Assessing the extent of exchange rate risk pricing in equity markets: emerging versus developed economies

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ABSTRACT

This paper assesses the extent of exchange rate risk pricing in emerging and developed economies to infer whether this risk is systematic or unsystematic in these economies. The pricing of this risk is based on the two- and three-factor extended CAPM (capital asset pricing model). The US and South Africa are used as proxy for developed and emerging economies, respectively. The findings suggest strong evidence for exchange rate risk premia in both cases and highlight that contrary to many studies, exchange rate risk is systematic in developed economies, despite the possibility and variety of instruments of exchange rate hedging in these economies, particularly in developed economies.

Key Words: *Exchange-Rate Exposure, Pricing, Premia, Arbitrage Pricing Theory, Rolling Window, Time-Varying, Emerging, Developed.*

1. Introduction

stock market' Exchange rate exposure describes the relationship - between stock returns and fluctuations in currency rate - that summarizes the effect of exchange rate movements on firm value[1] and competitiveness (Pierdzioch & Kizys, 2010; Jacque, 2013). According to Coyle (2000), firms with greater *exposure* are typically those that transact in foreign currencies[2] such that exchange rate fluctuations directly influence firm operations and thus affect asset prices and returns. However, in a globalized world where financial and product markets are essentially integrated, exchange rate volatility is likely to have a significant bearing on the value of all firms regardless of whether they engage in foreign transactions or not[3] (Hassan, 1998; Sabri, 2006; Papaioannou, 2006). Assuming an open economy with a flexible regime, variations in exchange rates generate both direct and indirect consequences through which business profits and operations are often affected (Priestley & Ødegaard, 2004; Mahapatra & Bhaduri, 2019). That is, currency rate changes could directly affect the value of the firm's '*real domestic assets*' and '*net foreign monetary assets*' or indirectly influence the price of traded inputs, inflation expectations, competition from imported products as well as overall aggregate demand (Van Marrewijk, 2005; Papaioannou, 2006; Mahapatra & Bhaduri, 2019). Consequently, with the growing impact of exchange rate volatility on global equity markets[4], a large amount of research has been dedicated to the subject of exchange rate risk exposure, firm value and asset pricing within global stock markets (Jorion, 1990; Jorion, 1991; Choi et al., 1998; Priestley & Ødegaard, 2004; Dominguez & Tesar, 2006; Al-Shboul & Anwar, 2014; Mahapatra & Bhaduri, 2019).

Of particular interest to this field of study has been the varying presence and impact of exchange rate risk pricing across different economies. Bansal and Dahlquist (2000) find within their study on the forward premium puzzle in developed and emerging economies that country-specific traits tend to play an essential role in describing the variations in risk premia over different cross-sections. Bailey and Bhaopichitr (2004), for instance highlight the relevance of currency structures and exchange rate regimes in noting the presence of exchange risk premia within equity markets.

[1]As an indirect or direct effect of exchange rate fluctuations, firms may face a reduction in value of revenue or cash flows, increased value of liabilities (such as debt obligations), greater cost of imported inputs, reduced net profit and so on.

[2] Firms that buy, sell, borrow or lend in currencies other than the domestic currency.

[3] Papaioannou (2006) highlights how different types of exchange risk affect businesses on the domestic market and provides some insight on the indirect aspects that can affect those not engaged in foreign transactions. See also, Mahapatra and Bhaduri (2019).

[4] See, Mechri et al. (2019), Perera (2016) and Okwuchukwu (2015).

Others such as Jiménez-Martín and Cinca (2010), show that *'variations in private agents' perception of risk'* and *'macroeconomic uncertainty'* produce exchange rate risk pricing within the Eurozone for a sample period of 1986 to 1998, concluding that currency risk premia exists in European markets in this regard. Brown and Otsuki (1993) on the other hand, observe currency risk premia in Pacific-Basin capital markets and point out that its presence essentially is a mirror of systematic responses to variations in international economic conditions. The authors further highlight that the level as well as effect of exposure is greater in this region than within the United States over their period of study.

According to classical portfolio theory (as explained through the CAPM) in well-developed markets, exchange rate risk is assumed unsystematic and can thus be hedged against, which explains why it would otherwise not be priced within these capital markets (Stålstedt, 2006; Korsgaard, 2009; Mahapatra & Bhaduri, 2019). Empirical findings in the seminal work of Jorion (1990) agree with this notion as he concludes that although a relationship between the value of domestic (U.S) currency and stock returns can be established, currency risk does not appear to be significantly priced with the U.S stock market over the given period of his study. Loudon (1993) also arrives at similar inferences for the Australian market during a post-float interval of 1984-1989, highlighting that the market exhibits weak exposure despite the link between stocks and currency rate fluctuations. Further still, Kodongo and Ojah (2011) extend to the African case and equally find insufficient evidence to conclude that unconditional pricing is present among the biggest markets on the continent. However, drawing from the Arbitrage Pricing theory presented by Ross (1976), currency risk can instead be described as one of several factors that contribute to overall market risk, constituting a systematic element that investors would willingly pay a premium to avoid particularly when taking internationally diversified portfolios into account (Al-Shboul & Anwar, 2014; Kumar, 2015; Mahapatra & Bhaduri, 2019). As such, contrary to classical portfolio theory, this implies that currency risk should indeed be priced by the market as a '*reward*' for accepting this type of risk (Mahapatra & Bhaduri, 2019). A number of studies provide empirical evidence in this regard and find that currency risk is priced within various international markets from both developed and emerging economies (Doukas, Hall & Lang, 1999; Di Iorio & Faff 2002; Carrier & Majerbi, 2006; Al-Shboul & Anwar, 2014; Mahapatra & Bhaduri, 2019). Doukas, Hall and Lang (1999), for instance, investigate currency risk pricing on the Japanese equity market and discover that exchange risk premium contributes significantly to Japanese stock pricing and returns. Mahapatra and Bhaduri (2019) perform a similar study for the Indian case and note growing currency risk premium expectations among Indian investors particularly in the post-crisis interval of their sample (2012-2016). Di Iorio and Faff (2002), on the other hand, review the

Australian market and conclude that pricing occurs more commonly in periods of economic decline and weak currency. Carrier and Majerbi (2006) also reach similar results using emerging market data and affirm that exchange rate risk is priced unconditionally by the emerging markets included in the study over their period of investigation. In prinicpal, although there exists strong evidence in support of exchange rate risk pricing in both developed and emerging market economies, much of the literature on the subject is mixed and urges continuing research in the area in order to gain greater insight on the presence as well as variation of exchange rate risk premia across different economies.

Generally, many of the studies reviewed focus on the U.S market and other developed nations[5], while others investigate various emerging markets and some compare results across numerous economies[6]. However, few extend to emerging African markets[7] in comparing exchange rate risk exposure and pricing within this context to that of developed economies such as the United States. Given the growing importance of emerging markets, particularly leading African economies in a world that is more integrated than before, making this comparison is likely to provide valuable information towards understanding modern investment and international diversification in a contemporary economic climate[8] (Carrier & Majerbi, 2006; Trichet, 2007; Kodongo & Ojah, 2011). To this effect, this paper therefore aims to contribute to existing literature by extending in the following ways. Firstly, this study primarily hopes to build on the work of Al-Shboul and Anwar (2014), by applying the instance of conditionality to a comparison of exchange rate risk pricing in developed and emerging African economies. Secondly, a methodological extension to Al-Shboul and Anwar's (2014) approach is introduced by using the Volatility Index (VIX) as a proxy for the global market volatility. Finally, this paper aims to expand the *unconditional* case put forth by Kodongo and Ojah (2011) for major African markets by testing *conditional* pricing in a major emerging African economy. To successfully attain these contributions, this study tests for the presence of exchange rate risk exposure and pricing in equity markets for the United States (developed market) and South Africa (emerging market). The choice of selecting the US as the developed economy for comparison is influenced by the country's level of integration within the world economy, large number of multinational firms and weighty contribution of local markets to global market movements (Choi & Prasad, 1995; Tai, 2000; Bae, Kwon & Li, 2008; Rothkopf, 2008). Equally, South Africa is included in this study as one of the most prominent emerging

[5] See, Al-Shboul and Anwar (2014), Jorion (1990), Liang (1996), Loudon (1993), Di Iorio and Faff (2002) Choi et al. (1998), Doukas, Hall and Lang (1999) and others.

[6] See, Mahapatra and Bhaduri (2019), Carrieri and Majerbi (2006) and others.

[7] See, Kodongo and Ojah (2011).

[8] See, Di Iorio and Faff (2002), Semertzidou (2019), Mechri et al. (2019) and others.

markets in African, with a remarkable stock market that ranks among the top 20 in the world based on market capitalization and is the largest on the continent (Yartey, 2008; Hassan, 2013). Thus, the two countries chosen for this study provide effective proxies for developed and emerging economies through which an adequate comparison can be made. The study also makes use of the two-factor and three-factor CAPM models to empirically assess whether or not exchange rate risk is priced in these markets via OLS and GLS estimation techniques.

The reminder of this paper is therefore organized as follows; section 2 presents a literature review, section 3 provides the methodology, section 4 puts forth the data, estimation, results and discussion of findings and section 5 concludes.

2. Literature Review

In this section, we review the theoretical foundations that guide research within the area of exchange rate risk pricing along with the empirical findings that support and contradict with these notions.

2.1 Theory

The theoretical frameworks of asset pricing and portfolio selection build on the concept of *Modern Portfolio Theory* established in the pioneering work of Markowitz in 1952 (Korajczyk, 1999). According to Mangram (2013), Modern Portfolio Theory (MPT) technically compromises of a combination of Markowitz' 1952 '*Portfolio Selection*' theory and Sharpe's 1964 '*Capital Asset Pricing Model'* (CAPM), which together form the basis for pricing assets and constructing portfolios that simultaneously maximize return and minimize risk[9]. Thus, some of the underlying assumptions of MPT include; a) markets are efficient[10] and b) investors are rational as well as risk-averse[11] (Korajczyk, 1999; Krause, 2001; Amenc & Le Sourd, 2005) . That is, investors seeks to avoid risk within the market, making investments that provide the best possible risk-return trade-off given their level of wealth and only taking on risk when there is a reward (premium) attached to it (Amenc & Le Sourd, 2005; Francis & Kim, 2013; Jurczenko, 2017; Ibbotson et al., 2018). However, it is important to note that not all risk within the market is rewarded through pricing

[9] See also Fabozzi, Gupta & Markowitz (2002) and Veneeya (2006).

[10] All available information is captured within the current price.

[11] They seek to maximize utility given as a function of risk and return.

within the market[12]. Modern Portfolio Theory provides a distinction between the two main types of risks associated with an investor's portfolio as being either systematic or unsystematic (Mangram, 2013). Systematic risk refers to the risk that cannot be diversified away as it is common to the market at a macro-level (sometimes international level) and affects a broad spectrum of assets to one extent or the other (Stålstedt, 2006; Mangram, 2013). It can stem from changes in economic factors or from fluctuations within the market and because it can affect the market as a whole, investors are often offered rewards in the form of risk premiums for assuming this type of risk (Stålstedt, 2006; Francis & Kim, 2013; Jurczenko, 2017; Ibbotson et al., 2018). Unsystematic risk on the other hand, is the risk that is specific to an industry or firm (and in some cases country), and thus not rewarded by a premium because it can be diversified in this regard (Stålstedt, 2006; Korsgaard, 2009). Unsystematic risk is often specific to each asset arising from unexpected events such as poor weather or strikes that affect a particular firm or industry, hence it can easily be offset in a portfolio that is well diversified (Stålstedt, 2006; Korsgaard, 2009). Accordingly, under MPT, CAPM prices systematic risk or beta through risk premiums, but does not reward unsystematic risk as it is diversifiable (Mangram, 2013). As a result, based on CAPM, defining a risk as either systematic or unsystematic is a vital part in determining whether or not it should be priced by the market (Korsgaard, 2009). Korsgaard (2009) explains that following the logic presented by the classical portfolio theory CAPM, in an efficient market, an optimal well-diversified portfolio should protect against exchange rate volatility, implying that exchange rate risk is unsystematic. Stålstedt (2006) further justifies this definition by highlighting that on a global scale, investors with assets in foreign markets can offset movements in one market by the movements in other markets through diversification and can thus hedge against domestic market fluctuations such as changes in exchange rate.

On the other hand, ***Arbitrage Pricing Theory*** proposed by Ross 1976 provides a flexible extension to modern portfolio theory and allows for '*multi-factor*' asset price modelling (Korsgaard, 2009). Unlike the classical CAPM, APT relaxes some of the initial assumptions, arguing instead that the market is often not efficient and as such returns can linearly be linked to and explained by a number of unknown factors (Stålstedt, 2006; Korsgaard, 2009). This approach makes it more practical and easier to use in modelling real life markets as APT can account for numerous systematic risk factors rather than a single market risk factor as in CAPM (Stålstedt, 2006). The model builds on the concept of arbitrage in a market where information asymmetries exist such that individual investors can make riskless profits when the *'law of one price'* fails to hold and the exchange rates across countries vary (Korsgaard, 2009). Although APT implies that several

[12] See, Korsgaard (2009) Mangram (2013) and Ibbotson et al. (2018).

unknown systematic risk factors can explain return, it does not explicitly outline which factors are to be included in the model, leaving this aspect for theoretical and empirical inference (Kumar, 2015). In this regard, exchange rate risk can be described as systematic risk that is not diversifiable even on an international level (Ikeda, 1991; Ziobrowski & Ziobrowski, 1995). In practice, investing in foreign markets presents greater uncertainty when exchange rate fluctuations are factored in, reducing the prospect of riskless profit as currency changes often do not follow the same factor models as returns and thus require some additional reward in the form of a premium on the risky asset undertaken (Ikeda, 1991; Korsgaard, 2009).

By this logic, market pricing of exchange rate risk is justifiable and evidenced in several works as will be discussed in the preceding sub-section.

2.2 Empirical Findings

Much of the literature on the topic is divided. Some studies find in favour of classical MPT and conclude that exchange rate risk is not priced by equity markets particularly those of developed economies. One such notable study is that of Jorion (1990). In his review of 287 multinational U.S companies, he tested for unconditional exchange rate risk premia using the arbitrage pricing two-factor and multi-factor models (Jorion, 1990). His findings indicated that although some exposure is evident, pricing remains insignificant throughout his analysis (Jorion, 1990). Others such as Loudon (1993) provide similar conclusions for the Australian case where exchange rate risk pricing is tested over a period of 1984-1989 in which the country assumes a floating exchange rate regime. Using similar regression methods, he finds evidence of weak exposure and ultimately concludes that there is an absence of currency rate risk pricing in the Australian equity market for his study interval (Loudon, 1993). Likewise, Kodongo and Ojah's (2011) extension to major African markets produces a corresponding outcome as their study suggests that there is insufficient evidence to conclude that exchange rate risk is priced by major markets within the continent. They test for unconditional pricing using the APT multi-factor model across various African markets (Kodongo & Ojah, 2011). Notably, a common theme throughout these studies is the use of unconditional (non-time-varying) tests of exchange rate risk exposure and pricing which according to De Santis and Gerard (1998) potentially renders these tests ineffective as the *'prices'* examined do not to vary over time. Although they (De Santis & Gerard, 1998) find in favour of no exchange rate risk pricing within the US equity market, this notion is reflected throughout other works that find strong evidence of exchange rate risk premia when testing for the conditional case.

For instance, authors such as Dumas and Solnik (1995), Doukas, Hall and Lang (1999), Tai (2000), Al-Shboul and Anwar (2014) as well as others who test for conditional (time-varying) case typically find that developed and emerging markets alike show strong evidence of exchange rate risk pricing. In their study, Dumas and Solnik (1995) make use of kernel estimation on an international APM with time-varying premia in various developed markets over a 1970 to 1991 period. They find strong evidence of exchange rate risk pricing by all markets including the US. In his study of commercial bank stocks from the US, Tai (2000) also findings evidence of exchange rate risk premia using a kernel estimation approach on a conditional multi-factor pricing framework. He compares the unconditional and conditional models and highlights that the conditional approach is superior when testing for exchange rate risk pricing (Tai, 2000). A similar outcome is observed by Doukas, Hall and Lang (1999) when testing for conditional pricing using an intertemporal multi-factor APM on a large sample of Japanese firm stock data from 1975-1995. They find strong evidence to suggest that exchange-rate risk is priced in the Japanese equity market, even more so when considering the case of high exporting firms (Doukas, Hall & Lang, 1999).

Among emerging markets, evidence suggests both unconditional and conditional pricing exists. Carrier and Majerbi (2006) find significant evidence in favour of unconditional exchange-rate risk pricing using an international CAPM approach in testing a sample of 9 emerging economy[13] stock markets over a period of 1976 to 1999. They highlight, however, that in the case of emerging markets, model specification is particularly important in avoiding *'spurious significance'* resulting from the presence or absence of the local market risk factor (Carrier and Majerbi, 2006). Others such as Mahapatra and Bhaduri (2019) perform a similar study for conditional pricing in Indian equity markets and equally find evidence of pricing. In their study, Mahapatra and Bhaduri (2019) note that growing currency risk premium expectations among Indian investors particularly in the post-crisis interval of their sample from 2012-2016 result in greater exposure and increased pricing within the market. They use a random coefficient model in estimating a two-factor APM for a full set of data from 2005-2016 and find strong evidence to suggest the existence of exchange-rate risk premia in the Indian equity market (Mahapatra & Bhaduri, 2019).

Generally, it can be noted that when testing for exchange-rate pricing, carefully defining the risk, specifying the model and accounting for conditionality is likely to facilitate an effective and reliable outcome through which appropriate inferences can be made for various equity markets. Subsequently, the overall consensus of works reviewed in this paper suggests strong evidence for exchange-rate risk premia in both developed and emerging markets when prices are assumed to be time-varying. Accordingly, this study employs some of the specifications outlined within

[13] These include Argentina, Brazil, Chile, Mexico, Greece, India, Korea, Thailand and Zimbabwe.

existing literature, assuming prices are time-varying and testing for exchange rate risk exposure as well as pricing using the two-factor and three-factor models, with the hope of reaching similar findings.

3. Methodology

This study draws from the seminal work of Jorion (1991) as adapted by Al-Shboul and Anwar (2014) in applying the classical CAPM approach to assess whether or not exchange rate risk pricing exists within the US and South African equity markets[14]. Consequently, Jorion's (1991) traditional CAPM forms the starting point for the models within this study and is thus expressed as below.

$$R_{it} = r_{ft} + \beta_{im}(r_{mt} - r_{ft}) \tag{1}$$

Where R_{it} represents the *excess* return for a stock i at time t, r_{ft} is the risk free return, r_{mt} is the market return and β_{im} the market risk associated with stock i. According to Korsgaard (2009), in determining the pricing of risk factors such as exchange rate risk on equity markets, various empirical regression models pull from both CAPM and APT[15] to test whether or not these risks have an explanatory influence on stock returns. That is, considering the statistical frameworks developed by the works of Ross (1976) and Jorion (1991), two-factor and three-factor models can be drawn from equation (1) as in Al-Shboul and Anwar (2014). Exchange rate risk is therefore accordingly defined as *systematic* to the market within the context of this study and captured through the regression of equations (2) – the two-factor model, and (3) – the three-factor model, as outlined below.

Firstly, a two-factor model that accounts for a local market factor as well as an exchange rate factor is established and expressed as;

$$R_{it} = \alpha_0 + \alpha_{1i}R_{LMt} + \alpha_{3i}R_{EXt} + \epsilon_{it} \tag{2}$$

[14] Developed on the concepts of modern portfolio theory, this quantitative approach is particularly useful in capturing risk pricing relating to expected return as it accounts for pricing of systematic market risk and provides the basis on which extensions that include other factors are made.

[15] APT provides a multifactor extension to the traditional CAPM. See, Stålstedt (2006), Korsgaard (2009) and Kumar (2015).

Where R_{it} represents the excess return[16] on firm i's stock, R_{LMt} represents the excess return on a portfolio in the local market, R_{EXt} is the return on the change in exchange rate (in this case the nominal effective exchange rate for each respective country) and ϵ_{it} is the two-factor model error term. Assuming that there is no systematic risk in the market (zero risk factors), it can be inferred through the CAPM equation that the expected return is exactly equal to the risk free rate captured by a constant α_0 in this case (Jorion, 1991; Korajczyk, 1999; Korsgaard, 2009; Mangram, 2013).

Secondly, a three-factor model that includes both local and global market factors as well as an exchange rate factor is applied and expressed as below.

$$R_{it} = \alpha_0 + \alpha_{1i}R_{LMt} + \alpha_{2i}R_{GMt} + \alpha_{3i}R_{EXt} + \varepsilon_{it} \quad (3)$$

R_{it}, R_{LMt} and R_{EXt} are described as in the two factor model, ε_{it} is the three-factor model error term and R_{GMt} represents the excess return on a portfolio in the global market. As in Al-Shboul and Anwar (2014), the three-factor model is included to provide a more comprehensive study and contribute enhanced analysis to existing literature on the topic. However, unlike Al-Shboul and Anwar (2014), this study notes that the use of a global equity market to capture world market returns may present an issue of multi-collinearity within the analysis given the influence of global market movements[17] in most local markets (Beirne et al., 2010; Hiang Liow, 2012). Subsequently, the Volatility Index (VIX) is applied as a proxy for world market fluctuations within this study in order to capture a more accurate effect of global market risk (Whaley, 2009; Zhou, Zhang & Zhang, 2012; Bahadur & Kothari, 2016).

The coefficients within equation (2) and (3) capture the cross-sectional average risk exposure associated with each risk factor. It therefore follows that the coefficient of interest in solving the problem presented in this paper is α_{3i} which captures the cross-sectional average of exchange rate risk exposure within the models. Given that both the two-factor and three-factor equations presented have a *time index*, the coefficient α_{3i} can be plotted against time to illustrate the time-varying outcomes. Al-Shboul and Anwar (2014) highlight that these dynamic parameters are shown to follow a random walk without drift, providing the basis on which an empirical model can be established for the time-varying behaviour of regression coefficients, where constant

[16] Excess of the risk-free rate as shown in the classical CAPM equation (1).

[17] This may particularly be challenging as the S&P 500 index is used for the US local market which is also highly correlated with global market movements (See, CFA Institute, 2016).

coefficients offer a unique case. Along these lines, this paper also corrects for estimated standard error heteroskedasticity and autocorrelation using the Newey-West method for the estimates.

To test for time-varying currency risk exposure and pricing, the traditional rolling regression approach is applied on both models (2) and (3) to obtain dynamic, reliable estimates that can explain for this aspect as in Al-Shboul and Anwar (2014)[18] as well as others (Williamson, 2001; Bodnar & Wong, 2003; Bryne, Ibrahim & Sakemoto, 2017). The rolling window approach is particularly useful in this instance as it permits stochastic progression of the exposure coefficients and accounts for parameter instability within the time series models (Engle & Watson, 1987; Kizys & Pierdzioch, 2007; Al-Shboul & Anwar; 2014). From the estimates of equations (2) and (3), the problem of risk pricing can then be studied by means of equations (4) and (5) as expressed below.

$$\alpha_{0i} = \delta_0 + \delta_1\alpha_{1i} + \delta_3\alpha_{3i} + \xi_i \tag{4}$$

$$\alpha_{0i} = \delta_0 + \delta_1\alpha_{1i} + \delta_2\alpha_{2i} + \delta_3\alpha_{3i} + \varsigma_i \tag{5}$$

Where α_{0i} is the rolling window output of the constants from equation (1) and (2) respectively and essentially represents the expected return assuming zero risk factors, α_{3i} is as previously described, α_{1i} is the rolling coefficient that represents the cross-sectional average of risk exposure to the local market, α_{2i} is the coefficient that represents the cross-sectional average of risk exposure to the global market and ξ_i,ς_i are error terms. It is these equations that allow us to test the hypothesis that exchange rate risk pricing is present in the US and South African equity markets.

Equation (4) is obtained using the estimated parameters of equation (2) and tests exchange rate risk pricing for the two-factor case, whereas equation (5) is obtained using the estimated parameter of equation (3) and tests for the three-factor case. The respective parameters from equations (2) and (3) are obtained using an OLS rolling window regression[19], while the parameters of equations (4) and (5) are obtained using both OLS and GLS. Given that the generalized least squares have a greater power than OLS where residuals exhibit some correlation, we apply this method to

[18] Given that our sample size is smaller than in Al-Shboul and Anwar (2014), we adjust our window to 25 so as to obtain more outputs than would otherwise be observed using a window size of 50.

[19] The use of only a rolling window OLS is adequate for equations (2) and (3) as the main objective at this step is to obtain the time-varying parameters using a simple, but effective process.

equations (4) and (5) along with the traditional OLS for a more comprehensive analysis (Ledoit & Wolf, 2003; Al-Shboul & Anwar, 2014).

4. Estimation and Results

4.1 Data

This study makes use of monthly stock price, volatility and exchange rate data starting 01/01/2009 and ending 01/07/2019. All stock price data for individual firms and local markets included within the study are sourced from *Yahoo! Finance*, while the volatility index data is obtained from *Bloomberg*. The South African exchange rate data is acquired from the Reserve Bank of South Africa's official *ResBank* database, whereas the US exchange rate data is obtained from Federal Reserve Bank of St. Louis (FRED) database. The stock price data is converted into returns using the following calculation before any estimations are carried out.

$$R_t = \left[\ln\left(\frac{p_t}{p_{t-1}}\right)\right] \times 100$$

R_t represents the return at time t, p_t the price at time t and p_{t-1} the previous price at time. The returns are calculated on each share price for all the firms as well as for the market prices, volatility index and exchange rates.

The data is then tested for stationarity using the Augmented Dickey-Fuller (ADF) test which suggests that the data is stationary at the initial level as shown in table 1. Next the data is tested for autocorrelation and find evidence of autocorrelation at lag 1 in most instances.
The data used in this study explicitly includes the following;

a) 10 of the largest firms in South Africa;
   - Standard Bank (Banking)
   - First Rand (Banking)
   - MTN (Telecommunications)
   - Sasol
   - Anglo American (Mining)
   - Naspers
   - Shoprite (Food and Beverage)
   - Woolworths (Retail)
   - Truworths (Retail)

- Tiger Brands (Food and Beverage)

Each of the firms included are randomly selected from among the top 100 companies[20] across various industries within the country on the basis of high market capitalization and data availability over the study period.

b) 10 of the largest firms in the United States;
  - Apple (Technology)
  - Berkshire (Finance)
  - CVS (Health Care)
  - Ford (Automobile)
  - Amazon (Online Retail)
  - McKesson (Health Care)
  - AT&T (Telecommunications)
  - United Health (Health Care)
  - Walmart (Retail)
  - Exxon Mobil (Energy)

Each of the firms included are randomly selected from among the top 100 companies[21] across various industries within the country on the basis of large market capitalization and data availability over the study period.

c) The JSE index as the local market proxy for the South African equity market[22].
d) The S&P 500 index as the local market proxy for the United States equity market[23].
e) The Volatility Index[24]

[20] See, https://www.sashares.co.za/top-100-jse-companies/#gs.cu0uk8.

[21] See, https://revenuesandprofits.com/top-50-us-companies-by-market-value/.

[22] The JSE is the largest, most widely recognized equity market within South Africa as well as on the continent and is as such the natural choice for the South African local market proxy. See, https://www.jse.co.za/about/history-company-overview.

[23] According to the CFA Institute (2016), the S&P 500 index is generally used as an appropriate measure of equity performance throughout the United states as it accounts for about 80 percent of overall equity market capitalization within the country and thus this study opts to include this index as the local market proxy for the American case over other indices.

[24] This is used instead of a global equity market share price index to avoid the problem of multicollinearity as previously highlighted in the methodology section.

f) The South African Nominal Effective Exchange Rate[25] (Trade Weighted Index – TWI).

g) The United States Broad Effective Exchange Rate[26].

The descriptive statistics of the data series are highlighted in table 1 below, along with the ADF test statistics and autocorrelation coefficients at lag 1[27] as well as other lags where observed. Interestingly, the US data series correlograms show spikes only on the first lag and later die out. According to Chatfield (2003), it is typical of stationary time series to exhibit short-term correlation before dying out over larger lag horizons. This is equally the case in the South African data series, that is, R_{EXt} *(TWI)* and $Ave\ R_{it}$. However, the JSE series shows spikes up to the third lag, which is once again common for stationary series (Chatfield, 2003). Notably, the S&P 500 series does not show any spikes (visual evidence of serial correlation) even in the short run.

[25] The use of an effective Exchange Rate (EER) provides a more comprehensive indicator for analysis than individual bilateral exchange rates as it includes the weighted average of bilateral rates for all the country's major trading partners. Given that this study is particularly interested in the external value of the currency against a basket of other currencies rather than its competitiveness at an international level, the Nominal Effective Exchange Rate (NEER) is selected over the Real rate as an adequate measure. See, Klau and Fung (2006) and Motsumi et al. (2008).

[26] Once again the effective exchange rate is applied for the same reason, however, in this instance, the Broad Effective exchange rate is utilized. The BEER provides greater coverage in terms of the number of trading partners included in the weighted basket of currencies and presents a more global picture by accounting for emerging economies. Although it is cannot explicitly be highlighted as the *better* measure, it adequately captures the aspect of an extensive trade weighted currency. See, Klau and Fung (2006).

[27] The data series for each variable show serial correlation at different lags and we include these results in table 1 out of a maximum of 15 lags.

Table 1 (Descriptive Statistics)

Country	Variable	Obs.	Mean	Min.	Max.	Std. Dev	AR(1)	Additional Corr.	ADF
South Africa	$Ave\ R_{it}$	126	1.7940	-183.2975	184.3923	63.9688	-0.480	-	-10.3037***
	R_{LMt} (JSE)	126	1.2344	-482.036	469.1429	154.0771	-0.353	-0.358 AR(2) 0.291 AR(3)	-10.3862***
	R_{GMt} (VIX)	126	-0.8119	-48.5967	85.2588	21.5535	-0.291	-	-14.9600***
	R_{EXt} (TWI)	126	-0.1888	-8.45207	9.1685	2.8065	0.221	-	-8.7666***
United States	$Ave\ R_{it}$	126	1.1002	-10.5366	128429	3.6471	-0.165	-	-13.4197***
	R_{LMt} (S&P)	126	1.0185	-11.6457	10.2306	3.8933	-	-	-13.3006***
	R_{GMt} (VIX)	126	-0.8119	-48.5967	85.2587	21.554	-0.291	-	-14.9600***
	R_{EXt} (BEER)	126	0.1009	-3.0827	2.9074	1.2054	0.417	-	-7.2334***

This table shows a summary of the descriptive statistics including the ADF stationarity test statistics and estimated autocorrelation coefficients. The ADF test statistics indicate that there is sufficient evidence to reject the null hypothesis of a unit root in the individual data series (i.e. no stationarity). The maximum lag length reviewed is 15 lags and correlogram analysis reveals spikes at lag 1 for most series with the exception of the S&P 500 and JSE series as shown. $Ave\ R_{it}$ is the average returns on stocks for the firms included in the study for each respective country case. The remaining variables are described as in the methodology. *, ** and *** represent 10%, 5% and 1% significance levels respectively.

4.2 Estimation

This paper addresses the problem of exchange rate risk pricing in the US and South African equity markets in three phases. First, the question of ***exchange rate risk exposure is examined*** by estimating the two-factor and three factor models presented in equations (2) and (3) in the previous section. These equations are estimated using an OLS rolling window regression method with step size 1 and window size 25. Although the approach used draws from Al-Shboul and Anwar (2014), a shorter window is utilized to provide a greater output over the smaller sample (for better visual analysis of the plots) than would otherwise be observed under a large window of say 50 observations. The rolling window approach provides dynamic estimates that can be plotted against time to study the existence and behaviour of exchange rate risk exposure as well as pricing over a given horizon. Upon estimating the exposure parameters, the cross-sectional average coefficients of each country for a given exchange rate are calculated and then plotted against time. If fluctuations are observed throughout the graph of the plotted coefficient of interest α_{3i}, it can then be noted that time-varying exchange rate exposure is present. This is shown for the two-factor case in *figure 1* which implies that fluctuations in exchange rate influence firm value in each country and that this influence varies over time.

In the three-factor case shown in *figure 2*, although time-varying exchange rate risk exposure is equally present, the variations do not significantly differ from the those shown in *figure 1*. This implies that on a visual level, the inclusion of the world market does not influence the test for and presence of time-varying exchange rate exposure, much like what is observed by Al-Shboul and Anwar (2014). *Figures 1* and *2* are displayed below.

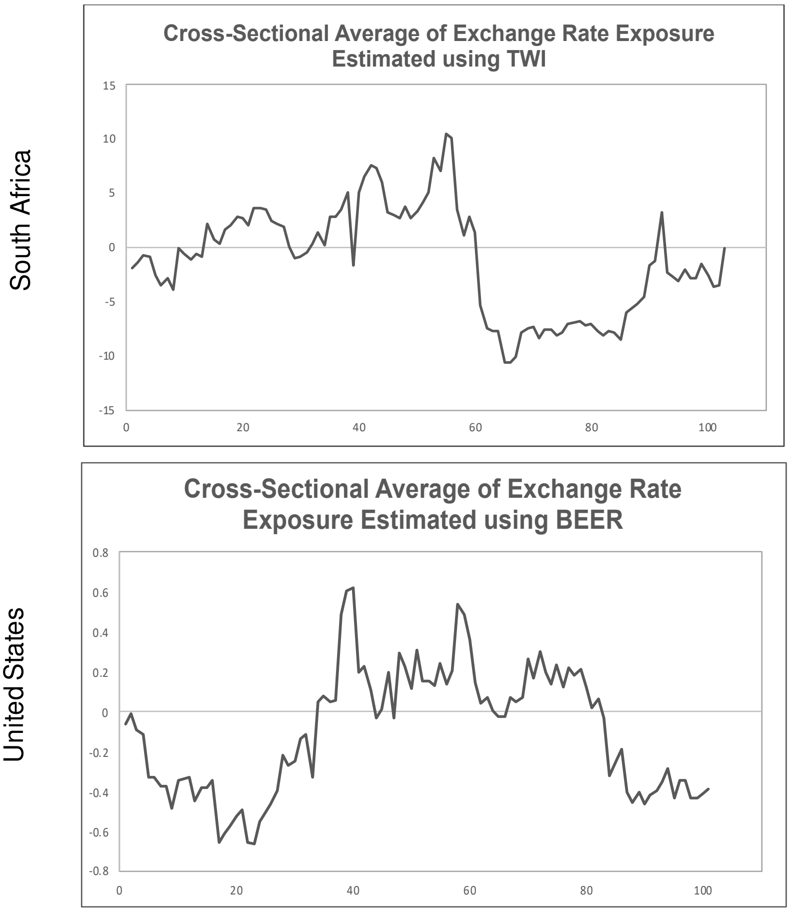

Figure 1: The Two-Factor Model Time-varying Cross-Sectional Exchange Rate Exposures, with sample size shown on horizontal axis.

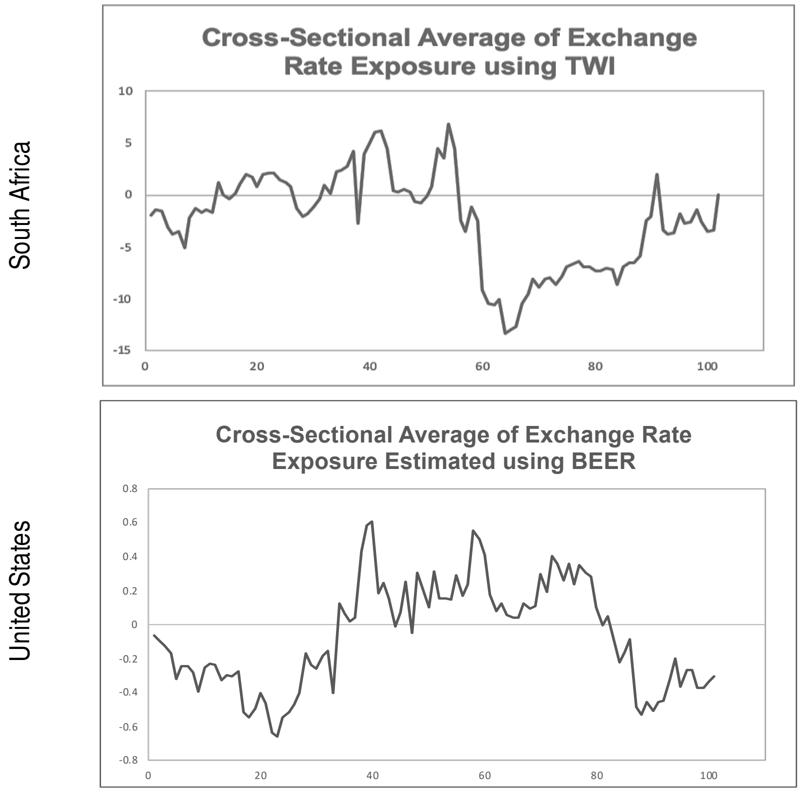

Figure 2: The Three-Factor Model Time-varying Cross-Sectional Exchange Rate Exposures, with sample size shown on horizontal axis.

Next, the ***pricing of exchange rate risk is tested*** as the suggests existence of exchange rate risk exposure over time. To do this, equation (4) and (5) are initially estimated using an OLS rolling window method with step size 1 and window size 50. This time, a bigger window is used following Al-Shboul and Anwar (2014) as a large number of observations is required to adequately run the regressions at this stage. The rolling coefficients obtained are plotted against time with the coefficient of interest, δ_3, being shown in *figure 3* and *4* for the respective two-factor and three-factor case below. These provide a visual indication of the presence of time-varying exchange rate risk pricing if the rolling coefficient δ_3 exhibits variation throughout the graph. For the two-factor case, figure 3 indeed suggests the existence of exchange rate risk pricing in both the US and South Africa. Figure 4 for the three-factor case also provides a similar conclusion for South Africa, implying that the inclusion of the world market is insignificant in that scenario. For the US however, the inclusion of the world market appears to stir the graph towards a more negative range over a longer period than in observed in the two-factor instance. This may indicate greater influence of exchange rate risk on the value of US firms when the world market is considered. According to Rothkopf (2008)[28], as of 2007, a large number of firms listed on the S&P 500 sourced

[28] See also, https://www.reuters.com/article/us-usa-results-dollar/currency-fluctuations-hit-more-north-american-firms-earnings-data-show-idUSKCN0X82G1.

much of their revenue from overseas sales which possibly explains the observed differences once world market risk is factored into the equation in *figure 4*, with the increase negative range suggesting a likely inverse relationship or influence. Ultimately, a visual assessment of both *figure 3* and *4* implies distinct evidence of exchange rate risk pricing in both countries.

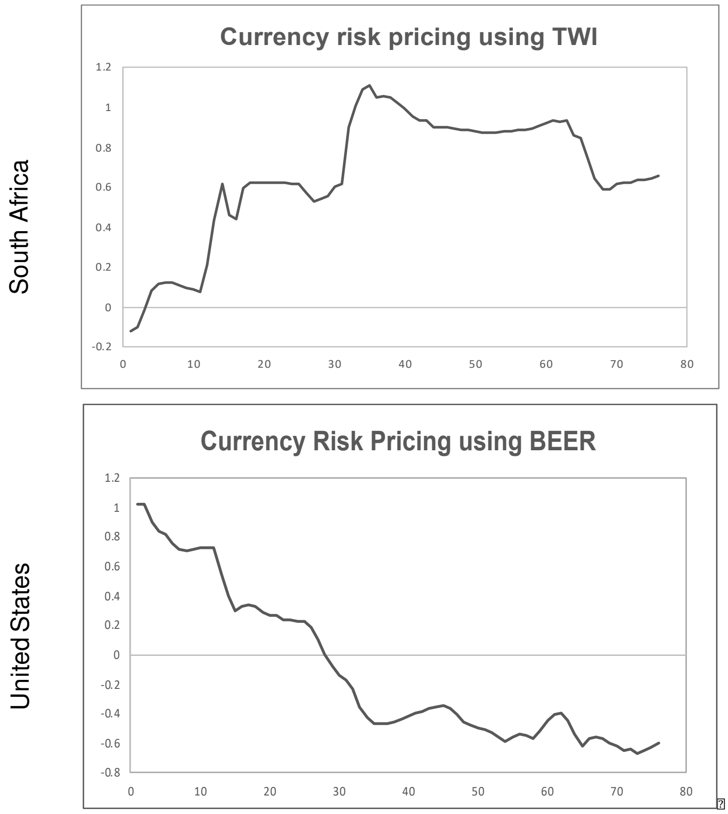

Figure 3: The Two-Factor Time-varying Exchange Rate Pricing showing $_3$ over time obtained from the OLS rolling window estimation of equation (4).

South Africa

United States

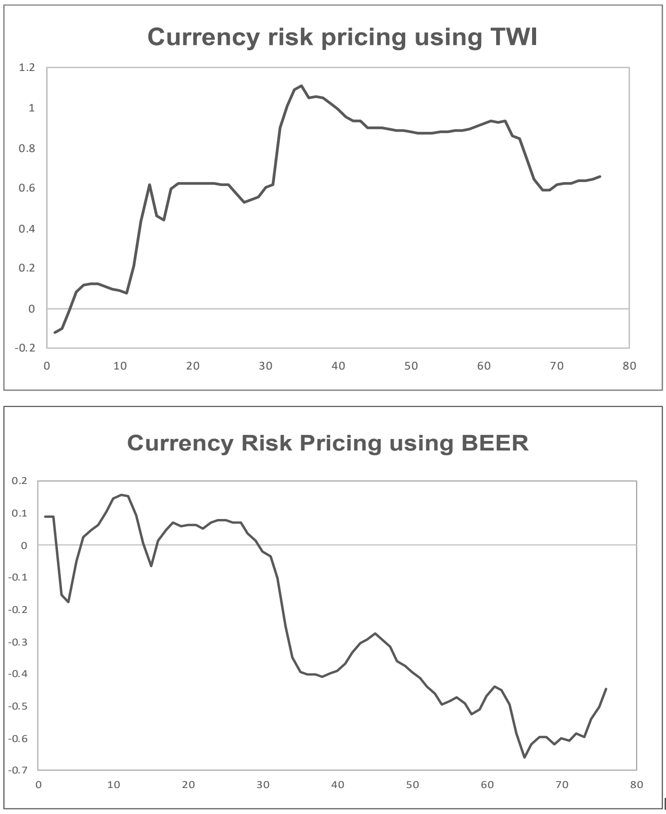

Figure 4: The Three-Factor Time-varying Exchange Rate Pricing showing $_{3}$ over time obtained from the OLS rolling window estimation of equation (5).

Finally***, a GLS estimation is run*** on equation (4) and (5). The GLS approach holds a higher power than classical OLS and allows for testing of cross-sectional constraints imposed on the model via a likelihood ratio test (Al-Shboul & Anwar, 2014). Additionally, this provides a more robust approach to the multifactor model analysis of exchange rate risk pricing (Ledoit & Wolf, 2003; Al-Shboul & Anwar, 2014). The results of this analysis are presented table 2 and 3 along with an explanation in the preceding subsection.

4.3 Results and Discussion

Table 2 and 3 below outline the GLS estimation results obtained from equations (3) and (4).

Table 2: *Two-Factor Model GLS Estimation*

$$R_{it} = \alpha_0 + \alpha_{1i} R_{LMt} + \alpha_{3i} R_{EXt} + \epsilon_{it}$$

$$\alpha_{0i} = \delta_0 + \delta_1 \alpha_{1i} + \delta_3 \alpha_{3i} + \xi_i$$

	δ_0	δ_1	δ_3	$\chi^2(3)$
TWI	3.4077*** (5.7684)	-2.5966*** (-2.7432)	0.6474*** (8.8520)	44.5928***
BEER	1.2372*** (27.7931)	-1.3487*** (-26.9251)	-0.3717*** (-8.1085)	71.9264***

The table presents the estimated coefficients and t-statistics obtained from the GLS estimation of equation (4). This pricing model utilizes cross-sectional average coefficients obtained from the rolling window regression of the two-factor model represented by equation (2). ***, ** and * represent a 1%, 5% and 10% level of significance, respectively.

Table 3: *Three-Factor Model GLS Estimation*

$$R_{it} = \alpha_0 + \alpha_{1i} R_{LMt} + \alpha_{2i} R_{GMt} + \alpha_{3i} R_{EXt} + \varepsilon_{it}$$

$$\alpha_{0i} = \delta_0 + \delta_1 \alpha_{1i} + \delta_2 \alpha_{2i} + \delta_3 \alpha_{3i} + \varsigma_i$$

	δ_0	δ_1	δ_2	δ_3	$\chi^2(2)$
TWI	6.2871*** (6.4491)	-2.36534*** (-4.9988)	6.3695*** (1.2773)	0.8757*** (12.5442)	60.2289***
BEER	1.2647*** (14.8139)	-1.39771*** (-16.9561)	6.0053*** (5.7754)	-0.3690*** (-4.0128)	60.5550***

The table presents the estimated coefficients and t-statistics (in the brackets) obtained from the GLS estimation of equation (5). This pricing model utilizes cross-sectional average coefficients obtained from the rolling window regression of the three-factor model from equation (3). ***, ** and * represent a 1%, 5% and 10% level of significance, respectively.

From the estimation output in table 3 this study focuses on the results obtained for δ_3 as the coefficient of interest - which represents average cross-sectional exchange rate risk pricing within the models, to address the problem posed by this paper. The results in table 3 show that δ_3 is statistically significant in both countries, with a negative value in the case of the US and a positive value in the case of South Africa. The negative values suggest that firms in each of the respective countries likely gain higher returns when exposed to negative currency risk[29]. The opposite may also be true for a positive coefficient value. Table 2 also reports a chi-square test statistic of each country for the two factor model. The estimated value exhibits statistical significance at a 1% level of significance, indicating the specifications and overall model are a good fit. Notably, all the other

[29] See Al-Shboul and Anwar (2014).

variables appear to be statistically significant at a 1% level and when tested for joint significance, the null hypothesis that the coefficients are statistically equal to zero is rejected. Overall, the results obtained in table 2 signal the presence of exchange rate risk pricing in both the South African and US markets. This observation contradicts the findings of Jorion (1991) who concludes that exchange rate risk is not significantly priced in the US market within his study. Jorion's (1991) study however, does not account for the time-varying element in estimated risk coefficients. De Santis and Gerard (1998) highlight that in order adequately test for the presence of pricing, the *'prices'* should be allowed to vary throughout time. Although their (De Santis & Gerard, 1998) study equally concludes that exchange rate risk pricing is not significantly priced within the US markets, various other studies that account for time-varying pricing find strong evidence for the presence of exchange rate risk premia in US equity markets (Dumas & Solnik, 1995; Tai, 2000; Bae, Kwon & Li, 2008). This paper's findings as in table 2 are consistent with the latter publications.

Table 3 on the other hand reports the results of the estimation of the three-factor model test for exchange rate risk pricing. The findings are similar to those in table 2 and equally imply the presence of exchange rate risk pricing within equity markets in both countries, respectively. The coefficient of interest δ_3 remains negative for the US case, positive for the South African case and statistically significant at a 1% level in both instances. This indicates that although the world market coefficient is statistically significant within the model, its inclusion within the model does not have any substantial effect on the outcome of the test for exchange risk pricing within the model. This outcome agrees with the findings of Al-Shboul and Anwar (2014). Once again, in testing the joint significance of the variables, the null hypothesis is rejected and the model proves a good fit which is also highlighted by the statistically significant chi-squared test statistics for each country.
Ultimately, the results within the tables suggest the existence of exchange rate risk pricing within both the US and South Africa respectively and is consistent with the conclusions put forth by various other studies on developed and emerging economies when the time-varying element of prices is considered[30]

5. Conclusion

This study set out to - 1) build on the work of Al-Shboul and Anwar (2014) by applying the conditional approach in testing for exchange-rate risk pricing in developed and emerging equity

[30] See, Brown and Otsuki (1993), Dumas and Solnik (1995), Tai (2000), Carrieri and Majerbi (2006), Bae, Kwon and Li (2008), Al-Shboul and Anwar (2014), Mahapatra and Bhaduri (2019) and others.

markets, 2) provide an alternative global market proxy that avoids the problem of multicollinearity with local markets and 3) extend literature comparisons to an African case that includes conditionality. The findings suggest strong evidence of conditional exchange-rate risk pricing in both the developed and emerging case with the US showing a negative coefficient value and South Africa showing a positive value in this instance. This observation agrees with the findings of Al-Shboul and Anwar (2014) in highlighting that negative values suggests that firms in each of the respective countries likely gain higher returns when exposed to negative currency risk and vice versa. It is also found that although use of the Volatility index provides a better global index measure as highlighted in Zhou, Zhang and Zhang (2012), the inclusion of the global market risk overall does not signifcantly affect the pricing test on a statistical level. This is once again similar to the findings of Al-Shboul and Anwar (2014) for the Canadian market. however, on a visual level, the inclusion of the market appears to have some minor impact in terms of indicating greater exposure which is expected given the level of integration of the S&P500 index included in this study with the rest of the world. Finally, the study finds that in the emerging African market scenario, represented by the South African market, the is strong evidence to infer the existence of conditional pricing, contrary to Kodongo and Ojah's (2011) findings for in their unconditional test, but similar to Carrieri and Majerbi (2006) on a broader emerging market scale.

Given these observations, it would firstly be recommended that countries with floating systems and open economies (whether emerging or developing) maintain care and consideration when implementing exchange rate policies as these are shown to have a pronounced effect on capital markets, particularly in countries where these markets play a substantial role in economic activity. Secondly, investors seeking to diversify at an international level should take into account the systematic nature of exchange rate risk and factor this aspect into their portfolio choices, noting that this risk is often priced in most markets around the world (as highlighted by several of the studies reviewed as well as this one).

Although this study has found evidence of exchange-rate risk exposure and pricing within the US and South African markets, it does not determine the determinant of this risk or compare possible variations and the reasons behind this. Given that this aspect is equally essential in adequately understanding the degree of exposure and strength of pricing, this topic is left for further study in the future.

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