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Key words: currency effect, aggregate currency, stock index, foreign exchange, returns, volatility spillovers, predictability, macroeconomic variables, causality

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Dedication

To the tripod of my stability- my adorable wife, my stoical mother and my dearest sister- thank you for all the love, support and encouragement. This tribute is to you, and this is our collective success, couldn't have done it without you.

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Part I: Theory, Background, and Main Findings

1 Introduction

As global financial markets become more integrated and fast paced, the effect of asset price movements on the stability of the global financial system and economies has become more accentuated. This effect is attributable to the various related roles that asset prices play as credible leading indicators for activity, financial distress and general economic wellbeing. Although investors closely monitor asset price behaviour for indications of market opportunities, risks and expectations, policymakers seek to interpret the messages therein for forecasting purposes and their implications for policy decisions.

All assets prices are expressed in a unit of account, usually the home currency of the jurisdiction in which the asset is domiciled, and the values of these currencies vary depending on the balance of demand and supply. Although Smith (1776) is of the opinion that a commodity that continually changes in value can only be an inaccurate measure of the value of other commodities, yet, assets are valued in units of account that, in themselves, continually vary. This fact is further highlighted for cross-border investments because the realized return is not only the return on the asset as measured by the domestic currency of valuation but also the rate at which the foreign currency exchanges with the investor's home currency at the point of translation.

This notion is supported by evidence from a study conducted by Armstrong, Knif, Kolari and Pynnonen (2011) on universal returns, exchange risk and capital asset prices. They decompose changes in asset prices into a universal return, which is the sum of the return of the asset without the exchange rate risk (measured in a stable basket of currencies' unit of account), and the return due to domestic currency variations (measured against the same stable basket of currencies). The results of their study show that the return on any asset comprises two components – a change due to movement in the underlying asset, which is the universal return earned by all investors, and a change due to the variation in the currency of valuation of the asset.

For a measure of exchange rate risk that captures the various ways by which random changes in the value of a currency can affect a firm and, invariably, its valuation, Adler and Dumas (1984) propose empirically regressing stock returns on exchange rate returns computed from the value of a currency relative to a basket of major currencies. To overcome the distortions that may arise from variation in the value of a randomly selected basket of currencies, Hovanov, Kolari and Sokolov (2004) provide a framework to achieve a stable basket of currencies whose value is the same, irrespective of the base currency. The outcome of their study is an aggregate currency basket that has proven less volatile than the globally referenced Special Drawing Rights (SDR) of the International Monetary Fund (IMF), and the world currency basket suggested by Mundell (2000).

In light of the foregoing issues around fluctuations of an asset's currency of valuation, this study re-examines some of the previously documented relationships that employed home currency-denominated variables or pairwise exchange rates. Our motivation arises from the above-enumerated shortcomings of a single currency as an appropriate unit of measure. The changes that occur between the outcome of the home currency models and the aggregate currency models constitute what we have termed the currency effect.

Our first study investigates the currency effect on the return and volatility spillovers between the stock market and the foreign exchange (FX) market. Whereas most previous studies have examined the relationship between these markets using pairwise exchange rates of the home country relative to other foreign currencies, and the home currency-denominated stock indices, we examine this relationship by valuing both the stock indices and the exchange rate in the same aggregate currency unit of account.

In our second study, we examine the currency effect on the predictability of stock returns in the short term. Although previous studies have concentrated on investigating the factors or models that best predict asset returns, our study investigates the effect of currency of valuation on stock return predictability. We examine this effect in one emerging market and one developed economy. Our study estimates models that pair the home currency-denominated stock index returns with a set of home currency-denominated explanatory variables and compares the results with the models that pair aggregate currency-denominated stock index returns with the same set of explanatory variables valued in an aggregate currency unit of account. We empirically forecast the in-sample and out-of-sample returns of each country's stock index.

Our last study empirically investigates the currency effect on the long-term relationship between the stock market and macroeconomic variables. We estimate two different models, one pairing an aggregate currency-denominated stock index with US macroeconomic variables, and the other pairing the US macroeconomic variables with the US dollar-denominated stock index. We also examine the changes in the causal relationship arising from the change in the currency of valuation.

The remainder of the introductory part is organized as follows. Section two provides a brief overview of the relevant theoretical frameworks and models. Section three presents a summary of our main findings.

2 Review of Asset Pricing Theories and Empirical Models

The watershed moment in the theory surrounding the pricing of financial assets can be traced back to that fateful day in 1738 when Bernoulli presented a seminal paper at the Imperial Academy of Sciences in St. Petersburg. The paper, originally published in Latin, centred on a new theory on the measurement of risk. The series of issues addressed in that paper have become the cardinal point around which modern financial economics revolve. One of the issues raised by Bernoulli was the concept of utility. He argued that the value ascribed to an item should be dependent upon the utility derived from the item rather than its price. His argument was premised on the supposition that as wealth increases, increase in utility will be inversely related to the amount of goods possessed by an individual. He opines that there is a trade-off between expected changes in wealth and the risk associated with such opportunity. Although Bernoulli's work was widely referenced among mathematicians, it only gained prominence in the economics of decision making involving risk after the development of the expected-utility theory by von Neumann and Morgenstern (1944).

Markowitz (1959) further transformed the finance landscape with his pioneering work on diversification and modern portfolio theory. His publication on portfolio selection provides insight on distinguishing the variability of returns from a security and its contribution to risk weighting of a portfolio. His position is that investing in securities with low covariance among themselves will reduce the variance of the portfolio, rather than arbitrarily investing in many securities. Markowitz shows that for a given level of risk, it is possible to identify a set of portfolios that yield the highest possible expected return and that limiting the portfolio selection to this efficient frontier is advisable for investors that care only about the trade-off between expected return and risk.

Modern asset pricing theories are built on the work of Markowitz and underpin attempts by academia and investors to explain changes in asset prices. Neo-classical-based asset pricing theories, such as the Capital Asset Pricing Model ((CAPM), Sharpe, 1964, Lintner, 1965) and Arbitrage Pricing Theory ((APT), Ross, 1976), have dominated discourse until recently, with behavioural-based theories such as optimism (Weinstein, 1980, Taylor and Brown, 1988), overreaction (DeBondt and Thaler, 1985) and overconfidence (Daniel and Titman, 1999, Barber and Odean, 1999) now becoming mainstream and challenging the old neo-classical construct. However, we will limit ourselves to neo-classical theories due to their relevance to our study because the behavioural theories are beyond the remit of this dissertation.

2.1 Capital Asset Pricing Models

Although every asset-pricing model is a capital asset pricing model, the acronym CAPM is usually synonymous with the Sharpe-Lintner-Black model among finance professionals. Sharpe (1964) and Lintner (1965) extended the market portfolio model developed by Markowitz (1959), retaining his assumptions but adding a number of new critical dimensions.

2.1.1 Sharpe-Lintner CAPM

Sharpe (1964) and Lintner (1965) add two key assumptions to the Markowitz mean-variance portfolio model: homogeneity of investor expectations and the ability of all investors to borrow or lend at the risk-free rate. The CAPM equation as specified by Sharpe and Lintner is expressed as follows:

$$E(R_i) = R_f + \beta_{i,M}\left[E(R_M) - R_f\right] \quad (1)$$

where: $$\beta_{i,M} = \frac{COV(R_i, R_M)}{\sigma^2(R_M)}, \quad (2)$$

where $E(R_i)$ is the expected return on asset i, R_f is the risk-free rate, R_M is the market return and $\beta_{i,M}$ is the market beta of asset I, which measures the sensitivity of the asset's return to variation in the market return. Although the left side of the equation is the risk-free rate, the other half is a measure of the compensation required by an investor for taking an additional risk. Beta is measured by the covariance of the asset return with the market return divided by the variance of the market return. Sharpe and Lintner suggest that the expected return on any asset i is the risk-free interest rate plus a risk premium, which is the asset's market beta, multiplied by the premium per unit of beta risk.

2.1.2 Black Zero-beta CAPM

The assumption of unrestricted risk-free borrowing and lending by Sharpe and in Lintner's CAPM has come under criticism in a number of studies. Black (1972) suggests this assumption is unrealistic and develops another version of the CAPM, relaxing that assumption but introducing two new assumptions. The first assumption is the non-availability of riskless asset, riskless borrowing or lending. He further assumes that there is a riskless asset in which lending (long position) is allowed but borrowing (short position) is restricted. Black (1972) assumes the liberty of the investor to borrow or lend the risky asset, unrestricted, in both cases, and concludes that an efficient market portfolio will be achieved with unrestricted short sales of the risky assets. The results of the study further show that the risky portion of any portfolio is a weighted combination of portfolios m and z, in which portfolio m depicts the market portfolio and z is the zero-beta portfolio with the minimum variance attribute. The study concludes that the investors will select portfolios that exhibit the minimum risk (zero beta) because the beta of their portfolio returns are uncorrelated with the beta of the market returns. According to Black's (1972) zero-beta CAPM, the equation of the return on risky asset i is specified as follows:

$$E(R_i) = E(R_z) + \beta[E(R_M) - E(R_z)] \quad (3)$$

where $E(R_z)$ is the expected return on zero-beta portfolio Z, which is defined as the portfolio that has the minimum variance of all portfolios uncorrelated with M. The different versions of the CAPM developed by Sharpe, Lintner and Black all indicate that beta is the correct measure of systematic risk, implying that changes in expected returns of individual security and portfolio are due to changes in the market beta.

2.1.3 Intertemporal-CAPM (ICAPM)

Merton (1973) derives the ICAPM, an extension of the CAPM that relaxes the single time period assumption of the traditional CAPM. In the ICAPM, there is an assumption of continuous trading, in which investors are not only concerned with the pay-off at the end of the current period but also with the opportunities of consumption and investment throughout the life of the risky asset. Unlike the traditional CAPM, the investor's decision at time period t-1 is influenced by how the wealth at time period t might vary with the future state of variables such as income, the prices of consumption goods, and the nature of investment opportunities. Thus, in Merton's (1973) ICAPM, investors act to maximize the expected utility of lifetime consumption. The ICAPM equation is as follows:

$$E(R_i) = R_f + \beta\left[E(R_M) - R_f\right] + \beta_j\left[E(R_n) - R_f\right], \quad (4)$$

where $E(R_n)$ denotes the expected rate of return of a portfolio that has perfect negative correlation with the risk-free asset and β_j represents the measure of volatility with respect to the hedging security. All rates of return used in this model are allowed to vary.

2.1.4 Arbitrage Pricing Theory (APT)

Another important asset-pricing model is the APT developed by Ross (1976). A clear distinction between the CAPM and the APT is that, whereas the former relies on only the systematic investment risk, which is the market risk, the latter includes several risk factors in explaining returns of individual assets or a portfolio. The theory contends that all asset returns are influenced by multiple risk factors that are driving security returns in a linear fashion. The APT equation is specified in its simplest form as follows:

$$E(R_i) = \lambda_0 + \lambda_1 \beta_{i,1}, \quad i = 1, 2, \ldots, n, \tag{5}$$

where the values of λ_0 and λ_1 are the same for every asset. Equation 5 holds as a strict equality only for a single-factor model. If there is a risk-free asset included, its return, R_f, equals λ_0. Conversely, if the factor model is constructed to explain excess returns, $R_i - R_f$, then $\lambda_0 = 0$. When $\lambda_0 = R_f$, the APT is specified as follows:

$$E(R_i) = R_f + \lambda_1 \beta_{i,1}, \ i = 1, 2, \ldots, n. \tag{6}$$

Weight λ_1 is interpreted as the risk premium of the source of the systematic risk. Similarly, a multifactor model is specified as follows:

$$E(R_i) = R_f + \lambda_1 \beta_{i,1} + \lambda_2 \beta_{i,2} + \cdots + \lambda_k \beta_{i,k}, \quad i = 1, 2, \ldots, n. \tag{7}$$

The asset pricing theories have also been tested empirically. One such study that succinctly captures and simplifies the vast literature on asset pricing theories is Fama and French (1993). They propose a three-factor model that adds two new factors to the traditional CAPM in an attempt to explain portfolio returns better. Their result provides evidence that the two new factors, size and firm value, are priced risk factors along with the market risk. The Fama-French approach has become a useful reference tool for both academia and professional investors.

Although many of the above-enumerated asset pricing theories and empirical validations have been criticized for their shortcomings, they continue to evolve to capture innovations and remain the foundation upon which modern asset pricing theories are built.

2.2 Empirical Models

In each of the three essays, there are various competing models. Our choice of models is informed by a combination of the justifications for their application in previous related studies and their suitability for the purpose.

2.2.1 Univariate ARMA-EGARCH Model

The general ARMA(r, s)-EGARCH (p, q) model specification for the return and volatility spillover between the FX market and the stock market is given in the following two equations:

$$X_t^{return} = \mu + \delta Y_{t-1}^{return} + \sum_{j=1}^{r} \emptyset_j X_{t-j} - \sum_{j=0}^{s} \theta_j \varepsilon_{t-j} \tag{8}$$

$$\log(\sigma_t^2) = \omega + \sum_{j=1}^{q} \beta_j \log(\sigma_{t-j}^2) + \sum_{j=1}^{p} \gamma_j \frac{\varepsilon_{t-j}}{\sqrt{\sigma_{t-j}^2}} + \sum_{j=1}^{p} \alpha_j \left[\frac{|\varepsilon_{t-j}|}{\sqrt{\sigma_{t-j}^2}} - \sqrt{\frac{2}{\pi}} \right] + \Psi\, Y_{t-1}^2 \qquad (9)$$

where $\varepsilon_t|\Omega_{t-1} \sim N[0, \sigma_t^2]$, and X_t^{return} = Stock return or FX return at time t, Y_t^{return}= FX or Stock return at time t.

Equation (1) is the conditional mean equation, indicating that X_t depends on the past value of Y_{t-1}, $\emptyset_j$ is the AR term, and θ_j is the MA term. Equation (2) represents the conditional variance. Parameters α_j and β_j capture the market news and forecast variance effects, respectively, whereas the Ψ parameter, which is the coefficient for the squared value of Y_{t-1}, captures the market volatility spillover effects on the market returns conditional variance. Furthermore, γ_j allows asymmetry in effects of news from the respective markets.

2.2.2 ARIMAx Model

In our second essay, we forecast using an ARIMAx model, specified as follows:

$$S_t = \mu + \beta_1 INF_{t-1} + \beta_2 IR_{t-1} + \beta_3 FX_{t-1} + \beta_4 OIL_{t-1} + \sum_{j=1}^{p} \emptyset_j\, S_{t-j} - \sum_{k=0}^{q} \theta_k\, \varepsilon_{t-k} \qquad (10)$$

where S_t is the log returns of the stock index, μ is the constant, INF_{t-1}, IR_{t-1}, FX_{t-1}, and OIL_{t-1} are the lags of the first difference of inflation and interest rates and the log returns of the exchange rate and oil price, respectively, for each country, ∅ is the AR term, and θ is the MA term.

2.2.3 Vector Autoregressive Model

In our third study, linkages between the stock market and macroeconomic variables are investigated using the unrestricted VAR model. The multivariate VAR is specified as follows:

$$Z_t = \alpha + \Phi_1 Z_{t-1} + \cdots + \Phi_k Z_{t-k} + \varepsilon_t \qquad (11)$$

where Z_t is a k vector of endogenous variables, $\Phi_1 \ldots \Phi_k$ are matrices of estimated coefficients, and ε_t is a vector of innovations that may be contemporaneously correlated with each other but uncorrelated with their own lagged values and uncorrelated with all of the right-hand side variables (Lütkepohl,1991).

3 Summaries of essays

The three essays in this PhD thesis, '***the currency effect on stock market relationships and stock return forecast***', are all single authored. Below is a summary of the essays, their key findings and their contribution to the body of knowledge.

3.1 Currency effect on the linkages between stock and FX markets

This study examines the currency effect on the return and volatility spillovers between the stock market and the exchange rate market in four countries using daily data from 2006 to 2010. This effect is investigated for Germany, the UK, Japan and the US in separate univariate ARMA-EGARCH models. Although our results for the home-currency-denominated model are consistent with the literature, which suggests significant mean and volatility spillovers from the stock market to the FX market and significant volatility spillover from the FX market to the stock market (Bodart & Reding, 2001, Yang & Doong, 2004, Aloui, 2007), the results of our aggregate currency models are, however, insightful.

In the aggregate model, we value stock indices and exchange rates in an aggregate basket of currencies, ensuring that both the stock indices and exchange rates are denominated in the same unit of account, rather than examining spillovers between pairwise exchange rates and stock indices denominated in different units of account. Our results show a reduction in magnitude of the return spillovers from the stock market to the FX market when compared with the home currency model. The return spillover from the FX market to the stock market is, however, strong and significant in two of the four countries examined. Previous studies have often failed to find significant return spillover from the FX market to the stock market, and when significant, it was weak.

Our results are particularly important to policymakers who track the relationship among macroeconomic indicators but also for asset managers who seek to diversify and invest in the two markets. Our study shows that the exchange rate market provides more information on the stock market than has been previously documented, which is important in designing a hedging strategy for portfolios and suggests that even domestic investors must be compensated for their exposure to currency risk. Our results also show that previous findings that show no significant predictive power from the exchange rates market to the stock market might not necessarily hold when both the stock and exchange rates are valued in the unit of account.

3.2 Currency effect and the short-term predictability of stock returns

This study examines the currency effect on stock returns forecast in the short term using monthly data from 2006 to 2010. We examine this effect in one advanced and one emerging economy. We estimate home currency and aggregate currency-denominated ARIMAx models for both countries. We conduct an in-sample forecast covering the whole sample period using the OLS method. An out-of-sample forecast was also conducted by estimating an ARIMAx model for the first half of the sample period and using the outcome to forecast the second half of the data sample. Correlations between our forecasts and the actual observed returns were also estimated.

Evidence from our evaluation parameters shows that aggregate currency models outperform home currency models 75% of the time, whereas the correlation between aggregate currency forecasts and their eventual outcomes also outperforms those of the home currency models across the board. Surprisingly, the correlation between the forecast for the aggregate currency-denominated index and the actual observations of the home currency-denominated returns outperform the correlation between the forecast of the home currency-denominated index and its actual observation 75% of the time. It is also instructive that the out-of-sample forecasts of the aggregate-denominated currency index returns correctly predicted the negative sign of the global market crash of October 2008 in both countries.

Our findings suggest that reducing the volatility of the explanatory variables can change the dynamics of asset predictability. The less volatile basket of currencies explains the better performance of the aggregate currency forecast results, which is an indication that stock returns can be better predicted in the short term if a more stable currency component is applied. This indication is particularly useful for professional investors because they always seek to outperform the market. Our results lend more credence to the literature that documents the predictability of stock returns (Fama, 1990, Chen, 2012, Gupta & Modise, 2012).

3.3 Currency effect on the long-term relationship between the stock market and macroeconomic variables

This paper investigates the currency effect on the long-term relationship between the stock market and macroeconomic variables in the US, employing monthly data from 2001 to 2010. Two VAR models were estimated, one pairing the US dollar-denominated S&P500 and macroeconomic variables, the other pairing an aggregate currency-denominated S&P500 and aggregate currency-denominated macroeconomic variables. Our study also examined the causal relationship between the stock market index and the economy.

The results of our aggregate currency-denominated VAR models show a weaker relationship between the stock market and macroeconomic variables compared with the US dollar-denominated model. We also note a change in the relationship between the stock indices and macroeconomic variables in the two models. Whereas the relationship between the stock returns and interest rate in the home currency model was significantly negative through the four lags, only the first lag of interest rate was significant in explaining stock returns in the aggregate currency model. The significance exhibited by stock returns in explaining some of the macroeconomic variables in the first model, particularly industrial production and money supply through the four lags, was absent in the aggregate currency model.

The granger-causality block significance results show a stronger causal relationship between the US dollar-denominated stock returns and macroeconomic variables than between the aggregate currency-denominated stock returns and aggregate currency-denominated macroeconomic variables. Our results suggest the currency of valuation is an important factor to be considered when examining the relationship between the stock market and the macro-economy. For the actual relationship between the variables to be clearly distilled, changes due to movement in the value of the currency of valuation and those due to changes in the value of the indices must be distinguished. This view is also supported by the works of Anderson, Bollerslev, Diebold and Vega (2007), and Mun (2011).

This result is important for both policymakers and investors alike. For policymakers, it is important that this relationship is not over- or understated because it will influence their policy targets and the policy levers to be deployed. Similarly, for investors, knowledge of the true magnitude and nature of the relationship between these variables is important in informing their design of investment strategies and choice of relevant parameters to track.

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Part II: The Essays

The currency effect on the linkages between stock and FX markets

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Abstract

The purpose of this study is to investigate the currency effect on return and volatility spillovers between the stock market and the foreign exchange (FX) market. Whereas most previous studies have examined the relationship between these markets using pairwise exchange rates of the home country relative to other foreign currencies and the home currency-denominated stock indices, we examine this relationship by valuing both the stock indices and the exchange rate in the same aggregate currency unit of account. The empirical results from our univariate ARMA-EGARCH models using an aggregate currency show a reduction in the magnitude of the mean spillover from the stock market to the FX market. The results also show strong and significant mean and volatility spillover from the FX market to the stock market in some of the countries examined. Many previous studies have documented FX market influence on the stock market to be weak and mostly insignificant. Our results suggest that the observed relationship between the stock and FX markets without accounting for the influence of the currency of valuation might not necessarily hold when the currency effect is discounted.

Keywords- ARMA-EGARCH, aggregate currency, stock index, FX, return and volatility spillovers.

JEL classification: C32, G15

1 Introduction

The relationship between the stock market and the foreign exchange (FX) market continues to enjoy significant interest from policymakers, academia and financial market participants because of the important role both markets play in a country's macroeconomic development and stability. Knowledge of this relationship is particularly important to the cross-border investor because the success of each investment is dependent on what occurs in both markets – because investing in an asset also means investing in the asset's currency of denomination. Thus, the net future value of such investments will be determined by the performance of the foreign asset and the performance of the home currency relative to the foreign currency.

Theoretically, two main approaches to the relationship between the stock market and the foreign exchange market have been established: the 'flow oriented' approach (Dornbusch & Fisher, 1980) and the 'stock oriented' approach (Branson, 1983). The 'flow oriented' approach expects an inverse relationship between the home currency and the stock market, with causality flowing from the FX market to the stock market. This expectation is premised on the expectation that exchange rate changes affect international competitiveness and trade balance. A depreciating domestic currency improves the competitiveness of domestic companies because their exports will be cheaper in international trade and invariably leads to an increase in stock prices.

The 'stock oriented' approach conversely suggests a positive relationship between the stock market and the domestic currency, with the causality flowing from the stock market to the FX market. This approach considers an internationally diversified portfolio and suggests that the demand and supply of domestic and foreign financial assets adjust to the changes in FX rates. Thus in this approach, increase in domestic stock prices will lead to an appreciation of the domestic currency because investor demand for domestic currency increases to purchase domestic equities.

Several empirical studies have also examined the relationship between the stock and FX markets. Although many studies show a strong and significant effect of the stock market on the FX market (Kanas, 2000, Bodart & Reding, 2001, Yang & Doong, 2004), many fail to establish any effect of the FX market on the stock market, and when it exists, the magnitude is usually low.

The presence of an exchange rate premium in stock returns has been widely documented (Dumas & Solnik, 1995, De Santis & Gerard, 1998, Francis, Hasan & Hunter, 2002, and Armstrong, Knif, Kolari & Pynnonen, 2012). The premium suggests that returns on stock consist of two components – the return due to change in the value of the stock and the return component due to change in the stock's currency of valuation. The changes in the pairwise exchange rates are also influenced by the strength or weakness of each of the paired currencies.

By failing to discount the exchange rate premium in the stock returns, we are unlikely to be able to determine the true relationship between the stock and the exchange rate market. The difference in the outcome between when the exchange rate is discounted and when it is left uncontrolled is what we have termed the currency. Our approach of converting both the stock index and the exchange rate to the same unit of account assumes that the exchange rate component on both sides of the equation evens out.

Thus, the objective of this study is to examine the currency effect on the mean and volatility spillovers between the stock market and the spot FX market. Whereas most previous studies have examined this relationship using home currency-denominated stock returns and pairwise exchange rates, our study utilizes stock returns and exchange rates denominated in the same aggregate currency unit of account. By valuing both the stock and exchange rate in the same currency, we expect to see the actual relationship between both markets. This approach is an extension of the existing body of knowledge and seeks to explain why previous studies failed to capture the effect of the FX market on the stock market.

The rest of the paper is organized as follows: section two will present a literature review. The methodology is described in section three. Data will be presented in section four and empirical results in section five. Section six will provide the summary and conclusion of the research.

2 Literature Review

There are two broad sets of literature that are of relevance to this study. The first set comprises those studies that investigate the presence of exchange rate premium in stock returns. The other set comprises studies that examine the mean and volatility spillover between the stock and FX markets.

Dumas and Solnik (1995) investigate whether exchange rate risk is priced in international asset markets across the four largest stock markets in the world – Germany, Japan, the United Kingdom and the United States. Their results show that exchange rate premium is priced in stock returns. The size of the currency premium in the stock and currency markets was examined in the same set by De Santis and Gerard (1998). Their results suggest the presence of an exchange rate premium, which could be either positive or negative.

Armstrong et al. (2012) investigate the international arbitrage pricing theory's proposition that changes in home currency affect asset factor loadings and risk premiums. Their results support the notion that currency movements are priced in stock returns. Muzindutsi and Niyimbanira (2012) examine the exchange rate risk in the Johannesburg Stock Exchange market using the arbitrage pricing theory model. Their results show that exchange risk is a priced factor in stock returns; hence, investors should earn a premium for exposure to the exchange rate risk.

Several studies have examined the dynamics of the interrelationship between the different financial markets. Although many of the earlier studies concentrated on the developed markets, recent studies have extended their views to emerging markets because global financial borders continue to narrow and international fund flows across markets are increasing greatly.

Aggarwal (1981) investigates the contemporaneous relationship between the stock market and exchange rates in the US under the floating exchange rate regime. The result of the study suggests a positive correlation between stock prices and the trade-weighted US dollar. Soenen and Hennigar (1988) conversely document a strong negative correlation between the stock market and the US dollar. Bahmani-Oskooee and Sohrabian (1992) examine the relationship between the stock market and the effective exchange rate of the US dollar, and their results suggest pairwise causality between the stock market and the effective exchange rate of the US dollar. In examining the spillover effect of the US stock market on the value of the dollar, using daily observations of the S&P 500 and the US dollar in terms of seven foreign currencies for the 1971-2002 time period, Johnson and Soenen (2004) find a consistently positive relationship in the daily movements of the S&P 500 and the US dollar.

Studies on the relationship between the stock market and exchange rates have also been examined in other industrialized countries. Ajayi and Mougoue (1996) examine the dynamic relationship between the stock market and exchange rates in eight industrialized countries. Their results show both short-term and long-term relationships between the two markets. Kanas (2000) examines the interdependence between the stock market and exchange rates in six industrialized countries, concluding that there is significant spillover from the stock market to the exchange rate changes in five of the six countries, but that spillover from the foreign exchange market to the stock market is insignificant in all of the countries.

Nieh and Lee (2001) document short-term relationships between the stock market and exchange rate but no long-term effect in the G-7 countries. Francis et al. (2002) investigate international linkages in the return and volatility spillovers of the stock and currency markets of four industrialized countries. Their results show bi-directional and significant relationships between the two markets after controlling for the currency effect. Yang and Doong (2004) examine price and volatility spillovers between stock prices and exchange rates in the G-7 countries in a multivariate EGARCH framework. Their results show that stock price movement affects exchange rate movements, but exchange rate changes exhibit less direct effect on future stock-price movements.

Aloui (2007) examines the price and volatility spillovers between exchange rates and stock indexes in the pre-Euro and post-euro period. The results of the study suggest causality in the mean and variance of the exchanges rates and stock indices in both sub-samples, with stock returns having more significance on the exchange rates than the reverse. Raghavanand and Dark (2008) investigate the return and volatility spillovers between the stock and foreign exchange markets in Australia. Their results show unidirectional return and volatility spillovers from the USD/AUD to the Australian all ordinaries index.

The relationship between the stock market and exchange rates has also been investigated in emerging markets. Granger, Huang and Yang (2000) examine causality between the stock and the FX markets in Asia using data from the Asian flu period. Although Malaysia, Thailand, Hong Kong, Taiwan and Singapore data show a strong linkage between the two markets, data from Japan did not follow any established pattern. The data from South Korea, however, follow the ‘flow oriented’ expectation of the FX market leading the stock market, and those of the Philippines follow ‘the stock oriented’ expectation of the stock market leading the FX market.

The interrelationship between the stock and FX markets was examined by Apte (2001). The results of the study suggest volatility spillover from the FX market to the stock market but not the other way around. In the study by Assoe (2001), evidence of unidirectional volatility spillover from the stock market to the FX market is documented.

Qayyum and Kemal (2006) examine the volatility spillover between the stock and foreign exchange markets in Pakistan. Their result shows volatility from one market affects the return of the other market. Mishra, Swain and Malhotra (2007) find bi-directional volatility spillovers between the stock market and exchange rates in India. Choi, Fang and Fu (2009) examine the volatility spillover between the stock market and exchange rate changes in New Zealand. The authors find a significant unidirectional volatility spillover from the stock market to the NZD/AUD exchange rate in the full sample and the sub-periods, and volatility spillover from the stock market to the NZD/USD only in the pre-Asian financial crisis sub-period.

Zhao (2010) investigates the dynamic relationship between the real effective exchange rate of the Renminbi and the Shanghai composite price index in a VAR-MGARCH framework. The results of the study suggest there are no mean spillovers between the foreign exchange rates and the stock market, but there is evidence of bidirectional volatility spillover between the two markets. Ulku and Demirci (2012) examine the joint dynamics of the FX and stock markets in the emerging economies in Europe. Their results show that the global developed and emerging stock markets’ returns influence a large proportion of the co-movement of the FX and stock markets.

Kumar (2013) investigates the returns and volatility spillover between stock prices and exchange rates in three emerging economies. The study outcome shows significant return and volatility spillover between the two markets, with the stock market exerting a more significant influence on the exchange rate market.

The literature on the relationship between both markets is, at best, inconclusive, with many of the studies only establishing mean spillover from the stock market to the FX market, and volatility spillover between both markets. The literature on the pricing of exchange rate in stock prices is, however, robust in supporting the existence of an exchange rate premium in stock prices.

3 Methodology

We examine the currency effect on the mean and volatility spillovers between the stock market and the FX market in four developed economies using a univariate ARMA(r, s)-EGARCH (p, q) model. Although there are a number of competing models that can adequately capture the strong ARCH effects exhibited by all of the return series of our dataset, Hamilton (1994) documents a significant number of studies that support the use of the EGARCH to model the conditional variance and volatility spillover. One of the advantages of the EGARCH over other competing models is the log form of the conditional variance, which guarantees that the conditional variance forecasts are non-negative. The model also allows us to capture the asymmetric effect in stock return data (Nelson, 1991). The inclusion of the ARMA structure is to adjust for possible serial correlation in the data. Our results suggest the model is a good fit.

For each country, our models will pair the home currency-denominated index with three pairwise exchange rates, using one pairwise exchange rate at a time. These results will then be compared with the results from the models pairing the aggregate currency-denominated stock index for each country with the aggregate currency exchange rate. The general ARMA(r, s)-EGARCH (p, q) model specification for the return and volatility spillover between the FX market and the stock market is given in the following two equations:

$$X_t^{return} = \mu + \delta\, Y_{t-1}^{return} + \sum_{j=1}^{r} \emptyset_j\, X_{t-j} - \sum_{j=0}^{s} \theta_j\, \varepsilon_{t-j} \qquad (1)$$

$$\log(\sigma_t^2) = \omega + \sum_{j=1}^{q} \beta_j \log\left(\sigma_{t-j}^2\right) + \sum_{j=1}^{p} \gamma_j \frac{\varepsilon_{t-j}}{\sqrt{\sigma_{t-j}^2}} + \sum_{j=1}^{p} \alpha_j \left[\frac{|\varepsilon_{t-j}|}{\sqrt{\sigma_{t-j}^2}} - \sqrt{\frac{2}{\pi}}\right] + \Psi\, Y_{t-1}^2 \qquad (2)$$

where $\varepsilon_t|\Omega_{t-1} \sim N[0, \sigma_t^2]$, X_t^{return} = Stock return or FX return at time *t,* and Y_t^{return}= FX or Stock return at time *t*.

Equation (1) is the conditional mean equation, indicating that X_t depends on the past value of Y_{t-1}, $\emptyset_j$is the AR term, and θ_j is the MA term. Equation (2) represents the conditional variance. The parameters α_j and β_j capture the market news and forecast variance effects, respectively, whereas the Ψ parameter, which is the coefficient for the squared value of Y_{t-1}, captures the market's volatility spillover effects on the market returns conditional variance. Furthermore, the γ_j allows asymmetry in effects of news from the respective markets.

4 Data

The empirical data employed in this study include the daily close of the Dow Jones Industrial Average (DJIA), the FTSE100 (FTSE), the DAX and the NIKKEI225 (NIKKEI) as proxies for the US, the UK, Germany and Japan, respectively. The DJIA and Nikkei225 are price-weighted indices, whereas the FTSE and DAX are market capitalisation-weighted. The US market is typically used to proxy the global market, but in this study, the US market may not be a good representative of the global market; previous study by De Santis and Gerard (1998) suggests currency premium is not priced in the US stock market.

Our chosen countries have the four largest stock markets in the world, with their currencies the most traded globally. The four countries also have different economic structures as suggested by the size of their merchandise trade relative to Gross Domestic Product (GDP), and hence, the exchange rate determination and drivers will differ. In 2013, merchandise trade as a percentage of GDP was 70.8%, 31.5%, 44.7% and 23.3% for Germany, Japan, the UK and the US, respectively.

The daily close of the currency pairs USD/JPY, USD/GBP, USD/EUR, GBP/USD, GBP/JPY, GBP/EUR, EUR/JPY, EUR/USD, EUR/GBP, JPY/USD, JPY/EUR, and JPY/GBP from January 1, 2006 to December 31, 2010 are also used. This period equivalent to one Special Drawing Right (SDR) regime because the weights of the currencies in the SDR basket are adjusted every five years. There are 1,305 daily observations in this dataset. The ordering of the pairwise exchange rates is such that the home currency of each country is set as the base currency. The (SDR) as formulated by the International Monetary Fund (IMF) is a combination of the GBP, USD, EUR, and JPY and will be applied as the currency basket.

The stock market indices will also be converted to their daily SDR values in an attempt to control for the home currency effect on each index. DJIASDR, FTSESDR, DAXSDR, and NIKKEISDR are the DJIA, FTSE100, DAX, and NIKKEI225, denominated in the SDR unit of account, respectively. Our dataset is the most recent completed SDR regime – each regime is a 5-year period in which given weights for the four currencies in the SDR basket are left unchanged. Additionally, Francis et al. (2002) suggest that volatility increases the correlation between markets; thus, we assume that due to the volatility that characterized this period, particularly during the 2008 global meltdown, we might experience significantly more mean and volatility spillovers from the pairwise exchange rates than previously documented.

Table 1 shows the descriptive statistics of our variables. Out of the total series of 21, 15 are positively skewed, which suggests that most of their values are to the left of their mean. The positive kurtosis of all of the series also shows that our data series are leptokurtic and that they exhibit excess kurtosis greater than zero, which suggests deviation from a normal distribution.

Table 1 Descriptive Statistics

	Mean	Median	Max	Min	S.D	Skewness	Kurtosis	Jarque-Bera	Obs.	ADF t-stat.
DAX	0.0005	0.0010	0.13	-0.09	0.018	0.31	10.25	2876.41	1304	-36.80
DAXSDR	0.0004	0.0009	0.12	-0.08	0.018	0.31	9.89	2598.85	1304	-38.20
DJIA	0.0001	0.0004	0.11	-0.08	0.014	0.03	12.30	4701.96	1304	-30.00
DJIASDR	0.0000	0.0004	0.11	-0.08	0.016	0.23	10.86	3364.98	1304	-31.60
FTSE	0.0001	0.0007	0.12	-0.09	0.018	0.09	9.77	2493.41	1304	-38.10
FTSESDR	0.0000	0.0006	0.11	-0.09	0.017	0.01	10.30	2892.99	1304	-28.50
NIKKEI	0.0000	0.0000	0.1	-0.11	0.015	-0.13	9.49	2290.90	1304	-37.00
NIKKEISDR	0.0000	-0.0003	0.11	-0.10	0.015	0.00	8.75	1795.31	1304	-40.60
EURGBP	0.0002	-0.0002	0.05	-0.04	0.008	0.36	9.80	2542.50	1304	-44.80
GBPEUR	-0.0001	0.0002	0.04	-0.04	0.008	-0.16	9.65	2406.64	1304	-44.80
EURJPY	-0.0002	0.0000	0.08	-0.05	0.010	0.13	10.50	3056.50	1304	-28.20
JPYEUR	0.0002	0.0000	0.05	-0.07	0.010	0.13	9.78	2498.56	1304	-37.90
EURUSD	0.0001	0.0001	0.05	-0.04	0.007	0.31	7.69	1214.04	1304	-34.60
USDEUR	-0.0001	-0.0001	0.04	-0.05	0.007	-0.18	7.38	1051.31	1304	-34.50
GBPJPY	-0.0003	0.0000	0.09	-0.05	0.011	-0.09	11.14	3605.39	1304	-36.00
JPYGBP	0.0004	0.0000	0.06	-0.08	0.011	0.40	10.51	3096.44	1304	-35.90
GBPUSD	-0.0001	0.0000	0.05	-0.05	0.008	-0.22	8.86	1877.96	1304	-38.60
USDGBP	0.0001	0.0000	0.05	-0.04	0.008	0.41	8.95	1958.51	1304	-38.60
JPYUSD	0.0003	0.0000	0.04	-0.03	0.008	0.51	5.82	488.57	1304	-38.90
USDJPY	-0.0003	0.0000	0.03	-0.04	0.008	-0.41	5.65	418.21	1304	-38.80
SDR	0.0001	0.0000	0.06	-0.05	0.006	0.43	33.19	49557.25	1304	-26.00

Above values are the descriptive statistics for the returns, and first differences of the variables. Number of lags in ADF determined by Schwartz information criterion (SIC). Null hypothesis of unit root rejected at the level for all the return series at 1% critical level (MacKinnon 1996), critical value -3.49.

All of the aggregate currency-denominated stock indices exhibit lower kurtosis than do their respective home currency-denominated stock indices except that of the FTSESDR. The means of all of the eight stock indices are positive, suggesting that the series had more positive returns than negative.

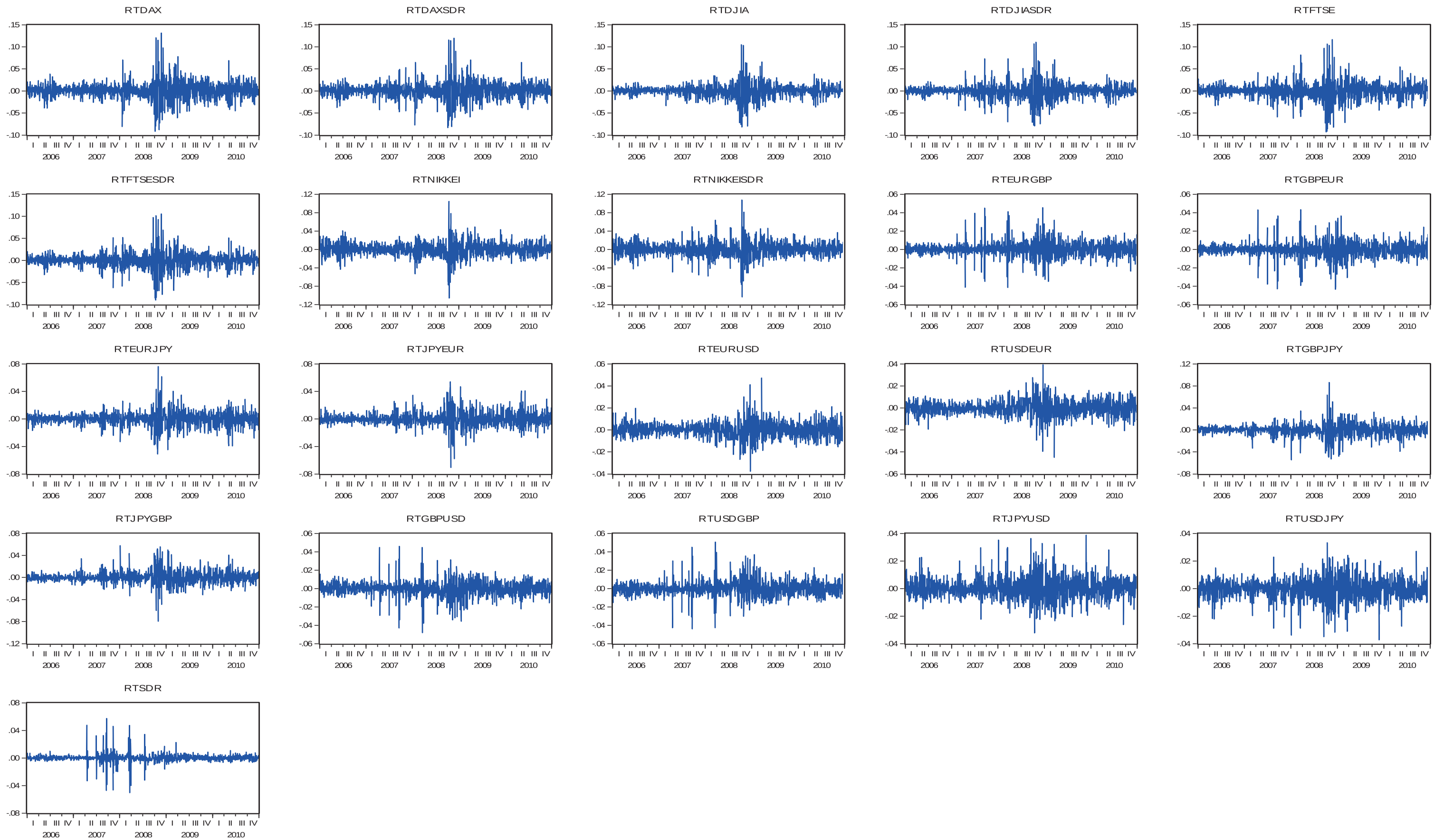
5 Empirical Findings

The stationarity of the return series of the variables employed is investigated using the Augmented Dickey-Fuller unit root test. The results of the unit root test in Table 1 show that the return series are all integrated of order zero.

We investigate the presence of ARCH effects in our variables by estimating a linear equation and applying Breusch-Godfrey and Engle's LM tests to the residuals at lags 10 and 20, respectively. The results suggest the presence of ARCH effect in our variables because their probability values are highly significant. The Ljung-Box Q-statistic of residuals and squared residuals also suggests autocorrelation in the residuals because the probability values at lags 10 and 30 are highly significant.

Figure 1 shows the graphical representation of the return series for the exchange rates and the stock market indices. The return series in Figure 1 suggests volatility clustering because we see volatile periods each are likely to be followed by a volatile period until the noise dissipates. The 2008 global financial crisis is clearly noticeable in both the indices and exchange rate returns because this was a period of high volatility and uncertainty in most financial markets around the world.

Figure 1 Return series of variables



5.1 Return and volatility spillover from the FX market to the stock market

The results of the ARMA-EGARCH models for Germany, the UK, Japan and the US are presented in Tables 2-5, respectively. For each country, the models pair the return series of the home currency-denominated stock index and one-day lag of three exchange-rate pairs, using one exchange rate pair at a time. The outcomes are then compared with the result of the model with the SDR-denominated stock index and one-day lag of the SDR exchange rate for each specific country.

In the home currency-denominated stock and pairwise exchange rate models, low-order ARMA and EGARCH were selected as the best fit for all of the countries, with the highest being an ARMA (2, 2) – EGARCH (2, 2), selected for Japan's NIKKEI and JPYUSD exchange rate. In the aggregate currency-denominated stock and exchange rate models, ARMA (1, 1)-EGARCH (1, 1) was selected for all of the countries with the exception of Germany, where an ARMA (2, 1)-EGARCH (2, 1) was the best fit.

The mean equations for Germany show no statistically significant return spillover (δ) from any of the three FX pairs to the DAX. In the aggregate currency-denominated mean equation, however, there is strong and significantly positive return spillover from the SDR exchange rate to the SDR-denominated DAX, with a coefficient of 0.27.

Table 2 Return and volatility spillover from FX and SDR to DAX and DAXSDR

	EURGBP	*EURUSD*	*EURJPY*	*SDR*
Mean Equation				
μ	0.00	0.00*	0.00	0.00
δ	-0.04	0.09	0.025	0.27***
Variance Equation				
ω	-0.26***	-0.35***	-0.37***	-0.27***
α_1	0.003	0.13***	0.01	0.17***
α_2	0.14***	-----	0.13**	-0.05
β_1	0.98***	0.97***	0.97***	0.98***
γ	0.13***	-0.12***	-0.12***	-0.13***
ψ	-23.69	252.79**	87.57**	-113.43***
Diagnostic tests				
LB-Q(10)	0.42	0.78	0.79	0.40
LB-Q(30)	0.39	0.59	0.58	0.12
LB-Q²(10)	0.10	0.26	0.10	0.32
LB-Q²(30)	0.10	0.18	0.11	0.90
ARCH-LM (5)	0.70	0.28	0.66	0.66
ARCH-LM (20)	0.13	0.14	0.16	0.82

Note: ***, **, & *, denote significance at 1%, 5% and 10% respectively. Q, Q^2 and LM are the residual diagnostic parameters, and reported diagnostic values are the corresponding p-values. Model estimated as: $X_t^{return} = \mu_1 + \delta_1 Y_{t-1}^{return} + \sum_{j=1}^{r} \emptyset_{1,j} X_{t-j} - \sum_{j=0}^{s} \theta_{1,j} \varepsilon_{t-j}$; $\log(\sigma_t^2) = \omega_1 + \sum_{j=1}^{q} \beta_{1,j} \log(\sigma_{1,t-j}^2) +$

$\sum_{j=1}^{p} \gamma_{1,j} \frac{\varepsilon_{t-j}}{\sqrt{\sigma_{t-j}^2}} + \sum_{j=1}^{p} \alpha_{1,j} \left[\frac{|\varepsilon_{t-j}|}{\sqrt{\sigma_{t-j}^2}} - \sqrt{\frac{2}{\pi}} \right] + \Psi_1 Y_{t-1}^2$. Where X_t is stock return, Y_t is FX return. Large P-values here indicate there are no serial correlations or ARCH effects in the model residuals.

In the variance equation of the DAX with the pairwise exchange rates, the results show significant volatility spillover (ψ) from the EURUSD and EURJPY to the DAX index. The significantly negative asymmetry (γ) in their variance equation implies that negative return shock engenders higher volatility than does positive return shock. The significantly high (β_1) coefficient confirms volatility persistence. The significantly positive α_1 values suggest the existence of volatility clustering.

There is substantial evidence of volatility spillover (ψ) from the SDR to the DAXSDR index. The significantly negative asymmetry (γ) in the variance equation of the DAXSDR implies that volatility increases more with negative shocks than with positive shocks. The volatility persistence is indicated by the (β_1) parameter, which is high and significant.

In the UK, only the GBPEUR is significant in the mean equation of the three pairwise exchange rates, with a negative sign that suggests there is negative return spillover from the GBPEUR exchange rate to the FTSE stock index. The result of the mean equation of the SDR-denominated FTSE, however, shows no significant return spillover from the SDR exchange rate to the SDR-denominated FTSE.

Table 3 Return and volatility spillover from FX and SDR to FTSE and FTSESDR

	GBPUSD	*GBPEUR*	*GBPJPY*	*SDR*
Mean Equation				
μ	0.00**	0.00	0.00	0.00
δ	-0.07	-0.14**	0.03	-0.05
Variance Equation				
ω	-0.24***	-0.29***	-0.43***	-0.29***
α_1	0.19***	0.19***	0.19***	0.17***
β_1	0.99***	0.98***	0.97***	0.98***
γ	-0.06***	-0.07***	-0.08***	-0.10***
ψ	-111.5*	-22.30	76.39*	-88.57**
Diagnostic tests				
LB-Q(10)	0.88	0.83	0.57	0.96
LB-Q(30)	0.97	0.97	0.87	0.83
LB-Q²(10)	0.30	0.49	0.25	0.67
LB-Q²(30)	0.95	0.98	0.94	0.85
ARCH-LM (5)	0.19	0.34	0.20	0.63
ARCH-LM (20)	0.90	0.96	0.84	0.91

Note: ***, **, & *, denote significance at 1%, 5% and 10% respectively. Q, Q² and LM are the residual diagnostic parameters, and reported diagnostic values are the corresponding p-values. Model estimated as: $X_t^{return} = \mu + \delta Y_{t-1}^{return} + \sum_{j=1}^{r} \emptyset_j X_{t-j} - \sum_{j=0}^{s} \theta_j \varepsilon_{t-j}$; $\log(\sigma_t^2) = \omega + \sum_{j=1}^{q} \beta_j \log(\sigma_{t-j}^2) + \sum_{j=1}^{p} \gamma_j \frac{\varepsilon_{t-j}}{\sqrt{\sigma_{t-j}^2}} + \sum_{j=1}^{p} \alpha_j \left[\frac{|\varepsilon_{t-j}|}{\sqrt{\sigma_{t-j}^2}} - \sqrt{\frac{2}{\pi}} \right] + \Psi Y_{t-1}^2$. Where X_t is stock return, Y_t is FX return. Large P-values here indicate there are no serial correlations or ARCH effects in the model residuals.

In the variance equation for the UK, the results show significant volatility spillover (ψ) from the GBPUSD and GBPJPY to the FTSE index; however, the GBPEUR volatility does not affect the FTSE. The significantly negative asymmetry (γ) in the variance equations of the FTSE with the three pairwise exchange rates implies that negative shock induces more volatility than do positive shocks. The volatility is also persistent, and there is sufficient evidence of volatility clustering. There is also significant volatility spillover (ψ) from the SDR to the FTSESDR index, and there is negative asymmetry (γ). There is significant evidence of volatility persistence and clustering.

The estimated coefficients of the conditional mean equation confirm, and statistically significantly, negative return spillover from the pairwise exchange rates to the stock index in Japan.

Table 4 Return and volatility spillover from FX and SDR to NIKKEI and NIKKEISDR

	JPYUSD	*JPYEUR*	*JPYGBP*	*SDR*
Mean Equation				
μ	-0.00	-0.00	-0.00	-0.00
δ	-0.21***	-0.22***	-0.14***	0.45***
Variance Equation				
ω	-0.51***	-0.26***	-0.26***	-0.23***
α_1	-0.10**	0.01	-0.02	0.09***
α_2	0.23***	0.10**	0.11**	-----
β_1	0.47***	0.98***	0.98***	0.98***
β_2	0.49***	-----	-----	-----
γ	-0.16***	-0.12***	-0.10***	-0.13***
ψ	-399.21***	43.90	37.36	-58.61**
Diagnostic tests				
LB-Q(10)	0.30	0.74	0.94	0.84
LB-Q(30)	0.57	0.85	0.88	0.72
LB-Q²(10)	0.10	0.10	0.12	0.35
LB-Q²(30)	0.26	0.18	0.19	0.89
ARCH-LM (5)	0.65	0.34	0.24	0.78
ARCH-LM (20)	0.37	0.36	0.24	0.73

Note: ***, **, & *, denote significance at 1%, 5% and 10% respectively. Q, Q² and LM are the residual diagnostic parameters, and reported diagnostic values are the corresponding p-values. Model estimated as: $X_t^{return} = \mu + \delta Y_{t-1}^{return} + \sum_{j=1}^{r} \emptyset_j X_{t-j} - \sum_{j=0}^{s} \theta_j \varepsilon_{t-j}$; $\log(\sigma_t^2) = \omega + \sum_{j=1}^{q} \beta_j \log(\sigma_{t-j}^2) + \sum_{j=1}^{p} \gamma_j \frac{\varepsilon_{t-j}}{\sqrt{\sigma_{t-j}^2}} + \sum_{j=1}^{p} \alpha_j \left[\frac{|\varepsilon_{t-j}|}{\sqrt{\sigma_{t-j}^2}} - \sqrt{\frac{2}{\pi}}\right] + \Psi Y_{t-1}^2$ where X_t is stock return , Y_t is FX return. Large P-values here indicate there are no serial correlations or ARCH effects in the model residuals.

The result of the mean equation of the SDR-denominated NIKKEI index also shows significant spillover from the SDR exchange rate to the SDR-denominated NIKKEI, although with a positive sign. These results indicate that current returns in Japan's stock market are influenced by previous returns in the FX market.

In the variance equation, the results show significant volatility spillover (ψ) only from the JPYUSD exchange rate to the NIKKEI index. There is also significantly negative asymmetry (γ) of information. The volatility is persistent and shows evidence of clustering. The aggregate equation shows significant negative volatility spillover (ψ) from the SDR to the NIKKEISDR index, with also significantly negative asymmetry (γ). There is evidence of significant volatility persistence and clustering.

In the mean equation for the US, there is no significant return spillover from any of the three pairwise exchange rates to the DJIA stock index; nor is there significant return spillover in the mean equation of the SDR-denominated DJIA. In the variance equation of the DJIA with the pairwise exchange rates, however, the results show significantly positive volatility spillover (ψ) from the USDEUR and USDJPY to the DJIA index. The significantly negative asymmetry (γ) suggests that the variance responds more to negative innovations than to positive shocks. The persistence parameter (β_1) is significantly high, and there is evidence of volatility clustering. In the aggregate equation, the volatility of the SDR does not influence the aggregate DJIA index.

Table 5 Return and volatility spillover from FX and SDR to DJIA and DJIASDR

	USDGBP	*USDEUR*	*USDJPY*	*SDR*
Mean Equation				
μ	0.00	0.00	0.00	0.00
δ	-0.05	-0.04	-0.01	0.10
Variance Equation				
ω	-0.36***	-0.44***	-0.52***	-0.29***
α_1	-0.17***	-0.18***	-0.22***	0.13***
α_2	0.31***	0.33	0.35***	-----
β_1	0.97***	0.97***	0.97***	0.98***
γ	-0.16***	-0.16***	-0.17***	-0.15***
ψ	54.46	201.59**	425.21***	-46.41
Diagnostic tests				
LB-Q(10)	0.22	0.43	0.37	0.41
LB-Q(30)	0.24	0.41	0.28	0.28
LB-Q²(10)	0.24	0.32	0.31	0.61
LB-Q²(30)	0.88	0.85	0.82	0.99
ARCH-LM (5)	0.81	0.72	0.73	0.69
ARCH-LM (20)	0.88	0.83	0.91	0.98

Note: ***, **, & *, denote significance at 1%, 5% and 10% respectively. Q, Q^2 and LM are the residual diagnostic parameters, and reported diagnostic values are the corresponding p-values. Model estimated as: $X_t^{return} = \mu + \delta Y_{t-1}^{return} + \sum_{j=1}^{r} \emptyset_j X_{t-j} - \sum_{j=0}^{s} \theta_j \varepsilon_{t-j}$: $\log(\sigma_t^2) = \omega + \sum_{j=1}^{q} \beta_j \log(\sigma_{t-j}^2) + \sum_{j=1}^{p} \gamma_j \frac{\varepsilon_{t-j}}{\sqrt{\sigma_{t-j}^2}} + \sum_{j=1}^{p} \alpha_j \left[\frac{|\varepsilon_{t-j}|}{\sqrt{\sigma_{t-j}^2}} - \sqrt{\frac{2}{\pi}} \right] + \Psi Y_{t-1}^2$, where X_t is stock return, Y_t is FX return. Large P-values here indicate there are no serial correlations or ARCH effects in the model residuals.

The Ljung-Box Q-statistics, Ljung-Box Q^2-statistics and ARCH-LM robustness tests of the residuals and squared residuals of all of our models suggest that the models are well specified and properly capture the ARCH effects.

Again, concentrating on the mean equation, we see a minimal effect of the information from the FX market on the stock market using the pairwise exchange rates. Only the UK and Japan show a significant effect of the FX market on the stock market. In Japan, previous changes in the three pairwise exchange rates influence the current return of the NIKKEI. In the UK, however, only the previous return of the GBP/EUR exchange rate influences the current returns of the FTSE. For the aggregate currency-denominated model, conversely, both Germany and Japan showed a significant effect of the FX market on the stock market. Germany and Japan's coefficients are also the largest at 0.27 and 0.45, respectively, in all of the estimates examining the direction of influence in both markets.

Based on the half-life of a shock ($\ln(0.5)/\ln(\beta_1)$), on average, volatility shocks to markets in Germany, the UK, Japan and the US lasted for approximately 31, 40, 30 and 26 days, respectively.

5.2 Return and volatility spillover from the stock market to the FX market

The results of the ARMA-EGARCH models for Germany, the UK, Japan and the US are presented in Tables 6-9, respectively. The models investigate the existence of mean and volatility spillover from the stock market to the FX market by pairing the return series of three pairwise exchange rates with one-day lag of the stock index for the respective countries, using one exchange rate pair at a time. Another model pairs the aggregate currency exchange rate and one-day lag of the aggregate currency-denominated stock index for the respective countries. We compare the results of the pairwise exchange rate and the aggregate exchange rate models. The best-fit models selected for both the pairwise exchange rate models and the aggregate currency models were low-order ARMA–EGARCH.

Out of the three mean equations of the pairwise exchange rates for Germany, there is significant spillover (δ) from the DAX to only the EURJPY, which suggests the DAX does not influence the returns of the EURUSD and EURGBP exchange rates. There is also no return spillover from the SDR-denominated DAX to the SDR exchange rate.

The weak mean spillover from the DAX to the FX market might be a function of the fact that the Euro is a currency used by approximately 19 countries in Europe; hence, its value is not unilaterally determined by activities in Germany, whose stock index was used as our proxy for the Euro area. The spillover may also be a function of the fact that Germany is not globally considered one of the major financial hubs; hence, activities in the country's stock market may not be sufficiently significant to induce changes in Euro bilateral exchange rates.

Table 6 Return and volatility spillover from DAX and DAXSDR to FX and SDR

	EURUSD	*EURJPY*	*EURGBP*	*SDR*
Mean Equation				
μ	0.00	-0.00	0.00	-0.00
δ	0.00	0.24***	0.01	0.00
Variance Equation				
ω	-0.13***	-0.39***	-0.89***	-1.17***
α_1	-0.12**	0.27***	0.26***	0.29***
α_2	0.19***	-0.16***	------	-0.04*
β_1	0.99***	0.97***	0.93***	0.91***
γ	-0.01	-0.07***	-0.01	0.20***
ψ	13.65**	25.62**	58.97***	28.75**
Diagnostic tests				
LB-Q (10)	0.91	0.72	0.74	0.60
LB-Q (30)	0.86	0.57	0.95	0.78
LB-Q²(10)	0.81	0.98	0.32	0.91
LB-Q²(30)	0.74	0.99	0.98	0.99
ARCH-LM (5)	0.90	0.98	0.19	0.99
ARCH-LM (20)	0.70	0.99	0.92	0.99

Note: ***, **, & *, denote significance at 1%, 5% and 10% respectively. Q, Q² and LM are the residual diagnostic parameters, and reported diagnostic values are the corresponding p-values. Model estimated as: $Y_t^{return} = \mu + \delta X_{t-1}^{return} + \sum_{j=1}^{r} \emptyset_j Y_{t-j} - \sum_{j=0}^{s} \theta_j \varepsilon_{t-j}$: $\log(\sigma_t^2) = \omega + \sum_{j=1}^{q} \beta_j \log(\sigma_{t-j}^2) + \sum_{j=1}^{p} \gamma_j \frac{\varepsilon_{t-i}}{\sqrt{\sigma_{t-i}^2}} + \sum_{j=1}^{p} \alpha_j \left[\frac{|\varepsilon_{t-i}|}{\sqrt{\sigma_{t-i}^2}} - \sqrt{\frac{2}{\pi}} \right] + \Psi X_{t-1}^2$ where Y_t is FX return, X_t is stock return. Large P-values here indicate there are no serial correlations or ARCH effects in the model residuals.

In the variance equation, however, there is significantly positive volatility spillover (ψ) from the DAX to the three pairwise exchange rates. The significantly negative asymmetry (γ) in the variance equation of the DAX with the EURJPY exchange rate implies that positive returns shock induces lower volatility than do negative returns shock. This result is intuitive and has been validated by a number of previous studies; uncertainty engenders higher variance in the financial markets than do positive innovations. The persistence parameter (β_1) is significantly high and, as expected, less than one in each of the models with the three pairwise exchange rate equations. The significantly positive α_1 values suggest the existence of volatility clustering, which implies that periods of calm are likely to be bunched together, as are periods of high volatility.

In the variance equation of the SDR-denominated DAX, the result shows significantly positive volatility spillover (ψ) from the DAXSDR index to the SDR. The significantly positive asymmetry (γ) in the variance equation of the DAXSDR implies that the volatility increases more with positive shocks than with negative innovations, which is counterintuitive because the expectation is usually for negative innovations to induce more volatility than positive innovations. The persistence parameter (β_1) is significantly high and less than one, as expected. The significantly positive α_1 value suggests the existence of volatility clustering.

In the UK markets, the return spillover (*δ)* from the FTSE to the exchange rates is significantly positive for both the GBPUSD and the GBPJPY, but not significant for the GBPEUR. The results suggest that today's FTSE return is useful in explaining the returns of the GBPUSD and GBPJPY the next day. In the mean equation of the SDR-denominated FTSE, there is significantly positive mean spillover from the SDR-denominated FTSE to the SDR exchange rate.

The UK result is unsurprising. According to the BIS 2013 triennial Central Bank survey, the UK remains the number one jurisdiction for currency trades globally, and the stock market is both developed and sizable. London also remains one of the top three financial hubs globally. There is also close integration between the UK financial market and those of other equally developed markets due to its role as a major facilitator of financial deals.

Table 7 Return and volatility spillover from FTSE and FTSESDR to FX and SDR

	GBPUSD	*GBPJPY*	*GBPEUR*	*SDR*
Mean Equation				
μ	0.00	-0.00	0.00	-0.00
δ	0.04***	0.25***	-0.02	0.02***
Variance Equation				
ω	-1.65***	-0.27***	-0.85***	-1.30***
α_1	0.22***	0.07***	0.23***	0.26***
β_1	0.85***	0.98***	0.93***	0.90***
γ	0.12***	-0.06***	0.002	0.22***
ψ	133.91***	22.56***	55.33***	55.16***
Diagnostic tests				
LB-Q(10)	0.94	0.47	0.76	0.60
LB-Q(30)	0.93	0.94	0.95	0.78
LB-Q²(10)	0.15	0.97	0.38	0.91
LB-Q²(30)	0.56	0.99	0.99	0.99
ARCH-LM (5)	0.17	0.96	0.23	0.99
ARCH-LM (20)	0.39	0.99	0.96	0.99

Note: ***, **, & *, denote significance at 1%, 5% and 10% respectively. Q, Q² and LM are the residual diagnostic parameters, and reported diagnostic values are the corresponding p-values. Model estimated as: $Y_t^{return} = \mu + \delta X_{t-1}^{return} + \sum_{j=1}^{r} \emptyset_j Y_{t-j} - \sum_{j=0}^{s} \theta_j \varepsilon_{t-j}$: $\log(\sigma_t^2) = \omega + \sum_{j=1}^{q} \beta_j \log(\sigma_{t-j}^2) + \sum_{j=1}^{p} \gamma_j \frac{\varepsilon_{t-i}}{\sqrt{\sigma_{t-i}^2}} + \sum_{j=1}^{p} \alpha_j \left[\frac{|\varepsilon_{t-i}|}{\sqrt{\sigma_{t-i}^2}} - \sqrt{\frac{2}{\pi}} \right] + \Psi X_{t-1}^2$ where Y_t is FX return, X_t is stock return. Large P-values here indicate there are no serial correlations or ARCH effects in the model residuals.

In the variance equation of the FTSE with the pairwise exchange rates, the results show strong significantly positive volatility spillover (*ψ*) from the FTSE to the exchange rates. There is significantly negative asymmetry (γ) of information from the FTSE to the GBPJPY exchange rate, which implies that the variance responds more to negative innovations than to positive shocks. There is, however, significantly positive asymmetry of information from the FTSE to the GBPUSD, which suggests that a negative returns shock to the GBPUSD produces lower volatility than does a positive returns shock. The significantly positive (γ) coefficient confirms that there is a leverage effect in the UK currency market. The persistence parameter, (β_1), is significantly high but finite, as expected, in each of the models with the three pairwise exchange rate equations. The significantly positive α_1 values suggest the existence of volatility clustering.

In the variance equation of the SDR-denominated FTSE, the result shows significantly positive volatility spillover (ψ) from the FTSESDR index to the SDR exchange rate. The asymmetry parameter (γ) is significantly positive in the variance equation of the FTSESDR with the SDR exchange rate, implying that the volatility responds more to positive shocks than to negative innovations. Good news to the FX market has an effect of 0.26. Volatility is persistent in the UK currency market, and the significantly positive α_1 value suggests the existence of volatility clustering.

In Japan, out of the three conditional mean equations for the pairwise exchange rates, the spillover from the NIKKEI (δ) is only significant on the JPYUSD. The NIKKEI is not significant in explaining the returns of the JPYGBP and JPYEUR exchange rates. In the mean equation of the SDR-denominated NIKKEI index, there is significantly positive return spillover from the NIKKEI to the SDR exchange rate, with a coefficient of 0.01.

The estimated coefficient of the conditional variance equation of the NIKKEI on the exchange rates is only statistically significant for the JPYUSD exchange rate. There is significantly positive asymmetry (γ) of information from the NIKKEI to the JPYUSD exchange rates, which confirms the existence of a leverage effect in the exchange rate market during this period. The significantly high (β_1) confirms volatility persistence. The significantly positive α_1 values also suggest the existence of volatility clustering. The volatility spillover from the SDR-denominated NIKKEI to the SDR exchange rate is, however, not significant.

Table 8 Return and volatility spillover from NIKKEI and NIKKEISDR to FX and SDR

	JPYGBP	*JPYUSD*	*JPYEUR*	*SDR*
Mean Equation				
μ_2	0.00**	0.00	0.00	-0.00
δ_2	-0.01	0.04**	-0.00	0.01**
Variance Equation				
ω_2	-0.16***	-0.23***	-0.22***	-1.06***
$\alpha_{2,1}$	0.08***	0.06***	0.09***	0.29***
$\alpha_{2,2}$	-----	-----	------	-0.07***
$\beta_{2,1}$	0.98***	0.98***	0.98***	0.92***
γ_2	0.08***	0.08***	0.09***	0.20***
ψ_2	9.8	9.02***	12.09	17.13
Diagnostic tests				
LB-Q(10)	0.10	0.16	0.30	0.71
LB-Q(30)	0.55	0.73	0.57	0.83
LB-Q²(10)	0.44	0.20	0.88	0.97
LB-Q²(30)	0.95	0.92	0.99	0.99
ARCH-LM (5)	0.41	0.98	0.89	0.97
ARCH-LM (20)	0.97	0.94	0.97	0.98

Note: ***, **, & *, denote significance at 1%, 5% and 10% respectively. Q, Q² and LM are the residual diagnostic parameters, and reported diagnostic values are the corresponding p-values. Model estimated as: $Y_t^{return} = \mu + \delta X_{t-1}^{return} + \sum_{j=1}^{r} \emptyset_j Y_{t-j} - \sum_{j=0}^{s} \theta_j \varepsilon_{t-j}$: $\log(\sigma_t^2) = \omega + \sum_{j=1}^{q} \beta_j \log(\sigma_{t-j}^2) + \sum_{j=1}^{p} \gamma_j \frac{\varepsilon_{t-i}}{\sqrt{\sigma_{t-i}^2}} +$

$\sum_{j=1}^{p} \alpha_j \left[\frac{|\varepsilon_{t-i}|}{\sqrt{\sigma_{t-i}^2}} - \sqrt{\frac{2}{\pi}} \right] + \Psi X_{t-1}^2$ where Y_t is FX return, X_t is stock return. Large P-values here indicate there are no serial correlations or ARCH effects in the model residuals.

The coefficients of the conditional mean spillovers from the US stock index, the DJIA, to the three pairwise exchange rates are all statistically significant. Although that of the USDJPY carries a positive sign, the signs of the other two are negative. In addition, the mean spillover from the SDR-denominated DJIA to the SDR exchange rate is statistically significant, implying that previous changes in the stock market influence current changes in the exchange rate market.

The significant results for the US market confirm their importance in the global financial markets. The US has the largest stock market in the world (World Federation of Exchanges), with the US dollar the most traded currency globally (BIS, 2013). The confluence of these two important positions makes integration stronger for the US market.

Table 9 Return and volatility spillover from DJIA and DJIASDR to FX and SDR

	USDGBP	*USDJPY*	*USDEUR*	*SDR*
Mean Equation				
μ_2	-0.00	-0.00	-0.00	-0.00
δ_2	-0.14***	0.05***	-0.04***	0.04***
Variance Equation				
ω_2	-1.86***	-0.38***	-0.14***	-1.02***
$\alpha_{2,1}$	0.27***	0.07***	0.06***	0.32***
$\alpha_{2,2}$	-----	-----	------	-0.10***
$\beta_{2,1}$	0.84***	0.97***	0.99***	0.92***
γ_2	-0.13***	-0.06***	0.006	0.21***
ψ_2	172.13***	41.56***	22.76***	38.12***
Diagnostic tests				
LB-Q(10)	0.86	0.50	0.96	0.60
LB-Q(30)	0.77	0.64	0.92	0.38
LB-Q²(10)	0.24	0.12	0.34	0.99
LB-Q²(30)	0.46	0.86	0.38	0.98
ARCH-LM (5)	0.13	0.93	0.31	0.99
ARCH-LM (20)	0.28	0.89	0.47	0.99

Note: ***, **, & *, denote significance at 1%, 5% and 10% respectively. Q, Q² and LM are the residual diagnostic parameters, and reported diagnostic values are the corresponding p-values. Model estimated as: $Y_t^{return} = \mu + \delta X_{t-1}^{return} + \sum_{j=1}^{r} \emptyset_j Y_{t-j} - \sum_{j=0}^{s} \theta_j \varepsilon_{t-j}$: $\log(\sigma_t^2) = \omega + \sum_{j=1}^{q} \beta_j \log(\sigma_{t-j}^2) + \sum_{j=1}^{p} \gamma_j \frac{\varepsilon_{t-i}}{\sqrt{\sigma_{t-i}^2}} + \sum_{j=1}^{p} \alpha_j \left[\frac{|\varepsilon_{t-i}|}{\sqrt{\sigma_{t-i}^2}} - \sqrt{\frac{2}{\pi}} \right] + \Psi X_{t-1}^2$ Where Y_t is FX return, X_t is stock return. Large P-values here indicate there are no serial correlations or ARCH effects in the model residuals.

In the variance equation of the DJIA with the pairwise exchange rates, the results show significantly positive volatility spillover (ψ) from the DJIA index to the three pairwise exchange rates. There is statistically significantly negative asymmetry (γ) of information from the DJIA to the USDGBP and USDJPY exchange rates. The result of the variance equation of the SDR-denominated DJIA also shows significantly positive volatility spillover (ψ) from the DJIASDR index to the SDR exchange rate, and significantly positive asymmetry (γ).

The Ljung-Box Q-statistics, Ljung-Box Q^2-statistics and ARCH-LM robustness tests of the residuals and squared residuals suggest that all of our models are well specified and properly capture the linear dependence in the mean and variance equations.

Focusing on the mean equation, there is evidence of significant influence on price discovery in the FX market from the stock market across the four countries examined. In Germany, the result shows that current returns in the EUR/JPY exchange rate are influenced by past returns of the DAX. Similarly, in the UK, the results also show that past returns of the FTSE influence the current returns of the GBP/USD and GBP/JPY exchange rates. In Japan, the current return of the JPY/USD exchange rate is influenced by past returns of the NIKKEI. The US market also shows the stock market, as represented by the DJIA, exerting influence on the three pairwise exchange rates examined. The US stock market is the only market exhibiting influence on all three pairwise exchange rates. It is interesting to note that in all of the countries, the stock market showed significant effect on the pairwise exchange rate that included the JPY, confirming the role of Japan as an alternative safe haven market to the US and other developed markets.

In the aggregate-denominated currency models, there is evidence of an effect of stock market returns on the FX returns in three of the four countries examined, with the coefficient of that of the US market the highest. The US and the UK stock markets play major roles in the dissemination of information that currency markets react to, which is unsurprising because the two markets account for a large proportion of global cross-border stock and currency trades.

Based on the half-life of a shock ($\ln(0.5)/\ln(\beta_1)$), on average, volatility shocks to markets in Germany, the UK, Japan and the US lasted for approximately 27, 14, 28 and 26 days, respectively.

6 Conclusion

This study examines the currency effect on return and volatility spillovers between the stock market and the exchange rate market using daily data from 2006 to 2010. We examine the return and volatility spillover between the stock index and three different pairwise exchange rates for Germany, the UK, Japan and the US in separate univariate ARMA-EGARCH models. Our results for the home currency-denominated stock index and pairwise exchange rate models are consistent with the literature that suggests significant mean and volatility spillovers from the stock market to the FX market and significant volatility spillover from the FX market to the stock market using pairwise exchange rates (Bodart & Reding, 2001, Yang & Doong, 2004, Aloui, 2007).

The results of the models that employed the aggregate currency-denominated stock and exchange rate data are, however, insightful. We examine this effect in univariate ARMA-EGARCH models by valuing the stock indices and the exchange rate in an aggregate currency denomination and investigating the return and volatility spillover between the aggregate currency and the aggregate-denominated stock index. This valuation ensures that both the stock index and exchange rates are denominated in the same unit of account rather than examining spillovers between pairwise exchange rates and stock indices. The results show that, whereas the previously documented strong and significant return spillover from the stock market to the FX market decreases in magnitude when the currency effect is controlled for (tables 6-9), the return spillover from the FX market to the stock market (tables 2-5), hitherto labelled weak or insignificant in many of the previous studies, is strong and significant in two of the four countries examined when the currency effect is introduced.

The sign of the relationship for all of the significant mean spillovers in the aggregate models were positive (tables 2-9), suggesting that negative mean spillovers between the stock market and pairwise exchange rates may also be due to a currency effect. De Santis and Gerard (1998) document that a negative exchange rate premium can offset a positive stock market premium, making the total premium negative. A possible area of interesting future research might be to investigate whether the economic composition and major drivers of an economy determine the sign of the relationship between a country's exchange rate and stock market or this sign is due to the currency effect.

Our results are particularly important to asset managers who seek to diversify and invest in the two markets, and show that the exchange rate market might provide more information on the stock market than previously documented when the currency effect is accounted for. This information helps asset managers in designing the hedging strategy for their portfolios and suggests that even domestic investors must be compensated for their exposure to the currency risk. Our results also show that previous findings that show no significant predictive power from exchange rates to the stock market might not necessarily hold when both the stock and exchange rates are valued in the same currency. Our results lend credence to both the 'flow oriented' and 'stock oriented' theoretical approaches.

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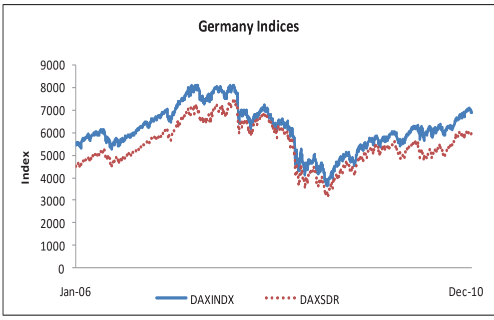
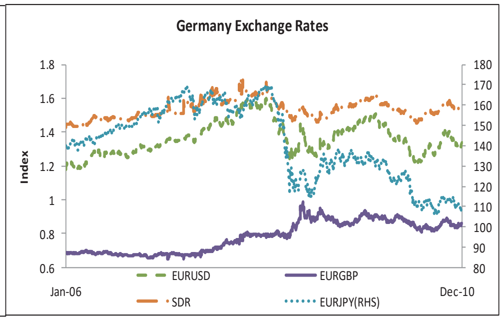
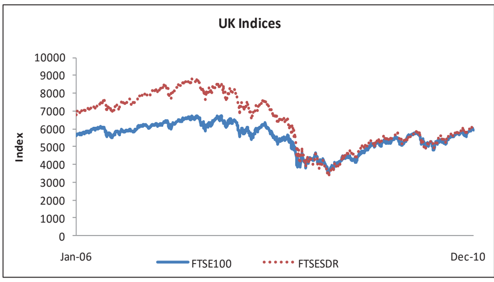
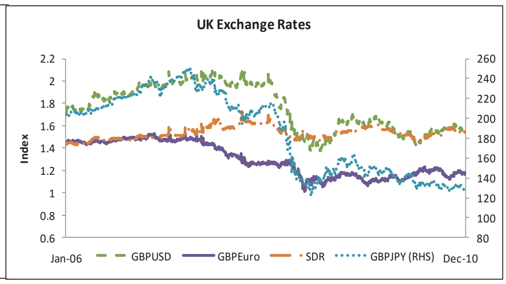
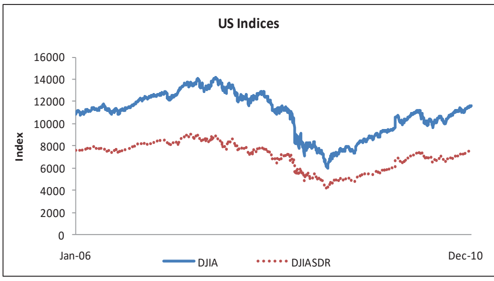
Appendix A: Trend charts of variables

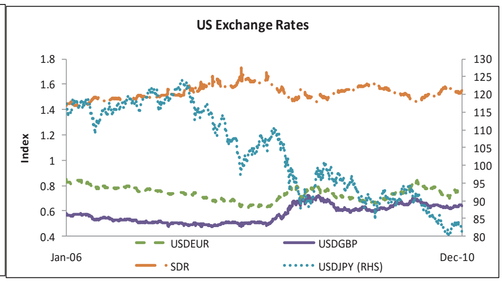


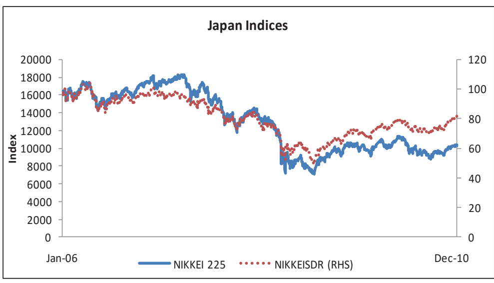


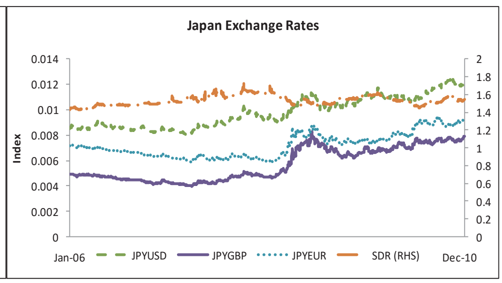












The currency effect and the short-term predictability of stock returns

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Abstract

The purpose of this study is to investigate the currency effect on stock-return forecasts on the short horizon. Whereas most previous studies have concentrated on investigating the factors or models that best predict stock returns, our study investigates the effect of valuing the exchange-rate component of the variables in our models in an aggregate currency unit of account on stock-returns predictability. Our study estimates models that pair home currency-denominated stock-index returns with a set of home currency-denominated explanatory variables, and it compares the results to the models that pair the aggregate currency-denominated stock-index returns with the same set of explanatory variables valued in an aggregate currency unit of account. The difference between the two sets of results is what we have termed the currency effect. We examine this effect in one emerging and one developed market. We employ the ARIMAx model for the in-sample and out-of-sample forecasts of each country's stock index returns. The empirical results from our study suggest that there is a higher correlation between the forecast of the aggregate currency-denominated index and its eventual outcome than the forecast of the home currency-denominated index and its eventual outcome. The result also notably shows that the forecasts of the aggregate currency-denominated index have a higher correlation to the actual returns of the home currency-denominated index than the correlation between the home currency-index forecast and its actual value. Our results suggest that reducing the volatility of the variables by valuing them in an aggregate unit of account improves the predictability of stock returns on the short horizon.

Keywords- ARIMAx, aggregate currency, stock index, predictability, correlation

JEL classification: C53, G15

1 Introduction

The predictability of stock returns continues to generate interest among policy makers, academics, and investors for various reasons. For policy makers, the importance of financial markets and their possible effects on the wider economy was again re-emphasised during the recent global economic crisis, which had its roots in financial markets. Knowledge of the direction of asset prices will influence policy decisions and the levers deployed by policy makers. Investors will seek to understand movement in asset prices so that they can take advantage of emerging opportunities to earn additional premium or to hedge their risks.

Although the early empirical evidence on the predictability of stock returns favoured the random walk hypothesis, there is now an overwhelming body of evidence, both theoretical and empirical, that supports the predictability of stock returns, particularly in the long run (Fama & French, 1988, Fama, 1990, Balvers, Cosimano & McDonald, 1990, Pesaran & Timmerman, 2000, Cremers, 2002). Some of these studies also show that the predictability of asset returns can actually co-exist with the efficient market hypothesis (EMH) theory.

A number of studies have also documented the predictability of stock returns in the short run. Most of the results show statistically significant short-term predictability, but it has a small magnitude (French and Roll, 1986, Lo and MacKinlay, 1988, Conrad and Kaul, 1988). Shiller (1984) posits that the trading of irrational investors increases volatility in the prices of equities, making predictability difficult in the short run.

Thus, our study investigates whether reducing the volatility of the variables by valuing them in an aggregate currency unit of account will improve the predictability of stock returns in the short run. Our assumption is that stock returns and the returns of the other variables consist of two components: the return due to the underlying variable and the return due to the currency of valuation of the variable. Hovanov, Kolari and Sokolov (2004) show in their study that a basket of currencies, weighted appropriately, is usually more stable than a single currency. By valuing our variables in an aggregate currency unit of account, we hope to reduce the volatility of the currency component of the variables and, invariably, the volatility of the variables.

The difference in the results of the models that pair the home currency-denominated variables and those that pair the aggregate currency-denominated variables is what we have termed the currency effect. Through this approach, we will investigate the dynamic change, if any, that occurs in the relationship between our stock forecast and the eventual outcome when the exchange-rate component is valued differently.

The rest of the paper is organised as follows: Section two will present the review of past literature. Sections three and four will present the methodology and data, respectively. The results of the empirical research conducted will be presented in section five. Section six will provide a summary and the conclusions of the research.

2 Literature Review

The advent of modern asset-pricing theories, such as the arbitrage pricing theory (APT), the capital asset-pricing model (CAPM) and their variants, has helped shed more light on the factors that affect the prices of different asset classes. Several studies have been conducted on the predictability of stock prices. Many of the earlier studies concentrated on developed markets, but recent studies are now focusing more on emerging markets because the international stock flows across markets have greatly increased.

2.1 Stock-market predictability, macroeconomic variables, and financial ratios

The forecastability of stock returns in an efficient market was examined by Balvers et.al (1990). Their study suggests that the predictability of stock returns is closely related to aggregate output forecastability, and through an equilibrium model relating output to consumption, they demonstrate the possibility of stock-return predictability in an efficient market. The extent to which stock return is affected by expected returns and real activity in the US was examined by Fama (1990). The study investigated the total variation in stock returns explained by shocks to expected cash flows, expected returns, and time-varying expected returns. The findings of the study suggest the variables jointly explain significant portion of stock returns' total annual variance.

The predictability of US stock returns using market microstructure variables and lagged stock-index futures returns was examined by Huang and Stall (1994) in a Generalised Methods of Moment (GMM) framework. Their results suggest the in-sample and out-of-sample predictive power of the employed variables. Patelis (1997) investigates the role of monetary policy in stock-market predictability in the US market, and the findings suggest monetary policy variables help predict future stock returns. The forecastability of stock returns was investigated by Pesaran and Timmermann (2000) in the UK market. The result of their study indicate the predictability of stock returns.

In examining stock-return predictability in the US stock market, using a Bayesian framework, Cremers (2002) documents in-sample stock-return predictability even after controlling for data snooping. The out-of-sample predictability, however, is relatively small. Lanne (2002) examines the predictability of US stock returns using the monthly value-weighted CRSP index of stocks traded on the NYSE, AMEX, and NASDAQ from 1928 to 1996. The results suggest some level of predictability. However, the stationarity test does not support the presence of predictability. The study concludes that predictability in stock returns as previously documented may be spurious and may be due to a neglected near unit root problem.

Fang and Xu (2003) examine asset-return predictability by applying a combination of technical analysis and time-series forecasts to the Dow Jones Averages over a hundred-year period. The results show that technical analysis was better at identifying the period to be in the market, whereas the time-series forecast was better at predicting when to be out of the market. A combination of both methods, however, outperformed each individual method. Marquering and Verbeek (2004) investigate the economic value of predicting stock-index returns and volatility using recursively estimated simple linear models. Their results suggest that out-of-sample forecasts are easier during a period of high volatility and are economically profitable even in the absence of short sales and in the presence of high transaction costs.

Ng (2004) examines the ability of dividend yield, forward premia and the exchange rate to capture the behaviour of stock returns in a dynamic ICAPM. The results of the study suggest these factors possess the ability to predict stock returns. Rapach, Wohar and Rangvid (2005) examine the ability of macroeconomic variables to forecast stock returns in 12 industrialised countries. Their findings suggest macroeconomic variables can help predict stock returns, and interest rate is the most consistent predictor of both the in-sample and out-of-sample forecasts across all 12 countries and in multiple time horizons. Inflation also performed relatively well as a predictor of stock returns for both the in-sample and out-of-sample forecasts.

The predictability of industrial stock returns in Australia was investigated by Yao, Gao and Alles (2005). Their findings suggest the unanticipated components of the term structure and short-term interest rates are the best predictors of Australian industrial returns. Ang and Bekaert (2007) investigate the predictability of stock returns in four industrialised countries, and their findings show the most reliable predictive variable of excess stock returns is the short-term interest rate, which is significant only on short horizons. The predictive ability of the dividend yield is not supported univariately, but it improves in a bivariate model together with the short rate.

McMillan (2007) examines the ability of volume to predict stock returns in the stock markets of the US, UK, France and Japan. The results suggest that volume is a good predictor of future stock returns because it acts as a threshold variable. Jarrett (2008) investigates the Hong Kong securities market for market efficiency. The results of the study suggests the weak-form efficiency does not characterise the Hong Kong stock market, and they identify the existence of the predictability of stock returns on the exchange in the short term.

Wu (2008) examines the ability of international asset-pricing models to predict the cross-sectional variations in expected returns in 16 industrialised countries. The results of the study show the International Capital Asset-pricing Model (ICAPM), with foreign exchange risk, to be a better predictor of stock returns than other asset-pricing models. In their study on the predictability of stock returns with aggregate discretionary accruals, Kang, Liu and Qi (2010) find that aggregate discretionary accruals positively predict stock returns through a discount-rate channel.

Ferreira and Santa-Clara (2011) examine stock-return predictability using the monthly and annual data of the S&P500 from 1927 to 2007. The results from their sum-of-parts forecast model suggest robust out-of-sample predictability, with the annual frequency data showing better predictive power than the monthly frequency data. Chen (2012) examines the importance of dividend yield in predicting Japanese aggregate stock returns. The results of the study indicate that dividend yield is able to predict stock returns in Japan. Gupta and Modise (2012) investigate the South African stock market for predictability of returns. Their findings show that the stock returns of South Africa’s major trading partners help predict local stock returns for the in-sample test in certain horizons. For the out-of-sample tests, the term spread, treasury bills rate, and stock returns of South Africa’s major trading partners help predict stock returns in South Africa in both the short and long run.

2.2 Stock-market predictability and oil prices

The relationship between oil prices and stock markets was examined by Jones and Kaul, 1996. Their results suggest that changes in oil prices are captured in the current and future changes in real cash flow and stock returns expectations. Kilian and Park (2009) examine the effect of oil-price shocks on the U.S stock market. They decompose oil-price shocks into three components: specific (precautionary) demand, supply and aggregate demand. The results of their study show that changes to global oil demand have a stronger effect on the movement of stock prices than shocks engendered by precautionary demand or supply.

Basher, Haug and Sardosky (2012) investigate the effect of oil prices and the exchange rate on emerging stock prices. The results of the study suggest that positive innovations to oil prices negatively affect the stock prices of emerging economies and the value of the US dollar, whereas increases in the stock prices of emerging economies lead to increases in oil prices. The effect of oil prices on the predictability of stock returns on a short horizon was investigated by Casassus and Higuera (2012). Their results show that changes in oil prices, measured as short-term oil futures returns, is a good predictor of stock returns over a short horizon.

3 Methodology

Estimating a model from non-stationary time series may lead to incorrect results. The Augmented Dickey-Fuller (ADF) test is applied to all our time-series data. A first-order autoregressive model $y_t = \gamma_1 y_{t-1} + \varepsilon_t$, is said to have a unit root if $\gamma_1 = 1$. We test the null hypothesis that $H_0\colon \gamma = 1$ against the alternative hypothesis that $H_1\colon \gamma < 0$.

We examine the currency effect on the stock-returns forecast in two countries: one developed market and one emerging market. For each country, the log returns of a home currency-denominated stock index are regressed on the lag of a set of five explanatory variables (stock index, inflation, interest rate, oil price and exchange rate), and the results are compared to that of the an aggregate currency-denominated stock index regressed on the same set of explanatory variables. The stock index, oil price and exchange rate are transformed to their log returns, whereas the first difference of the interest rate and inflation are employed. We forecast using an ARIMAx model. The model specification is

$$S_t = \mu + \beta_1 INF_{t-1} + \beta_2 IR_{t-1} + \beta_3 FX_{t-1} + \beta_4 OIL_{t-1} + \sum_{j=1}^{p} \emptyset_j S_{t-j} - \sum_{k=0}^{q} \theta_k \varepsilon_{t-k} \quad (1)$$

where S_t is the log returns of the stock index,μ is the constant, INF_{t-1}, IR_{t-1}, FX_{t-1}, and OIL_{t-1} are the lags of the first difference of inflation and interest rates and the log returns of the exchange rate and oil price, respectively, for each country, ∅ is the AR term, and θ is the MA term.

In the model with the home currency-denominated stock index, the stock returns and oil price are valued in each country's local currency, whereas the exchange rate utilised is the pair-wise exchange rate of the local currency with the US dollar. In the model with the aggregate currency-denominated stock index, however, the stock returns, the oil price and the exchange rates are valued in the SDR unit of account. The ARIMAx follows an ARMA form because all series are stationary. The Schwartz Information Criterion (SIC) and the Akaike Information Criterion (AIC) are used to select the ARIMA terms. We also conduct robustness checks on the estimated models.

This study will conduct both in-sample and out-of-sample forecasts. It will report the R^2, root mean square error (RMSE), mean absolute error (MAE), and bias proportion (BP) of both the local and aggregate currency-denominated results. For the in-sample forecast, we estimate the ARIMAx model with the complete dataset and forecast for the entire duration, whereas for the out-of-sample forecast, we estimate using data for the first 29 months, and we use the result to forecast the remaining 30 months.

3.1 Forecast Evaluation

Our selected forecast-evaluation measures are stand-alone accuracy measures; they can be obtained without additional reference forecasts. They are usually associated with a certain loss function. The MAE has the advantage of being simple to calculate and to interpret; it is simply the mean of the absolute errors and is an unambiguous measure of absolute error magnitude. Accuracy measures based on the mean squared error criterion have also been used extensively to evaluate forecast performance. Carbone and Armstrong (1982) document that the RMSE is the most employed and preferred forecast-accuracy measure. The performance of our estimated models will be evaluated for accuracy using the RMSE, MAE, and BP.

3.1.1 Root mean square error

The root mean square error is a good measure of accuracy for comparing the forecasting error of models. It measures the difference between the predicted value and the actual observed value. It is calculated as the sample standard deviation of the differences between the forecast values and the eventual outcome. It is calculated as

$$RMSE = \sqrt{\frac{\sum_{t=1}^{n}(\widehat{Y_t} - Y_t)^2}{n}} \tag{2}$$

where $\widehat{Y_t}$ is the predicted values of a regression's dependent variable Y_t, and n is the number of different predictions.

3.1.2 Mean absolute error

The mean absolute error measures how close forecast values are to the observed values. It is an average of the absolute errors, and it is given by

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|f_i - y_i| = \frac{1}{n}\sum_{i=1}^{n}|e_i| \tag{3}$$

where f_i is the predicted value, and y_i is the eventual outcome.

3.1.3 Bias proportion

Bias proportion is a forecast-evaluation option that measures how far the mean of the forecast is from the mean of the eventual outcome (Pindyck and Rubinfeld, 1991). It is given by

$$\frac{((\frac{\sum \hat{Y}_t}{n}) - \bar{Y})^2}{\sum(\widehat{Y_t} - Y_t)^2/n} \tag{4}$$

where $\widehat{Y_t}$ is the predicted values of a regression's dependent variable Y_t, n is the number of different predictions, and $\bar{Y}$ is the mean of Y.

3.1.4 Correlation

The correlation between our forecasts and eventual outcome will also be estimated. Although correlation does not presuppose causality, it provides some information on how closely related the parameters are. The interpretation to be given to the correlation coefficients is presented in table 1.

Table 1 Absolute value of correlation coefficient interpretation

0.90 - 1.00	Very high correlation
0.70 - 0.89	High correlation
0.40 - 0.69	Moderate correlation
0.20 - 0.39	Low correlation
0.00 - 0.19	Very low correlation

Source: Guide to the interpretation of correlation coefficient (Tersine, 1988)

4 Data

Many factors have been documented to help predict stock-market returns, from financial to macroeconomic variables. Stock prices, inflation, interest rates, exchange rates and oil prices are some of the variables that have been employed individually or jointly with other variables to predict future prices of stocks.

The empirical data employed in this study include the monthly close-of-stock index for the US (SP500) and Brazil (BOVESPA). The U.S is selected as a proxy for the advanced markets because it is the largest economy in the world, whereas the choice of Brazil as a proxy for the emerging market stems from its position as the largest emerging economy with a free market. The interest rate employed is the three-month treasury-bills rate for each country as a proxy for the risk-free interest rate. The oil price is that of Brent crude oil, and the exchange rate is the pair-wise exchange rate of Brazil's currency with the USD. For the US, we employ the USD and the British pound exchange rate.

The time period examined covers January 2006 to December 2010. This is equivalent to the special drawing right (SDR) regime. There are 60 monthly observations but 59 in the return and differenced series. The choice of this period is due to the fact that it is the most recent complete SDR regime, and this period was highly volatile, particularly during the 2008 global meltdown. Our assumption is that if these forecasts hold any information during a period of such high uncertainty, which now seems to be the norm rather than an aberration, then it should perform better in a period of calm. The SDR, as formulated by the International Monetary Fund (IMF), is a combination of different weights of the GBP (11%), USD (44%), EUR (34%), and JPY (11%), and it will be applied as the currency basket. The stock-market indices and the oil price are converted to their SDR values, and the exchange rate employed in the aggregate model is the SDR.

Table 2 shows the descriptive statistics of our variables. The home and aggregate currency stock returns for both countries are negatively skewed, which suggests that most of their values are to the right of their mean. The pairwise exchange rate for both countries and the aggregate currency are, however, positively skewed. The positive kurtosis of all our variables also shows that most of the data series are leptokurtic, and they exhibit excess kurtosis greater than zero, which suggests deviation from normal distribution. The standard deviation for the aggregate currency-denominated variables is higher than the home currency-denominated variables in only one instance: Brazil's stock index.

Table 2 Descriptive statistics

US										
	Mean	Median	Max	Min	S.D	Skewness	Kurtosis	Jarque-Bera	Obs.	ADF t-Stat
SP500	0.00	0.00	0.09	-0.17	0.05	-0.78	3.87	7.8	59	-5.47
SP500SDR	-0.00	0.01	0.09	-0.14	0.05	-0.6	2.97	3.5	59	-5.72
USDGBP	0.00	0.00	0.12	-0.1	0.04	0.46	4.31	6.31	59	-6.05
SDR	0.00	0.00	0.05	-0.04	0.02	0.06	2.93	0.05	59	-7.61
OILUSD	0.01	0.03	0.3	-0.35	0.11	-0.58	3.9	5.31	59	-5.74
OILSDR	0.01	0.03	0.3	-0.35	0.11	-0.55	3.94	5.14	59	-6.00
INF	-0.04	-0.05	2.02	-2.59	0.69	-0.59	6.04	26.13	59	-4.33
IR	-0.07	0.00	0.44	-1.37	0.29	-2.43	10.02	179.20	59	-7.68
Brazil										
	Mean	Median	Max	Min	S.D	Skewness	Kurtosis	Jarque-Bera	Obs.	ADF t-Stat
BOVESPA	0.01	0.01	0.16	-0.25	0.07	-0.81	4.86	14.94	59	-5.8
BOVESPASDR	0.02	0.03	0.28	-0.33	0.10	-0.93	6.16	33.14	59	-6.66
BRLUSD	0.00	-0.01	0.34	-0.21	0.08	1.38	9.46	121.23	59	-7.91
SDR	0.00	0.00	0.05	-0.04	0.02	0.06	2.93	0.05	59	-7.61
OILBRL	0.01	0.03	0.46	-0.27	0.12	0.52	5.35	16.19	59	-7.59
OILSDR	0.01	0.03	0.3	-0.35	0.11	-0.55	3.94	5.14	59	-6.00
INF	0.03	0.01	0.74	-0.81	0.35	-0.08	2.74	0.22	59	-3.43
IR	-0.09	-0.11	2.22	-1.47	0.71	0.59	4.00	5.89	59	-7.63

Above values are the descriptive statistics for the returns of the stock, exchange rate and oil, and first differences of inflation and interest rates. Number of lags in ADF determined by Schwartz information criterion (SIC). Null hypothesis of unit root rejected at the level for all the return series and all the first differences at 1% critical value level (C.V), except inflation for Brazil which was rejected at 5%. 1%, 5% and 10% C.V are -3.55, -2.91 and -2.59 respectively. BRLUSD is the Real/USD exchange rate, OILBRL is oil measured in Brazilian Real, BOVESPASDR is BOVESPA measured in SDR unit of account, OILSDR is oil measured in SDR unit of account, and SP500SDR is SP500 measured in SDR unit of account.

5 Empirical Findings

Although there are a number of competing forecast models, the use of the AR and ARIMAx models is widespread. Cochrane and Orcutt (1949) popularised the modelling of the error term of a forecast model using the AR (1). We apply the AR (1) in our estimation, but the residuals still display some serial correlation; hence, we apply the ARIMAx. The ARIMAx model is a good-fit for our estimation, and the terms of the ARIMAx models are selected using the SIC and AIC.

The in-sample and out-of-sample forecast-evaluation results of the ARIMAx models and the correlation between our forecasts and the actual values for both the home and aggregate currency estimations for the two countries are presented in tables 3-4 (appendix A). The regression results are presented in tables 5-6 (appendix B). We estimate dynamic forecasts using the ordinary least square (OLS) method. For the in-sample model, we estimate a regression using the whole data sample from January 2006 to December 2010. We then use the regression result to forecast the whole period. For the out-of-sample model, we estimate a regression using data from January 2006 to June 2008, and we use the result to forecast from July 2008 to December 2010. As the forecast-evaluation parameters become closer to zero, the forecasting ability of the model becomes better. Furthermore, as the correlation coefficients of our forecasts become closer to the eventual outcome, the forecasting ability becomes greater.

For both the in-sample and out-of-sample estimates of the home and aggregate currencies' denominated models for the U.S, the degree of variability (R^2) explained by the independent variables is lower than 50%. In the case of Brazil, the R^2 of the in-sample regression of the home and aggregate currencies' denominated models are below 50%, whereas those of their out-of-sample counterparts are above 50% (tables 3-4, appendix A). There is, however, no clear distinction between the R^2 of the home currency-denominated models and those of the aggregate currency-denominated models.

The results of the forecast errors (RMSE, MAE & BP), however, show that the aggregate currency models perform better than the home-currency models in three out of the four estimates. The values of the evaluation parameters are closer to zero for both the in-sample and the out-of-sample models of the aggregate currency than their respective home currency models for the U.S market. For Brazil, however, the RMSE, MAE & BP of the home-currency models are closer to zero for the in-sample than those of the aggregate currency model, but for the out-of-sample, those of the aggregate currency models are closer to zero than those of the home-currency models (tables 3-4, appendix A).

The correlation coefficients of the forecasts and their eventual outcomes, however, clearly further distinguish the aggregate currency models' performance from the home-currency models' performance. For the U.S market (table 3, appendix A), in both the in-sample and out-of-sample models, the correlation between the home currency forecast and eventual outcomes are both low (0.20-0.39), whereas those of the aggregate currency models are both moderate (0.40-0.69).

Brazil's correlation results (table 4, appendix A) also show better performance for the aggregate currency models than for the home currency models in both the in-sample and out-of-sample estimates. In the in-sample model, although the correlation between the home currency forecast and the eventual outcome is very low (0.00-0.19), that of the aggregate currency model is a notch higher, in the low category (0.20-0.39). For the out-of-sample model, the correlation between the forecast of the home currency returns and its eventual outcome is low (0.20-0.39), whereas that of the corresponding aggregate currency model is high (0.70-0.89).

Out of all the correlations examined, Brazil's home currency in-sample forecast is the least correlated with its eventual outcome at 18%. Surprisingly, Brazil's same aggregate currency out-of-sample forecast is the most correlated with its eventual outcome at 75%. On average, using the forecast error-evaluation parameters (RMSE, MAE &BP) and correlation coefficients, the models for the U.S are more accurate than those for Brazil.

Notably, the correlation between the forecasts of the aggregate currency stock returns and the actual outcome of the home-currency stock returns is higher in three out of four cases than the home-currency forecast and its eventual outcome. There is a clear indication that the aggregate currency improves the accuracy of stock-market forecasts, and our results show that stock-market returns can be predicted with some measure of accuracy.

The regression results in table 5 (appendix B) show that for the U.S home currency-denominated stock returns, the interest rate and exchange rate are significant predictors of the stock-price movements in the in-sample, whereas only the interest rate is significant in the out-of-sample model. For the aggregate currency-denominated stock returns, oil is significant in explaining stock-price movements in the in-sample model, whereas interest is again the only significant variable in the out-of-sample model.

Brazil's regression results (table 6, appendix B) suggest that none of the variables is significant in explaining BOVESPA returns for the home currency-denominated in-sample model, whereas its out-of-sample estimates show inflation and interest rate to be significant. For the aggregate currency-denominated in-sample model, only the exchange rate is significant, whereas the out-of-sample model suggests none of the variables is significant in explaining BOVESPA returns during the period under investigation.

The variables employed explain more of the variability of the home currency and aggregate currency returns in the in-sample models for the U.S, whereas they perform better in explaining the variability of the out-of-sample home-currency and aggregate currency stock returns of the Brazil index.

The results of our approach to modelling the exchange-rate effect on predicting stock-market returns suggests that valuing the stock component and some of the explanatory variables in an aggregate unit of account provides additional useful information that improves the forecast results. This is plausible because the SDR, which can be viewed as a trade-weighted exchange rate, is a more stable 'currency' than the individual home currencies, and thus, it is expected to reduce the volatility and to improve the accuracy of our results.

6 Conclusions

This study examines the currency effect on the stock-return forecast using monthly data from 2006 to 2010. We examine this effect in two countries, one as a proxy for the advanced economies and the other as a proxy for emerging markets. We estimate the ARIMAx models for the two countries for both the home currency-denominated and the aggregate currency-denominated variables. We estimate ARIMAx models with the whole dataset from 2006 to 2010 and conduct dynamic in-sample forecasting using the OLS method for this sample period. We also estimate ARIMAx models with the data of the first 29 months and conduct dynamic out-of-sample forecasting for the remaining 30 months using the OLS method. The correlations between our forecasts and the actual observed returns are also estimated. We apply a diagnostic and forecast evaluation checks to ensure our models fit our data.

In the home currency-denominated models, the stock component and the oil price are valued in the home-currency denomination, whereas the exchange rate is the bilateral of the home currency and the USD. In reality, however, the conversion of the oil price to the home-currency denomination will introduce the pair-wise exchange rate characteristics of the home country and the USD, which leaves the stock index as the only variable without the home-currency/USD exchange-rate influence. This makes the variables susceptible to the movements of the country's currency relative to the USD, which can be volatile. The aggregate currency model, by contrast, has the stock, oil price, and exchange rate variables valued in the same unit of account, the SDR, which is expected to provide more stability than the pairwise exchange rate.

The forecast error-evaluation parameters show that the aggregate currency models outperform the home currency models 75% of the time, whereas the correlation between the aggregate currency forecasts and their eventual outcomes outperform those of the home-currency models across board. The results also show that the correlation between the forecast for the aggregate currency-denominated index and the actual observations of the home currency-denominated index outperform the correlation between the forecast of the home currency-denominated index and its actual observation 75% of the time. It is also important to note that the model for the out-of-sample forecasts of the aggregate currency-denominated index returns correctly predicts the negative sign of the infamous global meltdown month of October 2008 in both countries.

Our results are particularly important to asset managers because any information about the future direction of the market could help their positioning in the market. The findings also suggest that reducing the volatility of the explanatory variables can change the dynamics of asset predictability. The common denominator in the aggregate currency models explains the better performance of the aggregate currency forecast results. This is an indication that stock returns can be better predicted on the short horizon if a more stable currency component is applied. Our results are consistent with extant literature that documents the predictability of stock returns (Fama, 1990, Chen, 2012, Gupta & Modise, 2012). Our results also support modern asset-pricing theory on the variables that have a significant effect on stock returns.

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Appendix A: Forecast and correlation results

Table 3 US Forecast Results

Panel A: R^2 and forecast errors

	In-Sample								Out-of-Sample							
	ARIMAx Home Currency				ARIMAx Aggregate Currency				ARIMAx Home Currency				ARIMAx Aggregate Currency			
	R^2	RMSE	MAE	BP	R^2	RMSE	MAE	BP	R^2	RMSE	MAE	BP	R^2	RMSE	MAE	BP
	33.37	0.05	0.04	0	33.61	0.04	0.03	0	43.29	0.07	0.06	0.1	24	0.05	0.05	0.05

Panel B: Correlation between actual values and forecasts

	In-Sample		Out-of-Sample	
	SP500F	SP500SDRF	SP500F	SP500SDRF
SP500	37.46	41.04	34.02	41.31
SP500SD	41.01	46.21	39.37	56.31

Note: RMSE, MAE & BP are the Root Mean Square Error, Mean Absolute Error and Bias Proportion respectively. SP500F and SP500SDRF are the forecasts for the USD and SDR denominated S&P500 respectively

Table 4 Brazil Forecast Results

Panel A: R^2 and forecast errors

	In-Sample								Out-of-Sample							
	ARIMAx Home Currency				ARIMAx Aggregate Currency				ARIMAx Home Currency				ARIMAx Aggregate Currency			
	R^2	RMSE	MAE	BP	R^2	RMSE	MAE	BP	R^2	RMSE	MAE	BP	R^2	RMSE	MAE	BP
	12.54	0.07	0.05	0	14.57	0.1	0.07	0	56.73	0.1	0.08	0.03	50.42	0.09	0.07	0.02

Panel B: Correlation between actual values and forecasts

	In-Sample		Out-of-Sample	
	BOVESPAF	BOVESPASDRF	BOVESPAF	BOVESPASDRF
BOVESPA	18.13	23.43	34.18	32.95
BOVESPASDR	21.97	31.02	24.5	75.4

Note: RMSE, MAE & BP are the Root Mean Square Error, Mean Absolute Error and Bias Proportion respectively. BOVESPAF and BOVESPASDRF are the forecasts for the Brazilian Real and SDR denominated BOVESPA respectively

Appendix B: Regression results

ARIMAx equation specified as:

$$S_t = \mu + \beta_1 INF_{t-1} + \beta_2 IR_{t-1} + \beta_3 FX_{t-1} + \beta_4 OIL_{t-1} + \sum_{j=1}^{p} \emptyset_j S_{t-j} - \sum_{k=0}^{q} \theta_k \varepsilon_{t-k}$$

Table 5 US Regression Results

In-Sample		Out-of-Sample	
Data covering Jan. 2006-Dec. 2010		Data covering Jan. 2006-June 2008	
Dependent Variable: RTSP500		**Dependent Variable: RTSP500**	
Independent Variables	Coefficient	Independent Variables	Coefficient
C	0.00 (-0.24)	C	-0.01 (-0.56)
DINF(-1)	-0.01 (-0.6)	DINF(-1)	0.01 (0.96)
DIR(-1)	-0.03** (-2.1)	DIR(-1)	-0.04** (-3.07)
RTUG(-1)	-0.58***(-3.45)	RTUG(-1)	-0.36 (-1.6)
RTOIL(-1)	0.09 (1.16)	RTOIL(-1)	-0.08 (-1.34)
AR(1)	-0.28 (-1.04)	AR(1)	-0.14 (-0.5)
MA(1)	0.69 (2.65)	MA(1)	0.92 (8.4)
MA(2)	-0.28 (-1.06)		
R-squared	0.33	R-squared	0.43
Adjusted R-squared	0.24	Adjusted R-squared	0.26
S.E. of regression	0.05	S.E. of regression	0.03
Sum squared resid	0.1	Sum squared resid	0.02
In-Sample		**Out-of-Sample**	
Data covering Jan. 2006-Dec. 2010		Data covering Jan. 2006-June 2008	
Dependent Variable: RTSP500SDR		**Dependent Variable: RTSP500SDR**	
Independent Variables	Coefficient	Independent Variables	Coefficient
C	0.00 (-0.64)	C	-0.01 (-1.17)
DINF(-1)	-0.01 (-1.23)	DINF(-1)	0.00 (-0.17)
DIR(-1)	0.00 (-0.24)	DIR(-1)	-0.03** (-2.06)
RTSDR(-1)	0.39 (1.31)	RTSDR(-1)	0.41 (1.12)
RTOILSDR(-1)	0.24*** (4.23)	RTOILSDR(-1)	0.05 (0.51)
AR(1)	-0.63 (-5.32)	AR(1)	0.55 (2.32)
MA(1)	0.98 (35.96)	MA(1)	-0.36 (-1.57)
R-squared	0.34	R-squared	0.24
Adjusted R-squared	0.26	Adjusted R-squared	0.02
S.E. of regression	0.04	S.E. of regression	0.04
Sum squared resid	0.09	Sum squared resid	0.03

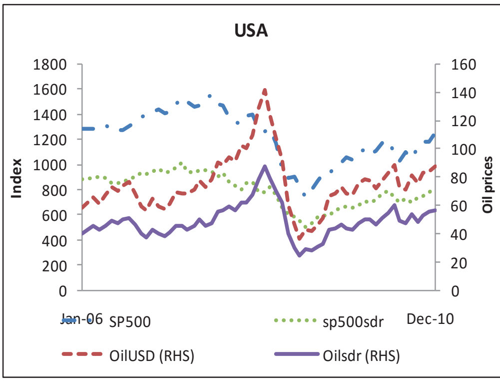
***, **,*, represent significant at 1%, 5% and 10% respectively. T-stats in parenthesis.

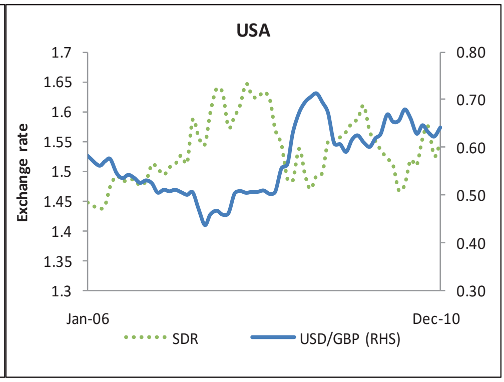
Table 6 Brazil Regression Results

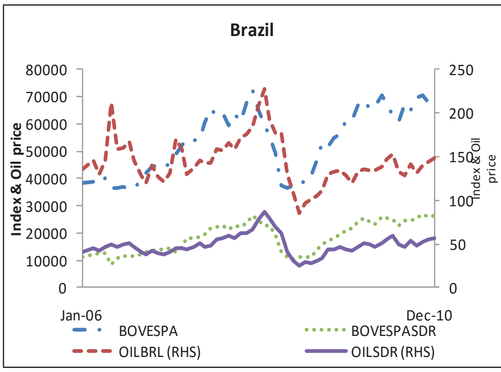
In-Sample		Out-of-Sample	
Data covering Jan. 2006-Dec. 2010		Data covering Jan. 2006-June 2008	
Dependent Variable: RTBOVESPA		**Dependent Variable: RTBOVESPA**	
Independent Variables	Coefficient	Independent Variables	Coefficient
C	0.01 (1.07)	C	0.02*** (4.37)
DINF(-1)	-0.02 (-0.70)	DINF(-1)	0.07* (1.94)
DIR(-1)	0.01 (0.42)	DIR(-1)	-0.03** (-2.68)
RTBRLUSD(-1)	-0.02 (-0.13)	RTBRLUSD(-1)	0.15 (0.02) (0.54)
RTOILBRL(-1)	0.02 (0.22)	RTOILBRL(-1)	-0.09 (-0.60)
AR(1)	-0.64 (-1.62)	AR(1)	1.1904
MA(1)	0.96 (2.46)	MA(1)	-0.06 (-0.15)
MA(2)	0.30 (2.01)	MA(2)	-0.94 (-2.80)
R-squared	0.13	R-squared	0.57
Adjusted R-squared	0.00	Adjusted R-squared	0.41
S.E. of regression	0.07	S.E. of regression	0.04
Sum squared resid	0.24	Sum squared resid	0.04
In-Sample		**Out-of-Sample**	
Data covering Jan. 2006-Dec. 2010		Data covering Jan. 2006-June 2008	
Dependent Variable: RTBOVESPASDR		**Dependent Variable: RTBOVESPASDR**	
Independent Variables	Coefficient	Independent Variables	Coefficient
C	0.02** (2.78)	C	0.02** (3.12)
DINF(-1)	-0.01 (-0.19)	DINF(-1)	0.05 (1.38)
DIR(-1)	-0.01 (-0.31)	DIR(-1)	-0.03 (-1.31)
RTSDR(-1)	1.91** (2.29)	RTSDR(-1)	1.87 (1.57)
RTOILSDR(-1)	0.13 (0.87)	RTOILSDR(-1)	-0.09 (-0.36)
AR(1)	0.83 (7.86)	AR(1)	-0.08 (-0.30)
MA(1)	-0.98 (-33.93)	MA(1)	-0.98 (-9.23)
R-squared	0.15	R-squared	0.5
Adjusted R-squared	0.04	Adjusted R-squared	0.36
S.E. of regression	0.1	S.E. of regression	0.09
Sum squared resid	0.54	Sum squared resid	0.16

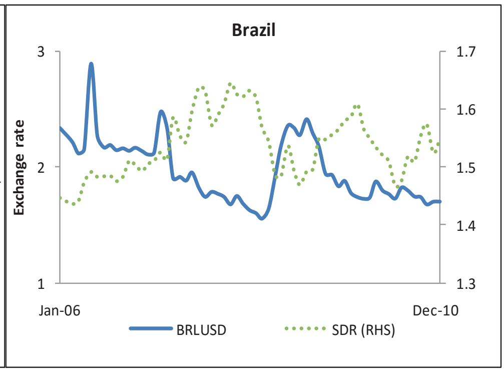
***, **,*, represent significant at 1%, 5% and 10% respectively. T-stats in parenthesis

Appendix C: Trend charts of variables









The currency effect on the long-run relationship between the stock market and macroeconomic variables

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Abstract

The purpose of this study is to investigate the currency effect on the long-run relationship between the stock market and macroeconomic variables. Two vector autoregressive models (VAR) are estimated: one pairing an aggregate currency-denominated stock index with aggregate currency-denominated US macroeconomic variables and the other pairing the US dollar-denominated stock index and macroeconomic variables. The Granger-causality block-significance test is also applied to our estimates. The empirical results suggest significant changes in the relations between the stock market and macroeconomic variables with the introduction of the aggregate currency factor, marked by reducing the effect of the aggregate currency-denominated US macroeconomic variables on the aggregate currency-denominated stock index. Our results also show that the exchange rate is an important factor that should not be ignored when examining the interactions between the stock market and macroeconomic fundamentals. Moreover, the results show that the previously documented relations between the stock market and macroeconomic variables, without accounting for the influence of the currency of valuation, might not necessarily hold when the currency factor is introduced.

Keywords- Vector autoregressive model (VAR), aggregate currency, stock index, macroeconomic variables, causality.

JEL classification: C32, G15

1 Introduction

The importance of the relationship between financial markets and the macro-economy was again highlighted by the recent global economic meltdown, which emanated from the financial market crisis in the US and threatened economies from Asia to Europe and extending all the way to Africa. This contagion suggests the financial markets' borders have greatly narrowed, with increased exposure to international market risks. In developed and emerging economies with vibrant financial markets, the markets usually mirror the larger economy.

Different approaches have been employed in previous studies to investigate the relationship between the different financial markets and macroeconomic variables. Whereas some studies have examined the relations between the stock market and macroeconomic variables (Fama, 1981, Mukherjee & Naka, 1995, Binswanger, 2000, Basistha & Kurov, 2008, and Gilbert, 2011), others have examined the relationship between exchange-rate movements and macroeconomic fundamentals (Simpson, Ramchander & Chaudry, 2005, and Bergin, 2006). Some studies have also examined the dynamic relationship between the stock and FX markets (Ajayi & Mougoue, 1996, Phylaktis & Ravazzolo, 2005, Kolari, Moorman & Sorescu, 2008, Spencer & Liu, 2010, and Katechos, 2011).

However, despite over thirty years of research interest examining these relationships in developed and developing economies, a limited number of studies has examined the influence of the exchange rate on the relationship between the stock market and macroeconomic variables (Anderson, Bollerslev, Diebold & Vega, 2007, Mun, 2011). The results of these studies suggest a significant linkage between the stock and FX markets, with both markets jointly affected by macroeconomic fundamentals. The implication of their results suggests the previously documented response of each market to macroeconomic fundamentals may change when jointly examined.

The main objective of this study is thus to empirically examine the currency effect on the long-run relationship between the stock market and macroeconomic variables. To investigate this effect, our study will pair the home currency-denominated stock index and macroeconomic variables in a multivariate model. The study will then compare them to the results of the relationship between an aggregate currency-denominated stock index, paired with the same set of macroeconomic variables but valued in an aggregate currency unit of account. Our study will also investigate the direction of the relationship, if any, through the block-significance and causality test.

The essence of valuing both the stock index and macroeconomic variables in an aggregate unit of account is to deemphasise the interactions of the US dollar component among the variables. This approach is premised on the assumption that the changes in both the stock index and the macroeconomic variables consist of two components: the change in the currency of valuation and the change in the parameter being measured. The difference between the results of the US dollar-denominated model and the aggregate currency-denominated model is what we have termed the currency effect. This extends the existing body of knowledge and suggests that some of the previously documented relationships between the stock market and macroeconomic variables may be due to the interaction of the currency component.

It is important to note that the primary focus of this study is not to investigate the explanatory variables that best explain the movements in the stock market or the macro-economy but rather to examine the changes that occur in this relationship when the home-currency factor is controlled. Our motivation arises from the fact that the previous studies that have examined this area have investigated this relationship using the home currency-denominated variables or included the pairwise exchange rates, which are affected by, amongst other things, the terms of trade of both countries. By employing a basket of the three most traded currencies on the FX market, we intend to deemphasise the influence of the home-currency component in the variables.

The rest of the paper is organised as follows: Section two will present the review of past literature, and section three will present the methodology and data section. Section four will describe the empirical research conducted and present and analyse the results. Section five will provide a summary of the research and a conclusions, compare our results to previous studies, state the contributions and limitations of the study, and suggest areas for future research.

2 Literature Review

This literature review is structured into three main parts: The first section reviews the relationship between the stock market and the macro-economy, which is our main focus. The second section reviews the relationship between the FX market and the economy. The third section covers the literature review on the relationship between the FX market and the stock market.

2.1 The relationship between the stock market and the macro-economy

Stock-price movements have been attributed to different reasons in behavioral theories and traditional asset-pricing models. The arbitrage pricing theory (APT), a traditional asset-pricing model initiated by Ross (1976), has been widely used in explaining stock-price movements. The APT posits that each stock's return is influenced partly by macroeconomic factors and partly by noise (events unique to a particular company). Studies have attempted to identify the principal macroeconomic factors that affect stock movements because the APT did not state those factors. Elton, Gruber and Mei (1994), however, identified interest rate, inflation, exchange rate, yield spread and real gross national production as macroeconomic factors affecting cash flows and, invariably, stock prices.

Fama and Schwert (1977) examine the relationship between macroeconomic variables and stock returns in the U.S., and they document evidence of a positive relationship between real stock returns and measures of real activity. Fama (1981) explores the relationship between stock return, real activity, money, and inflation in the US and concludes that there is a positive relationship between real stock returns and measures of real activity but that stock returns and inflation rates exhibit the strongest relationship, although with opposite signs. Hasbrouck (1984) investigates the relationship between stock returns, inflation, and economic variables in the US by surveying expectation data. The findings of the study suggest a quantity-theory relationship between expected inflation and expected economic activity when the monetary growth is controlled, and real uncertainty appears to significantly affect stock returns. The causal relation among stock returns, interest rates, real activity and inflation is investigated by Lee (1992). The multivariate VAR model is applied to U.S. data in the post-war era, and the results show stock returns help explain real activity, but inflation explains little variation in real activity.

Flannery and Protopapadakis (2002), in a more recent study, investigate the influence of US macroeconomic factors on aggregate stock returns using the generalised autoregressive conditional heteroskedasticity (GARCH) model to simultaneously examine the effect of macroeconomic announcements on the level and conditional volatility of daily stock returns. Their findings show monetary aggregate affects both returns and conditional volatility, whereas balance of trade, employment/unemployment, and housing starts affect only the returns' volatility. Their study also shows that two inflation measures, the consumer price index (CPI) and the producer price index (PPI), affect only the market portfolio's returns. Basistha and Kurov (2008) examine the cyclical variation in how monetary policy affects the stock market. Their results show a significant effect of the unexpected federal fund-rate changes on stock returns. Gilbert (2011) investigates the effect of the revision of macroeconomic series on daily returns of the S&P500 and finds that investors react to the revisions and final value of a macroeconomic release.

The US market has also been examined along with other developed markets. Choi, Hauser and Kopecky (1999) examine the predictive ability of the stock market on real activity using time-series data from the G-7 countries. Their co-integration tests show a long-run equilibrium between the log levels of industrial production and real stock prices for all countries except Italy. Hassapis (2003) examines the relationship between financial-market variables (stock prices, interest rates, interest rate spreads and monetary aggregates) in the U.S and Canada and the Canadian output growth using a non-parametric technique. The study finds stock prices, yield spreads and monetary aggregates to be useful predictors of output growth.

The role of asset prices in forecasting output and inflation is investigated by Stock and Watson (2003). Their results show that although term spread performed best in forecasting output growth in Germany and the U.S. before the mid-1980s, no single asset price is a reliable predictor of output growth in different countries and multiple time horizons. Another important conclusion from their study is that the in-sample Granger causality test is a poor method of forecasting performance. Binswanger (2004) investigates whether the relationship between stock returns and real activity in G-7 countries is a thing of the past. The findings suggest a change in the traditionally strong relationship between stock returns and real activity since the early 1980s; a stronger relationship is shown in aggregate levels than national levels, with the possible exception of Germany.

The relationship between the stock market and the economy has similarly been investigated in emerging and smaller economies. The long-term relationship between macroeconomic variables and the Chinese stock market is investigated by Liu and Shrestha (2008) using heteroskedastic co-integration. Their results suggest the presence of a co-integrating relationship between the highly speculative Chinese stock market and macroeconomic variables.

The long-run relationship between the stock market and macroeconomic variables in the presence of structural breaks is investigated by Cagli, Halac and Taskin (2010). They examine this relationship in the Turkish stock market using the Istanbul stock exchange index ISE-100 as a proxy for the stock market. They also employ the Gregory-Hansen (GH) co-integration test after controlling for structural breaks. The results show the stock index is co-integrated with the GDP and industrial production in Turkey and the U.S. crude oil price.

2.2 The relationship between the FX market and the macro-economy

Studies have also examined the effect of macroeconomic variables on the FX market. Simpson et al. (2005) investigate the effect of macroeconomic variables on spot and forward FX markets, and their results show a significant effect of macroeconomic variables on the FX rates and forward premiums. Bergin (2006) examines how well the new open-economy macroeconomics affect the exchange rate and current account. The results of the study suggest a close link between the macroeconomic variables, exchange rate, and current account.

2.3 The relationship between the stock market and the FX market

The relationship between the stock and FX markets has also been closely examined over time. Ajayi and Mougoue (1996) investigate the relationship between the stock and FX markets using the error-correction model, and their results suggest significant long-run and short-run relations between the two markets. Phylaktis and Ravazzolo (2005), in their study, explore stock prices and exchange-rate dynamics. Their findings show positive significant relations between the two markets. Kolari et al. (2008) investigate the relation between stock returns and exchange rates, and their results suggest that stocks are sensitive to FX changes. Katechos (2011) examines the relation between exchange rates and stock returns. The results of the study show a strong relationship between the two variables.

A limited number of studies, however, have examined how the FX rates affect the relations between the stock market and macroeconomic variables. Anderson et al. (2007) examine the real-time price changes in global stock, bond and FX markets. Their results show contemporaneous relations among all markets. The joint response of stock and FX markets to macroeconomic surprises is examined by Mun (2011). The results of the study suggest dynamic significant relations and the joint response of the stock and FX markets to macroeconomic fundamentals.

3 Methodology and Data

The research method is divided into three parts to meet the purpose of this study. The VAR-based Johansen co-integration analysis will be applied to all our variables, and in the absence of co-integration, we apply a vector autoregressive model (VAR) to the return series. Two multivariate models will be estimated to examine the currency effect on the relationship between the stock market and macroeconomic variables in a specific time horizon. One model will pair the home currency-denominated index with the macroeconomic variables, and the other will pair the same index valued in an aggregate currency unit of account, together with the same set of macroeconomic variable valued in an aggregate currency unit of account. The direction of the relationship will also be examined through the block-significance and causality tests.

Estimating a model from non-stationary time series may lead to spurious regression and incorrect results. The Augmented Dickey-Fuller (ADF) test is applied to all our time-series data. A first-order autoregressive model, $y_t = \gamma_1 y_{t-1} + \varepsilon_t$, is said to have a unit root if $\gamma_1 = 1$. We test the null hypothesis that $H_0: \gamma = 1$ against the alternative hypothesis that $H_A: \gamma < 0$

The VAR-based Johansen (1988) co-integration test is specified by the following equation:

$$ë_{trace}(r|n) = -T \sum_{i=r+1}^{n} log\,(1 - ë_i) \tag{1}$$

where r is the number of co-integrating relations. The null hypothesis for the trace statistics tests that there are at most r cointegrating relations, against the alternative of n cointegrating relations, $r = 0, 1,..., n-1$. The maximum eigenvalue statistics tests the null hypothesis that there are r cointegrating relations against the alternative that there are $r+1$ cointegrating relations. We report both the trace and the maximum eigenvalue statistics.

The dynamic interrelationship between the stock indices and macroeconomic variables will be investigated using the unrestricted VAR model. The multivariate VAR can be specified as

$$Z_t = \alpha + \Phi_1 Z_{t-1} + \cdots + \Phi_k Z_{t-k} + \varepsilon_t \tag{2}$$

where Z_t is a k vector of endogenous variables, $\Phi_1 \ldots \Phi_k$ are matrices of estimated coefficients, and ε_t is a vector of innovations, which may be contemporaneously correlated with each other but are uncorrelated with their own lagged values and all the right-hand side variables (Lütkepohl,1991).

This study estimates two VAR models to examine the interrelationship between the stock-market index and macroeconomic variables. One pairs the US dollar-denominated index with selected macroeconomic variables, and the other pairs the aggregate currency-denominated index with the same set of macroeconomic variables denominated in an aggregate currency unit of account. We test the null hypothesis that 'the exchange rate does not affect the magnitude of the relationship between the stock market and macroeconomic variables'; our alternative hypothesis is that 'the exchange rate affects the magnitude of the relationship between the stock market and macroeconomic variables'. We apply the block-significance and causality tests to examine bilaterally whether the lags of the excluded variable affect the endogenous variable. The null tests whether the lagged coefficients are significantly different from zero, and the joint tests that the lags of all other variables affect the endogenous variable.

The impulse-response function tracks the effect of a certain variable on the other variables within the model. In our study, we will apply the Cholesky decomposition to trace the effect of the shock of current innovation on the future values of the remaining variables.

We will apply a diagnostics test to our estimation output to be certain our models are correctly specified. To examine our models for serial correlation, we apply the Lagrange Multiplier (LM) test. The LM test for serial correlation has a null hypothesis of no serial correlation at lag order h. We test the residuals of our models to ensure there are no misspecifications. The true lag order indicated by at least two of our selection criteria will be employed. Lütkepohl (1993) demonstrates the importance of selecting the true lag; a higher-order lag leads to an increase in the mean square forecast errors of the VAR, and a lower order lag than the true lag usually generates auto-correlated errors. We will also conduct stability tests for our models. The estimated VAR is stationary if all roots have a modulus that is less than one and lie outside the unit circle (Lütkepohl, 1991). When the VAR is not stable, some of the results from the estimation output will be invalid.

The time-series data employed in our study include the monthly log returns of the US dollar-denominated S&P 500 (SR), the aggregate currency-denominated S&P 500 (ASR), the industrial production index (IP), the aggregate currency-denominated industrial production index (AIP), money supply (M2), the aggregate currency-denominated M2 (AM2), and the first difference of the 10-year long-term bond yield as a proxy for the long-term interest rate (IR) for January 2001 to December 2010. The time horizon is selected due to the fact that the euro currency, which forms part of our basket of currencies, was only introduced to the world market as replacement for the European Currency Unit (ECU) in 1999. The basket for our aggregate currency will include the US dollar, the euro, and the yen.

Mundell (2000) suggests a currency basket (MIM) comprised of the US dollar, the yen, and the euro with weights of 45%, 20% and 35%, respectively, for a relatively stable basket of currency. The SDR basket presently consists of the US dollar, the British pound, the euro, and the Japanese yen with weights of 41.9%, 11.3%, 37.4%, and 9.4% respectively, and the aggregate currency basket (SAC) suggested by Hovanov, Kolari, and Sokolov (2004) includes the USD, yen, and euro with weights of 31.77%, 33.49%, and 34.74%, respectively. The basket that exhibits the lowest correlation with the home currency-denominated stock index and accounts for the least variance in its returns series over the period under investigation will be employed. The second criterion is applied because one of the reasons for using a basket of currencies is the assumption of relative stability. Although the SDR should be a natural choice, the weights of the currencies in the SDR basket change every five years, and our dataset covers ten years. The different weights of the currencies in the two SDR periods that our dataset covers is likely to distort our data characteristics.

For our study, the SAC exhibits the lowest correlation and variance (see appendix A). The stock-market index against individual stocks is chosen to minimise the effect the unique attribute of individual stocks might have on our results, as postulated by Ross (1976) in the APT. The IP index stands as our measure for activity in the economy because we employ monthly data, and the GDP is released only quarterly. The IR is the risk-free rate, which doubles as our macroeconomic proxy for the cost of funds and an alternative investment vehicle to the stock index, and the M2 is our proxy for liquidity. These three macroeconomic variables have been documented to affect both the stock and FX markets (Mun, 2011, Anderson et al., 2007, Fama, 1981), and all series employed are available from DataStream.

Table 1 shows the descriptive statistics of our variables. All our series except the M2 and AM2 are negatively skewed, which suggests that most of their values are to the right of their mean. The positive kurtosis also shows that our data series are leptokurtic, and they exhibit excess kurtosis greater than zero, which suggests deviation from normal distribution. The SR, IP and M2 have a lower standard deviation than the ASR, AIP and AM2, respectively, which might be due to the incorporation of the aggregate currency exchange rate. The SR, however, has higher kurtosis than the ASR, and it is more negatively skewed than the ASR.

Table 1 Descriptive Statistics

	Mean	Median	Max	Min	S.D	Skewness	Kurtosis	Jarque-Bera	Obs	ADF t-stat
SR	-0.001	0.008	0.090	-0.19	0.048	-0.797	4.130	18.919	119	-8.73
ASR	-0.003	0.004	0.118	-0.17	0.052	-0.51	3.766	8.059	119	-10.21
IP	0.000	0.001	0.017	-0.04	0.008	-1.5	8.204	178.923	119	-4.42
AIP	-0.001	-0.008	0.134	-0.26	0.048	-0.651	9.025	188.383	119	-8.83
IR	-0.012	-0.040	0.58	-1.09	0.222	-0.521	7.621	111.247	119	-8.74
M2	0.003	0.002	0.029	-0.01	0.005	1.563	8.217	183.423	119	-7.60
AM2	0.001	-0.001	0.054	-0.05	0.019	0.102	3.122	0.279	119	-9.52

Above values are the descriptive statistics for the log returns of SR, ASR, IP, AIP, M2 & AM2, and first difference of IR. Number of lags in ADF determined by Schwartz information criterion (SIC). Null hypothesis of unit root rejected at the first difference for all at 1% critical level (MacKinnon 1996). Critical value -3.49.

4 Empirical Findings

The level series of all our variables are integrated of order one, as shown in Table 1. The stock prices and values of our macroeconomic variables are then employed in the co-integration tests.

The results of the unit-root test set the stage for our co-integration tests. We apply the Johansen co-integration test to the level series of the stock index and the macroeconomic variables. The results of the co-integration tests for our two datasets are presented in Tables 2 and 3:

Table 2 Trace and Max-Eigen Co-integration test results for SR, IP, IR, and M2

Hypothesized		Trace	5%	Prob.	Max-Eigen	5%	Prob.
No. of CE(s) H_o	Eigenvalue	Statistic	Critical Value		Statistic	Critical Value	
$r = 0$	0.163	38.898	47.856	0.264	20.479	27.584	0.309
$r \leq 1$	0.098	18.419	29.797	0.535	11.898	21.132	0.558
$r \leq 2$	0.048	6.521	15.494	0.634	5.662	14.265	0.657
$r \leq 3$	0.007	0.859	3.841	0.354	0.859	3.841	0.354

Trace and Max-Eigen tests indicate no cointegrating equation at the 5% level.MacKinnon-Haug-Michelis (1999) p-values. Model 3: Intercept in CE (No trend), and linear deterministic trend in VAR. $H^{*(r)} = \alpha(\beta' y_{t-1} - 1 + \rho_0) + \alpha_1 r_0$. Test applied to monthly values

Table 3 Trace and Max-Eigen Co-integration test results for ASR, AIP, IR, and AM2

Hypothesized		Trace	5%	Prob.	Max-Eigen	5%	Prob.
No. of CE(s) H_o	Eigenvalue	Statistic	Critical Value		Statistic	Critical Value	
$r = 0$	0.127	32.231	47.856	0.599	15.644	27.584	0.696
$r \leq 1$	0.092	16.586	29.797	0.670	11.131	21.131	0.634
$r \leq 2$	0.044	5.455	15.495	0.759	5.221	14.265	0.714
$r \leq 3$	0.002	0.234	3.841	0.629	0.234	3.841	0.629

Trace and Max-Eigen tests indicate no cointegrating equation at the 5% level.MacKinnon-Haug-Michelis (1999) p-values. Model 3: Intercept in CE (No trend), and linear deterministic trend in VAR. $H^{*(r)} = \alpha(\beta' y_{t-1} - 1 + \rho_0) + \alpha_1 r_0$. Test applied to monthly values

Tables 2 and 3 show the results of the co-integration test based on trace and Max-Eigen statistics. In selecting the optimal model for the deterministic components of our variables, we choose a model that allows for a linear deterministic trend in series and intercept but no trend in co-integrating equations. Although the unit root test shows all our variables are an integrated of order one, both the trace and max-eigen statistics indicate no co-integration among the variables because the trace and max-eigen statistics are below their critical values. We therefore cannot reject the null hypothesis of r=0, and the VAR is an appropriate model of estimation.

Table 4 shows the results of our VAR estimates for the US dollar-denominated S&P 500 returns and the macroeconomic variables, and Table 5 shows those for the aggregate currency-denominated S&P 500 and macroeconomic variables, respectively. All variables in Tables 4 and 5 are treated as endogenous in a multivariate unrestricted VAR model. The optimal lag employed in our VAR model is selected using the lag-order selection criteria. The Akaike information criterion (AIC) and likelihood ratio (LR) selection criteria tests indicate lag 4 as the optimal lag order for the SR model, whereas the AIC and final prediction error (FPE) indicate lag 2 as the optimal lag for the ASR model (see Appendix B, Tables 9 & 10). The results justify the selected lag lengths.

Table 4 VAR Estimates for SR, IP, IR and M2

	SR	IP	IR	M2
SR(-1)	0.187*	0.011***	0.520	-0.022***
SR(-2)	-0.119	0.031***	1.626	-0.014***
SR(-3)	0.082	0.049***	0.557	-0.009***
SR(-4)	-0.047	0.019***	0.478	-0.011***
IP(-1)	1.954	0.004*	-4.624	-0.061*
IP(-2)	0.959	0.220*	-0.669	-0.111*
IP(-3)	-0.746	0.148*	3.782	-0.157*
IP(-4)	-1.238	0.165	-4.820	0.010*
IR(-1)	- 0.003**	0.003***	0.064	-0.004***
IR(-2)	-0.009**	-0.004***	-0.338	0.001***
IR(-3)	-0.008**	0.005***	-0.009*	-0.003***
IR(-4)	-0.044**	-0.001***	-0.109*	0.002***
M2(-1)	-1.475	0.012	-4.283	0.072*
M2(-2)	-0.422	-0.003	-0.623	0.047*
M2(-3)	0.222	0.137	7.568	-0.071*
M2(-4)	0.459	0.147	4.114	-0.276*
C	0.002***	-0.000***	-0.042***	0.004***
R^2	**0.25**	**0.41**	**0.34**	**0.41**

SR, IP, and M2 are the log returns for the US dollar denominated S&P500, Industrial Production, and Money Supply, while IR is the first difference. ***, *, denote significance at 1% and 10% respectively. C is the constant.

The estimated result of our multivariate VAR includes the log returns of the US dollar-denominated SR, IP, M2, and the first difference of IR in Table 4 and the results of the model that consists of the log returns of the aggregate currency-denominated stock returns, AIP, AM2 and the first difference of IR in Table 5. From our results in Table 4, we see a negative and significant effect of interest rate on stock returns from the first through fourth lags. The inverse relationship between stock returns and interest rates suggests the two variables are alternative investment vehicles, showing that a decrease in interest rate leads to an increase in stock prices. As a proxy for the cost of funds, the inverse relationship between the stock returns and the interest rate suggests that the stock market benefits from a reduction in interest rates.

The effect of stock returns on industrial production and money supply is significant through the four lags, which suggests that a change in stock returns four months prior affects the present change in industrial production and money supply. The sign is positive for industrial production, as expected, but that of M2 is negative, which is contrary to expectations. Our results also show that the interest-rate change affects industrial production and money supply significantly from one month prior to four months. With an R^2 of approximately 41% each, the variability of money supply and industrial production are best explained by our selected variables.

Table 5 VAR Estimates for ASR, AIP, IR, and AM2

	ASR	AIP	IR	AM2
ASR(-1)	0.120	-0.333	-0.906	-0.074
ASR(-2)	0.192	-0.214	-0.420	-0.173
AIP(-1)	0.708**	0.567	2.116	0.750**
AIP(-2)	0.101	-0.722	-2.558	0.109
IR(-1)	-0.125*	-0.087	-0.284	-0.145**
IR(-2)	-0.033	0.110	0.336	-0.034
AM2(-1)	-0.084	0.325	1.321	0.210
AM2(-2)	-0.153	0.005	-0.342	0.226
C	-0.002	-0.003	-0.016	-0.001
R^2	**0.17**	**0.10**	**0.09**	**0.17**

ASR, AIP, AIR, and AM2 are the log returns for the aggregate currency denominated S&P500, Industrial Production, Interest Rate, and Money Supply.***, *, denote significance at 1% and 10% respectively. C is the constant.

The results of our aggregate currency-denominated model in Table 5 show that only the first lags of AIP and IR are significant in explaining the change in the aggregate currency-denominated stock returns. Similarly, the first lag of AIP and IR are also significant in explaining changes in the aggregate currency-denominated money supply (AM2). There are no other significant relationships in the aggregate currency-denominated model. Our selected variables best explain the degree of variability in the ASR and AM2, which both have the highest R^2, approximately 17%. The degree of variability of the aggregate currency-denominated industrial production is 10%, and the interest rate is 9%.

In the VAR model with aggregate currency-denominated stock returns and macroeconomic variables, we see a reduction in the R^2 across the board compared to the model with the US dollar-denominated stock returns and macroeconomic variables. The results of the aggregate currency-denominated model also suggest that the industrial production and interest rate are the two most important variables in the model. The R^2 for ASR shows a reduction of eight percentage points compared to that of the SR, which suggests that the explanatory power of the macroeconomic variables on the ASR in the model are reduced considerably.

Examining the roots of the characteristic polynomial for our estimated models, the results show no root lies outside the unit circle, and thus, our estimated VAR models satisfy the stability condition. Furthermore, the residuals of our models are examined for serial correlation using the LM test to ascertain the proper model specification. Our results do not reject the null hypothesis of no serial correlation at lag order h (see Appendix B, Tables 11 & 12).

The results of the block-significance test for the IP, IR, M2, and SR, and AIP, IR, AM2 and ASR models are presented in Tables 6 and 7, respectively. The results in Table 6 show that the four variables are not exogenous; the p-values of the joint test for the SR, IP, IR and M2 equations are 0.041, 0.004, 0.000, and 0.000, respectively. We therefore can reject the null hypothesis of excluding all four variables. There is bidirectional causality only between the stock returns and industrial production, and there is unidirectional causality of SR on IR, IP on IR, SR on M2, and IP on M2. We fail to reject the null hypothesis of excluding the IR and M2 from the SR equation, IR and M2 from the IP equation, M2 from the IR equation and IR from the M2 equation.

Table 6 Granger-causality/block exogeneity test for SR, IP, IR, and M2

Dependent variable: SR			
Excluded	Chi-sq	df	Prob.
IP	12.590	4	0.014
IR	4.411	4	0.353
M2	3.106	4	0.540
All	21.690	12	0.041
Dependent variable: IP			
Excluded	Chi-sq	df	Prob.
SR	15.673	4	0.004
IR	3.597	4	0.463
M2	2.497	4	0.645
All	29.050	12	0.004
Dependent variable: IR			
Excluded	Chi-sq	df	Prob.
SR	19.096	4	0.000
IP	7.535	4	0.046
M2	2.497	4	0.645
All	36.369	12	0.000
Dependent variable: M2			
Excluded	Chi-sq	df	Prob.
SR	8.740	4	0.068
IP	11.866	4	0.018
IR	4.312	4	0.365
All	37.009	12	0.000

SR, IP, IR, and M2 are the log returns for the US dollar denominated S&P500, Industrial Production, Interest Rate, and Money Supply

The p-values of the joint test results for the aggregate model in Table 7 show that only the ASR and AM2 are not exogenous. This finding suggests that we can reject the null hypothesis of excluding only those two variables. There are no bidirectional causalities between any pair of variables, but we observe unidirectional causality from AIP to ASR and from both AIP and IR to AM2.

Table 7 Granger-causality/block exogeneity tests for ASR, AIP, IR, and AM2

Dependent variable: ASR

Excluded	Chi-sq	df	Prob.
AIP	4.840	2	0.089
IR	3.364	2	0.186
AM2	1.537	2	0.464
All	21.511	6	0.002

Dependent variable: AIP

Excluded	Chi-sq	df	Prob.
ASR	1.037	2	0.595
IR	0.499	2	0.779
AM2	0.573	2	0.751
All	2.047	6	0.915

Dependent variable: IR

Excluded	Chi-sq	df	Prob.
ASR	0.343	2	0.842
AIP	0.666	2	0.717
AM2	0.370	2	0.831
All	1.568	6	0.955

Dependent variable: AM2

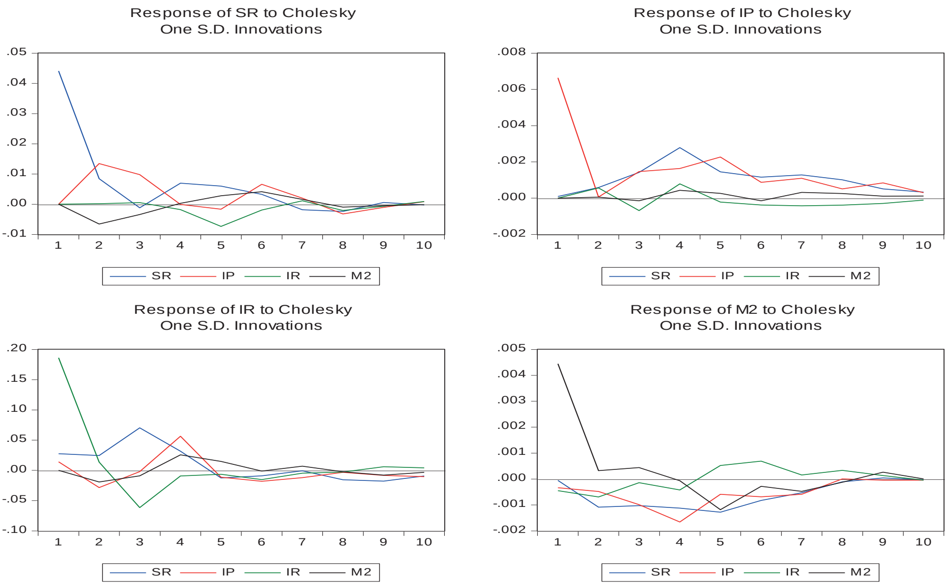
Excluded	Chi-sq	df	Prob.
ASR	1.536	2	0.464
AIP	5.815	2	0.055
IR	4.706	2	0.095
All	20.304	6	0.002

ASR, IP, IR, and M2 are the log returns for the aggregate currency denominated S&P500, Industrial Production, Interest Rate, and Money Supply

The results from the SR and ASR block-significance tests also suggest that the US dollar-denominated model exhibits a closer relationship between the stock market and the macroeconomic variables than the aggregate currency-denominated model. The significance levels for the ASR are lower than those for the SR. This finding suggests that the SR is more closely linked to the macroeconomic variables than the ASR. This suggestion is plausible because the aggregate currency-denominated model incorporates the exchange rate of the US dollar, the Japanese yen and the euro. Two of the exchange rates are determined outside the US and thus are not directly affected by activity in the US; therefore, the effect of the aggregate currency-denominated macroeconomic variables on the aggregate currency-denominated index is lower.

Figures 1 and 2 present the results of the impulse-response function of our estimated models. The figures show the effect of the shock from each variable to the others within the model. In Figure 1, which has the SR model, we see an asymmetric reaction of all variables to shocks emanating from itself.

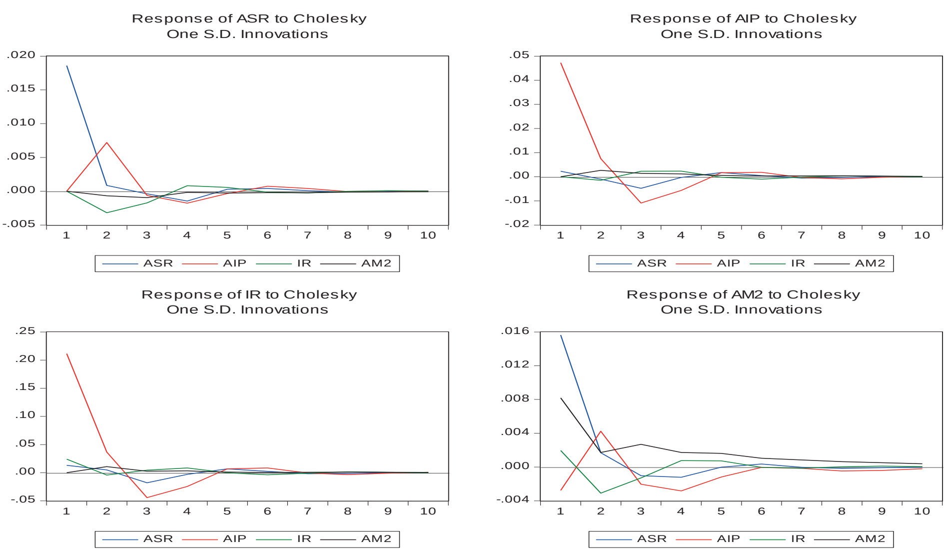
Figure 1 Impulse-response function for SR and macroeconomic variables



All the shocks die out during the 10-month period and are all bordering around zero. The impulse-response function shows the shocks from stock returns lasting longer on all other variables. We see a symmetric response of M2 to shocks from the other variables, with most of them generating slightly negative effects.

Figure 2 shows the ASR and macroeconomic variables' impulse-response function. We again observe that all variables respond asymmetrically to shocks emanating from itself, with all the shocks dissipating during the 10-month period and bordering around zero.

Figure 2 Impulse-response function for ASR and macroeconomic variables



The impulse-response function shows that for the ASR model, the shocks are almost fully dissipated by the eighth month, save for that of AM2. For the SR model, most of the shocks last until the tenth month. The response of the ASR to its own shock and the shock of other variables is much closer to zero than the response of SR is to its own shock and the shock from the other variables (see Appendix C, Table 13).

5 Conclusions

Employing monthly data from 2001 to 2010, this paper investigates the currency effect on the long-run relationship between the stock market and important macroeconomic variables in the U.S. Johansen co-integration tests indicate no co-integrating relationship in either set of our data series despite the fact that they are all integrated in an order of one. Therefore, the VAR is an appropriate model of estimation. Two VAR models are estimated, one pairing the US dollar-denominated S&P 500 and macroeconomic variables and the other pairing an aggregate currency-denominated S&P 500 and aggregate currency-denominated macroeconomic variables. Our study also examines the causal relationship between the stock-market index and the economy through the Granger-causality/block exogeneity Wald test to examine how our variables affect each other both individually and jointly and which variables have explanatory influence over others.

The interrelationship between the stock indices and our selected key macroeconomic variables was investigated using multivariate VAR models, where all our variables were treated as endogenous. The VAR model was applied to the log returns of all our variables except the interest rate, where the first difference was employed. Our log-returns data series exhibited stationarity when investigated using the ADF unit root test, whereas the interest rate was stationary at first difference. After estimating our VAR models, we applied diagnostic tests to ensure the validity and reliability of our models, and the results showed no misspecifications in our estimated models. The results of our study do not reject the alternative hypothesis that the introduction of the exchange rate alters the magnitude of relationship between the stock market and the macro-economy.

The results of our VAR model pairing the US dollar-denominated stock returns and macroeconomic variables showed a stronger relationship between the stock indices and the selected macroeconomic variables. The optimal lag for this model was four, and some of our variables showed a significant effect through the four lags. The second model that paired the aggregate currency-denominated stock returns and aggregate currency-denominated macroeconomic variables showed a weaker relationship between the variables, and the optimal lag indicated was only two lags.

Our results also show a change in the relationship between the stock indices and macroeconomic variables in the two models. Whereas the relationship between the stock returns and interest rate in the first model was negative and significant through the four lags, only the first lag of interest was significant in explaining stock returns in the second model. The significance exhibited by the stock returns in explaining some of the macroeconomic variables in the first model, particularly industrial production and money supply through the four lags, was absent in the aggregate currency model. The R^2 for the aggregate currency-denominated model was also reduced considerably compared to that of the US dollar-denominated model.

The negative relationship between the stock market and interest rate is extensively supported by theory and past literature (Fama & Schwert, 1977, Mukherjee & Naka, 1995, Mun, 2011). The economic implication suggests that an increase in the interest rate will affect the discount rate, which will reduce the return on the asset. A reduction in interest rate, by contrast, makes borrowing more attractive. Companies are likely to embark on expansionary activities, and investors are more likely to be willing to borrow to finance investments in assets with expected returns much higher than the ongoing interest rate. When the interest rate is viewed as an alternative investment vehicle to the stock market, an increase in the risk-free interest rate will see more investors opting for the risk-free rate, which will in turn depress the stock market.

The quantity theory of money suggests a positive relationship between stock returns and money supply, and it has been broadly supported by the extant literature (Mukherjee & Naka, 1995, Mun, 2011). This theory was premised on excess liquidity inducing an increase in consumption and investment, which lead to an increase in stock prices. Our results regarding the relationship between the stock market and M2, however, follow the contrarian argument that stock-price rises causes changes in the money supply and not the other way around, as postulated in the quantity theory of money. It is argued that movement in money supply reflects the shift of money from long-term deposits to demand deposits as a result of initial changes in stock prices, which provides an incentive to liquidate long-term savings deposits. The money is then invested in stocks and other financial instruments; this causes an increase in demand deposits, which in turn causes an increase in narrow money (M1). The effect of the industrial production on stock returns is significant in only the aggregate currency-denominated model, whereas the effect of stock returns on industrial production is significant in the US dollar-denominated model, both with positive signs.

The Granger-causality block-significance results show a stronger causal relationship between the US dollar-denominated stock returns and macroeconomic variables than between the aggregate currency-denominated stock returns and aggregate currency-denominated macroeconomic variables, with no causality flowing individually from any of the macroeconomic variables to the aggregate currency-denominated stock returns.

Our results suggest that the exchange rate is an important factor that should not be ignored when examining the interactions between the stock market and the macro-economy. This is clearly logical because there is a currency component in both the stock returns and the macroeconomic variables. Changes due to movement in the value of the currency and changes in the value of the indices would need to be distinguished in order to determine the true relationship between the stock market and the macroeconomic variables. Thus, the magnitude and nature of the previously documented relations between the stock market and macroeconomic variables without accounting for the currency component might not necessarily hold. This view is also supported by the works of Anderson et al. (2007), and Mun (2011).

This result is important for policy makers and investors alike. For policy makers, it is important to know the true relationship between financial markets and the macro-economy. If this relationship is over- or understated, then the policy targets may not be achieved. This also has an implication for the policy lever to be deployed. Similarly, for investors, knowledge of the magnitude and true nature of the relationship between financial markets and the macro-economy guides them on the parameters of the importance to track and inform their investment decisions and strategies.

Many factors affect stock-market activities, and the period under consideration experienced several upheavals, which might influence the relations between the financial market and macroeconomic variables in one way or another. Our study did not examine these changes in characteristics, which represents a limitation of our study and a possible area for future research.

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Appendix A: Characteristics of variables

Table 8 SP500 and basket currencies correlation

	SP500	SAC	SDR	MIM
SP500	1			
SAC	0.85	1		
SDR	0.87	0.97	1	
MIM	0.87	0.98	0.99	1

Figure 3 Variance of the S&P500 and basket of currencies

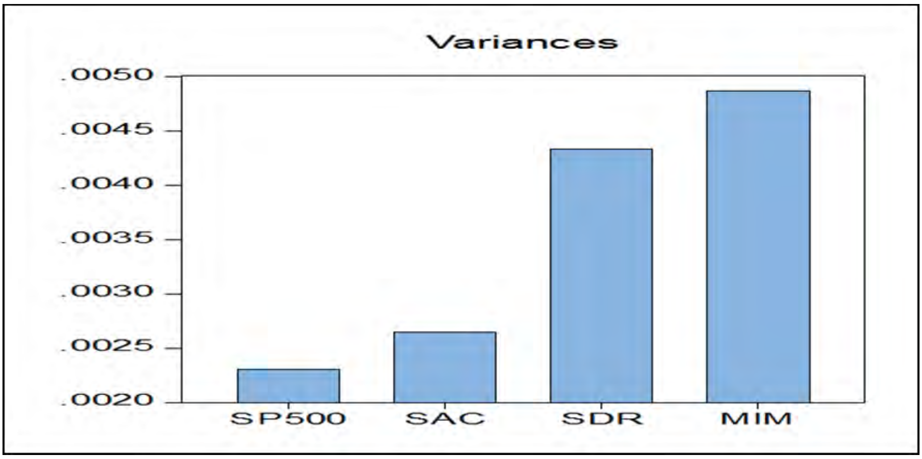
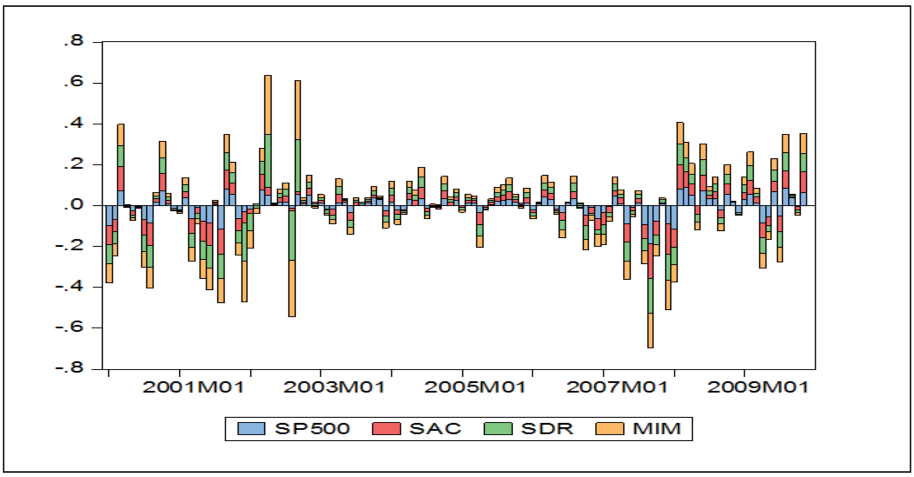


Figure 4 Returns of the S&P500 and the aggregate currency denominated S&P500



Appendix B: Robustness tests

Table 9 Lag order selection criteria for SR and macroeconomic variables

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1177.32	NA	7.74e-15	-21.14	-21.04*	-21.10
1	1206.92	56.53	6.06e-15	-21.39	-20.90	-21.19
2	1235.02	51.64	4.88e-15	-21.60	-20.73	-21.25*
3	1251.38	28.89	4.86e-15*	-21.61	-20.34	-21.10
4	1267.44	27.20*	4.88e-15	-21.61*	-19.95	-20.94
5	1278.33	17.66	5.40e-15	-21.52	-19.47	-20.69
6	1286.70	12.97	6.28e-15	-21.38	-18.94	-20.39
7	1295.93	13.63	7.22e-15	-21.26	-18.43	-20.11
8	1301.75	8.18	8.89e-15	-21.08	-17.85	-19.77

*indicates lag order selected by criterion. Each test at 5% level

Table 10 Lag order selection criteria for ASR and macroeconomic variables

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1059.09	NA	6.51e-14	-19.01	-18.91	-18.97
1	1099.77	77.70	4.18e-14	-19.46	-18.97*	-19.26*
2	1119.49	36.24	3.91e-14*	-19.52*	-18.64	-19.17
3	1128.14	15.28	4.48e-14	-19.39	-18.12	-18.88
4	1141.96	23.40	4.68e-14	-19.35	-17.69	-18.68
5	1160.55	30.14	4.51e-14	-19.40	-17.35	-18.57
6	1179.18	28.87*	4.36e-14	-19.44	-17.00	-18.45
7	1187.19	11.84	5.12e-14	-19.30	-16.47	-18.15
8	1197.55	14.55	5.81e-14	-19.20	-15.98	-17.89

*indicates lag order selected by criterion. Each test at 5% level

Table 11 VAR stability test for stock market and macroeconomic variables

SR		ASR	
Root	Modulus	Root	Modulus
0.78	0.78	0.77	0.77
0.01 - 0.75i	0.75	0.12 - 0.57i	0.59
0.01 + 0.75i	0.75	0.12 + 0.57i	0.59
-0.73	0.73	-0.49	0.49
-0.45-0.54i	0.70	0.12 - 0.38i	0.40
-0.45 + 0.54i	0.70	0.12 + 0.38i	0.40
0.54 - 0.44i	0.70	-0.27	0.27
0.54 + 0.44i	0.70	0.11	0.11
-0.48 - 0.50i	0.70		
-0.48 + 0.50i	0.70		
0.59 - 0.34i	0.68		
0.59 + 0.34i	0.68		
0.13 - 0.54i	0.56		
0.13 + 0.54i	0.56		
-0.22 - 0.33i	0.39		
-0.22 + 0.33i	0.39		

No root lies outside the unit circle

Table 12 Serial correlation LM test for stock market and macroeconomic variables

	SR		ASR	
Lags	LM-Stat	Prob	LM-Stat	Prob
1	16.28	0.43	28.16	0.03
2	15.41	0.49	20.36	0.20
3	11.16	0.80	23.65	0.10
4	9.01	0.91	14.83	0.54
5	17.07	0.38	25.93	0.13
6	13.94	0.60	18.12	0.34
7	11.02	0.81	19.44	0.25
8	14.99	0.53	10.74	0.83
9	16.20	0.44	27.65	0.10
10	14.84	0.54	6.52	0.98
11	12.39	0.72	12.05	0.74
12	11.38	0.79	20.96	0.18

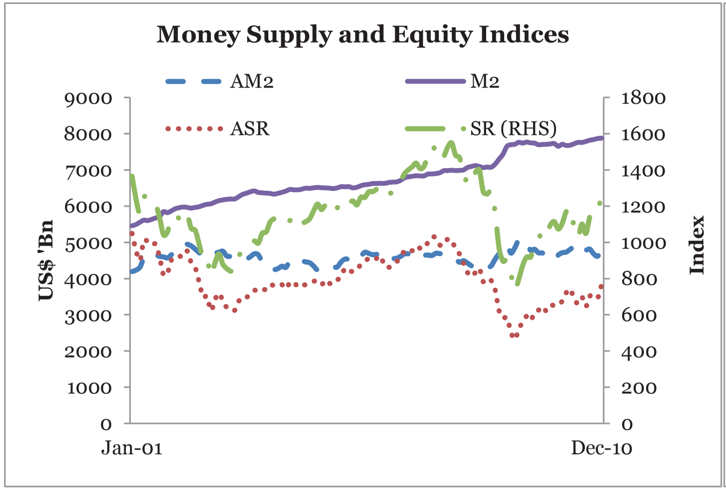
Probs from chi-square with 16 df.

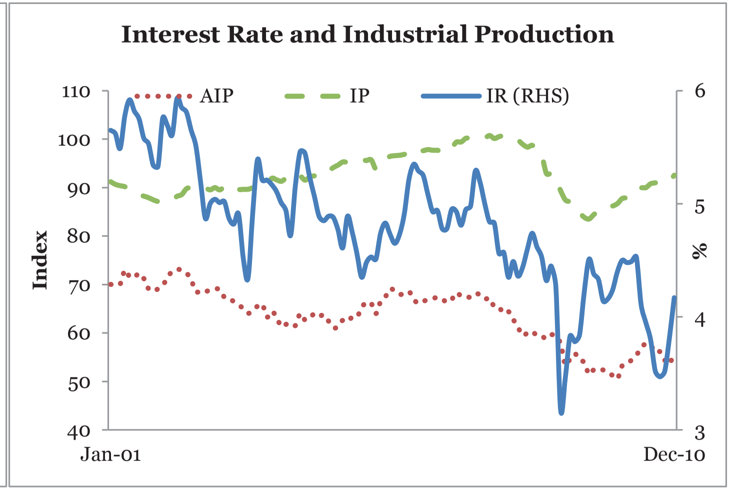
Appendix C: Impulse response table

Table 13 Impulse Response

Response of SR:					**Response of ASR:**				
Period	**SR**	**IP**	**IR**	**M2**	**Period**	**ASR**	**AIP**	**IR**	**AM2**
1	0.044	0.000	0.000	0.000	1	0.019	0.000	0.000	0.000
2	0.008	0.013	0.000	-0.007	2	0.001	0.007	-0.003	-0.001
3	-0.001	0.010	0.001	-0.003	3	0.000	-0.001	-0.002	-0.001
4	0.007	0.000	-0.002	0.000	4	-0.001	-0.002	0.001	0.000
5	0.006	-0.002	-0.007	0.003	5	0.000	0.000	0.001	0.000
6	0.003	0.007	-0.002	0.004	6	0.000	0.001	0.000	0.000
7	-0.002	0.002	0.001	0.002	7	0.000	0.000	0.000	0.000
8	-0.002	-0.003	-0.002	-0.001	8	0.000	0.000	0.000	0.000
9	0.001	-0.001	-0.001	-0.001	9	0.000	0.000	0.000	0.000
10	0.000	0.001	0.001	0.000	10	0.000	0.000	0.000	0.000
Response of IP:					**Response of AIP:**				
Period	**SR**	**IP**	**IR**	**M2**	**Period**	**ASR**	**AIP**	**IR**	**AM2**
1	9E-05	0.007	0.000	0.000	1	0.002	0.047	0.000	0.000
2	0.001	6E-05	0.001	6E-05	2	-0.001	0.007	-0.001	0.003
3	0.001	0.001	-0.001	0.000	3	-0.005	-0.011	0.002	0.001
4	0.003	0.002	0.001	0.000	4	0.000	-0.006	0.002	0.001
5	0.001	0.002	0.000	0.000	5	0.002	0.002	0.000	0.001
6	0.001	0.001	0.000	0.000	6	0.000	0.002	-0.001	0.000
7	0.001	0.001	0.000	0.000	7	-0.001	0.000	0.000	0.000
8	0.001	0.001	0.000	0.000	8	0.000	-0.001	0.000	0.000
9	0.001	0.001	0.000	0.000	9	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	10	0.000	0.000	0.000	0.000
Response of IR:					**Response of IR:**				
Period	**SR**	**IP**	**IR**	**M2**	**Period**	**ASR**	**AIP**	**IR**	**AM2**
1	0.027	0.014	0.186	0.000	1	0.013	0.211	0.024	0.000
2	0.024	-0.028	0.014	-0.019	2	0.005	0.036	-0.004	0.011
3	0.070	-0.002	-0.061	-0.009	3	-0.018	-0.044	0.004	0.003
4	0.032	-0.057	-0.009	0.026	4	-0.003	-0.024	0.008	0.003
5	-0.012	-0.011	-0.006	0.015	5	0.007	0.007	0.000	0.001
6	-0.009	-0.018	-0.015	-0.001	6	0.002	0.009	-0.004	0.001
7	-0.006	-0.119	-0.005	0.007	7	-0.002	-0.001	-0.001	0.001
8	-0.016	-0.003	-0.003	-0.002	8	-0.001	-0.003	0.001	0.001
9	-0.018	-0.008	0.006	-0.008	9	0.000	-0.001	0.001	0.001
10	-0.009	-0.010	0.004	-0.003	10	0.001	0.001	0.000	0.000
Response of M2:					**Response of AM2:**				
Period	**SR**	**IP**	**IR**	**M2**	**Period**	**ASR**	**AIP**	**IR**	**AM2**
1	-5E-05	0.000	0.000	0.004	1	0.016	-3E-03	0.002	0.008
2	-0.001	0.000	-0.001	0.000	2	0.002	4E-03	-0.003	0.002
3	-0.001	-0.001	0.000	0.000	3	-0.001	-2E-03	-0.001	0.003
4	-0.001	-0.002	0.000	-7E-05	4	-0.001	-3E-03	0.001	0.002
5	-0.001	-0.001	0.001	-0.001	5	-1E-05	1E-03	0.001	0.002
6	-0.001	-0.001	0.001	0.000	6	0.000	-4E-05	-3E-05	0.001
7	-0.001	-0.001	0.000	0.000	7	-2E-05	2E-04	0.000	0.001
8	0.000	6E-06	0.000	0.000	8	0.000	-5E-04	4E-05	0.001
9	4E-05	-4E-05	0.000	0.000	9	-8E-05	-4E-04	0.000	0.001
10	-3E-05	-4E-05	-4E-05	4E-06	10	8E-06	-2E-04	5E-05	0.000

Appendix D: Trend charts of variables





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OLUGBENGA OLUFEAGBA

ESSAYS ON THE CURRENCY EFFECT ON STOCK MARKET RELATIONSHIPS AND STOCK RETURN FORECAST

Asset price movements play credible role as leading indicator for activity, financial distress and general economic wellbeing, and as such, are closely monitored by investors and policymakers alike. All assets' prices are expressed in a unit of account, usually the home currency of the jurisdiction in which the asset is domiciled, and the values of these currencies continually vary, depending on the balance of demand and supply. The continuous variation in the value of currencies suggests that, at best, they can only be an inappropriate unit of measure of an asset.

This dissertation aims to shed more light on why single currencies are inaccurate units of measure of asset prices. Our first study investigates how the currency of valuation affects the outcome of the return and volatility spillovers between the stock market and the foreign exchange (FX) market. Evidence from our study suggests the presence of exchange rate premium in asset prices, which in turn significantly affects the nature of the relationship between the equity and FX markets when asset prices are measured in an aggregate unit of account rather than pair-wise or single currency.

In our second study, we examine the currency effect on the predictability of stock returns in the short term. Although previous studies have concentrated on investigating the factors or models that best predict asset returns, our study investigates the effect of currency of valuation on stock return predictability. Our results suggest that reducing the volatility of the variables by valuing them in an aggregate unit of account improves the predictability of stock returns on the short horizon.

Our last study investigates the currency effect on the long-term relationship between the stock market and macroeconomic variables. Our results show evidence of significant changes in the relations between the stock market and macroeconomic variables with the introduction of the aggregate currency factor, marked by reducing the effect of the aggregate currency-denominated US macroeconomic variables on the aggregate currency-denominated stock index. Moreover, the results show that the previously documented relations between the stock market and macroeconomic variables, without accounting for the influence of the currency of valuation, might not necessarily hold when the currency factor is discounted.

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