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Abstract

This study investigates the link between the currency carry trade operations and asset markets in South Africa, namely the equity and bond markets. The carry trade operation examined in this paper involves two strategies, both of which use the South African rand as the investment currency, with the dollar and the Yen as the funding currencies in each strategy. This study uses the vector autoregressive BEKK- Generalised Autoregressive Conditional Heteroscedastic model in assessing volatility spillover between carry trade profit from each strategy and the South African equity and bond markets. The results of the empirical analysis show evidence of volatility spillover relationships between the carry trade returns and the two capital market returns. These relationships are dependent on the choice of the funding currency, with the dollar funded strategy more related with the bond market whilst the yen funded strategy is related with the equity market. This study's findings emphasise the importance of volatility spillovers between the currency carry trade market and other asset markets in South Africa when assessing financial markets' risks and formulating risk management policies.

Introduction

The divergence between interest rates across countries, predominantly between developed and developing economies, has created an environment in which investors consider arbitrage strategies in order to earn risk-free profits. One of these strategies is the currency carry trade, which involves borrowing in a relatively low interest rate currency, in order to invest in a high interest rate currency. It is important to note that currency carry trade is a popular investment strategy prompted by the return-seeking nature of investors amid interest rate differentials across economies. The underlying principle behind the strategy is that investors borrow funds in a relatively lower interest rate currency, and invest the borrowed funds in a currency with a relatively higher interest rate. The carry trade strategy's profitability is essentially dependent on violating the Uncovered Interest Rate Parity (UIP) Theory, which posits that any profits presented by the interest rate differential should be offset by subsequent movements in the exchange rate. Given that the uncovered interest rate parity determines the equilibrium exchange rate between currencies, its violation ultimately provides the possibility of arbitrage occasioned by the currency's carry trade strategy.

The currency carry trade strategy necessitates: a funding currency - ideally a currency with a low interest rate; and an investment currency- one with a relatively higher interest rate. Japan's yen (yen) and the U.S dollar (dollar) in particular have been attractive funding currencies as a result of their respective economies' low interest rates, their relatively stable values in comparison to most currencies, and their liquidity (Habib & Stracca, 2012).

The violation of the UIP Theory in currency carry trade strategy is explained by the fact that high interest rates in investment currency attract capital flow, and therefore appreciation of the investment currency, rather than its depreciation, as postulated by the UIP Theory. This initial overreaction of the investment currency is corrected at the time of the investor's close out position in the foreign exchange markets, causing depreciation in the investment currency. Thus, the violation of the UIP Theory and the resulting profitability of the carry trade strategy can persist for as long as investors remain reluctant to close out their positions in currency markets.

Given that the carry trade strategy triggers capital flows from the funding currencies to investing currencies, it is essential to understand and determine the causal relationships between the carry trade market and the asset markets that these funds can be ultimately invested in. In this study we assume that any statistical significant relationship between carry trade returns and a specific capital market (bond or equity) may imply a comovement between the two markets and a possible capital flow (portfolio flow) into the capital market specific market.

This study sought to investigate the extent of the impact of the carry trade strategy on South African bond and equity markets, depending on the source of funding countries, namely Japan and the U.S. In particular, the study considered the carry trade strategy involving the South African rand and the dollar or yen, and analysed how carry trade returns and volatility shocks were transmitted into the South African equity and bond markets.

The objective of this research is to answer the questions as outlined below:

- What relationships exist between returns in the rand/dollar or rand/yen carry trade strategies and the South African equity and bond markets returns?
- What volatility spillover relationships exist between the carry trade market and the two capital markets?
- Are the comovements, if any, dependent upon the funding currency?

The data used herein includes weekly observations of the Johannesburg Stock Exchange's all share index (JSE) points, and the South African 10-year government bond yield, to represent the bond market. Given that carry trade returns are compiled from data related to uncovered interest parity, the study used the rand-dollar and rand-yen exchange rates. Moreover, the following interest rates were used as an indication of market interest rates in their respective markets:

- the South African average repo rate;
- the upper bound of the U.S. Federal Reserve fund target rate; and
- the Bank of Japan's unsecured overnight rate.

All three of these interest rates were converted to their respective periodic weekly interest rates, using a 52 week conversion basis.

This papers uses a multivariate GARCH model, namely the VAR BEKK GARCH model. The advantage of a multivariate GARCH model results in accounting for heteroscedasticity and covariances between the different variables when assessing shocks transmission carry trade returns and the equity and bond markets

The findings of this study could help to inform investment and policy decisions. The cross-market linkages, if any, will help to uncover which of the asset markets between the bond and equity markets are linked to carry trade activities, especially in terms of volatility spillovers. This is an important study in the context of South Africa, not only as one of the key emerging markets but also in understanding the vulnerability of domestic financial markets to external speculative decisions since the establishment of the flexible exchange rate regime. Financial sector regulators, supervisors and other

players including equity and bond issuers can benefit greatly from academic literature that adds to this filed of research.

The remainder of this study includes a literature review, an outline of the methodology, results and interpretation thereof, and ends with concluding remarks.

Literature review

The concept that underpins currency carry trade is essentially that investor borrow money in a relatively low interest rate currency and invests the money in currency with a relatively higher interest rate. Burnside et al. (2008) indicate that this strategy need not include only two currencies, but can include a portfolio of currencies, on both the funding side and the investment side. The portfolio can be reconstructed over time as per the investors' preferences and diversification requirements. As interest rates across countries change, influencing the interest rate differentials, the portfolios can be changed to optimise returns.

One critical point to is note that the carry strategy is ultimately dependent on the violation of the UIP Theory. For example, Burnside et al. (2011) presents three popular explanations that are believed to drive the carry strategy's profitability and the subsequent violation of the UIP Theory. These explanations are reviewed in greater detail below.

Price pressures

Burnside, Eichenbaum and Rebelo (2009) explains rigidity in price markets effectively, citing the adverse selection problem among investors as the reason for price pressures. In terms of Burnside et al. (2009) explanation, it is asserted that the currency market is characterised by imperfect information between traders and market-makers, in which the forward exchange rates quoted by market-makers can determine profitability. This occurs when the market-maker is faced with two types of investors, namely the informed and the uninformed. Whilst informed investors have private information that helps them to better predict movements in exchange rates, the less informed or uninformed investors only have public information at their disposal, and this public information is not sufficient to base accurate predictions on. However, when quoting an exchange rate, the market-maker is uncertain as to whether they are dealing with an informed or an uninformed investor, and may quote different prices based on who they believe they are dealing with. This presents informed investors with an opportunity to make positive returns due to the forward premium arising out of the market-maker's adverse selection.

Peso problems

Given that movements in asset prices and returns can be reasonably predicted based on a historical analysis of past behaviour and reaction to dynamics in the identified determining factors, it becomes increasingly more interesting as to why the carry trade strategy remains profitable even when economic and market fundamentals do not support such profitability. Burnside, Eichenbaum and Rebelo (2011) refer to this complication as a "peso problem", that is, a situation where the return earned on the carry trade strategy is largely driven by events that have a significantly low likelihood of occurring, and do not even have a history of occurring in the historical data being used to make inferences. In their study, Burnside et al. (2011) consider why the carry strategy is, on average, largely profitable, and why this profitability is unexplained by traditional risk factors. Their results show that models of asset prices and returns that capture traditional risk measures are unable to explain the large returns from the carry strategy. Their explanation of the peso problem is that investors can either hedge themselves against the possibility of large negative returns, or have large stochastic discount factors when undertaking an unhedged strategy. This reflects the large risk premia that investors require from the strategy, in order to be well compensated for any unforeseen events that might result in losses.

Risk premia

Whilst the violation of the UIP Theory is largely a result of unforeseen events, the risk premia situation refers to compensation for the events that have a reasonable probability and a history of occurring. Berg and Mark (2017) state that currency market investors are faced with significant uncertainty, owing to the multitude of global factors that significantly influence currency markets. These investors not only study the excess carry trade returns using macroeconomic factors, but also include a measure of global macroeconomic uncertainty. Their findings show that the excess returns on carry trade are likely to be very high during periods of relatively low uncertainty, but quite low during periods of mounting uncertainty. Similar to Burnside et al.'s (2011) findings, this is evidence that investors demand significant compensation in order to protect themselves against the massive losses that the strategy is susceptible to during periods of turmoil. The key driver for the high risk premia is the general instability of the commonly targeted currencies with high interest rates, as the funding currencies are generally those that are considered to be safe havens. Brunnermeier, Nagel, and Pedersen (2008) claim that crash fears concerning target currencies can result in carry trade remaining consistently profitable, by preventing currency speculators from taking positions that offset the violation of the UIP.

The characteristics behind carry trade strategies support the notion that positive returns are predominantly driven by investors' risks, particularly in taking long positions in currencies that are

relatively much riskier in order to realise high returns as compensation for the risk taken. The above-mentioned risks for which investors require a premia are characteristic in emerging market currencies, meaning that speculators can achieve significant, positive, equity-like returns when the long positions are funded by safe haven currencies such as the dollar. Gilmore and Hayashi (2012) findings support this strategy. Hossfeld and MacDonald (2015) provide support for several of the group of 10 currencies that are considered safe haven currencies or funding currencies.

All the above outlined explanations for positive excess returns in carry trade point to investors being compensated for the substantial uncertainty and major occasional substantial losses associated with the strategy, and currency markets in general (Doskov & Swinkels, 2014). This suggests that the carry trade premium mystery is in actual fact demystified by these risk-based explanations of carry trade excess returns.

Given that the funds invested in currency carry trade are ultimately invested in the assets in the country of the targeted currency, a critical point worthy of review is how activities in carry strategies can influence asset markets in which the carry trade funds are invested. In particular, how do price fluctuations in the carry trade market influence those in other markets, and can investor behaviour in the carry trade market have knock-on effects in other markets?

Whilst there is a clear link between carry trade and interest-bearing assets such, as bonds and money market instruments, Christiansen, Ranaldo, and Söderlind (2011) and Liu and Yang (2016) show that carry trade strategy can also affect stock markets. Both these studies provide evidence of a time-varying risk contagion between the carry trade market and stock markets. Using data from the group of 10 countries' currencies and stock markets, Christiansen et al.'s (2011) study utilised an asset pricing model, estimated using generalised methods of moments, with factor weightings dependent on volatility regimes that were largely determined by volatility in stock markets. The results show that volatility in carry trade returns is influenced mainly by volatility in equity returns. Liu and Yang (2016) considered the systemic contagion of carry trade, using data on developed countries' currencies and stock markets in the U.S, Europe, and Asia. They employed a conditional Value-at Risk model. Results extend Christiansen et al.'s (2011) study findings, by establishing a bilateral risk contagion between the carry trade and the stock markets, revealing the financial stability risks posed by carry trade positions.

In a separate study, Lee and Chang (2013) found that there is a positive relationship between currency carry trade returns and investor sentiment, and as a result, developments in the currency carry trade market can spill over into other asset markets. Lee and Chang (2013) used an investor sentiment index

(Baker & Wurgler, 2006) that reflects investor risk appetite in order to differentiate between bull and bear markets. They used a generalised Vector Autoregressive (VAR) model to measure return spillovers, and a Markov switching model to assess the extent and asymmetry of volatility spillover during bull and bear markets. Looking at daily data on carry trade returns using G10 currencies and returns on the Standard and Poor (S&P) 500 for the period January 1994 to March 2012, the study provides empirical evidence of asymmetric volatility spillovers between the two markets, with greater magnitudes evident during bear markets.

Given the great deal of literature support for the theoretical basis for the carry trade, this study aims to add to the empirical literature with a specific focus on the possible risk contagion that may exist between currency carry trading and capital markets. A lot of work has been published in this regard internationally but not enough has afforded South Africa sufficient detailed assessment. Several research has also been published in South Africa looking at the currency market and the carry trade in particular, but without necessarily focusing on the volatility relationships with capital markets.

Methodology

This study employed a BEKK-GARCH model to show the relationship between currency carry trade returns and the equity or bond returns in South Africa. The conditional mean equations, for the relationship between the currency carry trade returns and the JSE or bond returns for example, were estimated using a VAR model, with one period lagged regressors, as per equation 1. Having estimated the parameters of the mean equations, the conditional variances of the error terms (ε_t) were then estimated, as in equation 8. The mean equations in the VAR-BEKK-GARCH are specified as follows:

$$r_t = \Phi_0 + \sum_{i=1}^{p} \Phi_i \, r_{t-i} + \varepsilon_t \quad t = 1, \ldots . T \quad \varepsilon_t \sim N(0, H_t) \tag{1}$$

where the coefficients are:

- $(\mathrm{r}_{1\mathrm{t},\ldots\ldots}\mathrm{r}_{\mathrm{Nt}})'$ is a column of observations of all variables in the model at time t;
- $\Phi_0 = \begin{bmatrix} \Phi_{JSE/Bond,t} \\ \Phi\alpha_{CT,t} \end{bmatrix}$ is a 2 X 1 matrix of the constant terms in the two mean equations;
- $\Phi_i = \begin{bmatrix} \Phi_{11}\Phi_{12} \\ \Phi_{21}\Phi_{22} \end{bmatrix}$ is a 2 X 2 matrix of the coefficients for the lagged returns' observations,

- $r_{t-1} = \begin{bmatrix} r_{JSE/Bond,t-1} \\ r_{CT,t-1} \end{bmatrix}$ is a 2 X 1 matrix of the lagged JSE/bonds and currency carry trade returns;

- $\varepsilon_t = \begin{bmatrix} \varepsilon_{JSE/Bond,t} \\ \varepsilon_{CT,t} \end{bmatrix}$ is a 2 X 1 matrix of the error terms in both mean equations, and
- the elements of the covariance matrix H_t depend on past values of itself and past values of ε_t.

The equation of the covariance matrix is as follows:

$$H_t = C_0'C_0 + \begin{bmatrix} \alpha_{11}\alpha_{12} \\ \alpha_{21}\alpha_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon_{1,t-1}^2 & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{2,t-1}\varepsilon_{1,t-1} & \varepsilon_{2,t-1}^2 \end{bmatrix} \begin{bmatrix} \alpha_{11}\alpha_{12} \\ \alpha_{21}\alpha_{22} \end{bmatrix} + \begin{bmatrix} \beta_{11}\beta_{12} \\ \beta_{21}\beta_{22} \end{bmatrix}' H_{t-1} \begin{bmatrix} \beta_{11}\beta_{12} \\ \beta_{21}\beta_{22} \end{bmatrix} \quad (2)$$

where α_{jk} are elements of matrix A_{kj} and β_{jk} are elements of matrix B_{kj}

The diagonal parameters in matrices A_{kj} and β_{jk} capture the effects of own past shocks on volatility, whereas the off diagonal parameters measure the cross markets' effects of shock and volatility.

The volatility shocks are assumed to follow a normal distribution, allowing for the coefficients of the covariance matrix to be estimated by maximising the Quasi-Maximum Likelihood method below

$$L\,(\emptyset) = \frac{-Tm}{2}\ln(2\pi) - \frac{1}{2}\sum_{t=1}^{T}(ln|H_t| + \varepsilon_t' H_t^{-1}\varepsilon_t \quad (3)$$

Where the total number of used observations is represented by T; m represents the number of equations; H represents the covariance matrix; and the function is completed by the model determined unknown parameters as represented by vector $\emptyset$.

Estimation and discussion of results

Data description

As stated earlier, this study analysed the relationship between each carry trade return (from rand/dollar and rand/yen positions) and returns from South African equity and fixed income markets, looking particularly at how the returns and the volatility shocks were transmitted between the carry trade and equity and bond markets.

Carry trade returns for each currency pair (r_{CT}) were obtained from UIP, as the difference between the change in the exchange rate and the interest rate differential. Thus,

$$r_{CT} = \Delta E_t - (i_t - i_t^*)$$

where ΔE_t represents the change in the rand/dollar and rand/yen exchange rates, i_t represents the periodic weekly short-term interest rate in South Africa, and i_t^* represents the short-term interest rate in the U.S. or Japan.

The 10-year government bond yield was used to represent the fixed income market, and choice of using the benchmark 10-year government bond yield was based on the liquidity of this debt capital market instrument. Whilst it can be argued that speculative investors would opt to invest in assets with a short maturity to align to their investment strategy, the choice of the 10-year government bond was informed by the lack of fluctuation in the treasury bill market, which would defeat the purpose of this study. Treasury bills are not as frequently issued as bonds and as a result, nor are they frequently traded, as investors prefer to hold on to them. Thus it would be highly beneficial for a future work to consider both short and long term debt instruments, supported by the findings of this study. For this study however, the chosen benchmark will suffice as the aim is to establish any relationships between the carry trade and the two capital markets.

The JSE is used as proxy for the equities market to account for all listed companies in different sectors. Returns for the fixed income market are calculated by changes in the yield, taking into account the negative relationship between the yield and bond prices. This means that a positive return represents a decrease in the yield, which is effectively realised as an increase in the bond price. The data was collected from Bloomberg's terminal and Thomson Reuters, and was collected weekly for the period from January 2000 to December 2016. The currency carry trade pairs were used in this study, with a short position taken in the developed markets (the funding currencies were the yen and the dollar) and a long position taken in South Africa.

All data was tested for stationarity using the Augmented Dickey-Fuller test for unit root, and all series were stationery. The results for stationarity test are presented in the appendix. Table 1 hereunder presents the descriptive statistics for all the returns from the different asset classes, namely the equity market returns, the bond market returns, the dollar-funded carry trade returns, and the Yen-funded carry trade returns.

Table 1: Descriptive statistics for different returns series

	r_{JSE}	r_{Bond}	$r_{CT;dollar}$	$r_{CT;yen}$
Mean	0.23674283	0.002227	0.066045	0.082897
Standard Error	0.089494889	0.005798	0.086177	0.100169
Median	0.35200769	0.001386	0.200066	0.263104
Standard Deviation	2.5026586	0.162147	2.409884	2.801149
Sample Variance	6.263300066	0.026292	5.807539	7.846437
Kurtosis	4.01035082	13.0887	2.699335	5.601632
Skewness	-0.031679279	-0.89622	-0.3666	-0.57912
Range	25.67427903	2.490652	24.91007	36.15318
Minimum	-9.63468198	-1.57143	-11.0758	-18.2969
Maximum	16.03959705	0.919225	13.83425	17.85627
Sum	185.1328932	1.741537	51.64697	64.8253
Count	782	782	782	782

NB: r_{JSE} = JSE returns

r_{Bond} =10-year government bond yield returns

$r_{CT;dollar}$ = Dollar-funded carry trade strategy

$r_{CT;yen}$ = Yen-funded carry trade strategy

The values of the means, which indicate the average weekly returns over the period under study, indicate that all the series had positive returns, with the JSE yielding larger average returns than those from the carry trade and bond market. As can be expected from empirical literature (see Ghysels, Santa-Clara & Valkanov, 2005; Bali & Peng , 2006; Lundblad , 2007), the mean and standard deviation values evidence the positive risk-return relationship. Whilst the bond market returns averaged 0.0022 per cent, the associated standard deviation of 0.16 is substantially lower than the other returns series. The more pronounced standard deviations for the equity and currency carry trade returns indicate that there was much greater volatility in these markets than there was in the bond market, as can be expected. Equity and exchange markets are riskier than the bond market. The statistics reported in Table 1 support the reality that equities are generally much riskier than bonds.

The values of the kurtosis measure, which measure the sharpness of the peak of the frequency distribution curve, indicated a very sharp distribution curve for the bond market returns with a value of 13.01. This supported the relatively much smaller standard deviation for the bond market returns, pointing out that returns in this market did not deviate much from the average returns. The equity market returns distribution also experienced a sharp peak, albeit less sharp in comparison to that of the bond market return, indicating a relatively more dispersed return distribution. The currency carry

trade strategies' distribution curves were relatively flat, with greater distribution of returns evident in the tails, compared to the equity and bond markets' return distributions.

To supplement the descriptive statistics, all the returns series were plotted and are presented in figures 1, 2, 3, and 4.

Graphical representations of returns

The returns for the equity market, bond market, and both currency carry trade strategies are represented in the graphs hereunder, and the representation exhibits a great deal of volatility in all the returns series and a synchronised reaction to certain global and South African specific financial markets shocks. The key events were the 2008 global financial crisis, which is evident in the significant rate of fluctuations in all the returns series, and the December 2015 unanticipated cabinet reshuffle, which also amplified the volatility in the South African financial markets. Both these events indicated pronounced systemic risk, in line with the finding that contagion across financial markets is heightened during turbulent times (Christiansen et al., 2011).

Several other key insights were evident after analysing the graphical representations. Firstly, figures 1 and 2 below clearly indicate that the carry trade return dynamics in the two strategies are greatly synchronised. This could suggest that the two carry trade returns are influenced by similar factors, which may include the rand-dollar and the rand-yen exchange rates. Figure 3 further supports this by showing that the exchange rates of the two funding currencies against the rand co-move to a certain extent, albeit with the dollar exhibiting greater fluctuations than the yen. The greater fluctuation of rand-dollar exchange rate can be expected, because the dollar is used in pricing a lot of commodities, in which South Africa trades. The eyeball view of figures 1, 2, and 3 suggests that carry trade returns from the two strategies are somewhat negatively related to movements in the exchange rate between the rand and the respective funding currency. This finding supports the carry trade theory in that an appreciation of the rand against the funding currency would render the strategy more profitable as an investor would receive more of the funding currency when closing the position. The figures also indicate that the rand's depreciation against both the dollar and the yen during the 2008 global financial cycle, and the 2015 South African cabinet reshuffle involving finance ministers, resulted in losses in the currency carry trade market.

Figure 1: Dollar-funded carry trade returns

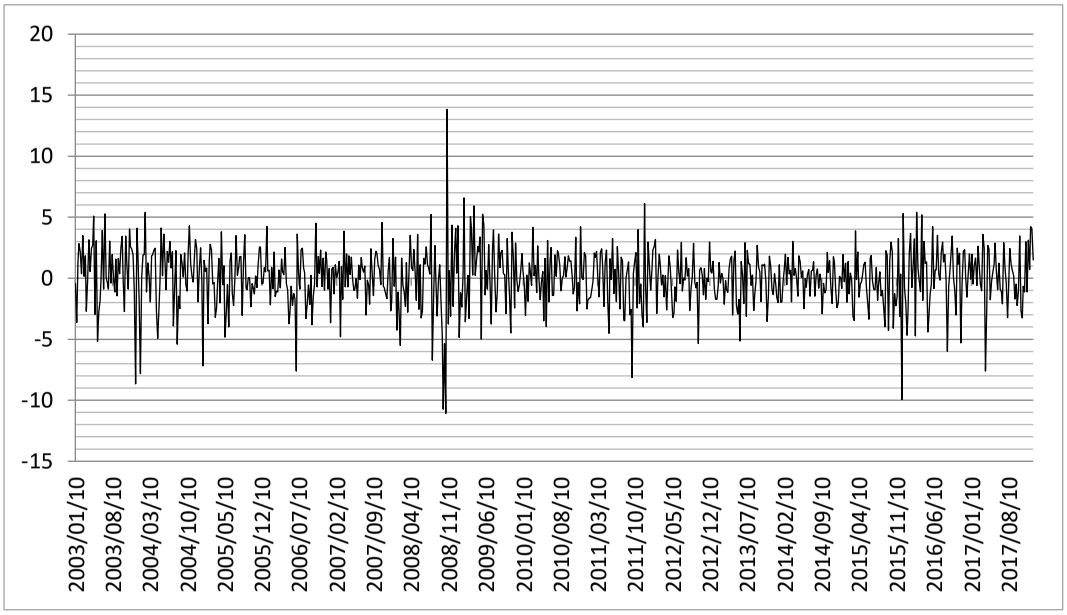


Figure 2: Yen-funded carry trade returns

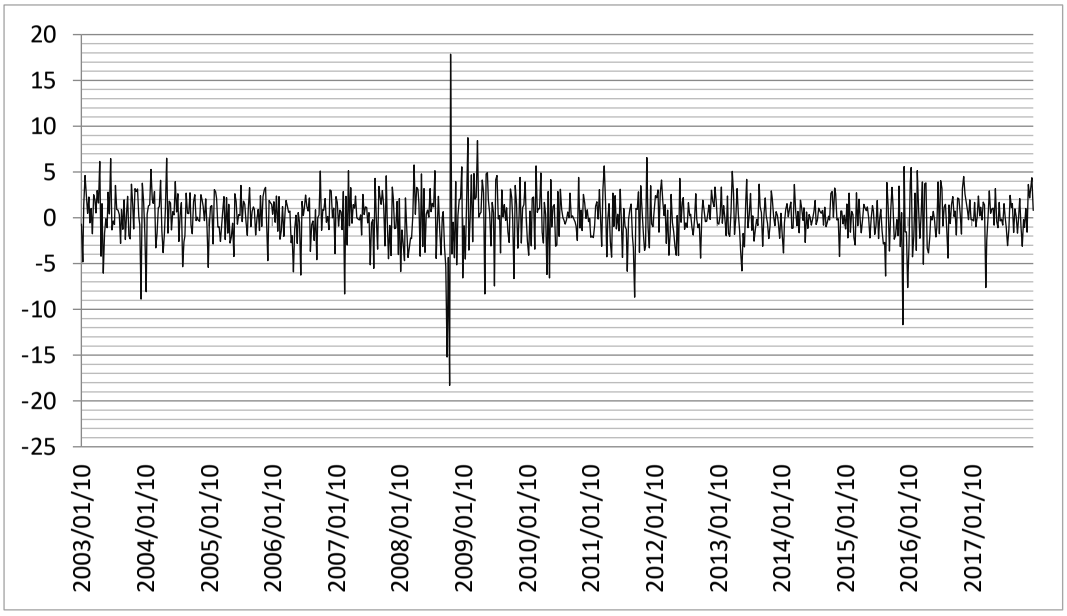
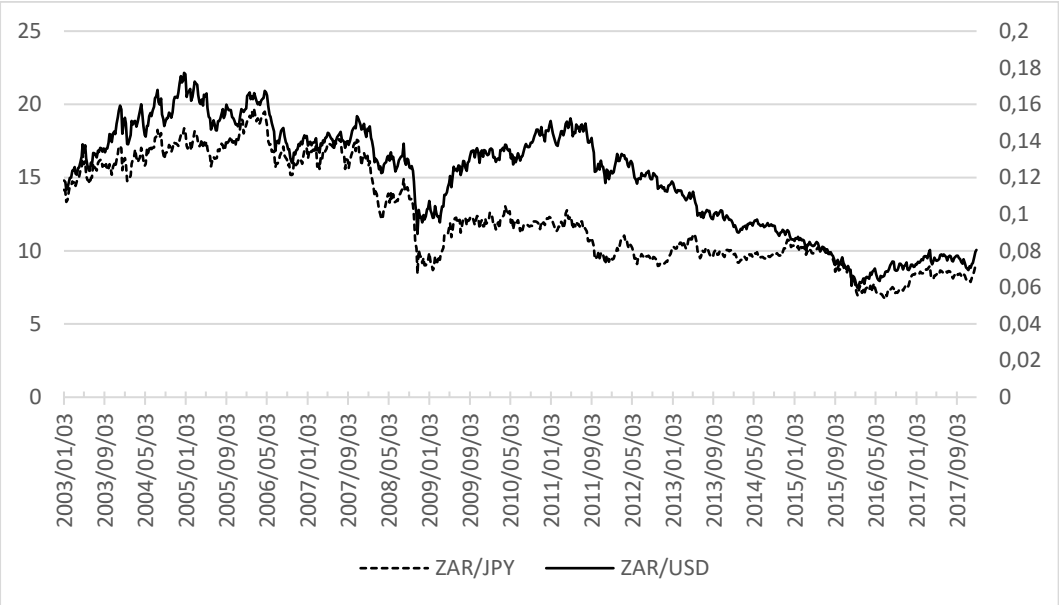


Figure 3: Exchange rates



Figures 4 and 5 indicate that the stock market returns are more volatile than the bond market returns. This is unsurprising as equities markets have historically been more volatile, owing to the relatively higher risk associated with equities, the nature and volume of transactions in these markets. The stock market experiences relatively greater risk, as equities do not generally guarantee any income, or a pre-determined repayment price. Due to the relatively significant size and liquidity of stock markets, transactions can be significantly large and more frequent than in the fixed income market. A lot of speculative activity also takes place in stock markets, contributing to the more pronounced volatility. Stock markets have also been the main driver of volatility contagion across different asset markets (Bonga-Bonga, 2018). It may be argued that greater volatility in equity markets could trigger carry trade speculators/arbitrageurs to choose to invest in the bond market rather than equity market to realise greater profits.

Figure 4: Stock market returns

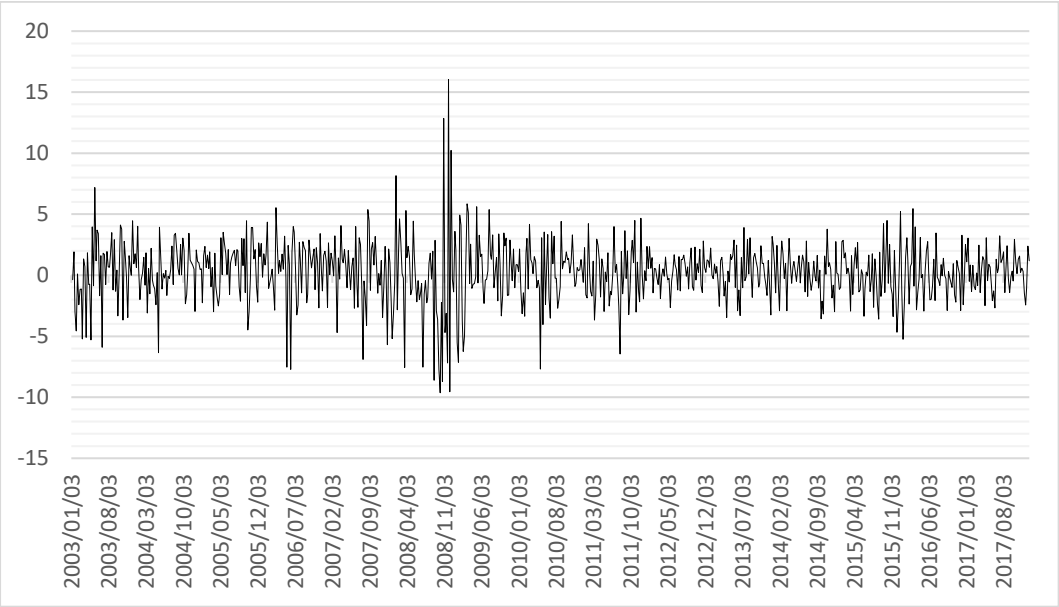
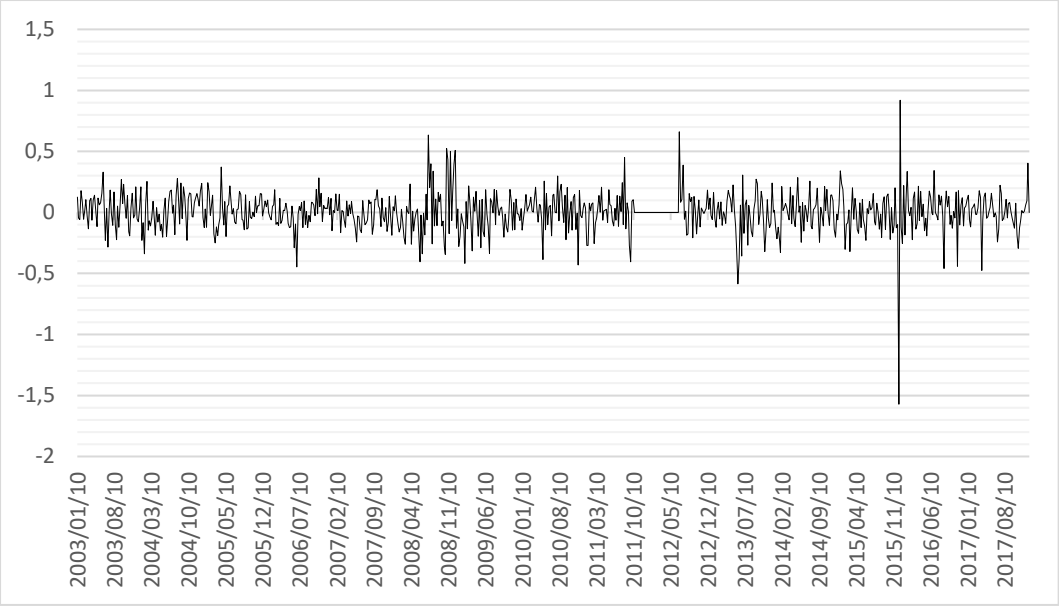


Figure 5: Long-term bond returns



Returns correlation

The correlations matrix shows how fluctuations in the equity market, bond market, and currency carry trade market returns are correlated. This is a good initial check of possible volatility spillovers, as correlations, regardless of the direction, can either be a result of fluctuations in one market spilling over into another, or because fluctuations in both markets are influenced by common factors. The returns series JSE, bond yield, ZAR/DOLLAR carry trade, and ZAR/JPY carry trade represent returns for

the equity market, the bond market, returns from the dollar-funded carry trade strategy, and returns from the yen-funded carry trade strategy respectively. Looking at the correlation coefficients, several interesting insights are uncovered. The first key insight is that all returns series are positively correlated, providing support for further investigation into possible relationships between the markets. This can either be an indication that returns in both the South African equity and debt capital market have a positive influence on returns in the currency carry trade market for speculators targeting the rand, or that currency carry traders' positions influence the equity and bond markets through the speculators' asset allocation strategies.

Table 2: Correlation matrix

	JSE	Bond yield	RAND/DOLLAR carry trade	RAND/JPY carry trade
JSE	1			
Bond yield	0.080454	1		
RAND/DOLLAR carry trade	0.233733	0.458604	1	
RAND/JPY carry trade	0.271131	0.370482	0.860726	1

The second key insight is that relative to the equity market, there is a greater correlation between the bond market returns and the currency carry trade returns, which may be due to the fact that the two variables' common driver is interest rates. It is important to note that bond prices are an inverse function of the interest rate or yields, while carry trade returns rely on interest rate differentials. Moreover, as stated above, this high correlation may due to the fact that bond markets, rather than the equity markets, are the preferred investment targets for carry trade strategists. Besides the reason related to the high volatility of equity markets, the relatively lower correlation between equity and carry trade could also be due to the unpredictable dependency between the exchange rate and equity returns. For example, Barr and Kantor (2002) show that the impact of the rand value (exchange rate) on the JSE (equity market) is not as straightforward, due to hedging strategy-related reasons.

4.2 Results' estimates and interpretation

Tables 3, 4, 5, and 6 below present the likelihood estimation of the BEKK-GARCH model represented in equation 2. Of important to note is that the process for obtaining the parameters of the BEKK-GARCH model involved two steps, as outlined below:

1. estimating the mean equations as depicted in equation 1; and
2. taking the residuals of the mean equations and using them to estimate the covariance matrix in equation 2.

The Quasi-Maximum Likelihood function in equation 3 was used to estimate the mean and variance coefficients of the BEKK-GARCH.

As per equation 2, matrix C captures the coefficients of the constant terms, whilst matrix A captures the shock spillover effects, with α_{ij} showing for example how shocks to variable *i* affect the volatility of *j*, and matrix B, especially β_{ij} captures how past volatility of I affects volatility of *j*. Matrix C is represented by the coefficients C_{ij}, matrix A is represented by the coefficients α_{ij}, and Matrix B is represented by the coefficients β_{ij}. Of particular interest is coefficients α_{ij} as they show how shocks to *j* affect *i*. Moreover, as in equation 9, coefficients Φ_i also show the cross-relationship between returns.

Dollar-funded carry trade strategy

Equity and carry trade

Considering the estimates for equation 2, none of the off-diagonal elements of matrices A (α_{12} and α_{21}) are statistically significant. This implies that there is no relationship when looking at the volatility spillovers induced by shocks in either market.

Bond market and carry trade

The estimated coefficients of the variance equation 2, particularly the off-diagonal elements of matrix A (α_{12} and α_{21}). Both coefficients reveal negative spillover relationships, with values of -1.522 and -0.0253 . This shows that past shocks in the bond market returns have a negative effect on volatility in the carry trade market, and the same holds in the reverse direction. Yet again, the above explanation that volatility can be transmitted between markets through investor sentiment, also holds in this case.

The significant bi-directional volatility spillover relationship between the carry trade and the bond market returns implies that there is a greater influence stemming from the bond market returns on the carry trade market. This stronger volatility relationship further emphasises the expectation that carry trade speculators are essentially involved in a search for yield, which is associated more with the bond market. Whilst it can be argued that equity markets in emerging markets also offer high returns relative to their developed markets counterparts, South Africa has a very well-developed equity market, with sufficient liquidity to ensure at least the weak-form market efficiency, as evidenced by

Jefferis and Smith (2005) and Philpot and Firer (1994). This should reduce the return premium generally associated with emerging markets, and drive carry trade speculators to favour the less liquid bond market, which would still present a greater risk premium. This is supported by Hassan and Smith (2011), who posit that carry trade activity contributes a significant amount of foreign capital flows into the South African fixed-income market.

Table 3:

Results of the bivariate BEKK-GARCH model between the dollar-funded carry trade and JSE returns

	JSE		
Conditional mean equation estimates		**Conditional variance equations estimates**	
Estimates for carry trade returns mean equation			
Φ_{CT}	-0.0227 (0.0401)	C_{11}	0.4051*** (0.0733)
Φ_{JSE}	-0.0173	C_{21}	0.1723*
	(0.0354)		(0.1007)
Φ_1	0.0578 (0.0773)	C_{22}	0.3420*** (0.0624)
Estimates for equity market returns mean equation		α_{11}	0.2798*** (0.0303)
Φ_{CT}	0.0233 (0.0355)	α_{12}	0.0170 (0.0316)
Φ_{JSE}	-0.0458 (0.0392)	α_{21}	0.0337 (0.0306)
Φ_1	0.3152*** (0.0790)	α_{22}	0.2900*** (0.0288)
		β_{11}	0.9466*** (0.0103)
		β_{12}	-0.0105 (0.0122)
		β_{21}	-0.0125 (0.0105)
		β_{22}	0.9433*** (0.0099)

*** = 1% level of significance ** = 5% level of significance * = 10% level of significance

Table 4:

Results of the bivariate BEKK-GARCH model between the dollar-funded carry trade and bond returns

	BOND		
Conditional mean equation estimates		**Conditional variance equations estimates**	
Estimates for carry trade returns mean equation			
Φ_{CT}	-0.0302 (0.0404)	C_{11}	0.8143*** (0.1647)
Φ_{Bond}	1.0325* (0.6192)	C_{21}	0.0455*** (0.0138)
Φ_1	0.0970 (0.0814)	C_{22}	0.0000 (0.0219)
Estimates for bond market returns mean equation		α_{11}	-0.2470*** (0.0685)
Φ_{CT}	-0.0012 (0.0029)	α_{12}	-1.5211* (0.8296)
Φ_{Bond}	0.0362 (0.0440)	α_{21}	-0.0253*** (0.0018)
Φ_1	0.0045 (0.0053)		
		α_{22}	-0.0430 (0.0377)
		β_{11}	1.0028*** (0.0454)
		β_{12}	-9.2176*** (0.6378)
		β_{21}	0.0344*** (0.0027)
		β_{22}	0.5202*** (0.0350)

*** = 1% level of significance ** = 5% level of significance * = 10% level of significance

Yen-funded carry trade strategy

Equity market and carry trade market

A look at the cross volatility spillover effects' coefficient shows that volatility shocks spread from the equity market to the carry trade market, as indicated by coefficient α_{12} with a value of 0.0949.

The implications for this set of results is that yen funded carry trade strategies have a greater interest in equity markets, which can be supported by the greater standard deviations highlighted earlier and suggests that this is a riskier strategy that also seeks greater (and ultimately riskier) rewards.

Bond market and carry trade market

Tables 6 shows that there are no cross-relationships in the mean equations between the bond market and the carry trade market. The cross volatility spillover effects coefficients show that spillovers only stem from the carry trade market to the bond market, as shown by coefficient α_{21}, which is positive with a small value of 0.0077. This implies that yen-funded carry trade strategies favour equity over bond investment as no influence is derived from the bond market. This is supported by Hassan and Smith (2011), who show that return characteristics for a yen-funded carry trade strategy that targets the rand, are very similar to a diversified passive investment in the South African equity market.

In summary, the BEKK-GARCH parameter estimates for both models, including the dollar and Yen as funding currencies, indicate that the conditional variance of each market is significantly reliant on their own past shocks and variances, respectively. Furthermore, the volatility spillover relationships differ depending on the asset market and the funding currency. The dollar funded carry trade strategy only reveals a spillover relationship with the bond market, whilst the yen-funded carry trade strategy exhibits a more convincing relationship with the equity market than with the bond market. This shows that speculators may have a preference for one asset class over another depending on the funding currency, and this can possibly be explained by the underlying risks arising from respective exchange rates. The existence of cross-market relationships between the carry trade market and both the bond and equity markets are supported by previous studies. For example, Hassan and Smith (2011) looking at the rand as a target currency in carry trade finds evidence of significant speculative capital flows into the South African fixed income market, driven by the carry trade. Meanwhile, the relationship between the carry trade and the equity market builds on Barr and Kantor (2002) and Hsing's (2011) findings, both of which highlight the importance of the rand value and both domestic and foreign (U.S.) interest rates on the JSE.

The evidence of volatility spillovers between the carry trade and both the equity and bond markets in South Africa poses a stability risk to these two asset markets, the rand, and the overall South African financial system. This requires that policy-makers pay a great deal of attention to the movement of foreign capital flows that are triggered by carry trade strategies in domestic markets. Policy-makers and investors need to be aware that carry trade strategy appears to be related more closely to the equity market than the bond market. These findings signify that emerging markets' stock markets are susceptible to volatility transmission through carry trade activities.

Table 5:

Results of the bivariate BEKK-GARCH model between the yen-funded carry trade and JSE returns

	JSE		
Conditional mean equation estimates		**Conditional variance equations estimates**	
Estimates for carry trade returns mean equation			
Φ_{CT}	-0.0215 (0.0351)	C_{11}	-0.1327 (0.1058)
Φ_{JSE}	0.0132 (0.0393)	C_{21}	-0.5132*** (0.0673)
Φ_1	0.0976 (0.0892)	C_{22}	-0.0000 (4.7404)
Estimates for equity market returns mean equation		α_{11}	0.2010*** (0.0273)
Φ_{Ct}	0.0290 (0.0313)	α_{12}	0.0949** (0.0373)
Φ_{JSE}	-0.0422 (0.0364)	α_{21}	0.0417 (0.0277)
Φ_1	0.3364*** (0.0768)	α_{22}	0.3211*** (0.0253)
		β_{11}	0.1281 (0.1063)
		β_{12}	1.0747*** (0.0532)
		β_{21}	0.8167*** (0.0286)
		β_{22}	-0.1584 (0.1077)

*** = 1% level of significance ** = 5% level of significance * = 10% level of significance

Table 6:

Results of the bivariate BEKK-GARCH model between the yen-funded carry trade and bond returns

	JSE		
Conditional mean equation estimates		**Conditional variance equations estimates**	
Estimates for carry trade returns mean equation			
Φ_{CT}	-0.1005** (0.0417)	C_{11}	1.1325*** (0.2511)
Φ_{Bond}	0.8034 (0.6573)	C_{21}	0.1134*** (0.0203)
Φ_1	0.1412 (0.0881)	C_{22}	0.0271*** (0.0090)
Estimates for bond market returns mean equation		α_{11}	0.3264*** (0.0537)
Φ_{CT}	-0.0007 (0.0022)	α_{12}	-0.5929 (0.6590)
Φ_{Bond}	0.0322 (0.0446)	α_{21}	0.0077** (0.0033)
Φ_1	0.0037 (0.0057)	α_{22}	0.2626*** (0.0674)
		β_{11}	0.9003*** (0.0423)
		β_{12}	-3.1287 (2.0392)
		β_{21}	-0.0063** (0.0032)
		β_{22}	0.6259*** (0.1374)

*** = 1% level of significance ** = 5% level of significance * = 10% level of significance

Conclusion

The findings of this study are as follows:

- The mean return equations reveal that carry trade returns in their raw form do not influence returns in either the equity or the bond market;
- The BEKK GARCH estimates present clear volatility relationships between the carry trade and the two key assets market returns in South Africa; and
- This bi-directional volatility spillover relationship is largely dependent on the choice of the funding currency

This study's findings emphasise the importance of volatility spillovers between the currency carry trade market and other asset markets in South Africa when assessing financial market risks and formulating risk management policies. This is because such volatility relationships pose a threat to the South African financial markets' stability and could also lead to untoward consequences should industry regulators and supervisors not award sufficient attention to these aspects of systemic risk.

Recommendations for future studies

Given the scarcity of studies on the relationship between carry trade and the debt capital market, it is suggested that future studies explore other debt capital instruments and products, such as commercial paper and preference shares, not only bond instruments. Furthermore, it would be worthwhile for researchers to consider returns over a longer period, as it may be assumed that carry trade speculators may be involved in long-term investments and not only short-term investments. This can be enhanced even further by considering samples for periods before, during and after the 20008 financial crisis to distil the volatility impacts with and without the influence of the distress of 2008. Given that this study was aimed at assessing if any relationships exist, there is definitely room for inclusion of other variables that can enhance the robustness of findings.

References:

1. Acharya, V.V. and Steffen, S., 2015. The "greatest" carry trade ever? Understanding Eurozone bank risks. *Journal of Financial Economics*, *115*(2), pp.215-236.
2. Ahmed, S. and Zlate, A., 2014. Capital flows to emerging market economies: a brave new world? *Journal of International Money and Finance*, *48*, pp.221-248.
3. Anatolyev, S., Gospodinov, N., Jamali, I. and Liu, X., 2017. Foreign exchange predictability and the carry trade: A decomposition approach. *Journal of Empirical Finance*, *42*, pp.199-211.
4. Anzuini, A. and Fornari, F., 2012. Macroeconomic determinants of carry trade activity. *Review of International Economics*, *20*(3), pp.468-488.
5. Baillie, R.T. and Cho, D., 2014. When Carry Trades in Currency Markets are not Profitable. *Review of Development Economics*, *18*(4), pp.794-803.
6. Baker, M. and Wurgler, J., 2006. Investor sentiment and the cross-section of stock returns. *The journal of Finance*, *61*(4), pp.1645-1680.
7. Bali, T.G. and Peng, L., 2006. Is there a risk–return trade-off? Evidence from high-frequency data. *Journal of Applied Econometrics*, *21*(8), pp.1169-1198.
8. Barr, G. and Kantor, B., 2002. The South African economy and its asset markets: –An integrated approach-. *South African Journal of Economics*, *70*(1), pp.53-77.
9. Bauwens, L., Laurent, S. and Rombouts, J.V., 2006. Multivariate GARCH models: a survey. *Journal of applied econometrics, 21*(1), pp.79-109.
10. Berg, K.A. and Mark, N.C., 2018. Measures of global uncertainty and carry-trade excess returns. *Journal of International Money and Finance*, *88*, pp.212-227.
11. Bollerslev, T., 1986. Generalized autoregressive conditional heteroskedasticity. *Journal of econometrics*, *31*(3), pp.307-327.
12. Bonga-Bonga, L. and Hoveni, J., 2013. Volatility Spillovers between the Equity Market and Foreign Exchange Market in South Africa in the 1995-2010 Period. *South African Journal of Economics*, *81*(2), pp.260-274.
13. Bonga-Bonga, L., 2018. Uncovering equity market contagion among BRICS countries: an application of the multivariate GARCH model. *The Quarterly Review of Economics and Finance*, *67*, pp.36-44.
14. Brana, S. and Lahet, D., 2010. Determinants of capital inflows into Asia: The relevance of contagion effects as push factors. *Emerging Markets Review, 11*(3), pp.273-284.
15. Brunnermeier, M.K., Nagel, S. and Pedersen, L.H., 2008. Carry trades and currency crashes. *NBER Macroeconomics Annual*, *23*(1), pp.313-348.
16. Brunnermeier, M.K., Nagel, S. and Pedersen, L.H., 2008. Carry trades and currency crashes. *NBER macroeconomics annual*, *23*(1), pp.313-348.

17. Burnside, C., Eichenbaum, M. and Rebelo, S., 2008. Carry trade: The gains of diversification. *Journal of the European Economic Association, 6*(2-3), pp.581-588.
18. Burnside, C., Eichenbaum, M. and Rebelo, S., 2009. Understanding the forward premium puzzle: A microstructure approach. *American Economic Journal: Macroeconomics*, *1*(2), pp.127-54.
19. Burnside, C., Eichenbaum, M. and Rebelo, S., 2011. Carry trade and momentum in currency markets. *Annaul Review of Financial Economics*, *3*(1), pp.511-535.
20. Byrne, J.P. and Fiess, N., 2016. International capital flows to emerging markets: National and global determinants. *Journal of International Money and Finance*, *61*, pp.82-100.
21. Christiansen, C., Ranaldo, A. and Söderlind, P., 2011. The time-varying systematic risk of carry trade strategies. *Journal of Financial and Quantitative Analysis, 46*(4), pp.1107-1125.
22. Clarida, R., Davis, J. and Pedersen, N., 2009. Currency carry trade regimes: Beyond the Fama regression. *Journal of International Money and Finance*, *28*(8), pp.1375-1389.
23. Das, S., Kadapakkam, P.R. and Tse, Y., 2013. Is carry-trade a viable alternative asset class?. *Journal of International Financial Markets, Institutions and Money, 24*, pp.247-257.
24. Debt Management Report, 2017/1. National Treasury of the Republic of South Africa
25. Diebold, F.X. and Yilmaz, K., 2009. Measuring financial asset return and volatility spillovers, with application to global equity markets. *The Economic Journal, 119*(534), pp.158-171.
26. Diebold, F.X. and Yilmaz, K., 2012. Better to give than to receive: Predictive directional measurement of volatility spillovers. *International Journal of Forecasting, 28*(1), pp.57-66.
27. Dimic, N., Orlov, V. and Piljak, V., 2016. The effect of political risk on currency carry trades. *Finance Research Letters*, *19*, pp.75-78.
28. Doskov, N. and Swinkels, L., 2015. Empirical evidence on the currency carry trade, 1900–2012. *Journal of International Money and Finance*, *51*, pp.370-389.
29. Engle, R., 2002. Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business & Economic Statistics, 20*(3), pp.339-350.
30. Engle, R.F., 1982. Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica: Journal of the Econometric Society*, pp.987-1007.
31. Fama, E.F. and French, K.R., 2004. The capital asset pricing model: Theory and evidence. *Journal of Economic Perspectives*, *18*(3), pp.25-46.
32. Frank, N. and Hesse, H., 2009. *Financial spillovers to emerging markets during the global financial crisis (No. 9-104)*. International Monetary Fund.
33. Frankel, J. and Poonawala, J., 2010. The forward market in emerging currencies: Less biased than in major currencies. *Journal of International Money and Finance*, *29*(3), pp.585-598.
34. Friedrich, K. and Cathcart, C.D., 1977. Short-term capital flows under flexible exchange rates. *Review of World Economics, 113*(1), pp.48-57.

35. Fung, H.G., Tse, Y. and Zhao, L., 2013. Are stock markets in Asia related to carry trade?. *Pacific-Basin Finance Journal*, *25*, pp.200-216.
36. Gagnon, J.E., 2009. Currency crashes and bond yields in industrial countries. *Journal of International Money and Finance, 28*(1), pp.161-181.
37. Galati, G. and Heath, A., 2007. What drives the growth in FX activity? Interpreting the 2007 triennial survey.
38. Ghysels, E., Santa-Clara, P. and Valkanov, R., 2005. There is a risk-return trade-off after all. *Journal of Financial Economics*, *76*(3), pp.509-548.
39. Gilmore, S. and Hayashi, F., 2012. Corrigendum: Emerging Market Currency Excess Returns. *American Economic Journal. Macroeconomics*, *4*(1), p.283.
40. Habib, M.M. and Stracca, L., 2012. Getting beyond carry trade: What makes a safe haven currency? *Journal of International Economics, 87*(1), pp.50-64.
41. Hassan, S. and Smith, S., 2011. *The rand as a carry trade target: Risk, returns and policy implications*. Economic Research Southern Africa. Working Papers.
42. Hassan, S., 2013. *South African capital markets: An overview.* South African Reserve Bank Working Paper Series WP/13/04. Pretoria: South African Reserve Bank.
43. Hossfeld, O. and MacDonald, R., 2015. Carry funding and safe haven currencies: A threshold regression approach. *Journal of International Money and Finance*, *59*, pp.185-202.
44. Hsing, Y., 2011. The stock market and macroeconomic variables in a BRICS country and policy implications. *International Journal of Economics and Financial Issues*, *1*(1), pp.12-18.
45. Jefferis, K. and Smith, G., 2005. The changing efficiency of African stock markets. *South African Journal of Economics*, *73*(1), pp.54-67.
46. Jordà, Ò. and Taylor, A.M., 2012. The carry trade and fundamentals: Nothing to fear but FEER itself. *Journal of International Economics, 88*(1), pp.74-90.
47. Jurek, J.W., 2014. Crash-neutral currency carry trades. *Journal of Financial Economics*, *113*(3), pp.325-347.
48. Karolyi, G.A., 1995. A multivariate GARCH model of international transmissions of stock returns and volatility: The case of the United States and Canada. *Journal of Business & Economic Statistics*, *13*(1), pp.11-25.
49. Khan, M.S. and Khan, A.H., 1998. Capital Flows to Developing Countries: Blessing or Curse? [with comments]. *The Pakistan Development Review*, pp.125-151.
50. Kohlhagen, S.W., 1977. The Stability of Exchange Rate Expectations and Canadian Capital Flows. *The Journal of Finance*, *32*(5), pp.1657-1669.
51. Laborda, J., Laborda, R. and Olmo, J., 2014. Optimal currency carry trade strategies. *International Review of Economics & Finance, 33*, pp.52-66.
52. Lee, H.C. and Chang, S.L., 2013. Spillovers of currency carry trade returns, market risk sentiment, and U.S. market returns. *The North American Journal of Economics and Finance, 26*, pp.197-216.

53. Ling, S. and McAleer, M., 2002. Stationarity and the existence of moments of a family of GARCH processes. *Journal of Econometrics*, *106*(1), pp.109-117.
54. Liu, C.L. and Yang, H.F., 2017. Systemic risk in carry-trade portfolios. *Finance Research Letters, 20*, pp.40-46.
55. Lundblad, C., 2007. The risk return trade-off in the long run: 1836–2003. *Journal of Financial Economics*, *85*(1), pp.123-150.
56. Manex, Y., 2011. Stock market co-movement and volatility spillover between USA and South Africa. *M. Sc. Theses submitted to UMEA University available online at http://googlescholar. com*.
57. McAleer, M., Hoti, S. and Chan, F., 2009. Structure and asymptotic theory for multivariate asymmetric conditional volatility. *Econometric Reviews, 28*(5), pp.422-440.
58. Melvin, M. and Taylor, M.P., 2009. The crisis in the foreign exchange market. *Journal of International Money and Finance, 28*(8), pp.1317-1330.
59. Menkhoff, L., Sarno, L., Schmeling, M. and Schrimpf, A., 2012. Carry trades and global foreign exchange volatility. *The Journal of Finance, 67*(2), pp.681-718.
60. Mlambo, C., Maredza, A. and Sibanda, K., 2013. Effects of exchange rate volatility on the stock market: A case study of South Africa. *Mediterranean Journal of Social Sciences, 4*(14), p.561.
61. Moolman, E. and Du Toit, C., 2015. An econometric model of the South African stock market. *South African Journal of Economic and Management Sciences, 8*(1), pp.77-91.
62. Nelson, D.B., 1990. Stationarity and persistence in the GARCH (1, 1) model. *Econometric theory*, *6*(3), pp.318-334.
63. Nelson, D.B., 1991. Conditional heteroskedasticity in asset returns: A new approach. *Econometrica: Journal of the Econometric Society*, pp.347-370.
64. Philpott, M.F. and Firer, C., 1994. Share price anomalies and the efficiency of the JSE. *Investment Analysts Journal*, *23*(40), pp.39-51.
65. Sadorsky, P., 2014. Modeling volatility and correlations between emerging market stock prices and the prices of copper, oil and wheat. *Energy Economics, 43*, pp.72-81.
66. Smal, M.M. and De Jager, S., 2001. *The monetary transmission mechanism in South Africa*. Pretoria: South African Reserve Bank.
67. Tse, Y.K. and Tsui, A.K.C., 2002. A multivariate generalized autoregressive conditional heteroscedasticity model with time-varying correlations. *Journal of Business & Economic Statistics, 20*(3), pp.351-362.
68. Wu, C.C. and Wu, C.C., 2017. The asymmetry in carry trade and the US dollar. *The Quarterly Review of Economics and Finance*.

69. Yue, Y.D., Liu, D.C. and Shan, X.U., 2015. Price linkage between Chinese and international nonferrous metals commodity markets based on VAR-DCC-GARCH models. *Transactions of Nonferrous Metals Society of China, 25*(3), pp.1020-1026.