and used in this study, overcomes these shortcomings (full details of this methodology are included in Section 4.1.1).

2.4. Investment style-basis and previous results for strategies

2.4.1. Isolated strategies used in previous studies

Based on the literature reviewed, momentum was the most popular investment style strategy used for currencies, with Moskowitz et al. (2011), Novy-Marx (2011), Tajaddini and Crack (2012), Narayan et al. (2015), and others all examining momentum in various forms.

Moskowitz et al. (2011) used time-series momentum to look at various asset classes, including equities, currencies, commodities and bond futures. Having analysed 25 years' worth of data, the authors found persistence in the time-series momentum returns for one to 12 months, with partial reversal over longer horizons (Moskowitz et al., 2011). These findings were robust against every individual asset class studied. Moskowitz et al. (2011) ran simulations using a number of look-back and holding periods (trying one-, three-, six-, nine-, 12-, 24-, 36- and 48-month periods for both look-back and holding

periods). With particular reference to currencies, a 12-month look-back period, with a one-month holding period, was found to be optimal, and proved to be a positive predictor of future returns (Moskowitz et al., 2011). The authors also found that substantial abnormal returns could be generated through a diversified portfolio of time-series momentum strategies across all asset classes, and performed best during extreme markets (Moskowitz et al., 2011). Moskowitz et al. (2011) argued that their predictions using time-series momentum directly matched those of many other "prominent behavioural and rational asset pricing theories".

Gómez-González and García-Suaza (2012) used a probabilistic approach to test the presence of momentum in eight emerging economies (Brazil, Chile, Colombia, Hong Kong, Mexico, Peru, South Africa and Turkey), relative to the USD. They found evidence that exchange rate inertia existed. Interestingly, they found that momentum was asymmetric, with it being stronger and more significant in moments of currency depreciation, rather than currency appreciation, which they believed to be a reflection of the "fear of floating" in emerging markets. Central bank intervention results in short periods of currency reversion, allowing traders to exploit these periods with short positions, leading to positive gains and further exchange rate depreciation (Gómez-González & García-Suaza, 2012).

Novy-Marx (2011) questioned whether "momentum" is really momentum, having found that momentum was primarily driven by the past 12 to seven months' prior performance, representing the intermediate horizon, rather than recent past performance. The intermediate horizon strategy was labelled as a "12-seven month strategy", which looked back 12 months and ignored the most recent six months' data. Recent past performance on the other hand looked at the past six months' performance, represented by "six-one" or "six-two" month strategy. The "six-two" strategy meant that the most recent month was ignored in the analysis. These look-back periods were used in conjunction with a one-month holding period. Novy-Marx (2011) validly noted that previous research focused on the length of the test period, with almost no studies done on how long a testing period should have been concluded for, before portfolio formation. According to Novy-Marx (2011), strategies using an intermediate horizon produced returns with a Sharpe ratio of more than double that of recent past performance, although recent past performance still generated positive returns.

These results were observed for international equity indices, commodities, and currencies. A total of 19 currencies were included in the sample, including both major and emerging currencies. The results using currencies showed that the "12-seven month" strategy produced average returns of 0.57 percent per month, with a Sharpe ratio of 0.84, while the "six-two month" strategy produced returns of 0.36 percent per month, with a Sharpe ratio of 0.35 (Novy-Marx, 2011).

Menkhoff, Sarno, Schmeling and Schrimpf (2012) attempted to understand the "economic anatomy" of profits from momentum in forex markets. They did this by forming portfolios, going long on those with greatest past excess returns and short on those with lowest past excess returns. This was done on data consisting of 48 currencies (both developed and emerging) from January 1976 to January 2010 and found that momentum strategies deliver high excess returns of up to 10 percent per annum. In unpacking the sources of momentum, Menkhoff et al. (2012) stated that the excess returns obtained through the momentum trading strategy could not be explained by covariance risk with traditional risk factors, rather evidence of return continuation and reversals over the periods up to 36 months. This they attributed to behavioural biases, such as investor under- (and subsequent) over-reaction. Excess returns were partially attributed to transaction costs, since momentum portfolios are skewed towards currencies with high transaction costs (usually the least liquid currencies). Menkhoff et al. (2012) found that currencies with high idiosyncratic volatility (approximately eight percent per annum) produced higher returns in comparison to currencies with low idiosyncratic volatility (approximately four percent per annum). Additionally, they found that returns were also related to country risk, with high-risk rating currencies yielding significantly positive excess returns, whereas countries with low risk ratings do not (Menkhoff et al., 2012).

Burnside, Eichenbaum and Rebelo (2011), examined carry trade and momentum as two individual trading strategies and discussed explanations for the excess returns creating using these strategies. They first looked at whether investors were being compensated for observable risk factors, which they termed as the dollar risk factor, the return differential between largest and smallest forward discount portfolios and global volatility, but found little evidence to support this theory. Burnside et al. (2011) concluded that the covariance between the returns of the two strategies and conventional risk factors were not statistically significant. Secondly, Burnside et al. (2011) looked at whether the

profitability of the two strategies resulted from a rare disaster or “peso problem” and argued that the global 2008 financial crisis could not be used to rationalise the profitability of currency trading as a result of a rare disaster. Finally, the authors looked at whether the profitability of the two strategies could be attributed to the role of pricing pressure (as a result of large quantities transacted) and found some promise in this theory, however questioned if the pricing pressure was empirically plausible for currency markets and what the source of the pricing pressure was (Burnside et al., 2011).

Tajaddini and Crack (2012) analysed momentum-based trading strategies on emerging currencies, using a long time series and good cross-sectional sample. The authors made use of short-run (one-12 month) and long-run (two-36 month) moving averages and subtracted long-run moving averages from short-run moving averages and ranked them according to the differences. The first trading strategy used was to go long on the highest performing strategy and short the weakest performing strategy (the lowest ranked). The second strategy tested was to go long on the two highest ranked currencies and short the lowest performing currency. Tajaddini and Crack (2012) found that long-short momentum strategies gained on average approximately one to three percent (1-3%) per annum after taking into account transaction costs, however profits declined over time, making losses during the last five years of their analysis (2005 to 2009). The authors believed that the decline in profitability was due to improved efficiencies in emerging markets as a result of the movement toward electronic markets (Tajaddini & Crack, 2012).

Narayan et al. (2015) used a similar method to that of Tajaddini and Crack (2012); they however made use of high-frequency, intra-day data. They too found that momentum based trading strategies yielded statistically significant profits from the four emerging currencies studied (Brazil, India, China, and South Africa), with the South African Rand being the most profitable. Profitability was tested over various look-back frequencies (one minute; 20 minutes; and 120 minutes). The paper showed that profitability persisted during the day and that it was frequency dependent, changing steadily from one to 120 minutes. Narayan et al. (2015) also looked at whether the 2007 global financial crisis affected the exchange rate profitability of the emerging currencies studied. They did this by analysing data pre-crisis, during crisis, and post-crisis (Narayan et al., 2015). The results showed that the profitability of currency trading was maximised during the period of the financial crisis, regardless of the currency trading frequency (Narayan et al., 2015).

This is a significant finding as it gives weight to the necessity of the inclusion of volatility as a potential investment style for currencies.

Chung and Hong (2007) used a model-free statistical evaluation procedure to examine directional predictability in forex markets (both spot exchange rates and futures prices) in six major currencies including the Australian dollar, Canadian dollar, British pound, Japanese yen, Swiss franc and Deutschemark. According to Chung and Hong (2007), their methodology allowed for testing whether the history of own changes could predict the direction of changes of an economic time-series (a similar methodology as used in this project). This was done using forex returns and interest rate differentials. Substantial evidence was found that the direction of forex returns can be predicted by both the history of forex returns, as well as the history of interest differentials (Chung & Hong, 2007). Their results showed that directional predictability could be explained by higher order conditional moments, such as volatility, skewness and kurtosis of past own forex returns (Chung & Hong, 2007).

Although not specifically related to currencies, the literature showed that stock returns are not normally distributed. Bester, Auret and Page (2016) showed that Johannesburg Stock Exchange (JSE) data was not normally distributed, with the All Share Index showing a skewness of -0.764 and kurtosis of 6.706 on data analysed from January 1993 to December 2013. Similar characteristics were found by Bali (2003) on United States Treasury yields. Bali (2003) emphasised that the statistical theory of extremes was a more accurate approach for risk management and value at risk calculations, and that beta risk was significantly influenced by extreme market conditions. According to Doan et al. (2014), Bali's (2003) findings suggested that whilst skewness assisted in explaining beta asymmetry, kurtosis was a more useful measure for extreme market conditions. Doan, Lin and Chng (2014) showed that investors who exhibit higher order risk preferences and decreased absolute prudence would have a preference for skewness and an aversion towards kurtosis. A similar logic could be applied to predicting currencies in extreme market conditions.

There is therefore sufficient evidence in the literature to suggest that volatility, skewness and kurtosis are all investment styles that should be considered in predicting currency returns, particularly in volatile markets, which are very often emerging markets.

2.4.2. Combination strategies used in previous studies

According to Barroso and Santa-Clara (2015) the core literature focused on style-based strategies in isolation, with very few papers studying combination strategies and virtually none of which made use of empirical means to optimise combination strategies. Papers written by Asness et al. (2013), Pojarliev et al. (2008) and Barroso and Santa-Clara (2015) were the only three recent papers found which analysed style-based investment strategies in combination, rather than in isolation, for currencies.

Asness et al. (2013) looked at a 50:50 combination strategy of value and momentum across eight diverse asset and market classes, including currencies. The authors found consistent evidence that momentum and value premiums were present across all markets studied.

Spot exchange rate data were used for 10 currencies from 1979 to 2011 (none of which were emerging currencies). Asness at al. (2013) measured momentum using returns of the last 12 months, ignoring the last one month's data to avoid the reversal in "stick returns". Value was measured slightly differently for each asset class. For currencies, value was measured as a five-year change in purchasing power parity (PPP). This was calculated by taking the negative of the five year return on the exchange rate (measured as the log of the average spot exchange rates from four-and-a-half to five years' prior) divided by the most recent exchange rate, minus the log difference in the change of consumer price index (CPI) in the foreign country relative to the United States of America over the same time period (Asness et al., 2013). Cumulative returns were used in the analysis and were represented graphically, with the Sharpe ratio for currencies being 0.44 for value, 0.32 for momentum, and 0.69 using a 50:50 combination of value and momentum (Asness et al., 2013). The combination strategy clearly showed enhanced returns in comparison to the isolated strategies.

Pojarliev and Levich (2008) studied the returns of currency funds and compared them against individual currency fund managers. Four distinct factors were used to examine the relationship of returns from different styles of currency trading strategies, including carry, trend, value, and volatility (Pojarliev & Levich, 2008). The authors used the four factors as proxies to represent common types of trading strategies and exposures that

currency managers would be likely to use. These are discussed below (Pojarliev & Levich, 2008):

- Carry trade factor: using this style, currency traders typically borrow low interest rate currencies (for example the Yen) and use the money to buy high interest rate currencies (such as the New Zealand dollar or South African Rand). There is a risk that the high interest rate currency will depreciate, resulting in losses. Pojarliev and Levich (2008) used the Citibank's Beta1 G10 Carry Index as a proxy for carry; the index takes a long position on high yielding currencies and a short position of low yielding currencies.

- Trend-following factor: the trend-following factor used was similar to that of a typical momentum strategy, making use of moving averages. Pojarliev and Levich (2008) noted risks associated with the style, which included sudden reversals in currencies, false signals and excessive trading costs. It is therefore important to analyse returns after taking into account transaction fees. As a proxy for the trend-following factors, Pojarliev and Levich (2008) used the AFX Currency Management Index, which is an equal-weighted portfolio making use of three moving average rules (32, 61 and 117 days).

- Value factor: according to Pojarliev and Levich (2008), PPP is often used as a determinant to show whether currencies are over- or under-valued, with literature suggesting that currencies return back to their PPP in the long-run. Traders try to determine if a currency is misaligned to its PPP value and trade this misalignment. There is a risk that the base point for the PPP was calculated incorrectly in the first place, resulting in uninformed decision-making. As a proxy for the value factor, Pojarliev and Levich (2008) used the Citibank G10 Purchasing Power Parity Index, which takes long positions on currencies perceived to be more than 20 percent under-valued and short positions on currencies perceived to more than 20 percent over-valued.

- Volatility factor: according to Pojarliev and Levich (2008), traders also trade on the volatility of currencies, and do this through gaining exposure by taking open currency positions. There is a risk that volatility could decline if they have taken a long position, or increase after going short (Pojarliev & Levich, 2008). As a proxy for volatility, the one-month average implied volatility for the EUR/USD and for USD/JPY exchange rates was used. Pojarliev and Levich (2008) noted

> that these two currency pairs accounted for roughly 54 percent of currency-option trading in Bank of International Settlements (BIS) for 1995 to 2004 and have the most liquid options in the forex markets.

Pojarliev and Levich (2008) used a standard factor model to measure the systematic components of currency returns, isolating the portion attributable to skill. They then compared the four factors (represented by proxies) against the Barclay Currency Traders Index (BCTI), which had a mean monthly return of 0.62 percent, or 7.44 percent per annum between 1990 and 2006 (Pojarliev & Levich, 2008).

A multiple regression model was used to estimate the relationship between the overall returns of the BCTI and the explanatory factors. With all four factors present in the regression, the R-squared value was 0.6643, therefore 66 percent of the return could be accounted for by the four factors (Pojarliev & Levich, 2008). The results with all four factors present were greater than any of the factors tested in isolation.

According to Pojarliev and Levich (2008), their results were as follows: the intercept of the regression was -0.0009, meaning that no alpha returns were achieved by the currency managers. The trend following factor appeared to be the most significant of all the factors, and when tested in isolation accounted for almost 65 percent of the excess return (Pojarliev and Levich, 2008). The carry factor was also positive and significant. The value factor was significant but negative, suggesting that currency managers held positions with a continuation trend rather than mean reversion (Pojarliev & Levich, 2008). Volatility was not a significant factor, however when removed from the regression, the R-squared value was slightly lower. Volatility was however significant when analysed in isolation. Pojarliev and Levich (2008) argued that the positive volatility coefficient could imply that returns are excessive in periods of rising volatility. This is in-line with the findings of Narayan et al. (2015).

Barroso and Santa-Clara (2015) analysed carry, momentum and value proxies in combination with a number of fundamentals in order to test their economic relevance in forming currency portfolios. This was done using a parametric portfolio policies approach, which was developed by Brandt, Santa-Clara and Valkanoc (2009). The authors tested the relevance of interest rate spread, momentum, and three proxies for value (namely long-term value reversal, the real exchange rate, and the current account). Interest rate spread, momentum, and value reversal were found to create

economic value for investors, whereas the real exchange rate and current account were found to have no significance (Barroso & Santa-Clara, 2015).

The following variables were used in Barroso and Santa-Clara's (2015) analysis:

- SIGN: the sign of the forward discount of a currency with respect to the US dollar.
- FD: the forward discount or interest rate spread on the currency, standardised using the cross section mean and standard deviation across all available countries.
- MOM: momentum, calculated as the cumulative currency appreciation for the last three months and standardised cross-sectionally. Where currencies depreciated relative to the US dollar, those that depreciated less had a positive momentum.
- REV: long-term reversal was taken as the cumulative real currency depreciation over the previous five-year period. This is essentially the same as "value" used by Asness and Moskowitz (2013), however Barroso and Santa-Clara (2015) used cumulative deviation from PPP, rather than cumulative return, to obtain a longer test period.
- Q: the exchange rate standardised by its historical mean and standard deviation.
- CA: current account of the foreign economy as a percentage of gross domestic product (GDP).

Barroso and Santa-Clara (2015) used the following selection criteria in order for a particular currency to be included in their trading model:

- A minimum of 10 years of previous real exchange rate data was required to be available.
- The current forward and spot rate exchange quotes must have been available.
- The country must have already been a member of the OECD during the period under consideration.

Barroso and Santa-Clara (2015) concluded that diversified currency investments, using the styles including momentum, yield differential, and value reversal, substantially outperformed the carry trade. Additionally, they noted that value reversal and momentum had large positive returns when the carry trade crashed. According to Barroso and Santa-Clara (2015), economic performance of optimal currency portfolios

cannot be explained by risk factors or time-varying risks, suggesting that market inefficiency, or at least that the right risk factors to explain currency momentum and value reversal, have not been identified yet. Investing in currencies significantly improved portfolios already exposed to stocks and bonds, therefore currencies either offer exposure to some set of unknown risk factors or have anomalous return (Barroso & Santa-Clara, 2015). Portfolios exposed to currencies increased the Sharpe ratio of diversified portfolios by 0.5 on average, while reducing crash risk (Barroso & Santa-Clara, 2015).

2.5. Transaction costs for currency trades

The inclusion of transaction costs was not common in the literature for the trading of currencies. Neither Asness et al. (2013), Pojarliev et al. (2008), Barroso and Santa-Clara (2015), Moskowitz et al. (2011), Novy-Marx (2011), Tajaddini and Crack (2012) nor Narayan et al. (2015) made mention of the transaction cost as a result of concluding a trade.

In Fernández-Pérez, Fernández-Rodríguez and Sosvilla-Rivero's (2012) paper titled "Exploiting trends in the foreign exchange markets", they accounted for transaction costs by subtracting 0.05 percent off the total return when switching from a long to a short position or vice versa.

King, Osler and Rime (2011) stated that the introduction of customer electronic trading platforms have significantly lowered dealers' operating costs, which has drastically lowered the bid-ask price in the interdealer market. This has also meant that certain cross-rates (for example EUR/AUD and USD/EUR) can be traded directly at tight bid-ask spreads (King et al., 2011). Since the mid-1990s interdealer spreads reduced from three basis points to approximately one pip ($100 for a $1million transaction) within a decade (King et al., 2011). The bid-ask price gaps continues to narrow, with fractional-pip pricing emerging on very liquid markets, such as USD/EUR trades.

2.6. Chi-square tests

According to Franke, Ho and Christie (2012), Pearson's chi-square tests are one of the most useful tools in statistical analysis for determining the association or difference between categorical variables. There are three tests in the omnibus of Pearson's chi-square tests, namely goodness of fit, independence and homogeneity, each of which have distinct hypotheses, interpretations and post-hoc options following the rejection of the null hypothesis (Franke et al., 2012). Each of the tests are computationally similar and the test statistic can be calculated using Equation 1 below and compared against a critical value from the chi-square distribution for the respective degrees of freedom (Franke et al., 2012).

Equation 1: Chi-square test statistic formula (Franke et al., 2012).

$$x^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i},$$

Where n = the number of cells in the table; O_i= observed value; E_i = expected value;
Degrees of Freedom = (r – 1)(c – 1); r = rows and c = columns

The type of chi-square test to be used is dependent on the application. Franke et al. (2012) noted that the chi-square goodness of fit test is used when a variable of interest in a sample is compared against a population with known parameters, allowing for testing of whether the data follows a specified distribution. The chi-square test of independence allows for testing whether two categorical variables of interest, in a single sample, are either independent from or associated with each other (Franke et al., 2012). Finally, the chi-square test of homogeneity allows for testing whether two or more independent samples' distributions differ on a particular variable of interest. Table 1 provides a summary of the chi-square tests with their associated attributes.

Table 1: Chi-square tests and associated attributes (Franke et al., 2012)

Chi-square Test Attribute	Test of Goodness of Fit	Test of Independence	Test of Homogeneity
Sampling type	Sample from population	Single dependent sample	Two (or more) independent samples
Interpretation	Difference from population	Association between variables	Difference in proportions
Null Hypothesis	No difference in distribution between the sample and population	No association between variables	No difference in proportions between groups

2.7. Conclusion on literature reviewed

The literature reviewed highlighted a number of key aspects to be considered for the research report. In terms of the most suitable methodology, time-series analysis seemed to be the most highly recommended methodology to follow, as measurements are made against an asset's own performance, rather than against its relative performance as in cross-sectional analysis. Additionally, cumulative returns should be used (rather than averages) to produce more meaningful results.

The use of developed currencies was more popular in studies, with Asness et al. (2013), Barroso and Santa-Clara (2015), Moskowitz et al. (2011), Novy-Marx (2011) all finding that the use of momentum-based strategies yielded statistically significant returns. Barroso and Santa-Clara (2015) noted that they used only developed currencies as they were more liquid than emerging currencies. This is true, however should not be used as an argument for excluding emerging currencies as there are a number of emerging currencies, such as the Chinese yuan (renminbi), Mexican peso and the Russian rouble, which according to the Bank of International Settlements (2013) rank amongst the top 15 traded currencies by value, and there are significantly more emerging currencies amongst the top 25 (Society for Worldwide Interbank Financial Telecommunication, 2016).

There is a definite need for future research to be conducted on additional style-based investment strategies for currencies, perhaps with the exception of momentum, although there is scope for using a more robust methodology such as a graphical time-series approach, as well as empirical optimisation of the style. Research has been conducted on optimising the look-back and holding periods for momentum, however no evidence

of the optimisation of any of the other investment styles was found in the literature. Volatility, skewness and kurtosis are likely to be suitable investment styles to explore the optimisation of returns in volatile markets, as was proven through the work of Chung and Hong (2007). More research is required to understand the impact of market instability on currency returns, perhaps most likely to be visible in emerging currencies.

Very little literature exists on finding an optimal combination of investment styles and further work in this area would be invaluable to the literature, particularly for emerging currencies. However, this is beyond the scope of this study. Based on the literature, suitable styles for analysis include momentum, volatility, value, carry, kurtosis and skewness.

In general, little research has been conducted on emerging market currencies in areas other than momentum, and there is a need to establish whether there are significant differences in results between major and emerging currencies. The chi-square test of homogeneity is a suitable test to use as it allows for determining whether two or more independent variables (such as developed and emerging currencies) differ in their distributions on a single variable of interest.

3. Research Questions

Based on the literature reviewed, there are many gaps that require further research; thus a number of research questions needed to be answered in order to close some of the knowledge gaps. Six research objectives were made for the research report, many of which were deduced through the use of a graphical time-series approach developed by Muller and Ward (2013), as well as using Pearson's chi-square test of homogeneity (Franke et al., 2012):

- Objective 1: Determine whether each of the isolated styles studied have a significant impact (positive or negative) when trading selected currencies;
- Objective 2: Optimise the look-back and holding periods of each of the investment styles used in isolation (where practically possible);
- Objective 3: Determine the extent to which transaction costs impact the optimal holding period of style-based trading strategies for currencies;
- Objective 4: Identify and rank the most profitable isolated investment styles for selected currencies;
- Objective 5: Determine whether there is a statistically significant difference in results between the currencies of developed and emerging countries for each of the styles studied, and if so explore what the possible reasons are for differences. The null and alternate hypothesis are represented below (Franke et al., 2012):
    - $Hypothesis_0$: The proportions between developed and emerging currencies are the same;
    - $Hypothesis_1$: The proportions between developed and emerging currencies are different;
- Objective 6: Determine whether the trading of selected currencies is profitable, after transaction costs, using style-based investment strategies.

With the above mentioned research objectives in mind, the underlying research question is to determine which investment styles are feasible investment strategies for trading currencies and whether any differences in results occur between the currencies of developed versus emerging countries in each of the styles studied.

4. Research Methodology

4.1. Research design

The overarching research design was similar to that used by Muller and Ward (2013) in their paper titled “Style-based effects on the Johannesburg Stock Exchange: a graphical time-series approach”. More than 15 years of secondary time-series data was used on currency exchange rates from 2001 to 2016, available from INET BFA database. A starting date of 31 December 2000 and an ending date of 31 July 2016 was used on all data, unless otherwise stipulated. Currencies were introduced or removed as and when the correct data became available, meaning that the population size varied slightly throughout the analysis period.

A total of 25 currencies were selected for the analysis (see Appendix A, Table 18), of which 13 were classified as developed and 12 classified as emerging (the methodology for classification is discussed in Section 4.1.2 below). This allowed for five equal-weighted portfolios to be constructed (quintiles), each having five currencies per portfolio, depending on data availability. Where practical, various look-back periods (L_1), look-to ranges (L_2) and holding periods (H) were analysed to determine the optimal for each of the styles studied (refer to Appendix A, Figure 22 for a schematic of formation period). Look-back periods were generally kept within approximately 12 months, due to partial reversals in returns beyond 12 months (Moskowitz et al., 2011). However, in some instances look-back periods were extended beyond 12 months to visually confirm if the partial reversal discussed in the literature existed.

Returns on each currency were calculated on a daily basis in each equal-weighted portfolio (from a one-USD base investment), with the cumulative value of each portfolio (total of individual currencies) being calculated on the last day of every holding period analysed (Muller & Ward, 2013). The cumulative value of the previous holding period was retained for a particular portfolio, and the currency data re-calculated and re-ranked in terms of style scores (for example momentum) for the following holding period, allowing for the quintiles to be reconstructed based on the updated rankings. This process of calculating style scores, ranking and putting into portfolios, rolling forward and accumulating the portfolio value, was continued for each holding period ending 31 July 2016. This allowed cumulative values to be represented in a graphical time-series approach and quintiles visually compared against each other to determine results

(Muller & Ward, 2013). A “price-relative” was created to assist with the comparative analysis of portfolios, which was done by dividing the value of quintile one by the value of quintile five on a daily basis (Muller & Ward, 2013).

The above approach was followed for each of the styles studied, both with and without transaction costs, which are effectively incurred as a result of rebalancing the portfolios after each holding period. As discussed in the literature review, the traditional approach in similar analyses uses average returns, usually on a monthly or quarterly basis, however this is methodologically weak in comparison to the use of cumulative returns on portfolios of assets, as averages of small gains and losses reveal little about the data studied (Muller & Ward, 2013).

Another major component of the research design was the use of statistics (chi-square test of homogeneity) to test if observed differences between currencies of developed and emerging countries were of significance or as a result of randomness. This formed a critical part of the research objectives as very little literature existed on the subject and no literature was found to confirm if differences in results exist. The methodology for testing the significance of observed differences is discussed in Section 4.1.4 below.

4.1.1. Style engine

A “style engine”, developed and described by Muller and Ward (2013), was used to facilitate the analysis of the currency data. The style engine is a Microsoft Excel™ based model with a Visual Basic for Applications (VBA) back-end, allowing for easy manipulation of data from a Microsoft Access™ database, where data sourced from INET BFA was available (Muller & Ward, 2013).

Inputs to the model were parameterised where possible to enable the easy modification of settings and enabled various investment styles to be created and or manipulated (Muller & Ward, 2013). The parameterised model allowed for a number of parameters to be manipulated, including the selection of the start and end date of currencies, number of portfolios used, look-back period, look-to period, holding period, months of back data required prior to the starting date, ranking of styles, filtering of currencies and allowance

for the inclusion or exclusion of specified transaction costs. The style-engine was used to optimise and analyse the three individual styles chosen (discussed in Section 4.1.3 below).

4.1.2. Classification of currencies as developed or emerging

There is currently no global standard for the classification of countries as either developed or emerging. To minimise any bias in currency classification for this study, four well-known sources were used, including IMF (2015), Standard & Poor's (S&P) (2013), BRICS plus Next Eleven (Bloomberg, 2012) and FTSE (2015), for the classification of each country, which was used for currency classification. For the purposes of this research it was assumed that should two or more of the four sources have classified the country as emerging, then only would the country be classified as emerging, and hence as a developed country if only less than two of the sources classified the country as emerging. The results of each source's classification are available in Appendix A, Table 19. As a result of the classification used, 13 currencies were classified as developed and 12 as emerging currencies, providing a similar sample size of each classification type. Of the 25 currencies classified, Argentina seemed to be an outlier in terms of its classification as a developed country and due to its relatively low level of liquidity in comparison to the rest of the currencies. This however this would not have a fundamental impact on the overall result.

4.1.3. Investment styles used

To keep the scope of the research manageable, three investment styles were chosen for analysis, namely momentum, volatility and value. Selection was informed after reviewing the recent literature on the subject of style-based investment strategies, particularly for currencies (furthermore, less common styles, as well as a combination style, have been recommended in Section 7.4 for future research).

4.1.3.1. Momentum as a style

As discussed in the literature review, momentum is the most commonly studied style for investments, with the most common methodology for analysing results being the use of average returns. In this paper cumulative currency returns were plotted and used to the

significance of a style. This was done using various look-back periods, look-to periods and holding periods to find the optimum combination to maximise returns. Momentum as a style is defined in Equation 2 below. Initially the holding period was held constant at one month, and the look-back period increased incrementally (by one month) from one month to usually a maximum of 12 months. The same process was used for optimising the holding period, keeping the optimised look-back period constant, up to a maximum of 12 months. According to the literature, 12 months is the maximum look-back period before partial reversal occurs (Moskowitz et al., 2011), this was therefore kept in mind when determining the maximum range to test.

Once the optimum look-back period and holding period was believed to be established, the look-back range was manipulated by changing the reference point prior to portfolio formation; this is termed the look-to period. For example, should the optimum look-back and holding period have been found to be 12 months and one month respectively, the holding period was again kept constant and the look-back period adjusted to 12-two months prior to formation (i.e. ignoring the most recent month), until finally a formation period with 12-11 months' data was used for the basis for returns calculations. As discussed in the literature, the process of optimising the formation period (i.e. both the look-back and look-to period) is very rarely done, however Novy-Marx (2011) found that using a 12-seven month look-back period generated higher returns in comparison to the recent past performance.

Although not covered in the literature review, it was deemed necessary to include an interest growth factor (I) to account for interest earned whilst holding a currency, as this could have an impact on the optimal holding period (this was included in Equation 2 below). As a standard, short-term interest rates were used for the interest growth factor calculation. If data for short-term interest rates did not exist for a particular country's currency, then three-month interest rates were used as an alternative. Interest rate data was taken directly from the INET BFA database for the period under study. This was applicable to all styles studied.

Equation 2: Defining the measure of momentum as a style (MOM)

$$\text{MOM} = \ln\left(\frac{x_t + L_{1-2}}{x_t}\right) \times (1 + \text{I})$$

Where x_t= exchange rate, at time (month) = t; $L_{1\text{-}2}$= look-back period less the look-to period; Interest growth (I) = interest rate/12×holding period (months)

4.1.3.2. Volatility as an investment style

The literature review showed that returns can be maximised during turbulent times (Pojarliev & Levich, 2008; Moskowitz et al., 2011), hence volatility was chosen as an investment style for analysis. Pojarliev and Levich (2008) identified volatility as a factor that explained the variability in index returns, however as discussed in the literature survey, proxies were used to reference the style as a trading strategy. Volatility was represented by the annualised standard deviation of the prior 60-day array of daily return (**a**) at time (t), as represented by Equation 3 below.

A similar approach as described in Section 4.1.3.1 was used to graphically verify the significance of volatility as an investment style. For this style, the look-back period was held constant at three-months over the previous 60 trading days and the holding period was kept constant at three months.

Equation 3: Defining the measure of volatility as a style (VOL)

$$\text{VOL} = \left(\text{stdev}(\mathbf{a}) \times 250^{\frac{1}{2}}\right) \times (1 + \text{I})$$

Where Array of returns(**a**) $= (a_1 \ldots a_{60})$, x_t= exchange rate, at time (month) = t; 250 = the assumed trading days per annum; Interest growth (I) = interest rate/12 × holding period (months)

4.1.3.3. Value as an investment style

As was discussed in Section 2.4.2, Asness et al. (2013) used value in a combination style to produce positive excess returns, by using a five-year change in PPP. This was calculated by taking the negative of the five year return on the exchange rate (measured as the log of the average spot exchange rates from four-and-a-half to five years ago), divided by the most recent exchange rate, minus the log difference in the change of CPI in the foreign country relative to the United States of America over the same time period (Asness et al., 2013).

In this paper, a slightly different, simpler approach was taken for measuring the value of a currency for the basis of style-based investing. The value of each of the 25 sample currencies was measured using the Big Mac index, as published bi-annually by The Economist. This is a less formal measure of PPP between two currencies, in this case the sample currencies relative to the USD as the base currency (The Economist, 2016). Due to the bi-annual nature of the Big Mac index data, the optimisation of the look-back period, look-to period and holding period would have been of little value as six-month increments would have needed to be used. By default, a six-month look-back period was therefore used. This was done in association with a three-month holding period.

Equation 4: Defining the measure of value as a style (VAL)

$$\text{VAL} = \Delta BMi_t \times (1 + \text{I})$$

Where BMi_t = Big Mac index, at time (month) = t; Interest growth (I) = interest rate/12 × holding period (months)

4.1.4. Testing for significant differences in results between developed and emerging currencies

As was discussed in Section 2.6, according to Franke et al. (2012), the chi-square test of homogeneity was a suitable test for determining whether two or more independent samples differ in their distributions on a single variable of interest. In this study, the objective was to determine whether there were differences in proportions between developed and emerging currencies in independent samples (usually quintile one and quintile five representing the extremes). A significant test statistic indicated that the

proportions of developed and emerging currencies differ on a variable of interest, for example in quintile one currencies. The test statistic was calculated using the chi-square function (chisq.test) in Microsoft Excel™, rather than from first principles as was shown in Equation 1.

The null (H_0) and alternate (H_1) hypotheses are represented below (Franke et al., 2012):

- Hypothesis$_0$: The proportions between developed and emerging currencies are the same for momentum/volatility/value style.
- Hypothesis$_1$: The proportions between developed and emerging currencies are different for momentum/volatility/value style.

This was done individually for each of the styles studied. The null and alternate hypotheses above were therefore applicable specifically to either momentum, volatility or value styles. Testing was done using an alpha (α) level of 0.05, which gave results accurate with a 95 percent level of confidence, which was most commonly used in the literature.

4.2. Universe

The universe of the study included both developed and emerging currencies that trade freely, typically those falling in the top 25 currencies as ranked by value traded. This also ensured that data was readily available in INET BFA database. Both developed and emerging currencies were included in the universe to allow for comparisons to be made on the results. Typically, studies have focussed on developed countries (generally OECD countries) so by using both developed and emerging currencies (and classifying them) the literature could be expanded. None of the literature reviewed determined whether there were differences between the two groups of currencies, bearing in mind that according to Tajaddini and Crack (2012) emerging currencies are generally less liquid than major currencies. The ability to distinguish between developed and emerging was therefore important for establishing whether differences exist.

4.3. Sampling

Judgment sampling was used to select which currencies were used for the analysis. Research was done into the top most traded currencies, with the majority of the currencies selected coming from the top traded currencies by value. A total of 25 currencies were selected, which allowed for five portfolios (quintiles), each with five currencies per portfolio. The total number of currencies analysed at a cross-section varied, based on the number of currencies available for that particular period. The full list of currencies used, as well as their classification is included in Appendix A, Table 18.

The USD was excluded from the sample as it was used as the base currency for exchange rate comparison. Two additional currencies not included in the top 25 most traded currencies were selected using judgment sampling to ensure that developed versus emerging currencies were almost equally represented. This was done as the project aimed to determine whether there are significant differences in returns between developed and emerging currencies, and by having two distinct groups allowed for that comparison to be made with statistical analysis. Secondary data from INET BFA was used for the analysis. Daily data on currency exchange rates, relative to the US Dollar and other currency majors, was collected for the 25 currencies in the sample. The style engine allowed for currencies to be added or removed as and when data became available.

4.4. Unit of analysis

The unit of analysis used was daily returns, based on changes in exchange rates, based in USD. To minimise the variance in individual currency time-series, these were aggregated into equal-weighted quintile returns.

4.5. Measurement

The measurement used was the annualised cumulative quintile return values, which have been represented graphically throughout the time-series (Muller & Ward, 2013).

4.6. Limitations

There are a number of limitations to the study. Firstly, the findings are limited to currencies that are freely traded and deemed liquid. The exchange rate data was based on spot rates from the close of business of the trading day, and intra-day fluctuations were ignored. There was judgment used in the classification of developed and emerging currencies, which could have slightly impacted the results. According to Chung and Hong (2007), technical analysis in currencies is built on the premise that forex markets are regular and repeatable, which is often not the case, particularly in times such as currency crises. Optimisation of look-back period, look-to period and holding period were limited to one-month incremental changes, and this could have negatively impacted the optimisation period, particularly where a one-month period was found to be optimal.

5. Results

The following chapter provides the major results that were extracted from the style engine described in chapter four. The graphs are a representation of the time-series currency data, which allows for visual inferences to be made throughout the examined period (namely 31 December 2000 to 31 July 2016 unless otherwise stipulated), rather than in cross-section.

Three currency trading strategy styles were analysed, namely momentum, volatility and value. Results for each of the styles are provided below and discussed in chapter six. For each of the styles, the constituent currencies making up the quintiles were analysed using the chi-square test of homogeneity to infer whether the nature of the currencies (developed versus emerging) had a statistically significant impact on the results. Section 4.1.2 details the methodology used to classify currencies as either developed or emerging.

5.1. Momentum in currency time-series data

5.1.1. Currencies with the highest relative momentum

Currencies with the highest momentum relative to the 25 currencies studied were grouped into quintile one, with a maximum of five currencies and usually a minimum of four present at any given time. The results from the optimisation of the look-back period, look-back range, look-to range, holding period, as well as the impact of transaction costs are provided below.

5.1.1.1. Look-back period optimisation in currency with highest momentum

A summary of results using a varying look-back period, with a constant holding period of three months, from time (t) is provided in Table 2 below. The results showed that returns could be optimised by buying currencies that experienced the highest momentum (quintile one currencies) on the basis of a one-month look-back of the cumulative past performance of the currencies in quintile one. This assumed a holding period of three months, thus re-balancing of portfolios took place quarterly.

As can be seen from Table 2, results were optimal with a one-month look-back period (7.25 percent) and steadily declined until a minimum inflection point at a five-month look-back period of 4.32 percent. Returns then gradually increased to a second peak with a nine-month look-back period, which provided an average annual return (AAR) of 6.49 percent. As can be seen from Figure 1, the general trend in AARs after the second peak at nine-months was downward to the maximum measured look-back period of 15-months. Results beyond 15 months were not analysed, however it is unlikely that a more optimal result would be obtainable.

Table 2: AARs on momentum with varying look-back periods (quintile one currencies)

Look-back Period (months)	Average Annual Return (%)
1	7.25%
2	7.11%
3	6.89%
4	5.34%
5	4.32%
6	4.83%
7	5.25%
8	5.36%
9	6.49%
10	5.85%
11	5.36%
12	5.13%
13	5.01%
14	4.95%
15	4.78%

Figure 1: Graph showing optimisation of look-back period for quintile one currencies

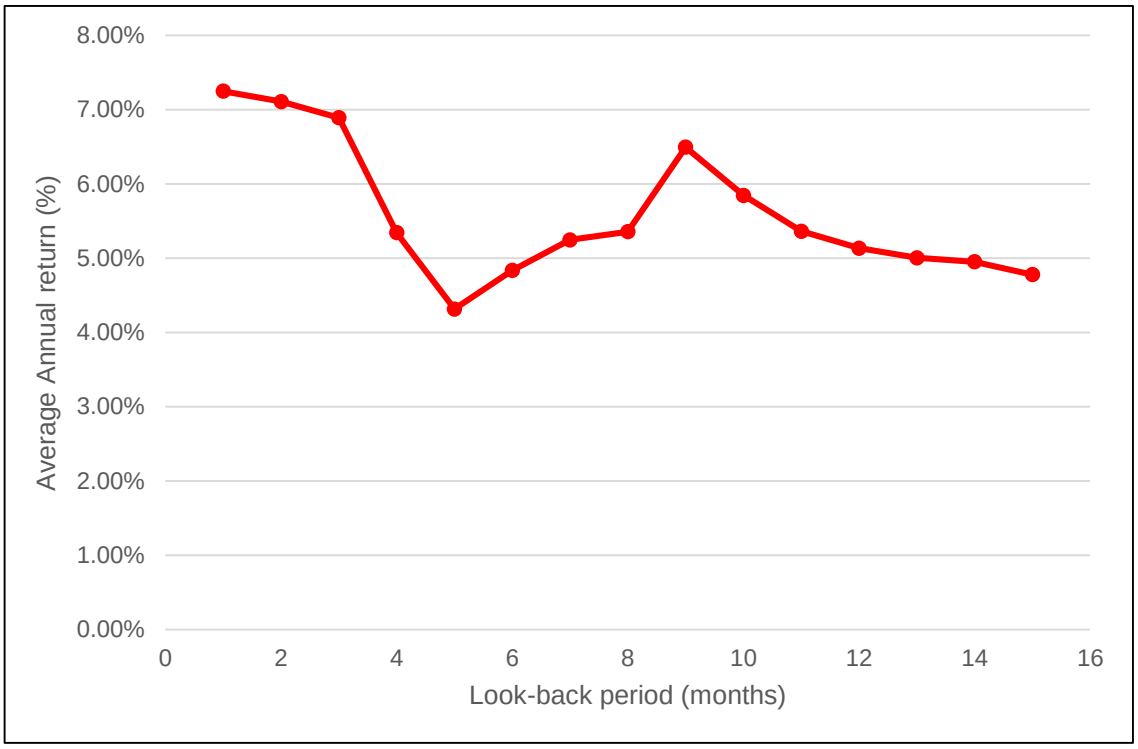
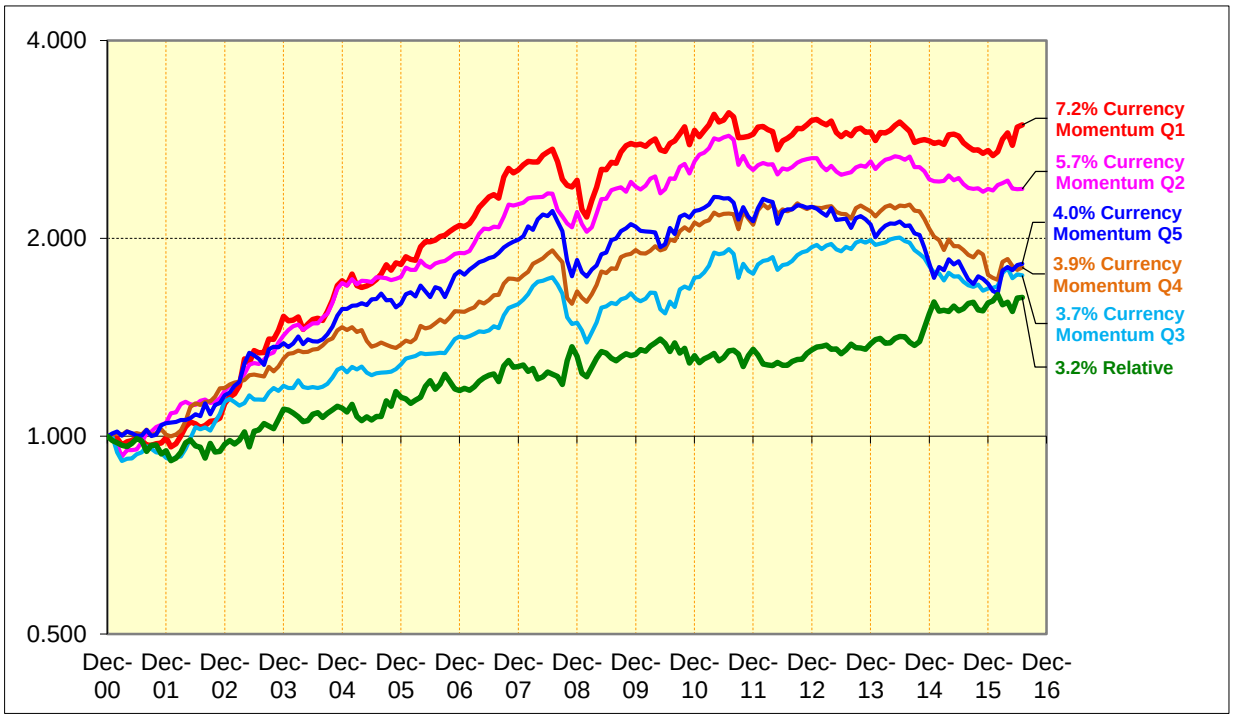


Figure 2 shows the optimal output for quintile one (CurrencyMomentumQ1). Currencies in quintile one represented the greatest positive momentum for the look-back period under review. In order to determine the optimal look-back period, simulations were run using a three-month holding period with zero transaction costs. As can be seen from Figure 2, returns were maximised using a one-month look-back, a look-to starting at month zero (i.e. a full look-back range from month zero to one month look-back), a three-month holding period and zero transaction costs, represented by MOM(1,0,3,0).There was a 3.2 percent return relative between currencies with the most positive momentum (quintile one) and the least positive momentum (quintile five).

Figure 2: Graphical output showing results from momentum style: MOM(1,0,3,0)



5.1.1.2. Optimisation of the holding period for currencies with the highest momentum (quintile one)

The optimal look-back period result for quintile one currencies was used (and held constant) whilst varying the holding period in one-month increments to obtain the optimal holding period. This was initially done with the exclusion of transaction costs. Table 3 is a summary of AARs with results gradually increasing from one month through to three months, and then peaking with a 7.00 percent AAR, thereafter gradually reducing.

Table 3: Holding period optimisation with one-month look-back period, excluding transaction costs (quintile one)

Holding Period (months)	Average Annual Return (%)
1	5.33%
2	6.64%
3	7.00%
4	6.75%
5	6.57%
6	6.30%

5.1.1.3. Look-to range optimisation in currencies with the highest momentum

With a one-month look-back period being optimal for quintile one currencies (see Section 5.1.1.1), the look-to range could not be optimised as the study limited the changes in look-back and look-to periods to one month. Varying the range by one-month increments would completely eliminate the range for analysis.

5.1.1.4. Impact of transaction costs on the holding period in currencies with the highest momentum

As was used by Fernández-Pérez et al. (2012), a suitable transaction cost for trading currencies was 0.05 percent off the cumulative return in a particular holding period. The introduction of transaction costs had a 0.33 percent impact on the AAR with a three-month holding period, reducing from 7.00 percent excluding transaction costs, to 6.67 percent including transaction costs. Three months remained the optimal holding period for quintile one currencies in scenarios both including and excluding transaction costs.

Table 4: Holding period optimisation with one-month look-back period, including transaction costs (quintile one)

Holding Period (months)	Average Annual Return (%)
1	4.36%
2	6.15%
3	6.67%
4	6.50%
5	6.37%
6	6.14%

5.1.2. Currencies with the lowest relative momentum

Currencies with the lowest momentum relative to the 25 currencies studied were grouped into quintile five, with a maximum of five currencies present and usually limited to a minimum of four currencies at any given time. The results from the optimisation of the look-back period, look-to range, holding period, as well as the impact of transaction costs are provided below.

5.1.2.1. Look-back period optimisation in currency with lowest momentum

A summary of results using a varying look-back period with a constant holding period of three months from time (t) is provided in Table 5 below. The results showed that returns could be optimised by buying currencies that experienced the lowest momentum (quintile five currencies) based on both a 10-month and 14-month look-back of the cumulative past performance of the said currencies. This assumed a holding period of three months, thus re-balancing of portfolios took place quarterly.

As can be seen from Table 5, results were optimal with both a 10-month and 14-month look-back period (8.57 percent) and minimised with a three-month look-back period (4.85 percent). This is indicative of a reversion to the mean. Returns were relatively stable with look-back periods between four and 15 months, with AARs fluctuating within a 1.66 percent range (refer to Figure 3 below).

Table 5: AARs on momentum with varying look-back period (quintile five currencies)

Look-back Period (months)	Average Annual Return (%)
1	6.75%
2	5.96%
3	4.85%
4	7.98%
5	7.92%
6	6.91%
7	8.08%
8	7.00%
9	7.72%
10	8.57%
11	8.11%
12	7.40%
13	8.42%
14	8.57%
15	6.91%
16	6.84%
17	6.75%
18	6.68%
19	5.76%
20	6.60%
21	6.98%
22	7.12%
23	6.87%
24	7.16%

Figure 3: Graph showing optimisation of look-back period for quintile five currencies

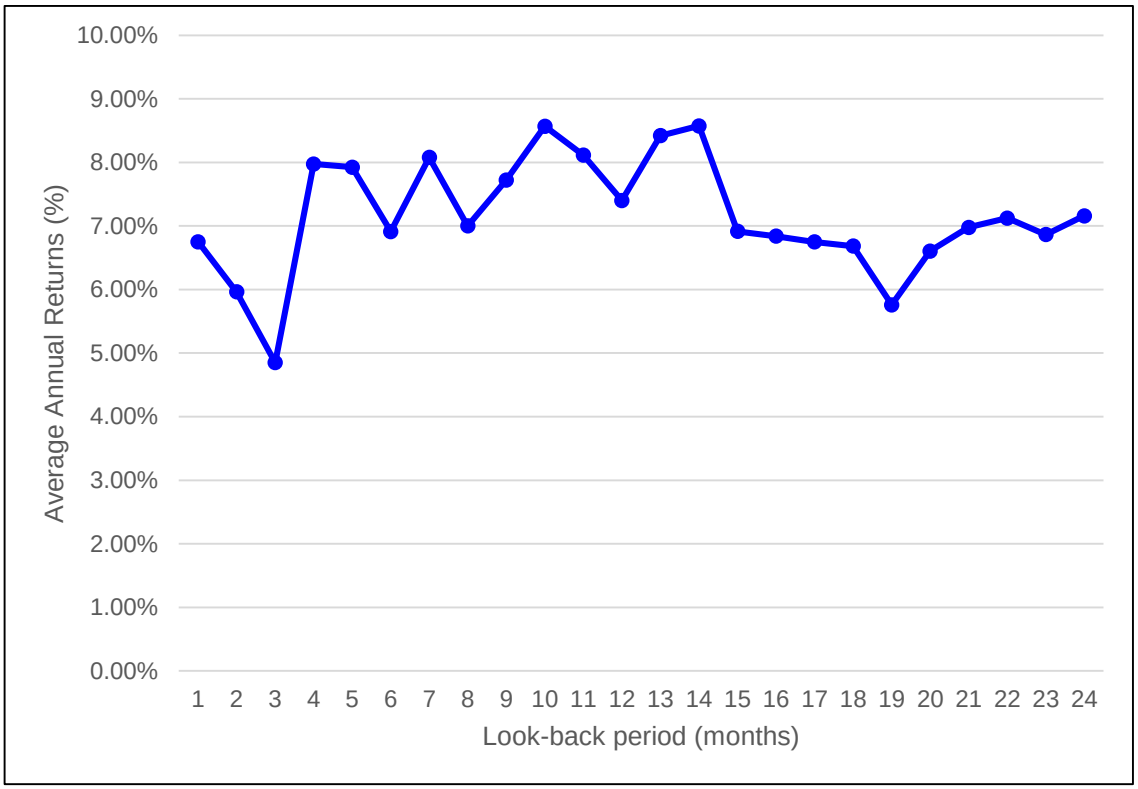
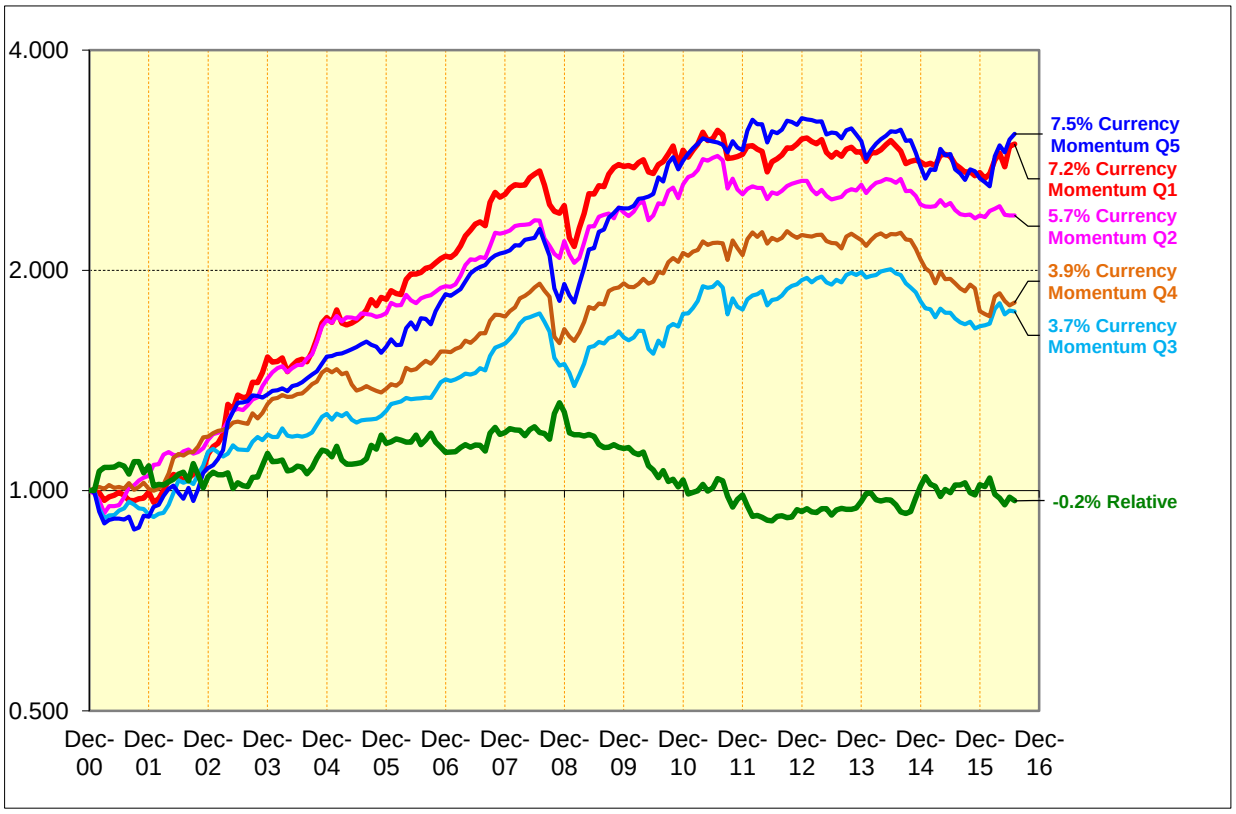


Figure 4 shows the optimal output for quintile five (Currency Momentum Q5). Currencies in quintile five represent the least positive momentum for the look-back period under review. In order to determine the optimal look-back period for currencies with the least positive momentum (or negative momentum), simulations were run using a three-month holding period with zero transaction costs. As evident in Figure 4, returns were maximised when using both a 10-month and 14-month look-back period, a look-to period of zero (i.e. a full look-back range from month zero to 10- or 14-month look-back), a three-month holding period and zero transaction costs, represented by MOM(10,0,3,0) and MOM(14,0,3,0). There was a negative 0.2 percent return relative between currencies with the most positive momentum optimised (quintile one) and least positive momentum optimised (quintile one).

Figure 4: Graphical output showing momentum: MOM(10,0,3,0)



5.1.2.2. Holding period optimisation in the quintile of currencies with the lowest momentum (quintile five)

The optimal look-back period result (10-months) for quintile five currencies was used and held constant whilst varying the holding period in one-month increments to obtain the optimal holding period. This was initially done with the exclusion of transaction costs. As can be seen from Table 6, the AARs were optimal with a two-month holding period (7.83 percent) and gradually decline as the holding period is incrementally increased. It should be noted the AARs were slightly reduced as a result of staggering the transaction start. With a two-month holding period, the transaction is staggered such that 50 percent of the initial investment was made in month one and the remaining 50 percent in month two, and as a result, market risk was spread and reduced AARs.

Table 6: Holding period optimisation with 10-month look-back period, excluding transaction costs (quintile five)

Holding Period (months)	Average Annual Return (%)
1	7.20%
2	7.83%
3	7.45%
4	7.38%
5	7.17%
6	7.18%

5.1.2.3. Look-to range optimisation in currencies with the lowest momentum (quintile five)

As can be seen in Table 7, using the optimised look-back period and holding period (10-months and two-months respectively), the optimal look-to range was found to be three months (8.57 percent). Ignoring the more recent two months' data resulted in increased AARs of 0.74 percent.

Table 7: Look-to range optimisation in currencies with the least momentum

Look-to Period (months)	Average Annual Return (%)
0	7.50%
1	6.91%
2	7.56%
3	8.57%
4	8.23%
5	7.38%
6	6.62%
7	6.33%
8	5.63%
9	6.92%
10	6.30%
11	5.46%
12	5.50%
13	4.76%
14	4.06%

5.1.2.4. Impact of transaction costs on the holding period in currencies with the lowest momentum (quintile five)

Transaction costs were introduced with a 10-month look-back and two-month look-to period. The results of AARs with a varying holding period are provided in Table 8 below. A two-month holding period remained optimal, with a 1.00 percent reduction in AARs as a result of the 0.05 percent transaction cost introduced.

Table 8: Impact of transaction costs on the holding period of quintile five currencies

Holding Period (months)	Average Annual Return (%)
1	6.82%
2	7.57%
3	7.24%
4	7.20%
5	7.01%
6	7.04%

5.1.3. Significance of differences in results between developed and emerging currencies using momentum as a style for investment

In line with the fifth objective of the research report, analysis was undertaken on the constituents of quintile one and quintile five portfolios, to determine whether there were statistically significant differences between results in terms of currencies of developed versus emerging countries, in trading momentum as a style.

Cumulative results of the frequencies of actual and expected occurrence of both developed and emerging currencies are provided in Table 9 below. The cumulative frequencies in actual results were observations over the 189-month range of time-series data (December 2000 to July 2016); refer to Appendix B, Table 20 for the full frequency table. In quintile one (most momentum currencies), the total observation of developed and emerging currencies was 148 and 139 respectively. On the other hand, in quintile five (least momentum currencies) the total observation of developed versus emerging currencies was 134 and 181 respectively.

In order to confirm whether the observed results were in fact significant, a chi-square test of homogeneity was performed using Microsoft Excel™. To do this, expected results needed to be populated, as per Table 9 below. In quintile one, the total expected observation of developed and emerging currencies was 134 and 153 respectively. On the other hand, in quintile five the total observation of developed versus emerging currencies was 148 and 167 respectively. The chi-square test resulted in a p-value of 0.0266, which is less than the target of 0.05 (refer to Table 9 below). The null hypothesis of the chi-square test of homogeneity was thus rejected, which confirmed that the differences between actual and expected results were in fact significant, with greater than 95 percent confidence. One can therefore conclude that differences did not occur by chance.

Table 9: Difference between developed and emerging currencies with momentum style (chi-square test)

Actual Results

Quintiles	Developed	Emerging	Total
CurrencyMomentum Q1	148	139	**287**
CurrencyMomentum Q5	134	181	**315**
Total	**282**	**320**	**602**

Expected Results

Quintiles	Developed	Emerging	Total
CurrencyMomentum Q1	134*	153	**287**
CurrencyMomentum Q5	148	167	**315**
Total	**282**	**320**	**602**
p-value	0.0266		

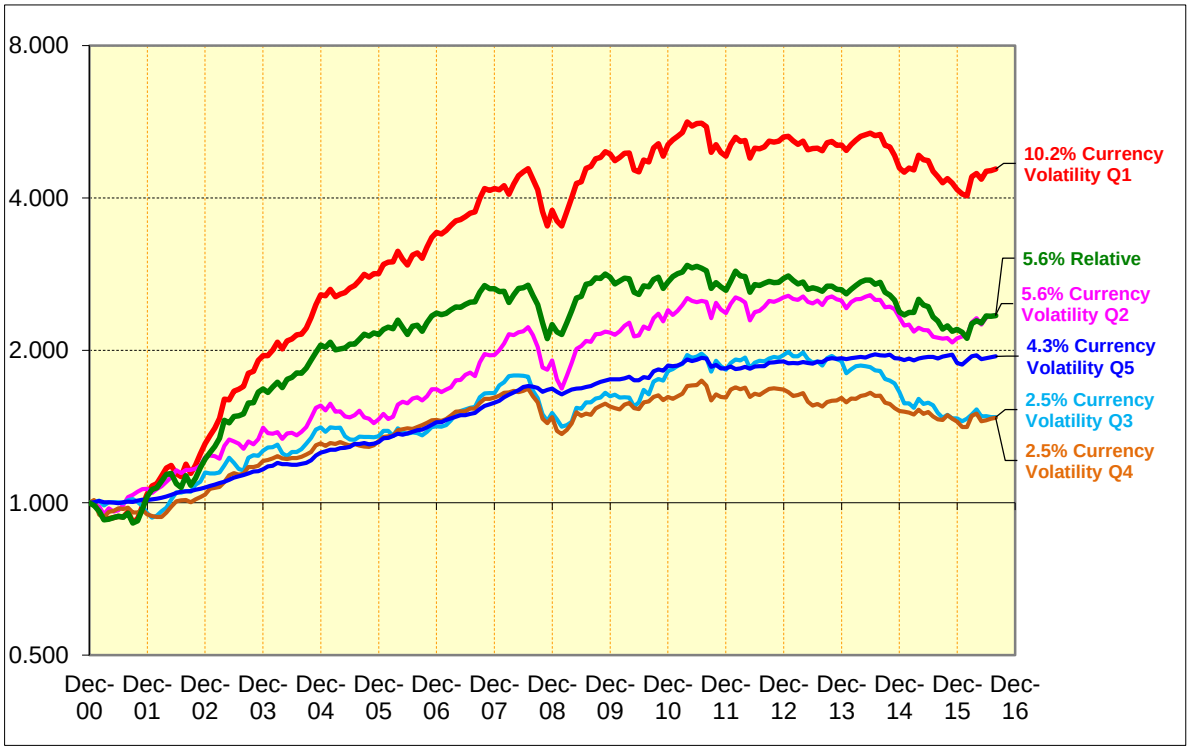
* Example calculation: Expected CurrencyMomentum Q1 (134) = Actual Total Developed observations (282) multiplied by Total CurrencyMomentum Q1 observations (287) divided by Total actual observations (602).

5.2. Volatility in currency time-series data

5.2.1. Results from the graphical time-series analysis on volatility style

The results of trading currency volatility are shown in Figure 5 below. Here the most recent 60 trading days were used as the look-back period, with a three-month holding period and zero transaction costs. If one considers the average results over the full time-series, results were promising. At a glance it seemed as though trading currencies with high volatility would generate the greatest AARs of 10.2 percent (quintile one) versus the least AARs of 2.5 percent in quintiles three and four, which translates into a returns relative of 5.6 percent between the greatest and least AAR.

Figure 5: Graphical output showing volatility style in currencies



As evident in Figure 5 above, the contribution to the AARs stemmed from the first half of the time-series and seems to taper off during the second half (from around 2009 to 2016), which distorts the reality of using a volatility-based trading strategy. A different picture is painted by segmenting and re-indexing the time-series range and analysing returns during each isolated range. This is discussed further in Section 6.2.

5.2.2. Significance of differences in results between developed and emerging currencies using volatility as a style for investment

In line with the fifth objective of the research report, analysis was undertaken on the constituents of quintile one and quintile five portfolios, to determine whether there were statistically significant differences between results in terms of currencies of developed versus emerging countries, in trading currency volatility as a style.

Cumulative results of the frequencies of actual and expected occurrence of both developed and emerging currencies are provided in Table 10 below. The cumulative frequencies in actual results were observations over the 189-month range of time-series data (December 2000 to July 2016); refer to Appendix B Table 21 for the full frequency table. In quintile one (the most volatile currencies), the total observation of developed and emerging currencies was 72 and 215 respectively. On the other hand, in quintile five (the least volatile currencies) the total observation of developed versus emerging currencies was 145 and 170 respectively.

As was done with momentum style, in order to confirm if the observed results were in fact significant, a chi-square test was performed using Microsoft Excel™. To do this, expected results needed to be populated, as per Table 10 below. In quintile one, the total expected observation of developed and emerging currencies was 103 and 184 respectively. On the other hand, in quintile five the total observation of developed versus emerging currencies was 114 and 201 respectively. The chi-square test of homogeneity output a p-value of 9.0053×10^{-8}, which was significantly less than the target of 0.05 (refer to Table 10 below). The null hypothesis in Section 2.6 was thus rejected. This confirms that the differences between actual and expected results are in fact extremely significant (with greater than 95 percent confidence) and concludes that differences did not occur by chance.

Table 10: Difference between developed and emerging currencies with volatility style (chi-square test)

Actual Results

Quintiles	Developed	Emerging	Total
CurrencyVolatility Q1	72	215	**287**
CurrencyVolatility Q5	145	170	**315**
Total	**217**	**385**	**602**

Expected Results

Quintiles	Developed	Emerging	Total
CurrencyVolatility Q1	103	184	**287**
CurrencyVolatility Q5	114	201	**315**
Total	**217**	**385**	**602**
p-value	9.0053E-08		

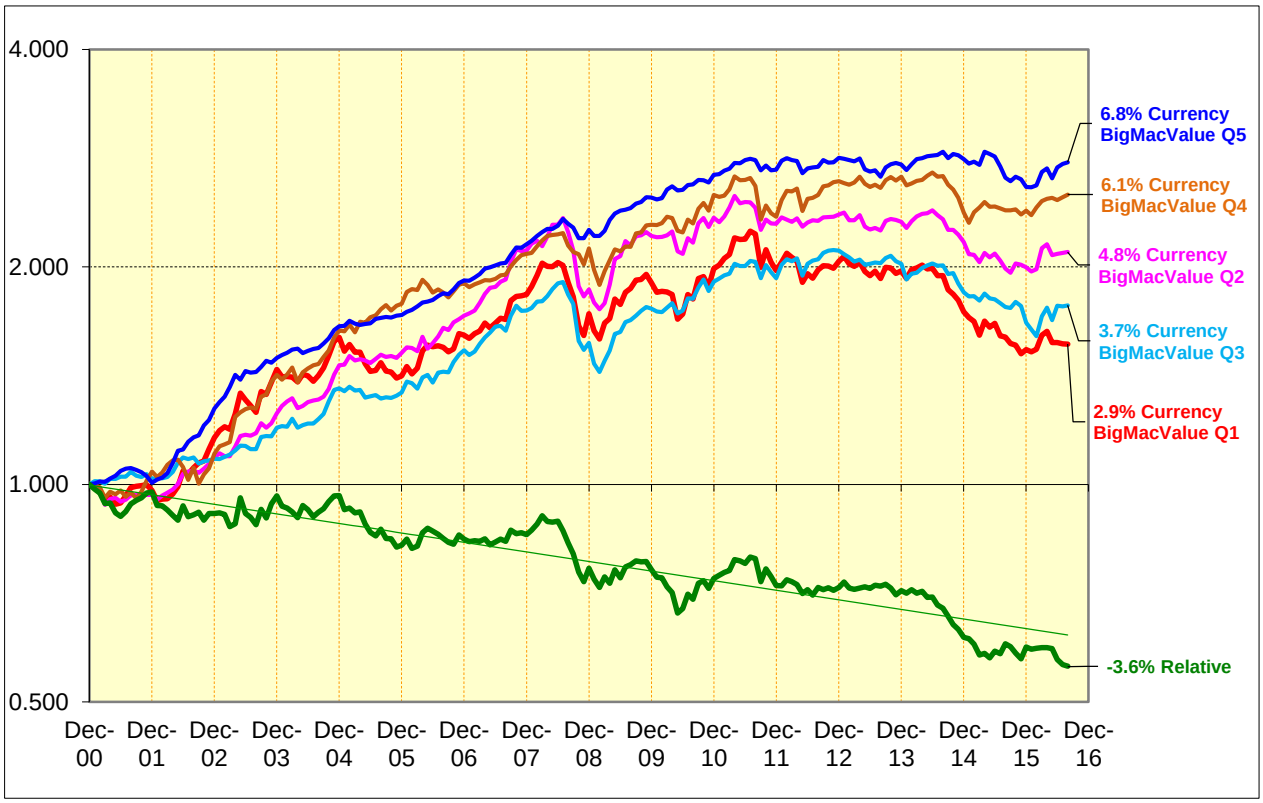
5.3. Value in currency time-series data

5.3.1. Results from the graphical time series analysis on value style

The results of the graphical time-series analysis are shown in Figure 6 below. Trading was simulated using bi-annual data from The Economist's Big Mac index, hence a six-month look-back period, with a six-month holding period was used. Optimisation of the look-back period, look-to period, or holding period were not practical due to the nature of the bi-annual data.

Currencies in quintile five (CurrencyBigMacValue Q5) outperformed the other portfolios, achieving AARs of 6.8 percent, versus 2.9 percent for quintile one portfolio (Currency BigMacValue Q1). This is represented by a returns relative of negative 2.9 percent between quintile one and quintile five currencies. Currencies in quintile five were representative of high value (or under-valued) currencies relative to the USD, i.e. those with the greatest negative Big Mac index value relative to the USD. Quintile one currencies were representative of lowest value (or over-valued) currencies relative to the USD.

Figure 6: Graph showing performance using value as a style



5.3.2. Significance of differences in results between developed and emerging currencies using value as a style for investment

Cumulative results of the frequencies of actual and expected occurrence of both developed and emerging currencies are provided in Table 11 below. The cumulative frequencies in actual results were observations over the 189-month range of time-series data (December 2000 to July 2016), refer to Appendix B Table 22 for full frequency table. In quintile one (lowest value currencies relative to the USD), the total observation of developed and emerging currencies was 242 and 24 respectively. On the other hand, in quintile five (highest value currencies relative to the USD) the total observation of developed versus emerging currencies was 71 and 238 respectively.

In order to confirm if the observed results were in fact significant, a chi-square test of homogeneity was performed using Microsoft Excel™. To do this, expected results were again populated, as per Table 11 below. In quintile one, the total expected observation of developed and emerging currencies was 145 and 121 respectively. In quintile five,

the total observation of developed versus emerging currencies was 168 and 141 respectively. The chi-square test output a p-value of $6.6047X10^{-60}$, which is significantly below the target of 0.05 and allowed for the null hypothesis in Section 4.1.4 to be rejected. This confirms that the differences between actual and expected results were in fact extremely significant and with greater than 95 percent confidence concludes that differences did not occur by chance.

Table 11: Difference between developed and emerging currencies with value style (chi-square test)

Actual Results

Quintiles	Developed	Emerging	Total
Currency BigMacValue Q1	242	24	**266**
Currency BigMacValue Q5	71	238	**309**
Total	**313**	**262**	**575**

Expected Results

Quintiles	Developed	Emerging	Total
Currency BigMacValue Q1	145	121	**266**
Currency BigMacValue Q5	168	141	**309**
Total	**313**	**262**	**575**
p-value	6.6047E-60		

6. Discussion of Results

6.1. Momentum style in currency data

As expected from the findings in the literature review, the results in Section 5.1 confirmed that momentum exists in currency data and positive returns can be achieved by trading off momentum as a style. There were however a number of findings, that both differed from, and/or confirmed that published in the literature, which are included in the discussion below.

6.1.1. Optimisation of momentum as a style

The results in this study found that returns could be optimised by following a trading strategy having selected the least momentum currencies (quintile five), using a 10-month look-back period, a three-month look-to period and a two-month holding period, represented by MOM(10,3,2). This was applicable both with and without transaction costs, resulting in AARs of 7.57 percent and 8.57 percent respectively. With a two-month holding period, the 0.05 percent trading cost had a 100-basis-point impact on the AAR.

By contrast, the optimal result using most momentum currencies (quintile one) was achieved by following a strategy using a one-month look-back period, with a three-month holding period, represented by MOM(1,0,3). Again this was applicable both with and without transaction costs, which implies that the transaction cost was not big enough to have a significant impact and extend the holding period to minimise transaction costs. As summarised in Table 12, AARs achieved were 6.67 percent including transaction costs and 7.00 percent excluding transaction costs. Interestingly, with most momentum currencies (quintile one) results were optimised with three-month holding period, in comparison to a two-month holding period with least momentum (quintile five) currencies. Here the transaction cost of 0.05 percent with a three-month holding period had a 33-basis-point impact on the AAR. As expected, the difference between the AARs with and without transaction costs decreased with the reduced holding period. The look-back period was limited to a minimum of one month, it was therefore not tested whether a shorter look-back period (perhaps days) would have resulted in an increased AAR. As previously discussed, manipulation of the look-to range was not possible using one-month increments, however should allowance have been made for optimisation using days or weeks, a more optimal result may have been achieved for the most momentum currencies.

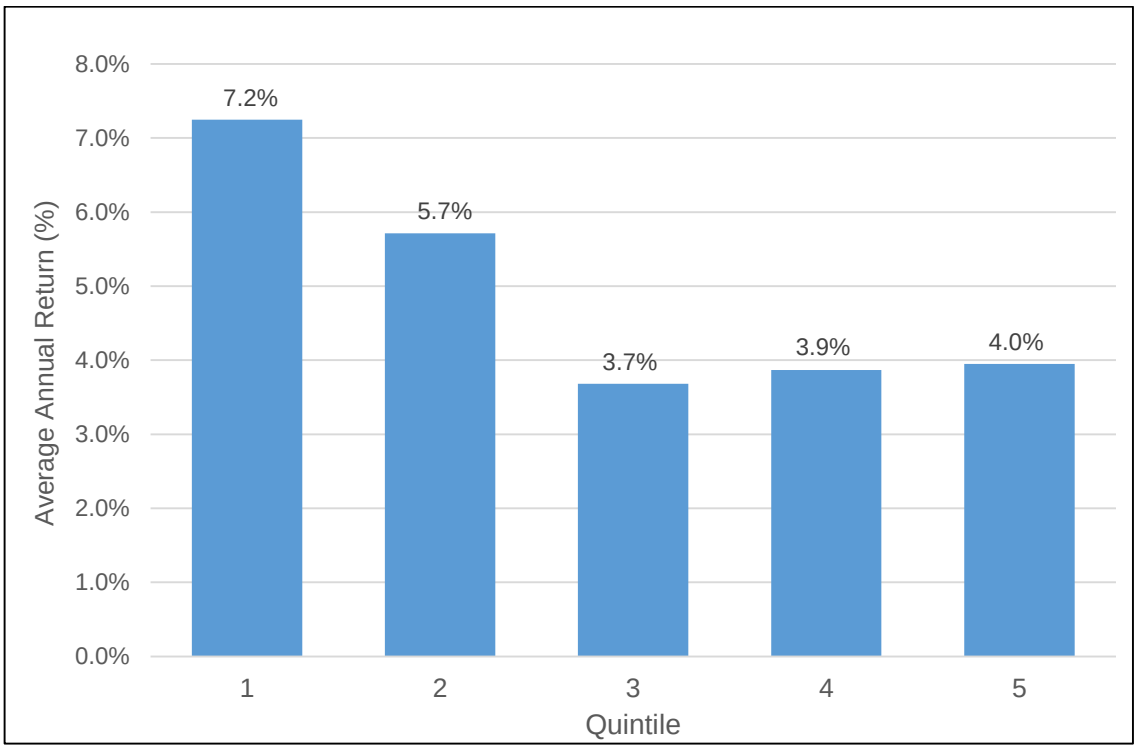
Table 12: Summary of optimal results for quintile one and quintile five portfolios

Description	Quintile One	Quintile Five
Momentum type	Most	Least
Look-back period (months)	1	10
Look-to period (months)	N/A	3
Holding period (months)	3	2
AAR, excluding transaction costs (%)	7.00%	8.57%
AAR, including transaction costs (%)	6.67%	7.57%

As previously discussed for both the optimal quintile one and quintile five strategies, the impact of the transaction costs of 0.05 percent was negligible and never materially changed the optimal strategy. As can be seen from Table 12, quintile one currencies were more affected by the transaction cost in comparison to quintile five currencies; however, this is attributable to the shorter holding period used to optimise quintile one returns. This could be the reason why most of the literature dealing with style-based studies on currency trading (such as Asness et al. (2013), Moskowitz et al. (2011) and Novy-Marx (2011)) exclude these costs, as they do not make a material impact on the optimisation of the trading strategy and are cumbersome to accurately calculate without the use of a sophisticated model such as the style-engine used in this study.

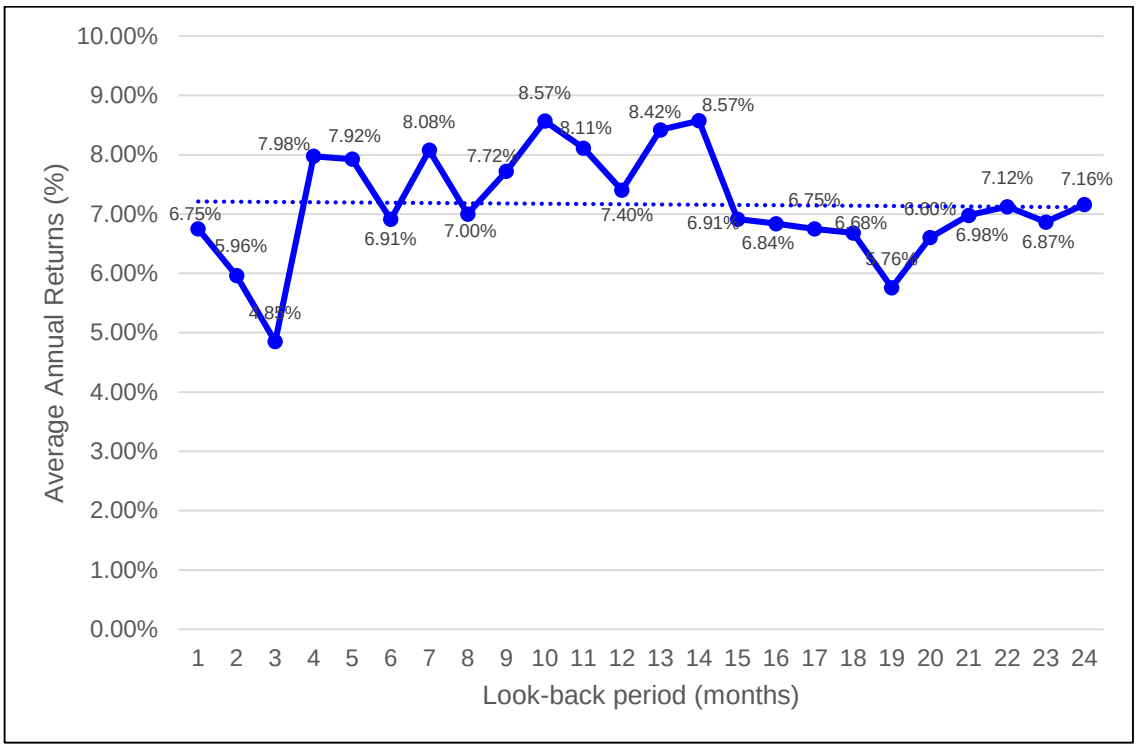
Initially, it was suspected that the optimal results would be found with the most momentum currencies (grouped in quintile one), as was done with a one-month look-back period, with the exclusion of a look-to period, and three-month holding period MOM(1,0,3). However, having plotted the initial results (see Figure 7), the trend suggested that further optimisation was possible as the returns did not continue downward from quintile one to quintile five, rather increasing again in quintile four and quintile five. This suggested that further optimisation would be possible for quintile five and prompted further testing using an extended look-back period on the least momentum currencies.

Figure 7: AARs of quintiles using a one-month look-back and three-month holding period MOM(1,0,3,0)



As was shown in Table 5, Section 5.1.2.1, results were optimal for least momentum currencies with both a 10-month look-back period (8.57 percent) and a 14-month look-back period (8.57 percent). Figure 8 shows that returns were relatively stable with look-back periods between four and 15 months, with AARs fluctuating within a 1.66 percent range. The average returns of the optimal months including their preceding and subsequent months (i.e. months nine to 11 and 13 to 15) provided averages of 8.13 percent and 7.97 percent respectively. It was therefore deduced that using a 10-month look-back period would be less risky and likely to result in higher returns on average, due to random fluctuations.

Figure 8: Graph showing AARs with optimisation of look-back period for quintile five currencies



6.1.2. Consistency of results to the literature studied

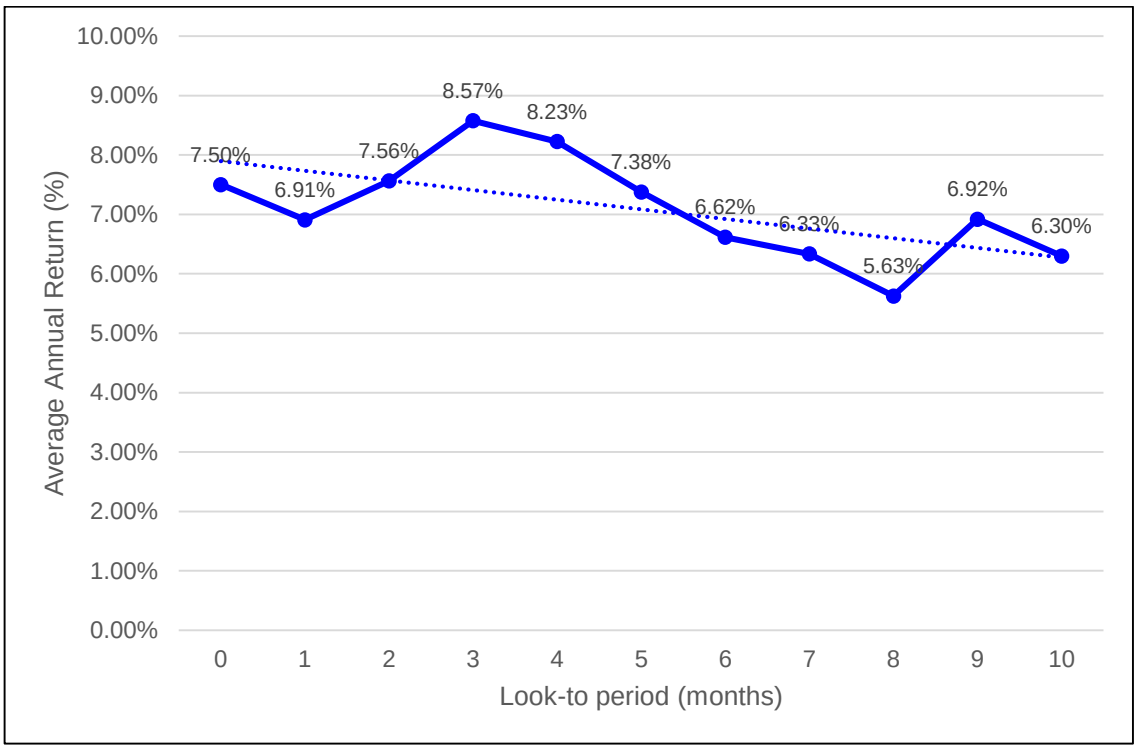
It was evident from the literature review that momentum was in fact a style that could be used to generate positive returns in trading currencies. The literature however presented a number of differing views on optimal look-back, look-to and holding periods.

Asness et al. (2013) measured momentum using returns from the previous 12 months, ignoring the most recent month to avoid the one-month reversal as is common practice in the literature. In this study, that would be termed as a 12-month look-back period, with a one-month look-to period. This was done on developed currencies. No mention was made of transaction costs, so it is assumed that they were excluded. The holding period used was also not mentioned in their paper. Asness et al. (2013) showed that momentum existed in currencies, which is consistent with these findings. However, based on the results achieved in this study, returns were not optimised.

Moskowitz et al. (2011) ran simulations using a number of different look-back and holding periods. They found that a 12-month look-back period, with a one-month holding period produced optimal results. As with Asness et al. (2013), Moskowitz et al. (2011) ignored the most recent month's data. It should be noted that the increments used for testing look-back and holding periods in Moskowitz et al.'s study were not the same as in this paper. Rather, they used one-, three-, six-, nine-, 12-, 24-, 36- and 48-month periods for both look-back and holding periods in their analyses, and as a result would not have been able to get results as accurate in comparison to what was achieved in this study. Their results did however closely correspond to the optimal result in this study using quintile five currencies (this is further discussed in Section 6.1.4).

In Novy-Marx's (2011) paper, they published that a 12-month look-back period, with a seven-month look-to period (i.e. the most recent six months' data was ignored) produced optimal returns on their sample involving both developed and emerging currencies. This was done with a one-month holding period and ignoring transaction costs. They termed this a "12-seven month strategy" representing the "intermediate horizon", rather than the most recent past performance. The use of the 12-month look-back period corresponds most closely to the results obtained using quintile five currencies, however the use of a seven-month look-to range is inconsistent with the results obtained in this study. As can be seen from Figure 9 below, the results in this study showed that the optimal look-to period, using a 10-month look-back period and two-month holding period was three-month and minimised using an eight-month look-to period. These findings are therefore contrary to those of Novy-Marx (2011), although it should be noted that their methodology differed slightly to that used in this study. There was no other literature reviewed that supported Novy-Marx's findings.

Figure 9: Graph showing AARs with optimisation of look-to period for quintile five currencies, excluding transaction costs



6.1.3. Impact of the global financial crisis on momentum

As was discussed in Section 2.4.1, Narayan et al. (2015) analysed whether the 2007 global financial crisis affected exchange rate profitability of the emerging currencies studied and found that the profitability of currency trading (using momentum) was maximised during the period of the financial crisis (regardless of trading frequency) – this in comparison to pre-crisis and post-crisis data. Narayan et al. (2015) used a period of 1 March 2007 to 30 November 2007 to represent pre-financial crisis, 1 December 2007 to 30 June 2009 to represent during the financial crisis and 1 July 2009 to 30 March 2009 to represent post-financial crisis.

In order to graphically verify the significance of the global financial crisis and understand the impact on trading off momentum, similar time frames to Narayan et al. (2015) were used. To do this, Figure 2 was modified by segmenting the time-series into three sections, namely pre-global financial crisis (31 December 2000 to 30 November 2007), during the global financial crisis (1 December 2007 to 30 June 2009) and post-global financial crisis (1 July 2009 to 31 July 2016). These segments are graphically

represented below in Figure 10, Figure 11 and Figure 12 respectively. It is acknowledged that an event study would perhaps have been a better methodology to determine the significance of the impact on returns as a result of the global financial crisis, however as can be seen in the figures below, the graphical time-series' provide sufficient evidence to draw meaningful conclusions.

As can be seen from the graphs, none of the quintiles showed improved performance during the global financial crisis, which is contrary to Narayan et al.'s (2015) findings. If one looks at quintile one and quintile five, both of which were optimised, for both cases, AARs were significantly higher pre-global financial crisis, drastically reduced during the global financial crisis and have only slightly improved post-global financial crisis, which is perhaps evidence suggesting that markets have only partially recovered from the global financial crisis.

Figure 10: Graphical output showing momentum style in currencies (pre-global financial crisis)

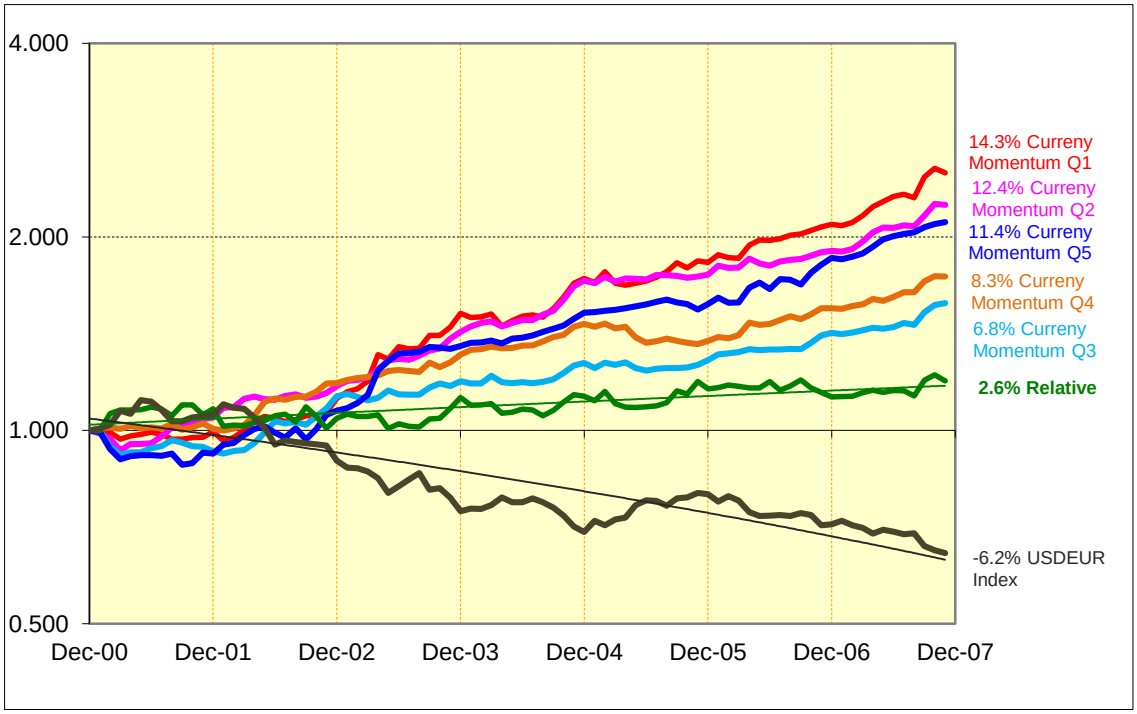


Figure 11: Graphical output showing momentum style in currencies (during-global financial crisis)

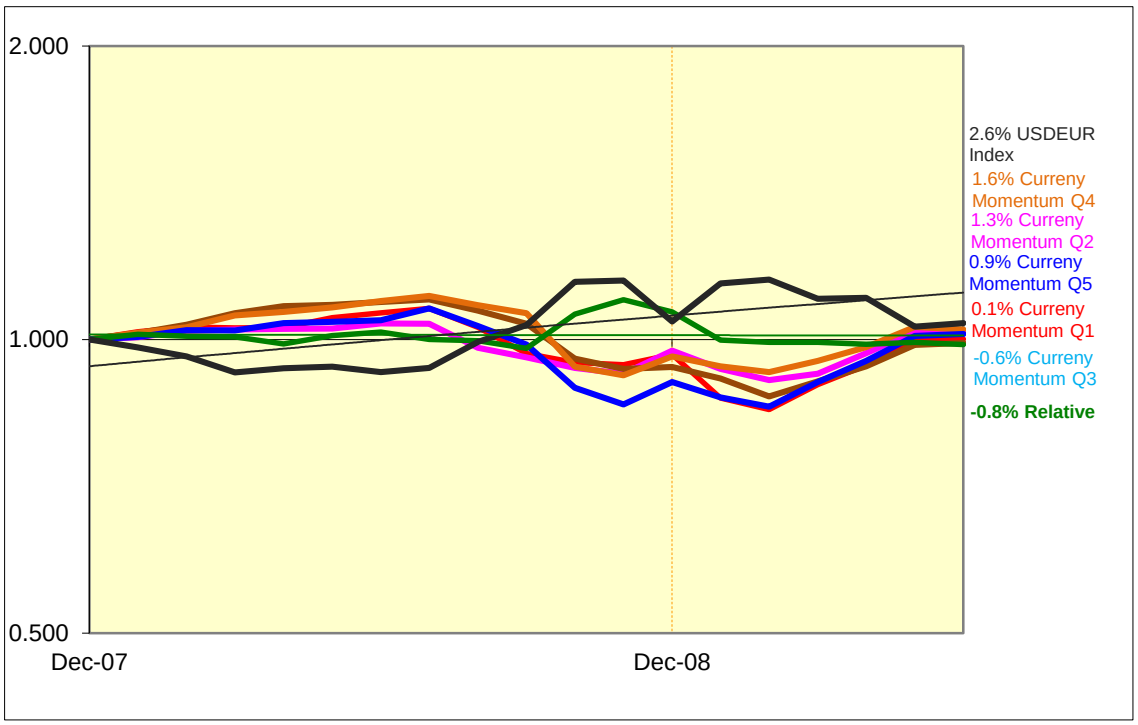
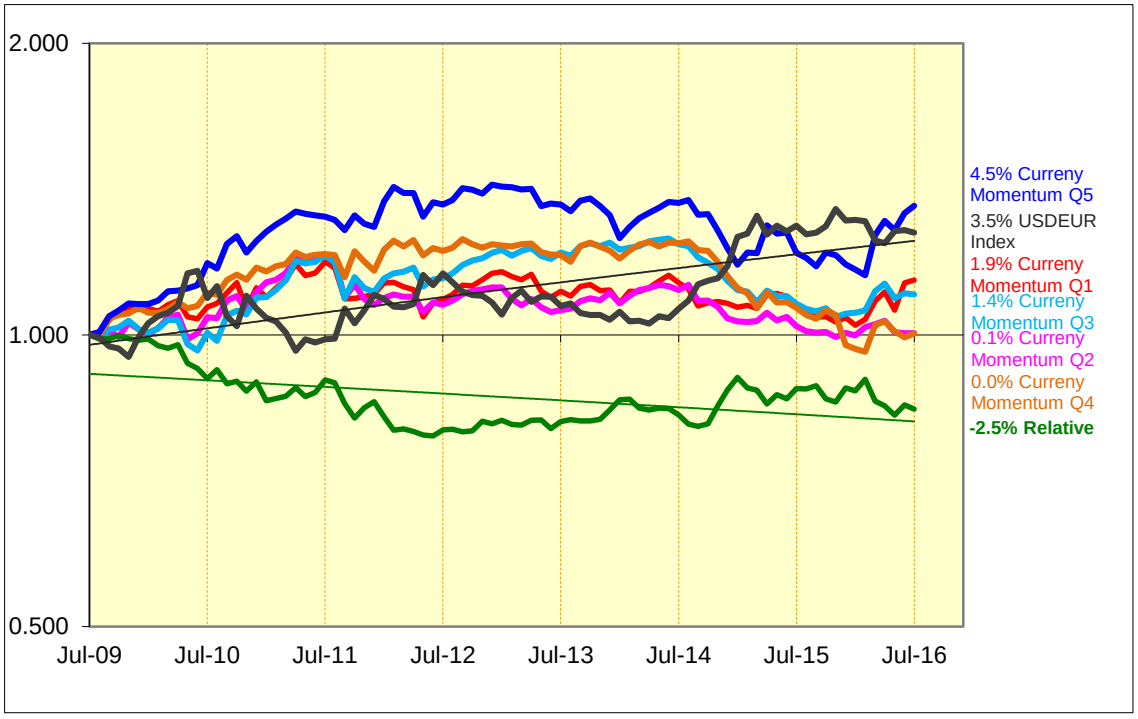


Figure 12: Graphical output showing momentum style in currencies (post-global financial crisis)



6.1.4. Differences between developed and emerging currencies in momentum studies with currencies

The literature studied made no distinction between results observed for developed and emerging currencies. Asness et al. (2013), Barroso and Santa-Clara (2015), Moskowitz et al. (2011) made use of developed currencies in their analyses, Narayan et al. (2015), Tajaddini and Crack (2012) used emerging currencies, and Novy-Marx (2011) made use of a combination of developed and emerging currencies. It was therefore deemed necessary to determine whether there were statistically significant differences in results between developed and emerging currencies when using momentum style. This would allow for the applicability of previous studies to be broadened should no differences exist, and particularly results on developed countries to be extended to emerging currencies, as historically there has been more literature published on developed currencies. In order to do so, a statistical test was used to test for differences the categorical data. The use of the chi-square test of homogeneity allowed for the differences between the categorical data to analyse and determine if differences were of statistical significance.

Results from the chi-square test show that there were in fact significant differences in results between actual and expected returns of developed and emerging currencies, with a p-value of 0.0266, confirming the significance with a 95 percent level of confidence. Based on the number of developed and emerging currencies in the sample (13 and 12 respectively), the expected frequency of occurrence, by currency category, is shown for most momentum (quintile one) and least momentum (quintile five) currencies (see Table 13 below, repeated for ease of reference). The results tabled show that it was more likely that developed currencies featured in the most momentum (quintile one) portfolio, hence it was less likely that emerging currencies would occur in quintile one portfolio. Additionally, the chi-square test shows that it was more likely that emerging currencies occurred in least momentum (quintile five portfolio), hence less likely that developing currencies occurred in quintile five.

As was discussed in Section 6.1.2, the results obtained by Moskowitz et al. (2011) were similar to that achieved with quintile five currencies. Interestingly, Moskowitz et al.'s (2011) simulations were run using currencies from Australia, Canada, Germany (spliced with the Euro), Japan, New Zealand, Norway, Sweden, Switzerland, United Kingdom

and United States – all of which are developed countries as per the classification used in this study – which does not correspond with the results of the chi-square test as presented in Section 5.1.3, Table 9. This is inconsistent with the chi-square test of homogeneity, as based on the results it was more likely for developed currencies to occur in quintile one which have an optimal look-back period of one month. Based on the fact that only developed currencies were used in Moskowitz et al.'s (2011) study, one would have expected results to be similar to that achieved in quintile one, where look-back periods of one to four months and six to 11 months all produced higher AARs than with a 12-month look-back period (refer to Section 5.1.1.1, Table 2). There would therefore be merit in doing a repeat study with the style-engine and running simulations with the same currencies to see if similar results could be simulated.

Table 13: Difference between developed and emerging currencies with momentum style (chi-square test)

Actual Results

Quintiles	Developed	Emerging	Total
CurrencyMomentum Q1	148	139	**287**
CurrencyMomentum Q5	134	181	**315**
Total	**282**	**320**	**602**

Expected Results

Quintiles	Developed	Emerging	Total
CurrencyMomentum Q1	134	153	**287**
CurrencyMomentum Q5	148	167	**315**
Total	**282**	**320**	**602**
p-value	0.0266		

6.2. Volatility style in currency data

6.2.1. Impact of the global financial crisis on volatility style

The results in Section 5.2.1 showed that the returns achieved trading off volatility style started strong, subsequently fading out around 2007 to 2008, around the time of the global financial crisis. As was done for momentum in Section 6.1.3 and previously discussed in Section 2.4.1, Narayan et al. (2015) analysed whether the 2007 global financial crisis affected exchange rate profitability of the emerging currencies studied and found that the profitability of currency trading was maximised during the period of the financial crisis (regardless of trading frequency) – this in comparison to pre-crisis

and post-crisis data. Narayan et al. (2015) used a period of 1 March 2007 to 30 November 2007 to represent pre-financial crisis, 1 December 2007 to 30 June 2009 to represent during the financial crisis and 1 July 2009 to 30 March 2009 to represent post-financial crisis. Narayan et al.'s (2015) published findings for momentum, along with the graphical evidence in Figure 5, led to further analysis around volatility as a style to see if similar results would be obtained with the volatility style.

In order to graphically verify the significance of the global financial crisis and understand the impact on trading off volatility, similar time frames to Narayan et al. (2015) were used. To do this, Figure 5 was modified by segmenting the time-series into three sections, namely pre-global financial crisis (31 December 2000 to 30 November 2007), during the global financial crisis (1 December 2007 to 30 June 2009) and post-global financial crisis (1 July 2009 to 31 July 2016). These segments are graphically represented below in Figure 13, Figure 16 and Figure 17 respectively. Again, it is acknowledged that an event study would perhaps have been a better methodology to determine the significance of the impact on returns as a result of the global financial crisis, however as can be seen in the figures below, the graphical time-series' provide sufficient evidence to draw meaningful conclusions.

As was discussed in Section 5.2.2, there are significant differences between developed and emerging currencies in terms of volatility over the entire time series studied. To analyse this further, chi-square tests were done over each of the three segments, namely pre-global financial crisis, during the global financial crisis and post-global financial crisis, to determine if there are statistically significant differences between developed and emerging currencies in each of the periods studied.

6.2.1.1. Volatility as a style: pre-global financial crisis

The pre-global financial crisis period is shown in Figure 13 and represents the time-series from 31 December 2000 to 30 November 2007, as was done by Narayan et al. (2015). As can be seen, volatility was clearly a style that could have been successfully traded off pre-global financial crisis. AARs were maximised with quintile one currencies and minimised with quintile five currencies, with AARs of 22.8 percent and 6.7 percent respectively. Figure 14 illustrates that quintile one currencies represent highest volatility

currencies and quintile five the lowest volatility currencies. AARs reduced exponentially with decreasing volatility (see Figure 15 below). This implies that, similar to the theory of the Capital Asset Pricing Model (CAPM), volatility risk was rewarded with higher AARs in this segment. A similar finding was made by Menkhoff et al. (2012) in their study from January 1976 to January 2010, where they deduced that returns were related to risk, with high-risk rating currencies generating higher excess returns on average over the period studied. In the pre-global financial crisis period, currencies with high volatility were an attractive means for making high USD-based returns. With a 15.1 percent relative between highest and lowest volatility quintiles, it would have also provided an attractive opportunity for hedge fund managers to go long on the quintile one currencies and short on the quintile five currencies.

Figure 13: Graphical output showing volatility style in currencies (pre-global financial crisis)

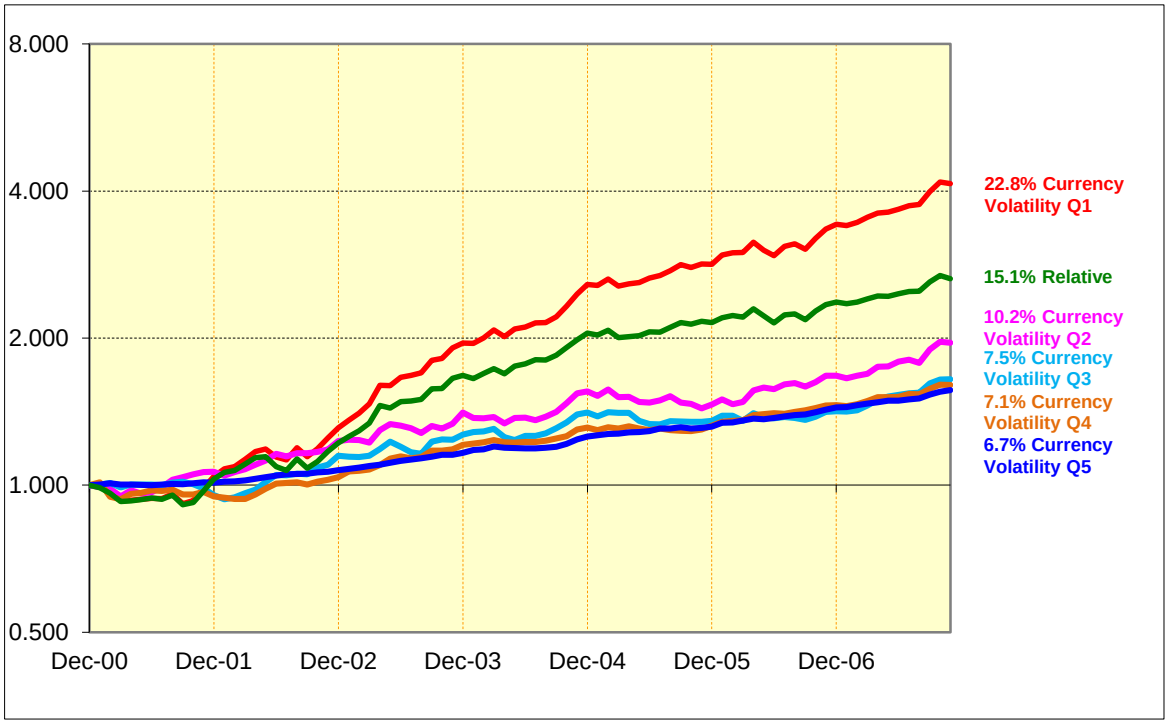


Figure 14: Graph showing the median of currency volatility over the full time-series (quintile one and quintile five)

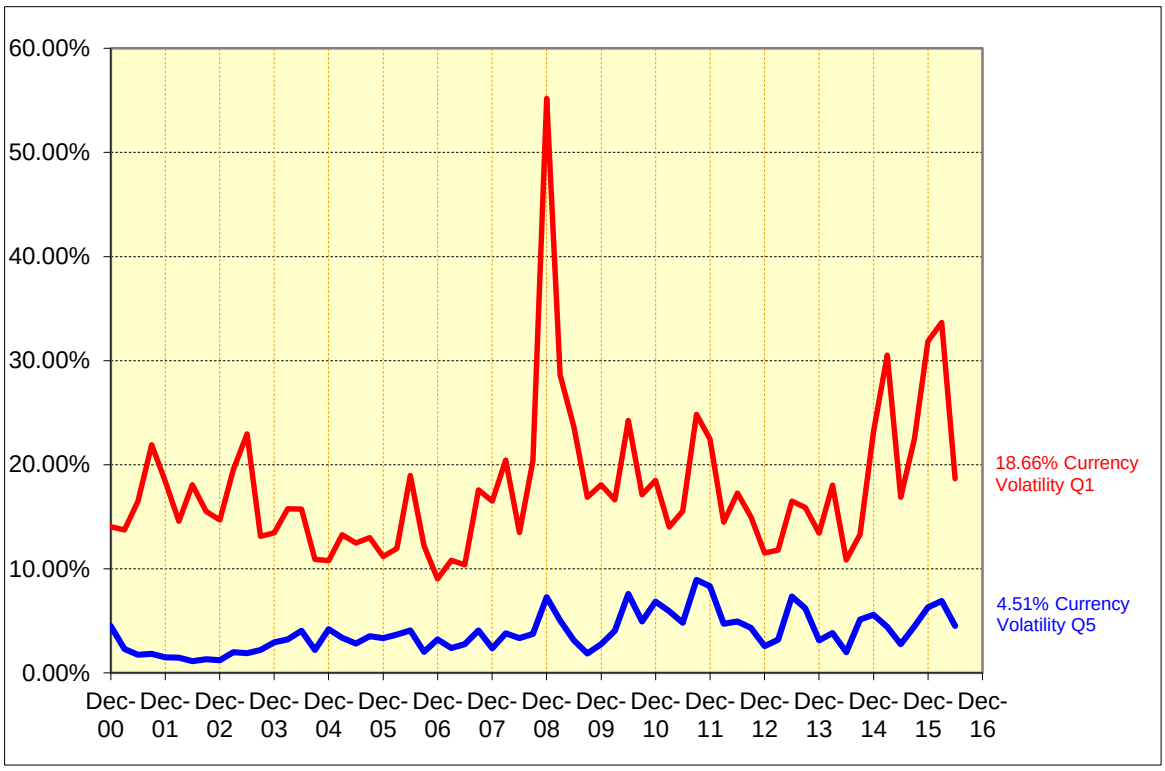
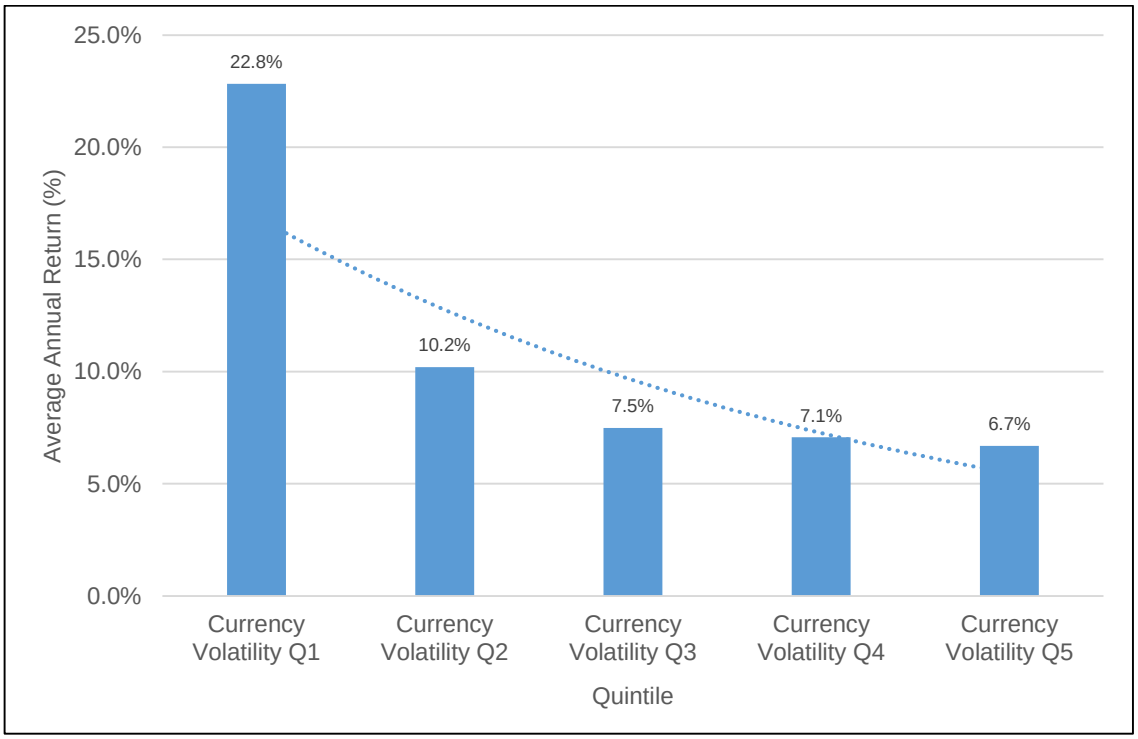


Figure 15: Currency volatility: AARs (pre-global financial crisis)



A chi-square test of homogeneity was used to test the significance of the difference between developed and emerging currencies' frequency during the pre-global financial crisis period. As can be seen from Table 14, differences were found to be significant (at a 95 percent confidence level), with a p-value of 0.0355. Emerging currencies were more prone to occur in the most volatile quintile (quintile one). The insight with this finding is that during the pre-global financial crisis period it was more likely to generate excess returns off highly volatile emerging currencies.

Table 14: Chi-square test: volatility (pre-global financial crisis)

Actual Results

Quintiles	Developed	Emerging	Total
CurrencyVol1	27	85	**112**
CurrencyVol5	51	89	**140**
Total	**78**	**174**	**252**

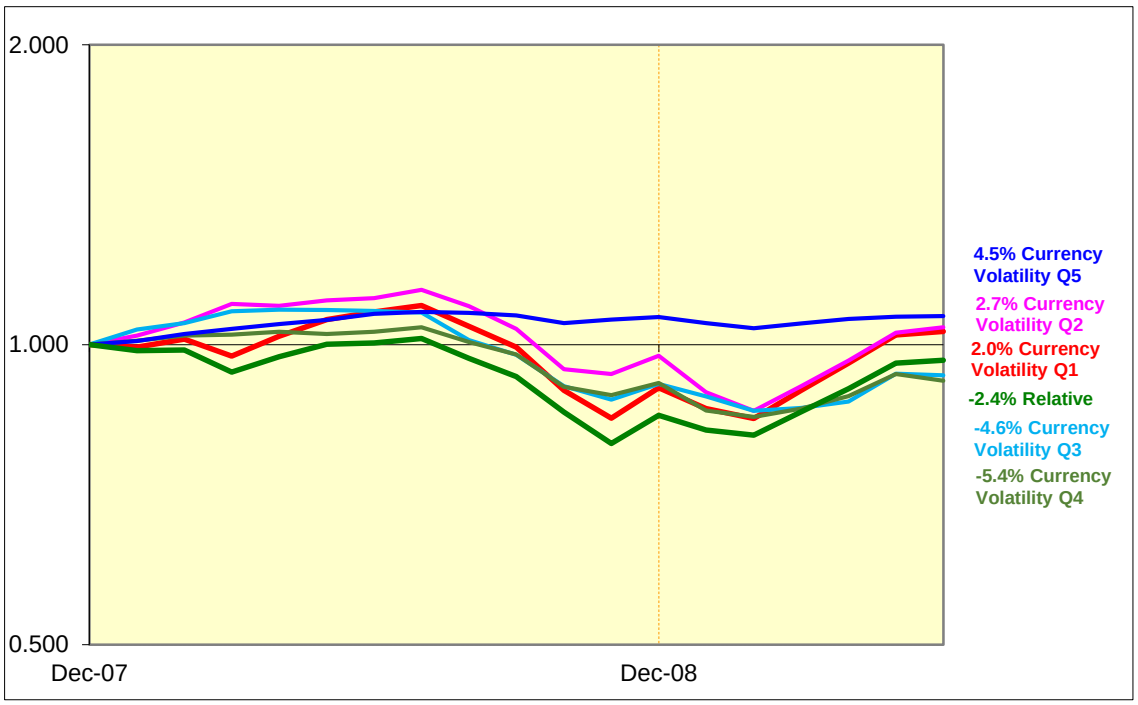
Expected Results

Quintiles	Developed	Emerging	Total
CurrencyVol1	35	77	**112**
CurrencyVol5	43	97	**140**
Total	**78**	**174**	**252**
p-value	0.0355		

6.2.1.2. Volatility as a style: during the global financial crisis

The period during the global financial crisis is graphically represented in Figure 16 below. This covers the period of 1 December 2007 to 30 June 2009. Contrary to Narayan et al.'s (2015) findings, AARs were substantially worse than pre-global financial crisis returns. Additionally, there was no longer a clear style for volatility. Quintile five went from being the worst performing portfolio pre-global financial crisis to being the best performing portfolio post-global financial crisis. Additionally, the quintile five currencies were outliers during this period, as they did not follow the similar trend of quintiles one to four (see Figure 16 below). It is evident that traders and hedge fund managers opted for less volatile currencies during this period, rather than the more volatile currencies, representative of higher risk.

Figure 16: Graphical output showing volatility style in currencies (during global financial crisis)



Again it was deemed necessary to determine if the significant difference between developed and emerging currencies pre-global financial crisis persisted during the crisis. As can be seen from the chi-square test in Table 15, the p-value was 0.6256, which signifies (at a 95 percent confidence level) that the differences in the result were not significant and occurred due to randomness. Perhaps this is reflective of the markets behaving irrationally during the global-financial crisis, but more likely just due to the short time period under review.

Table 15: Chi-square test: volatility (during global financial crisis)

Actual Results

Quintiles	Developed	Emerging	Total
CurrencyVol1	13	22	**35**
CurrencyVol5	15	20	**35**
Total	**28**	**42**	**70**

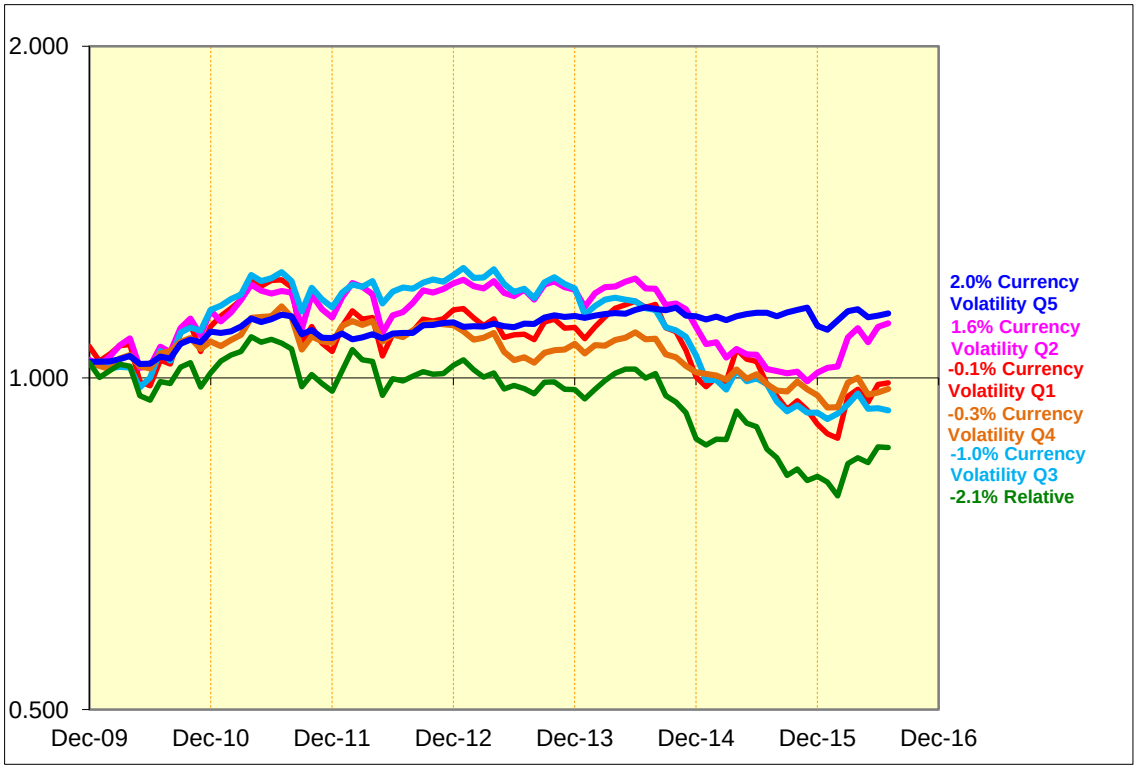
Expected Results

Quintiles	Developed	Emerging	Total
CurrencyVol1	14	21	**35**
CurrencyVol5	14	21	**35**
Total	**28**	**42**	**70**
p-value	0.6256		

6.2.1.3. Volatility as a style: post-global financial crisis

The period post-global financial crisis is graphically represented in Figure 17 below. This covers the period of 1 July 2009 to 31 July 2016. Similar to results during the global financial crisis, AARs after the global financial crisis were substantially worse than returns before global financial crisis and there was no longer a clear style for volatility. Quintile five went from being the worst performing portfolio pre-crisis to being the best performing both during the crisis and post-crisis. Additionally, quintile five currencies were again outliers during this period, as they did not follow the similar collapsing trend of quintiles one to four. It is evident that traders opted for less volatile currencies during this period, rather than the more volatile, riskier currencies. Excess returns were no longer achievable by purchasing high-volatility currencies, as was previously the case with quintile one currencies generating AARs of 22.8 percent pre-global financial crisis, suggesting that volatility style has been traded out. Expected returns were now only in the region of 2.0 percent before transaction costs, making for an unattractive investment strategy.

Figure 17: Graphical output showing volatility style in currencies (post-global financial crisis)



In order to confirm the significance of results between developed and emerging currencies post-global financial crisis, a chi-square test of homogeneity was performed. The p-value of 9.3500 $X10^{-9}$ clearly shows that differences observed were again significant (with a 95 percent confidence) post the financial crisis. As was the case pre-crisis, developed currencies were more prone to occur in quintile five, housing the least volatile currencies, and emerging currencies were more prone to occur in quintile one, housing the most volatile currencies. There was therefore significance in the fact that traders and fund managers preferred the less volatile currencies post-global financial crisis and based on the empirical evidence continue to do so. Although returns are not favourable, it is likely that fund managers are using forex as a hedge against other asset classes, such as equities and bonds.

Table 16: Chi-square test: volatility (post-global financial crisis)

Actual Results

Quintiles	Developed	Emerging	Total
CurrencyVol Q1	32	108	**140**
CurrencyVol Q5	79	61	**140**
Total	**111**	**169**	**280**

Expected Results

Quintiles	Developed	Emerging	Total
CurrencyVol Q1	56	85	**140**
CurrencyVol Q5	56	85	**140**
Total	**111**	**169**	**280**
p-value	9.3500E-09		

6.3. Value style in currency data

6.3.1. Performance review of value

As was discussed in Section 5.3.1, Figure 18 (repeated for ease of reference) clearly shows that trading off currency value was a feasible trading strategy. The graph shows that the most under-valued currencies out-performed the less under/over-valued currencies (those currencies higher up the Big Mac index, i.e. less negative, as illustrated in Figure 19 below). This performance trend has been consistent since the start date used in the study of 31 December 2000, with the exception of mid-2005 to

mid-2006, where quintile four currencies (the second most under-valued portfolio relative to the USD) slightly out-performed the most under-valued portfolio (quintile five).

The quintiles' performance (previously represented in Figure 6) were measured against a constructed index of the USDEUR. This was done to gauge if there was a relationship (and possibly a causal effect) between the strengthening or weakening of the USD with portfolio performance. As can be seen in Figure 18 below, graphically it appears that after August 2011 the USD began to strengthen (this being relative to the Euro), which dampens portfolio performance across all five quintiles. It is therefore likely that very few currencies were performing as well as the USD post-August 2011, which negatively affected portfolio performance.

Figure 18: Value style performance relative to the USDEUR index

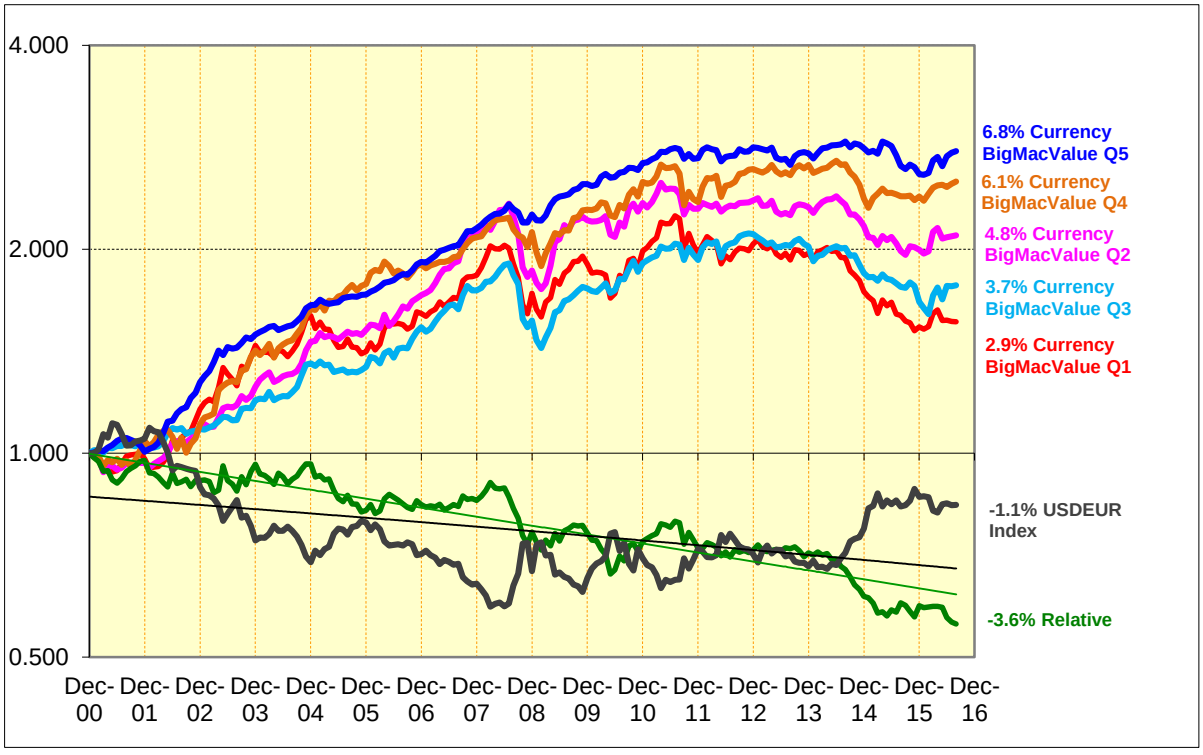
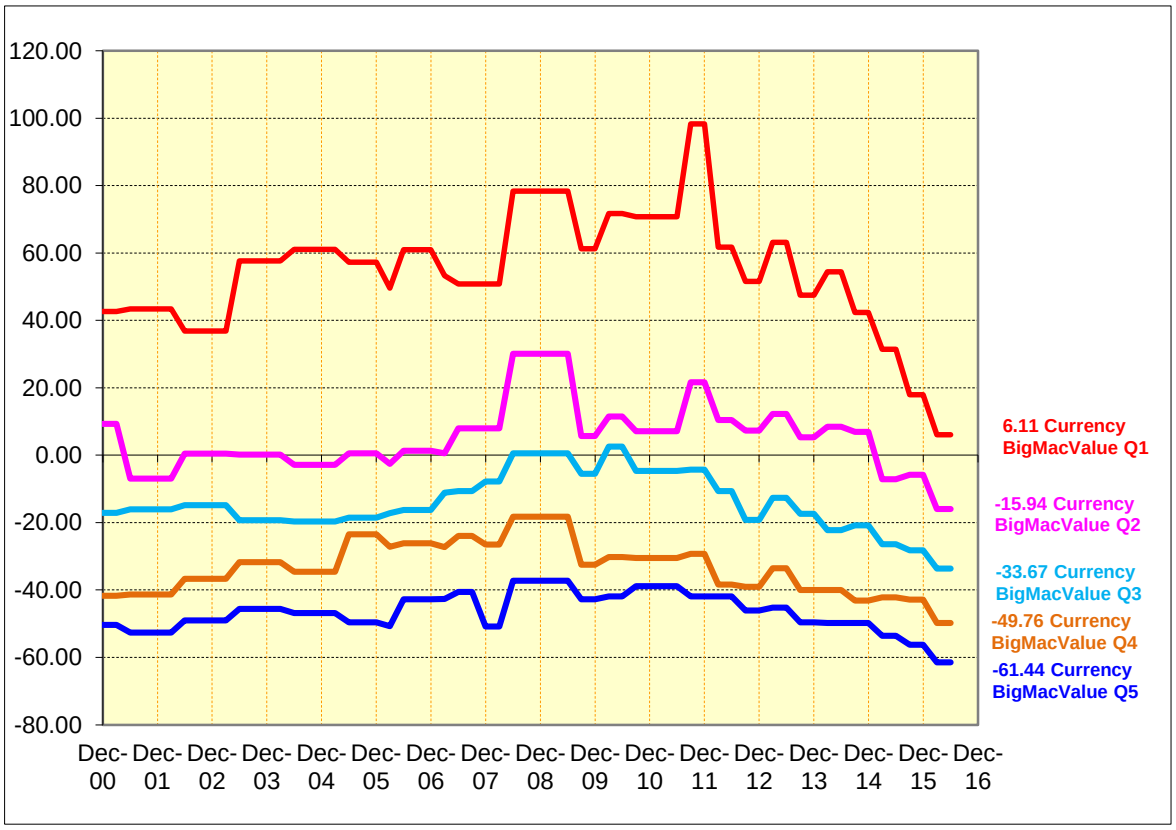


Figure 19: Median values of Big Mac index for quintiles one to five

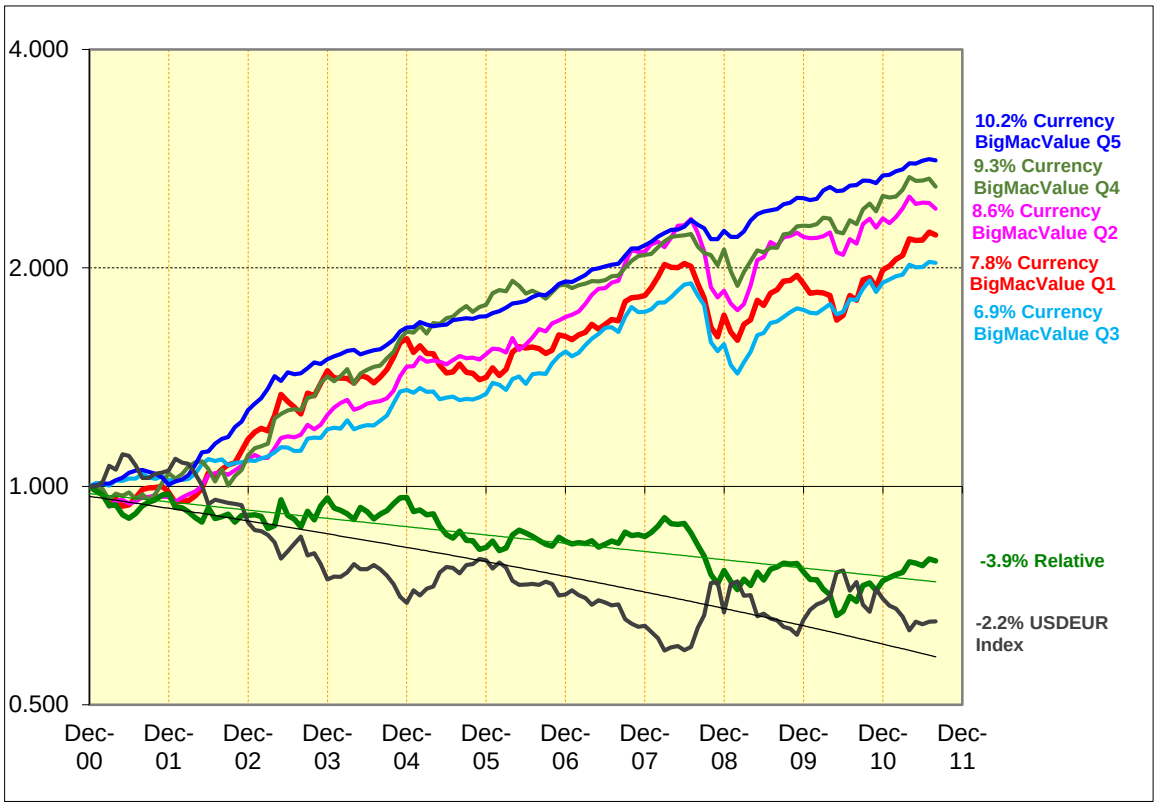


6.3.2. Impact of the strengthening of the USD on value style

To visually verify the observation made regarding the strengthening of the USD after August 2011, the time series in Figure 18 was segmented into two pieces, pre-31 August 2011 and post-31 August 2011, as illustrated in Figure 20 and Figure 21 respectively.

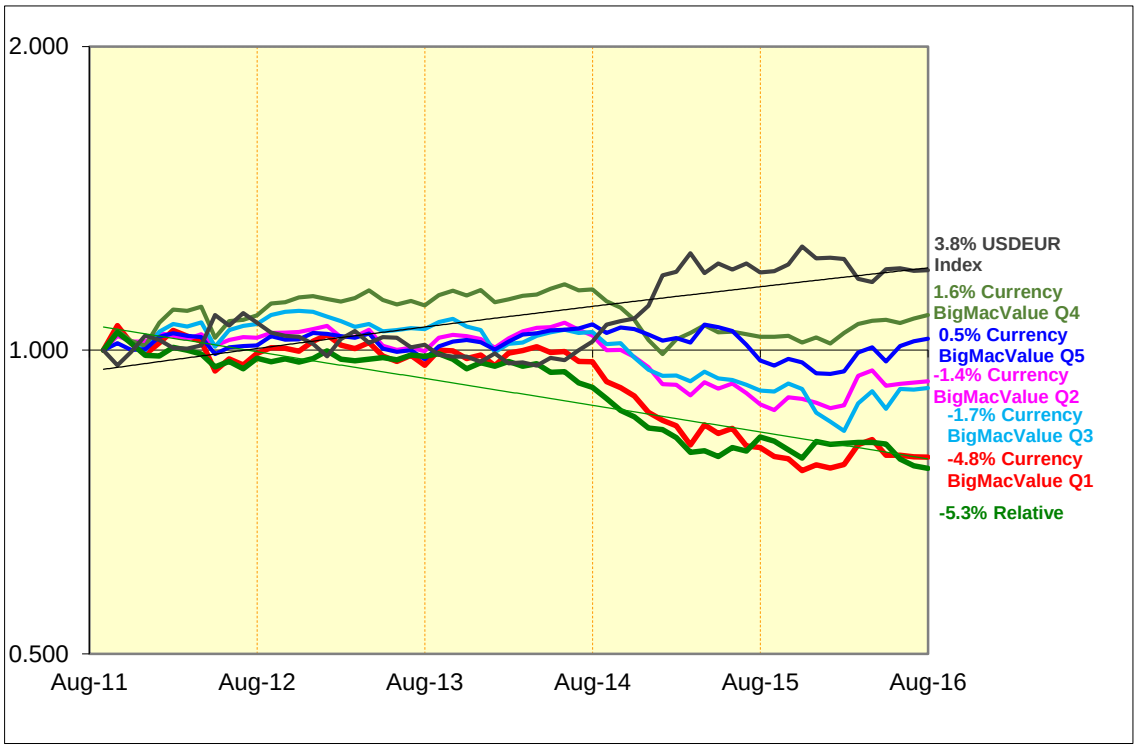
As can be seen in the pre-31 August 2011 results, an AAR of 10.2 percent was achieved with the quintile five portfolio, compared to the worst performing portfolio (quintile three) with an AAR of 6.9 percent, providing a returns relative of -3.9 percent and allowing for significant dollar-based returns to be achieved. The USDEUR index clearly shows a downward trend during this period, weakening on average by 2.2 percent per annum, which is likely to have contributed to the positive AARs achieved.

Figure 20: Value performance relative to the USDEUR index (pre-31 August 2011)



An interesting picture is painted in Figure 21 below. As can be seen from the graph, the AAR performance is substantially lower than that achieved in the pre-31 August 2011 segment. The general style trend did however remain, with the most under-valued currencies still performing better than the more over-valued and correctly valued currencies. The difference between the USDEUR performance pre-31 August 2011 and post-31 August 2011 is substantial. In the period after 31 August 2011, the dollar strengthened against the Euro by 3.8 percent on average per annum, versus the weakening by 2.2 percent per annum in the prior segment analysed. This is believed to be the fundamental difference in the results analysed in Figure 20 and Figure 21. The USD performance outpaced most other currencies and strengthened tremendously in the post-31 August 2011 segment, making returns relative to the USD significantly lower. This is a similar finding to that of Gómez-González and García-Suaza (2012), where they found that momentum returns were stronger in moments of currency depreciation. The base currency used for analysis is therefore of utmost importance when designing a style-based trading strategy.

Figure 21: Value performance relative to the USDEUR index (post-31 August 2011)



7. Conclusion

7.1. Principal findings

The study investigated various style-based investment strategies for currencies, including momentum, volatility and value. Momentum strategies were found to yield excess positive returns when trading currencies, thus confirming the findings of Asness et al. (2013), Pojarliev and Levich (2008), Barasso and Santa-Clara (2015), Narayan et al. (2015), Menkhoff et al. (2012), Tajaddini and Crack (2012), Novy-Marx (2011) and Moskowitz et al. (2011). Returns were optimised (surprisingly) in using the quintile five currencies (least positive momentum), where an AAR of 8.57 percent was achieved excluding transaction costs and 7.57 percent with a transaction cost of 0.05 percent. Although the impact of the transaction costs was significant (100 basis points), they did not impact the number of months of the optimal holding period (i.e. the period when the re-balancing of portfolios took place). Optimal returns for a momentum strategy were achieved with both a look-back period of 10 months and 14 months, using a three-month look-to period and a two-month holding period. Returns were thus mean reverting, which is consistent with Moskowitz et al.'s (2011) findings. This stands in comparison to a maximum AAR of 7.00 percent excluding transaction costs and 6.67 percent including transaction costs for the highest momentum (quintile one) currencies. The impact of transaction costs with quintile one currencies was less significant, as a result of optimal results being achieved with a 3-month holding period, thus re-balancing of portfolios took place less often. Contrary to Narayan et al.'s (2015) findings, there was no evidence of returns being maximised using a momentum-style during the period of the global financial crisis, rather before the global financial crisis.

Volatility initially showed positive returns, with an AAR of 10.2 percent being achieved over the full time-series. However, when segmenting the graphical time-series, it was evident that the returns were generated pre-2007 and subsequently faded off during the second half of the time-series (from around 2009 to 2016). This suggests that volatility as a style has been traded out and is presently no longer a feasible trading strategy. Optimisation of the strategy was therefore deemed unnecessary. As with momentum, returns using the volatility style were greatest before the global financial crisis, with AARs of 22.8 percent being achieved with highly volatile (quintile one) currencies, compared to 6.7 percent with the least volatile (quintile five) currencies. Post the global financial crisis, completely different results were achieved, with the least volatile currencies

providing the favourable returns, albeit reflecting only a two percent AAR. This is evidence of the volatility-style fading out, which is likely a result of a reduced appetite for the riskier volatile currencies whilst the economy continues to recover from the global financial crisis.

Value was shown to be a feasible trading strategy, with the most under-valued currencies outperforming the most over-valued (or close in PPP to the USD), i.e. the quintile five currencies out-performed the quintile one currencies. The out-performance from the value-style was dampened by the strengthening of the USD, around mid-2011, which was attributed to the USD outperforming most other currencies on average during that period. Value-style (measured using the Big Mac index) was largely dependent on the performance of the base currency, with the strengthening of the USD offsetting AARs. The relative strength of the base currency was therefore concluded to be of utmost importance in studies involving exchange rates to ensure that real returns are achieved.

This study was the first to investigate whether differences existed between developed and emerging currencies. The chi-square test of homogeneity was used to confirm that differences did exist in the results between developed and emerging currency types. For each of the styles analysed, the null hypothesis was rejected, thus concluding that differences between developed and emerging currencies were significant for momentum, volatility and value styles, at a 95 percent level of confidence.

7.2. Implications for management

The study highlighted a number of implications for managers of forex transactions, as well as academics researching forex transactions. Firstly, style-based investment strategies were determined to be a feasible means to generate excess returns. A return relative between quintile one and quintile five portfolios currencies was evident in most cases, thereby allowing for a long-short strategy to be applied. This would also allow for the investigation of hedging against various macro-economic risks. A major implication of the study was that there were significant differences in results between developed and emerging currencies with each of the styles studied. The classification of currencies is therefore important when developing a trading strategy. In terms of the type of styles

that should be pursued for trading, momentum and value were the most promising for generating excess returns, however although volatility has been traded out, the trading style could be revived in the future, perhaps when the financial markets have fully recovered from the global financial crisis.

7.3. Limitations of research

There are a number of limitations that must be noted for this research. Firstly, there was selection bias in choosing the 25 currencies that were used for the study. The selection of currencies was primarily limited to the most liquid currencies, however convenience and judgment sampling were used to complete the full sample of currencies used for the study. Another limitation was the classification of the currencies as developed or emerging, as described in Section 4.1.2. Here, judgment was used in choosing the classification sources, as well as in determining the criteria: that two classification sources needed to have classified a country as emerging in order for the currency to be classified as emerging for the purposes of this research.

With reference to the optimisation of the look-back, look-to and holding periods, the incremental changes were limited to a one-month period for optimisation of the various styles. In the case of high momentum currencies (quintile one), the optimal look-back period was found to be one-month, however this might not have been the case should smaller increments, such as weeks or even days, have been used for the optimisation of the style.

In order to keep impact of transaction costs simple, costs were kept constant at 0.05 percent, as was done in a previous study by Fernández-Pérez et al. (2012). This was done as transaction costs are significantly smaller with currencies (particularly for large transactions) in comparison to transacting with equities. However, in reality, those currencies with lower liquidity levels would incur higher transaction costs than the most liquid currencies such as Euros or Pounds.

Visual inferences were used to determine the impact of the global financial crisis, which have their limitations. A more accurate approach would be to undergo an event study.

This was unnecessary for the purposes of this study as the impact of the global financial crisis was a secondary aspect of the study and visual inferences were deemed sufficient.

7.4. Suggestions for future research

There are a number of future research topics and suggestions that stem from this study, including further styles that could be tested on currencies, and optimised if applicable. Firstly, as a derivative of conventional momentum (as used in this study), “risk-managed momentum” could be investigated as a potential style for currencies (Barroso & Santa-Clara, 2015). According to Barroso and Santa-Clara (2015) the exposure of momentum crashes in equities can be eliminated through risk management, resulting in a significantly lower Sharpe ratio. Similar risk-management measures might be achievable with currencies, which could limit the negative impact of market crashes and allow for increased AARs.

As discussed in the literature review, Barroso and Santa-Clara (2015) showed that carry contributed to portfolio performance and was represented using interest rate spread or forward discount. The forward discount was standardised using the cross-section mean and standard deviation across all countries available (Barroso & Santa-Clara, 2015). A similar approach as described in Section 4.1 could be used to verify the significance of carry as an investment style and optimise the look-back, look-to and holding period, thereby maximising returns. This could be done with both developed and emerging currencies to test for differences.

Both skewness and kurtosis have not yet been explicitly analysed in the literature as an investment style, particularly in currencies. They were however shown by Chung and Hong (2007) to be a positive predictor of the directional movement of forex markets. Additionally, according to Doan et al. (2014), skewness assisted in explaining beta asymmetry and kurtosis was found to be useful measure for extreme market conditions, and would therefore be an interesting style for future research in currencies. Again, the style could be optimised in a similar approach as described in Section 4.1. Skewness and kurtosis could be represented as the third and fourth power of the return, respectively.

On the basis of the political turmoil in South Africa, markets (in particular developing markets) have been perceived to be extremely sensitive to unexpected news. A further investment style could therefore be an assessment of some of the softer aspects of trading, such as the impact of investor sentiment on trading emerging currencies.

Further research is required to determine whether a combination style would yield higher returns than that of an isolated trading strategy, and if so, what the optimal combination would be. This was done by Muller and Ward (2013) in their paper involving equities on the JSE, where forward regression was used to optimise their combination style. A similar approach could be followed, whereby the best performing currency style is added to a modelling tool, such as the style engine used in this project, followed by the next best performing style, until such point that further improvement to the result is no longer achieved. Other optimisation measures involving artificial intelligence could also be explored, whereby the model continuously learns and adapts to ensure that high returns are sustained.

Further work is also required in understanding the differences in results between developed and emerging currencies. Perhaps emerging currencies should be split into advanced emerging and secondary emerging currencies, which may provide more insight into the behaviour of different currency categories. Additionally, research should be conducted on the impact of the selection of the base currency, perhaps using a developed or emerging currency with the potential to move its way up the Big Mac index in terms of PPP.

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Appendix A: Supporting Information - Methodology

Figure 22: Schematic showing look-back period, look-to period and holding period

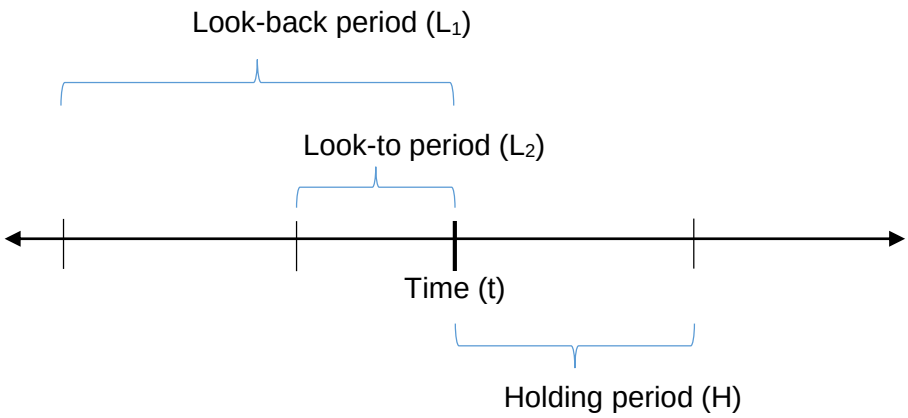

Table 17: Colour key used for graphs

Quintile	Colour Code
Quintile 1	Red
Quintile 2	Purple
Quintile 3	Light blue
Quintile 4	Brown
Quintile 5	Dark Blue
Relative	Green
USDEUR Index	Black

Table 18: Classification of the 25 currencies used in the graphical time-series analysis

Name of Country	ISO 4217 code	Name of Currency	Developed or Emerging
Argentina**	ARS	Argentine peso	Developed
Australia	AUD	Australian dollar	Developed
Brazil	BRL	Brazilian real	Emerging
Canada	CAD	Canadian dollar	Developed
China	CNY	Chinese Yuan Renminbi	Emerging
Denmark	DKK	Danish krone	Developed
Egypt	EGP	Egyptian pound	Emerging
Hong Kong	HKD	Hong Kong dollar	Developed
Hungary	HUF	Hungarian forint	Emerging
India	INR	Indian rupee	Emerging
Israel	ILS	Israeli shekel	Developed
Japan	JPY	Japanese yen	Developed
Malaysia	MYR	Malaysian ringgit	Emerging
Mexico	MXN	Mexican peso	Emerging
Norway	NOK	Norwegian krone	Developed
Poland	PLN	Polish zloty	Emerging
Russia	RUB	Russian ruble	Emerging
Singapore	SGD	Singapore dollar	Developed
South Africa	ZAR	South African rand	Emerging
South Korea	KRW	South Korean won	Developed
Sweden	SEK	Swedish krona	Developed
Switzerland	CHF	Swiss franc	Developed
Taiwan	TWD	New Taiwan dollar	Emerging
Turkey	TRY	Turkish lira	Emerging
United Kingdom	GBP	Pound sterling	Developed

Category	No. of Currencies
Developed	13
Emerging	12

** Argentina is deemed as an exception to the list in two aspects, firstly it is not a very well traded currency in terms of liquidity, and secondly is more thought of as an emerging country rather than developing, however according to the classification methodology used (see Section 4.1.2) only the IMF classified Argentina as emerging, whereas S&P, BRICS plus Next Eleven and FTSE did not.

Table 19: Methodology for country currency classification (developed versus emerging)

Country	Developed or Emerging	IMF	S&P	BRICS plus Next Eleven	FTSE	Count **
Argentina	Developed	1	0	0	0	1
Australia	Developed	0	0	0	0	0
Brazil	Emerging	1	1	1	1	4
Canada	Developed	0	0	0	0	0
China	Emerging	1	1	1	1	4
Denmark	Developed	0	0	0	0	0
Egypt	Emerging	0	1	1	1	3
Hong Kong	Developed	0	0	0	0	0
Hungary	Emerging	1	1	0	1	3
India	Emerging	1	1	1	1	4
Israel	Developed	0	0	0	0	0
Japan	Developed	0	0	0	0	0
Malaysia	Emerging	1	1	0	1	3
Mexico	Emerging	1	1	1	1	4
Norway	Developed	0	0	0	0	0
Poland	Emerging	1	1	0	1	3
Russia	Emerging	1	1	1	1	4
Singapore	Developed	0	0	0	0	0
South Africa	Emerging	1	1	1	1	4
South Korea	Developed	0	0	1	0	1
Sweden	Developed	0	0	0	0	0
Switzerland	Developed	0	0	0	0	0
Taiwan	Emerging	0	1	0	1	2
Turkey	Emerging	1	1	1	1	4
United Kingdom	Developed	0	0	0	0	0

KEY	
Developed	0
Emerging	1

**Rule: If count >= 2, then emerging, else developed

Appendix B: Supporting Information - Results

Table 20: Momentum frequency table of developed and emerging currencies

Quintile 1			
Period Ending	Developed	Emerging	Total
2000-12	2	2	4
2001-3	1	3	4
2001-6	1	3	4
2001-9	2	2	4
2001-12	1	3	4
2002-3	1	3	4
2002-6	4	0	4
2002-9	4	0	4
2002-12	3	1	4
2003-3	2	2	4
2003-6	2	2	4
2003-9	3	1	4
2003-12	2	2	4
2004-3	1	3	4
2004-6	2	2	4
2004-9	3	1	4
2004-12	0	4	4
2005-3	3	1	4
2005-6	1	3	4
2005-9	2	2	4
2005-12	1	3	4
2006-3	3	1	4
2006-6	2	2	4
2006-9	2	2	4
2006-12	0	4	4
2007-3	1	3	4
2007-6	2	2	4
2007-9	3	1	4
2007-12	2	3	5
2008-3	3	2	5
2008-6	2	3	5
2008-9	4	1	5
2008-12	4	1	5
2009-3	3	2	5
2009-6	2	3	5
2009-9	3	2	5
2009-12	2	3	5
2010-3	2	3	5
2010-6	3	2	5
2010-9	3	2	5
2010-12	4	1	5
2011-3	2	3	5
2011-6	3	2	5
2011-9	3	2	5
2011-12	1	4	5
2012-3	4	1	5
2012-6	2	3	5
2012-9	1	4	5
2012-12	3	2	5
2013-3	3	2	5
2013-6	3	2	5
2013-9	2	3	5
2013-12	3	2	5
2014-3	1	4	5
2014-6	4	1	5
2014-9	2	3	5
2014-12	5	0	5
2015-3	1	4	5
2015-6	4	1	5
2015-9	3	2	5
2015-12	3	2	5
2016-3	1	4	5
2016-6	3	2	5
Grand Total	**148**	**139**	**287**

Quintile 5			
Period Ending	Developed	Emerging	Total
2000-12	2	3	5
2001-3	2	3	5
2001-6	2	3	5
2001-9	2	3	5
2001-12	2	3	5
2002-3	2	3	5
2002-6	1	4	5
2002-9	1	4	5
2002-12	1	4	5
2003-3	2	3	5
2003-6	1	4	5
2003-9	2	3	5
2003-12	2	3	5
2004-3	2	3	5
2004-6	2	3	5
2004-9	2	3	5
2004-12	3	2	5
2005-3	2	3	5
2005-6	4	1	5
2005-9	4	1	5
2005-12	4	1	5
2006-3	4	1	5
2006-6	2	3	5
2006-9	1	4	5
2006-12	3	2	5
2007-3	1	4	5
2007-6	3	2	5
2007-9	3	2	5
2007-12	3	2	5
2008-3	4	1	5
2008-6	3	2	5
2008-9	3	2	5
2008-12	3	2	5
2009-3	2	3	5
2009-6	3	2	5
2009-9	1	4	5
2009-12	2	3	5
2010-3	3	2	5
2010-6	2	3	5
2010-9	3	2	5
2010-12	2	3	5
2011-3	3	2	5
2011-6	2	3	5
2011-9	1	4	5
2011-12	0	5	5
2012-3	1	4	5
2012-6	0	5	5
2012-9	1	4	5
2012-12	2	3	5
2013-3	2	3	5
2013-6	2	3	5
2013-9	3	2	5
2013-12	3	2	5
2014-3	1	4	5
2014-6	1	4	5
2014-9	2	3	5
2014-12	4	1	5
2015-3	3	2	5
2015-6	2	3	5
2015-9	1	4	5
2015-12	2	3	5
2016-3	1	4	5
2016-6	1	4	5
Grand Total	**134**	**181**	**315**

Table 21: Volatility frequency table of developed and emerging currencies

Quintile 1			
Period Ending	Developed	Emerging	Total
2000-12	3	1	4
2001-3	1	3	4
2001-6	2	2	4
2001-9	0	4	4
2001-12	1	3	4
2002-3	1	3	4
2002-6	1	3	4
2002-9	1	3	4
2002-12	1	3	4
2003-3	1	3	4
2003-6	0	4	4
2003-9	3	1	4
2003-12	1	3	4
2004-3	3	1	4
2004-6	1	3	4
2004-9	1	3	4
2004-12	1	3	4
2005-3	0	4	4
2005-6	0	4	4
2005-9	1	3	4
2005-12	0	4	4
2006-3	0	4	4
2006-6	0	4	4
2006-9	0	4	4
2006-12	1	3	4
2007-3	1	3	4
2007-6	1	3	4
2007-9	1	3	4
2007-12	2	3	5
2008-3	1	4	5
2008-6	3	2	5
2008-9	1	4	5
2008-12	2	3	5
2009-3	2	3	5
2009-6	2	3	5
2009-9	1	4	5
2009-12	1	4	5
2010-3	1	4	5
2010-6	1	4	5
2010-9	2	3	5
2010-12	3	2	5
2011-3	0	5	5
2011-6	2	3	5
2011-9	2	3	5
2011-12	0	5	5
2012-3	1	4	5
2012-6	0	5	5
2012-9	1	4	5
2012-12	1	4	5
2013-3	2	3	5
2013-6	2	3	5
2013-9	1	4	5
2013-12	0	5	5
2014-3	1	4	5
2014-6	0	5	5
2014-9	1	4	5
2014-12	2	3	5
2015-3	2	3	5
2015-6	1	4	5
2015-9	1	4	5
2015-12	1	4	5
2016-3	1	4	5
2016-6	1	4	5
Grand Total	**72**	**215**	**287**

Quintile 5			
Period Ending	Developed	Emerging	Total
2000-12	3	2	5
2001-3	2	3	5
2001-6	2	3	5
2001-9	1	4	5
2001-12	1	4	5
2002-3	1	4	5
2002-6	1	4	5
2002-9	1	4	5
2002-12	1	4	5
2003-3	1	4	5
2003-6	1	4	5
2003-9	1	4	5
2003-12	1	4	5
2004-3	1	4	5
2004-6	2	3	5
2004-9	1	4	5
2004-12	3	2	5
2005-3	2	3	5
2005-6	2	3	5
2005-9	2	3	5
2005-12	2	3	5
2006-3	3	2	5
2006-6	3	2	5
2006-9	2	3	5
2006-12	3	2	5
2007-3	3	2	5
2007-6	3	2	5
2007-9	2	3	5
2007-12	2	3	5
2008-3	3	2	5
2008-6	2	3	5
2008-9	2	3	5
2008-12	1	4	5
2009-3	2	3	5
2009-6	3	2	5
2009-9	3	2	5
2009-12	3	2	5
2010-3	3	2	5
2010-6	3	2	5
2010-9	4	1	5
2010-12	2	3	5
2011-3	3	2	5
2011-6	2	3	5
2011-9	3	2	5
2011-12	3	2	5
2012-3	3	2	5
2012-6	3	2	5
2012-9	3	2	5
2012-12	3	2	5
2013-3	2	3	5
2013-6	3	2	5
2013-9	4	1	5
2013-12	3	2	5
2014-3	3	2	5
2014-6	3	2	5
2014-9	4	1	5
2014-12	3	2	5
2015-3	2	3	5
2015-6	2	3	5
2015-9	2	3	5
2015-12	3	2	5
2016-3	3	2	5
2016-6	1	4	5
Grand Total	**145**	**170**	**315**

Table 22: Value frequency table of developed and emerging currencies

Quintile 1			
Period Ending	Developed	Emerging	Total
2000-12	3	0	3
2001-3	3	0	3
2001-6	3	0	3
2001-9	3	0	3
2001-12	3	0	3
2002-3	3	0	3
2002-6	3	1	4
2002-9	3	1	4
2002-12	3	1	4
2003-3	3	1	4
2003-6	4	0	4
2003-9	4	0	4
2003-12	4	0	4
2004-3	4	0	4
2004-6	4	0	4
2004-9	4	0	4
2004-12	4	0	4
2005-3	4	0	4
2005-6	4	0	4
2005-9	4	0	4
2005-12	4	0	4
2006-3	4	0	4
2006-6	4	0	4
2006-9	4	0	4
2006-12	4	0	4
2007-3	4	0	4
2007-6	4	0	4
2007-9	4	0	4
2007-12	4	0	4
2008-3	4	0	4
2008-6	4	0	4
2008-9	4	0	4
2008-12	4	0	4
2009-3	4	0	4
2009-6	4	0	4
2009-9	4	0	4
2009-12	4	0	4
2010-3	4	0	4
2010-6	4	0	4
2010-9	3	1	4
2010-12	3	1	4
2011-3	3	1	4
2011-6	3	1	4
2011-9	4	1	5
2011-12	4	1	5
2012-3	4	1	5
2012-6	4	1	5
2012-9	4	1	5
2012-12	4	1	5
2013-3	4	1	5
2013-6	4	1	5
2013-9	4	1	5
2013-12	4	1	5
2014-3	4	1	5
2014-6	4	1	5
2014-9	4	1	5
2014-12	4	1	5
2015-3	4	1	5
2015-6	4	1	5
2015-9	5	0	5
2015-12	5	0	5
2016-3	5	0	5
2016-6	5	0	5
Grand Total	**242**	**24**	**266**

Quintile 5			
Period Ending	Developed	Emerging	Total
2000-12	1	3	4
2001-3	1	3	4
2001-6	0	4	4
2001-9	0	4	4
2001-12	0	4	4
2002-3	0	4	4
2002-6	2	3	5
2002-9	2	3	5
2002-12	2	3	5
2003-3	2	3	5
2003-6	2	3	5
2003-9	2	3	5
2003-12	2	3	5
2004-3	2	3	5
2004-6	2	3	5
2004-9	2	3	5
2004-12	2	3	5
2005-3	2	3	5
2005-6	2	3	5
2005-9	2	3	5
2005-12	2	3	5
2006-3	2	3	5
2006-6	1	4	5
2006-9	1	4	5
2006-12	1	4	5
2007-3	1	4	5
2007-6	1	4	5
2007-9	1	4	5
2007-12	1	4	5
2008-3	1	4	5
2008-6	1	4	5
2008-9	1	4	5
2008-12	1	4	5
2009-3	1	4	5
2009-6	1	4	5
2009-9	1	4	5
2009-12	1	4	5
2010-3	2	3	5
2010-6	2	3	5
2010-9	1	4	5
2010-12	1	4	5
2011-3	1	4	5
2011-6	1	4	5
2011-9	1	4	5
2011-12	1	4	5
2012-3	1	4	5
2012-6	1	4	5
2012-9	1	4	5
2012-12	1	4	5
2013-3	1	4	5
2013-6	1	4	5
2013-9	1	4	5
2013-12	1	4	5
2014-3	1	4	5
2014-6	1	4	5
2014-9	1	4	5
2014-12	1	4	5
2015-3	0	5	5
2015-6	0	5	5
2015-9	0	5	5
2015-12	0	5	5
2016-3	0	5	5
2016-6	0	5	5
Grand Total	**71**	**238**	**309**

Appendix C: Ethical Clearance

Dear Mr Gregg Blomeyer

Protocol Number: **Temp2016-01161**

Title: **Style-based investment strategies for OECD and BRICS currencies**

Please be advised that your application for Ethical Clearance has been APPROVED.

You are therefore allowed to continue collecting your data.

We wish you everything of the best for the rest of the project.

Kind Regards,

Adele Bekker