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EXCHANGE RATE INFLUENCES ON STOCK MARKET RETURNS AND VOLATILITY DYNAMICS: EMPIRICAL EVIDENCE FROM THE AUSTRALIAN STOCK MARKET

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ABSTRACT: *This paper examines the influence of exchange rate exposure on Australian stock returns and their volatility, using daily data from January 2003 to February 2013. Furthermore, the current study uses the exchange rate between the Australian dollar and seven other currencies to quantify the extent of the influence of each currency's exposure on Australian stock returns and their volatility. The estimated results indicate that the lagged exchange rates of six of the seven currencies, and their unanticipated shocks, significantly influence Australian stock returns. However, the results show that the influences of the variances of exchange rates on Australian stock returns are insignificant. Unlike the influence of exchange rate volatility on Australian stock market returns, exchange rate volatility exposure on Australian stock market volatility indicates statistically significant results for the variance of two of the seven currencies.*

JEL Classification: *F31, G10, G15*

Keywords: *Stock returns, volatility, exchange rates, univariate GARCH model*

1. INTRODUCTION

In the new global economy, the interactions between international financial markets, as well as the international diversification of investment portfolios, have increased markedly. Changes in exchange rates have become an increasingly important area when dealing with this increasing international diversification of investment portfolios (Agrawal *et al*., 2010). According to Kanas (2000), changes in the foreign exchange market influence the international competitiveness of firms, thus affecting real income and eventually stock prices. Agrawal *et al*. (2010) also argue that the volatility of the foreign exchange rate affects the future cash flows of firms. Hence, the value of firms fluctuates, leading to changes in the stock price. Moreover, continuous fluctuations in world trade and capital movements have made the exchange rate one of the main determinants of business profitability and equity prices (Kim, 2003).

In recent years, there has been increasing interest among scholars, policy makers and investors in studying the effect of the foreign exchange market on stock market returns and

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their volatility. For instance, Muzindutsi and Niyimbanira (2012) argue that if foreign exchange rate risks cannot be diversified, investors will have to pay a premium on the assets that are exposed to currency risk.[1] Furthermore, investors decide on the composition of their investment portfolios based on existing and expected exchange rates and interest rates (Central Bank of Sri Lanka, 2006). Iorio and Faff (1999) argue that, for international investors, the exchange rate matters both when one stock market dominates other stock markets and when that stock market return is expressed in domestic currency. The foreign exchange rate is therefore recognised as one of the most important dimensions of foreign investment, international asset pricing and financial market regulations.

Many studies, for instance, Jorion (1991), Kanas (2000), Yang and Doong (2004), Kabigting and Hapitan (2011) and Du and Hu (2012), have examined the relationship between exchange rates and stock markets in various countries during different periods from different perspectives. However, these empirical research studies are rather controversial, and there is no general agreement about volatility interdependency between exchange rates and stock markets. Therefore, the aim of this paper is to examine and quantify the influences of exchange rates on stock returns and their volatility: consequently, to evaluate these influences, the objectives of the current paper are threefold. The first objective is to capture any existing exchange rate influences on stock returns and volatility. In this regard, most studies (e.g. Iorio & Faff, 1999; Smyth & Nandha, 2003; Kabigting & Hapitan, 2011) use exchange rates to examine the relationship between foreign exchange markets and stock markets to quantify exchange rate influences on stock markets. However, Jorion (1991) criticises the use of exchange rates, claiming that it leads to multicollinearity, which arises with the existing correlation between exchange rate fluctuations and stock return movements. To shed some light on this argument, the current study first uses exchange rates to quantify any existing influences from exchange rates on stock returns and volatility. Then, to address the multicollinearity issue, the study uses exchange rate residuals (or unanticipated shocks) generated in the foreign exchange market to quantify exchange rate influences on stock returns and volatility, as suggested by Jorion (1991). In addition to exchange rate residuals, the current paper uses variances of exchange rates as an alternative measure to enumerate exchange rate influences on both stock returns and volatility.

The second objective is to provide an insight into whether an investor reacts to the immediately available information. According to Saunders and Tress (1981), investors act and reflect quickly on market prices and hence on stock returns in efficient markets when relevant information is publicly available. To achieve the second objective, the current study quantifies the extent of the influence of the previous day's closing exchange rate values on the next day's opening values of stock returns and volatility. Finally, the focus of this paper is to quantify the magnitude of exchange rate influences from different currencies on a single stock market. From an investor's perspective, the measure of the magnitude of various currencies' influences on a single stock market would enable the investor to identify the relative importance of each foreign currency's fluctuations on that specific stock market.

The rest of this paper is organised as follows. Section 2 presents a review of the literature related to the theoretical framework of the current study, evaluating empirical work which has studied the relationship between the stock market and the exchange market. The next section, Section 3 'Methodology', builds upon the univariate GARCH model. The data and preliminary findings are set out in Section 4, followed by the empirical econometric results in Section 5. The final section provides some concluding remarks.

2. LITERATURE REVIEW

The literature on the relationship between stock prices and exchange rates has employed various econometric techniques. However, there is no general agreement about their findings. One group of analysts uses the Granger causality test and cointegration analysis to model stock returns and exchange rates. For example, Bahmani-Oskooee and Sohrabian (1992) find bidirectional causality between stock prices and exchange rates in the short run. Furthermore, their results from cointegration analysis reveal that no long-run relationship exists between the two variables. Similarly, Smyth and Nandha (2003) could not find a long-run equilibrium relationship between these two financial variables. In contrast to Bahmani-Oskooee and Sohrabian (1992), Smyth and Nandha (2003) find unidirectional causality running from exchange rates to stock prices. However, unidirectional causality from exchange rates to stock prices could only be found in data from India and Sri Lanka. Moreover, they could not find any causality relationship between these two financial variables in data from Bangladesh and Pakistan. More recently, using rolling unit root, cointegration and Granger causality tests, Kollias and Mylonidis (2012) identify time-varying causality between exchange rates and stock prices. More importantly, their results reveal that, under normal market conditions, this causality is from exchange rates to stock prices whereas, during periods of market turbulence, they find the possibility of holding this relationship from stock prices to exchange rates. Focusing on the long-run relationship, Tian and Ma (2010) utilise the autoregressive distributed lag (ARDL) modelling approach and find a cointegration relationship between the Shanghai A share index and the exchange rate of the Chinese renminbi against the US dollar. Furthermore, the cointegration relationship between the Shanghai A share index and the exchange rate of the Hong Kong dollar has only existed since the Chinese exchange rate regime became a flexible, managed, floating system in 2005.

Another group of researchers examine the time-varying nature of the relationship between exchange rates and stock returns using autoregressive conditional heteroskedastic (ARCH) and GARCH (generalised ARCH) models. However, their findings are controversial. For example, Kanas (2000) finds that volatility spillovers from exchange rates to stock returns are insignificant using the Exponential GARCH model. Using the multivariate Exponential GARCH model, Yang and Doong (2004) find less direct effects on the fluctuations of future stock prices from foreign exchange rate movements compared to the effects of stock markets on the foreign exchange market. Kabigting and Hapitan (2011) find evidence of volatility spillovers from stock markets to exchange markets, as well as from exchange markets to stock markets, whereas Du and Hu (2012) argue that foreign exchange rate volatility has no power to explain either the time-series or cross-section of stock returns. Furthermore, Kabigting and Hapitan (2011) use the GARCH model while Du and Hu (2012) employ both cross-sectional regression and time-series regression methodologies.

3. METHODOLOGY

The current study evaluates exchange rate influences on stock market returns and their volatility. Analysing this relationship is particularly demanding owing to the characteristics of the financial time-series data. The most common characteristics in financial data are non-linearity and time-varying variance and covariance. In addition, the presence of autocorrelations, the non-normal distribution of data, volatility clustering, mean revision in volatility, and volatility correlation and persistence are the most common stylised statistical facts of financial data discussed in the literature (see e.g. Bollerslev *et al*., 1992; Bollerslev *et al*., 1994; Patterson, 2000; Cont, 2001; Engle & Patton, 2001; Brooks, 2008). Those unobservable second- and higher-order moments in financial data are difficult to identify and model using traditional econometrics techniques. However, due to the following features, both the ARCH process (Engle, 1982) and its generalised form known as the GARCH process (Bollerslev, 1986) can be used in empirical studies. Firstly, these models are useful for forecasting variance which may change over time and be predicted by past forecast errors. Secondly, they hold as a function of the expected means and variance of the rates of return. Thirdly, they can be used as an approximation of ARCH models to more complex models with non-ARCH disturbances. The univariate GARCH methodology is utilised for the current analysis to capture first- and second-order moments in the data. Furthermore, Mussa (1979) observes volatility clustering for many exchange rates. In addition, Friedman and Vandersteel (1982) provide evidence of leptokurtic properties in daily exchange rates. To examine exchange rate exposure on stock returns and volatility while capturing volatility clustering and leptokurtic properties of exchange rates, this paper utilises the generalised version of the ARCH process introduced by Bollerslev (1986). Therefore, to quantify exchange rate influences on stock market returns, the current study firstly incorporates exchange rates into a mean equation, as illustrated in Equation (1). Furthermore, Equation (2) represents the GARCH process incorporating exchange rates to examine stock market volatility dynamics due to exchange rate exposure.

Model 1

$$STRET_t = \mu_0 + \sum_{j=1}^{m} \mu_{1j} EXRATE_{jt-1} + \sum_{j=1}^{m} \mu_{2j} EXRATE_{jt-2} + \varepsilon_t \tag{1}$$

$$HST_t = \delta_0 + \delta_1 \varepsilon_t^2 + \delta_2 HST_{t-1} + \sum_{j=1}^{m} \beta_{1j} EXRATE_{jt-1} + \sum_{j=1}^{m} \beta_{2j} EXRATE_{jt-2} \tag{2}$$

where $STRET_t$ represents the opening value of stock market returns and $EXRATE_{jt}$ is the daily closing value of foreign currency *j*/Australian dollar.[2]

Secondly, this study generates the residuals and variances of exchange rates using the univariate GARCH methodology for exchange rates. Equations (3) and (4) illustrate the mean and variances equations for exchange rates, respectively.

Model 2

$$EXRATE_{jt} = \beta_{j0} + \beta_j EXRATE_{jt-1} + e_{jt} \tag{3}$$

$$HEX_{jt} = \alpha_{j0} + \alpha_{j1} e_{jt-1}^2 + \alpha_{j2} HEX_{jt-1} \tag{4}$$

where $EXRATE_{jt}$ is the daily closing value of foreign currency *j*/Australian dollar; e_t is the specific error of the exchange rates, which is assumed to follow the ARCH process and $e_t \mid I_t \sim N(0, v_t)$; and HEX_{jt} represents the variance of exchange rates. Furthermore, coefficients α_0 and α_1 follow the condition $\alpha_0 > 0$ and $0 < \alpha_1 < 1$.

To quantify exchange rate influences on stock market returns, the current study then incorporates exchange rate residuals into a mean equation, as illustrated in Equation (5). Furthermore, Equation (6) represents the GARCH process incorporating exchange rate residuals to evaluate the exchange rate risk on stock market variances.

Model 3

$$STRET_t = \mu_0 + \sum_{j=1}^{m} \mu_{1j} EXSTRES_{jt-1} + \sum_{j=1}^{m} \mu_{2j} EXSTRES_{jt-1} + \varepsilon_t \tag{5}$$

$$HST_t = \delta_0 + \delta_1 \varepsilon_{t-1}^2 + \delta_2 HST_{t-1} + \sum_{j=1}^{m} \beta_{1j} EXSTRES_{jt-1} + \sum_{j=1}^{m} \beta_{2j} EXSTRES_{jt-1} \tag{6}$$

where $STRET_t$ represents stock market returns and $EXSTRES_{jt}$ is the standardised residuals from Equation (1).

Similarly, using variances of the exchange rate, Equation (7) measures exchange rate influences on stock market returns, while Equation (8) evaluates the exchange rate's effect on stock market volatility. Thus, Equations (7) and (8) incorporate the GARCH series generated from Equation (4) as the measures of the variance of exchange rates.

Model 4

$$STRET_t = \mu_0 + \sum_{j=1}^{m} \mu_{1j} EXGARCH_{jt-1} + \sum_{j=1}^{m} \mu_{2j} EXGARCH_{jt-2} + \varepsilon_t \tag{7}$$

$$HST_t = \delta_0 + \delta_1 \varepsilon_t^2 + \delta_2 HST_{t-1} + \sum_{j=1}^{m} \beta_{1j} EXGARCH_{jt-1} + \sum_{j=1}^{m} \beta_{2j} EXGARCH_{jt-2} \tag{8}$$

where $STRET_t$ represents stock market returns and $EXGARCH_{jt}$ is the GARCH series (variances) generated from Model (1).

As explained earlier, Model (1), Model (3) and Model (4) use the exchange rate, unanticipated shocks (residuals of exchange rates) arising in the foreign exchange market and variances of exchange rates to measure the influence from exchange rates. For Model (1), Model (3) and Model (4):

μ_{1j} quantifies the one-period lagged exchange rate influences on stock market returns;

μ_{2j} measures the two-period lagged exchange rate influences on stock market returns;

ε_t is the specific error of the stock returns from the mean equation which is assumed to follow the ARCH process and $\varepsilon_t \mid I_t \sim N(0, h_t)$;

HST_t represents the variance of stock returns;

δ_1 quantifies the effect of squared residuals from the mean equation;

δ_2 quantifies the shocks of exchange rate influences on stock market volatility;

β_{1j} measures the one-period lagged exchange rate influences on stock market volatility;

β_{2j} quantifies the two-period lagged exchange rate influences on stock market volatility;

m is the number of currencies considered in this study; and

coefficients δ_0 and δ_1 follow the condition $\delta_0 > 0$ and $0 < \delta_1 < 1$.

4. DATA AND PRELIMINARY FINDINGS

The data used in the current paper include daily opening values of the Australian stock market index (All Ordinaries measured in Australian dollars) and daily closing values of foreign currency *j*/Australian dollar exchange rates for seven currencies. These data were obtained from Yahoo!7 Finance (<http://au.finance.yahoo.com>) and the Reserve Bank of Australia (<http://www.rba.gov.au/statistics/tables/index.html>) for the period 2 January 2003 to 8 March 2013 (n = 2565 observations). The seven currencies are the Chinese renminbi, Japanese yen, New Zealand dollar, Singapore dollar, South Korean won, UK pound sterling and US dollar. These countries are Australia's top seven two-way trading partners (Department of Foreign Affairs and Trade, 2012). Based on the stock market index, the stock returns ($STRET_t$) at time t are calculated as $STRET_t = \ln(STINDX_t / SYTINDX_{t-1})$, where $STINDX_t$ is the stock market price index at time t. In the same way, exchange rates ($EXTRATE_t$) at time t are calculated as $EXRATE_t = \ln(EXINDX_t / EXTINDX_{t-1})$, where $EXINDX_t$ is the exchange rate index at time t.

Table 1 presents the descriptive statistics for both stock returns and the exchange rate series. During the sample period, the opening average value of the daily stock returns was positive and ranged from a minimum of -0.0692 to a maximum of 0.0579. Similarly, the mean exchange rate between foreign currency *j* and the Australian dollar was positive for all seven currencies. According to the standard deviations, New Zealand dollar/Australian dollar (0.0048) was the least volatile series, and Japanese yen/Australian dollar (0.0111) was the most volatile series. A graphical illustration of these series (Figure 1) also confirms these findings.

An augmented Dickey–Fuller (ADF) test was next carried out to test for stationarity of the data. The ADF test results in Table 1 show that the null hypothesis of the presence of a unit root in the data can be rejected at the 5 per cent level of significance. These findings suggest that Australian stock returns and all of the exchange rate series are stationary. The calculated Ljung–Box portmanteau test statistics in Table 1 provide strong evidence of higher-order serial correlation in all return series, the New Zealand dollar being the only exception, justifying the inclusion of the lag terms in Equations 1 to 8.

5. EMPIRICAL FINDINGS

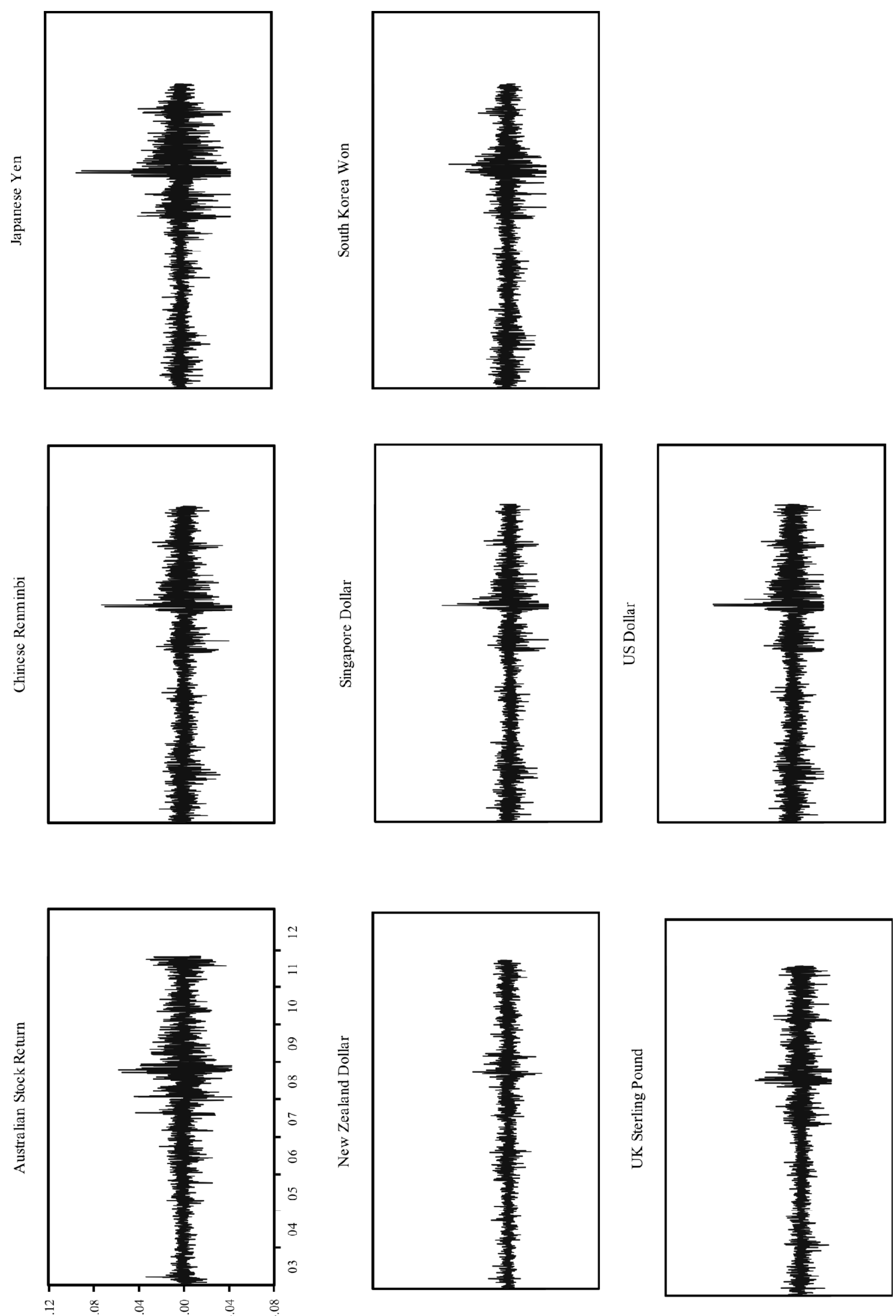
The aim of this empirical study is to quantify exchange rate influences on stock market returns and volatility. Therefore, the current study uses three variables—exchange rates, residuals of exchange rates (unanticipated shocks) and variance (GARCH series) of exchange rates—to

Table 1
Descriptive Statistics for the Stock Market Return Series and Exchange Rate Series

	Stock returns	*Chinese Renminbi*	*Japanese Yen*	*New Zealand Dollar*	*South Korean Won*	*Singapore Dollar*	*UK Pound Sterling*	*US Dollar*
Mean	0.0002	0.0001	0.0001	0.0001	0.0002	0.0001	0.0002	0.0002
Median	0.0005	0.0005	0.0007	0.0001	0.0004	0.0003	0.0005	0.0006
Maximum	0.0579	0.0731	0.0931	0.0310	0.0523	0.0603	0.0407	0.0716
Minimum	-0.0692	-0.0581	-0.0745	-0.0298	-0.0796	-0.0505	-0.0498	-0.0575
Std. Dev.	0.0095	0.0086	0.0111	0.0048	0.0076	0.0068	0.0069	0.0088
Skewness	-0.2859	-0.2319	-0.4371	0.1008	-1.1096	-0.4282	-0.3695	-0.2416
Kurtosis	8.0333	10.2412	12.8610	6.2142	15.5461	11.9472	7.3511	9.7608
Jarque–Bera	2741.46	5624.816	10470.01	1108.048	17342.29	8630.637	2080.860	4908.199
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*
ADF Test results								
AIC	-19.9877	-14.1884	-9.0089	-36.9454	-10.2569	-14.8143	-15.8161	-14.2834
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*
SC	-45.8819	-50.9017	-51.1156	-49.5508	-38.2871	-23.9627	-49.7600	-50.6163
	(0.0001)	*(0.0001)*	*(0.0001)*	*(0.0001)*	*(0.0000)*	*(0.0000)*	*(0.0001)*	*(0.0001)*

Sources: Based on author's calculation using daily opening stock market returns and daily closing exchange rates for the period 2 January 2003 to 8 February 2013 (n = 2565 observations) from Yahoo!7 Finance (<http://au.finance.yahoo.com>) and the Reserve Bank of Australia (<http://www.rba.gov.au/statistics/tables/index.html>). The corresponding p-values are given in parentheses. ADF test results are based on Akaike information criterion (*AIC*) and Schwarz criterion (SC)

Figure 1: Daily Stock Returns and Exchange Rates from 2 January 2003 to 8 February 2013



quantify the exchange rate influences. Furthermore, to provide some insight into investors' reactions to available information, the current study analyses whether the previous day's exchange rate variables have any significant explanatory power on the current period stock returns and their volatility. To achieve these objectives, the current study utilises univariate GARCH(1,1) specifications, as discussed in the 'Methodology' section. Table 2 presents the estimated results for Model (1), Model (3) and Model (4).[3] Based on the estimated results, the major findings from the mean equations of Model (1), Model (3) and Model (4), which evaluate exchange rate exposure on stock returns, can be highlighted as follows.

Firstly, the results from Model (1) indicate that the influence of the coefficients of exchange rate variables from the first lag is statistically significant for all currencies, with the only exception being the Chinese renminbi. Based on the absolute values of the exchange rate coefficients in Model (1), the US dollar indicates the strongest influence on Australian stock returns, while the New Zealand dollar indicates the weakest influence on Australian stock returns. Moreover, the sign of exchange rate exposure is positive for the Japanese yen, UK pound sterling and US dollar, while it is negative for other currencies. Secondly, the Model (3) results reveal that unanticipated shocks arising in the foreign exchange market also indicate a strong influence on stock returns. The influence from shocks is significant from the first lag of the Japanese yen, New Zealand dollar, South Korean won and US dollar, while all currencies except the Chinese renminbi indicate a significant influence from the second lag. As with the sign of exchange rate coefficients, the sign of exchange rate exposure through shocks arising in foreign exchange markets is positive for the Japanese yen, UK pound sterling and US dollar, while it is negative for other currencies.

Thirdly, the variance (or volatility) of the foreign exchange market does not indicate any significant influence on stock returns. Although the coefficients associated with exchange rate volatility in Model (4) are insignificant, one could argue that when exchange rates are highly volatile, the influence on stock market returns may pass immediately through either exchange rates or exchange rate shocks.

Turning now to the second-order moments, the estimated results for variance equations Model (1), Model (3) and Model (4) are as reported in Table 3. The major findings from the variance equations of the three models can be summarised as follows. Firstly, in terms of lagged exchange rate influences on stock return volatility, the Chinese renminbi/Australian dollar and US dollar/Australian dollar exchange rates are positive and statistically significant at the 5 per cent level. Moreover, the two-period lagged New Zealand dollar/Australian dollar and UK pound sterling/Australian dollar exchange rates are also statistically significant at the 10 per cent level. Secondly, the unanticipated shocks arising in the Chinese renminbi/Australian dollar, Japanese yen/Australian dollar, Singapore dollar/Australian dollar and US dollar/Australian dollar significantly influence Australian stock return volatility. Finally, unlike the first-order moments, in the second-order moments, lagged variances from the Japanese yen/Australian dollar and Singapore dollar/Australian dollar exchange rates have a significant effect on Australian stock market volatility.

Overall, the results from Model (1) and Model (3) indicate a significant influence from more recent exchange rate fluctuations on the current period's stock returns and their volatility (or previous day's closing values of exchange rates impact on the following day's opening values of stock returns) compared to exchange rate fluctuations in higher lags. Therefore, one can argue that investors reflect on immediate fluctuations of exchange rates when making portfolio decisions. Ramasamy and Yeung (2005, p. 165) state that 'in a financial world where information flow is near perfect, the time lag would be fairly short as investors react almost immediately to fluctuations in the market'.

In addition, it is interesting to note in the above findings that there is a positive influence from the currencies of larger economies (Japanese yen, UK pound sterling and US dollar) and a negative influence from the currencies of smaller economies (New Zealand dollar, Singapore dollar and South Korean won). Further investigation would be interesting into whether investors from smaller economies tend to decrease their level of investment in Australian stocks when their currency depreciates against the Australian dollar. However, Tian and Ma (2010) state that the sign of the relationship between exchange rates and stock markets due to currency

Table 2
Estimated Results from the Mean Equations of Model (1), Model (3) and Model (4)

	Model (1)	*Model (3)*	*Model (4)*
μ_0	0.0003**	0.0005***	0.0008**
	(2.68)	*(4.32)*	*(2.16)*
μ_{1CNR}	-0.0207	0.0002	-0.7415
	(-0.65)	*(0.87)*	*(-0.00)*
μ_{1JPY}	0.3288***	0.0005**	-0.8395
	(13.67)	*(2.83)*	*(-0.06)*
μ_{1NZD}	-0.04973*	0.0005***	-0.1936
	(-1.67)	*(3.49)*	*(-0.00)*
μ_{1SGD}	-0.4116***	-0.0001	-0.2189
	(-6.15)	*(-0.37)*	*(-0.00)*
μ_{1SKW}	-0.2838***	-0.0004*	-0.0540
	(-8.36)	*(-1.90)*	*(-0.00)*
μ_{1UKP}	0.09469***	0.0002	-0.5602
	(3.21)	*(1.20)*	*(-0.01)*
μ_{1USD}	0.5387***	0.0004**	-0.8182
	(22.61)	*(2.32)*	*(-0.00)*
μ_{2CNR}	0.1130	0.0004	-0.1112
	(0.85)	*(0.45)*	*(-0.00)*
μ_{2JPY}	0.0163	0.0021***	-0.1472
	(0.68)	*(10.81)*	*(-0.00)*
μ_{2NZD}	-0.0517*	-0.0003**	1.2147
	(-1.83)	*(-2.18)*	*(0.09)*
μ_{2SGD}	-0.0812	-0.0011**	0.0493
	(-1.26)	*(-2.81)*	*(0.00)*
μ_{2SKW}	0.0318	-0.0022***	-0.2185
	(0.90)	*(-9.13)*	*(-0.00)*
μ_{2UKP}	-0.0481*	0.0007***	0.1352
	(-1.65)	*(4.00)*	*(0.00)*
μ_{2USD}	-0.0664	0.0030**	-0.1664
	(-0.52)	*(3.13)*	*(-0.00)*

Notes: *** indicates statistical significance at the 1 per cent level, ** indicates statistical significance at the 5 per cent level and * indicates statistical significance at the 10 per cent level.

appreciation is ambiguous. Furthermore, goods market theory states that domestic currency appreciation adversely affects the share market in an export-oriented country because domestic currency appreciation less favourably influences exporters in the country (Tian & Ma, 2010).

Table 3
Estimated Results from Variance Equations of Model (1), Model (3) and Model (4)

	Model (1)	*Model (3)*	*Model (4)*
δ_0	0.000001***	0.000008***	0.0000
	(4.97)	*(4.66)*	*(1.29)*
δ_1	0.0553***	0.178571***	0.0595***
	(5.07)	*(6.10)*	*(4.08)*
δ_2	0.9293***	0.665942***	0.8997***
	(80.53)	*(11.59)*	*(38.62)*
β_{1CNR}	0.0013**	0.000005***	0.2406
	(2.17)	*(3.96)*	*(0.17)*
β_{1JPY}	-0.0000	0.000002	0.3887***
	(-0.07)	*(1.10)*	*(3.62)*
β_{1NZD}	0.0004	0.000002	0.1925
	(1.48)	*(1.58)*	*(0.35)*
β_{1SGD}	-0.0002	-0.0000001	-1.0783**
	(-0.29)	*(-0.04)*	*(-2.50)*
β_{1SKW}	-0.0003	0.000001	-0.1802
	(-0.66)	*(0.39)*	*(-0.72)*
β_{1UKP}	-0.0004	-0.000001	0.3043
	(-1.45)	*(-0.82)*	*(1.27)*
β_{1USD}	-0.0012**	-0.000007**	0.3560
	(-1.93)	*(-2.24)*	*(0.26)*
β_{2CNR}	-0.0018**	-0.000015**	-0.2951
	(-3.17)	*(-2.18)*	*(-0.21)*
β_{2JPY}	-0.0002	-0.000004**	-0.3676***
	(-0.71)	*(-2.46)*	*(-3.49)*
β_{2NZD}	-0.0005*	-0.000001	-0.1453
	(-1.71)	*(-0.54)*	*(-0.27)*
β_{2SGD}	0.0001	0.000007**	1.0464**
	(0.24)	*(2.08)*	*(2.44)*
β_{2SKW}	0.0004	-0.0000001	0.1913
	(1.07)	*(-0.03)*	*(0.77)*
β_{2UKP}	0.0004*	0.000001	-0.2865
	(1.66)	*(0.73)*	*(-1.20)*
β_{2USD}	0.0015**	0.000009	-0.3086
	(2.75)	*(1.21)*	*(-0.23)*

Notes: *** indicates statistical significance at the 1 per cent level, ** indicates statistical significance at the 5 per cent level and * indicates statistical significance at the 10 per cent level.

Finally, the above findings are validated by the performance of several diagnostic tests. Table 4 presents the normality test statistics, the unit root test results and the Ljung–Box portmanteau test statistics for the standardised residual series for Model (1), Model (3) and Model (4). The estimated results from these tests confirm that the resulting residuals are not normally distributed; all four standardised residual series are stationary; and there is no serial correlation. In addition, the estimated portmanteau Box–Pierce/Ljung–Box Q-statistics support the null hypothesis of no autocorrelations in higher lags at the 5 per cent level, which provides further support for Model (1), Model (3) and Model (4), as they absorb a great deal of inertia and the ARCH and GARCH effects are present in the original return series.

Table 4
Diagnostic Tests on the Standardised Residuals of the Model (1), Model (3) and Model (4)

	Model (1)	*Model (3)*	*Model (4)*
Skewness	-0.130421	-0.020128	-0.274819
Kurtosis	3.95522	3.780613	3.624800
Jarque–Bera	58.90361	65.22186	73.92197
	(0.0000)	(0.0000)	(0.0000)
Ljung–Box test statistics for standardised residuals			
Q(1)	5.00	6.21	5.49
	(0.03)	*(0.01)*	*(0.02)*
Q(2)	7.65	9.28	5.64
	(0.02)	*(0.01)*	*(0.06)*
Q(3)	9.06	11.36	5.99
	(0.03)	*(0.01)*	*(0.11)*
Q(4)	9.26	11.48	6.46
	(0.06)	*(0.02)*	*(0.17)*
Q(5)	11.48	12.32	8.54
	(0.04)	*(0.03)*	*(0.13)*
Q(6)	11.49	12.36	8.75
	(0.07)	*(0.05)*	*(0.19)*
Q(7)	11.49	12.73	11.90
	(0.12)	*(0.08)*	*(0.10)*
Q(8)	12.62	12.78	11.91
	(0.13)	*(0.12)*	*(0.16)*
Q(9)	12.62	12.81	12.21
	(0.18)	*(0.17)*	*(0.20)*
Q(10)	13.42	12.81	12.38
	(0.20)	*(0.23)*	*(0.26)*
Q(11)	13.44	12.98	12.53
	(0.27)	*(0.30)*	*(0.33)*
Q(12)	14.10	13.14	13.31
	(0.29)	*(0.36)*	*(0.35)*
Q(13)	16.00	13.79	13.83
	(0.25)	*(0.39)*	*(0.39)*
Q(14)	16.10	13.80	14.19
	(0.31)	*(0.47)*	*(0.44)*

contd. table 4

	Model (1)	*Model (3)*	*Model (4)*
Q(15)	16.17 *(0.37)*	15.44 *(0.42)*	15.22 *(0.44)*
Q(16)	16.58 *(0.41)*	15.66 *(0.48)*	15.26 *(0.51)*
Q(17)	16.59 *(0.48)*	15.90 *(0.53)*	15.30 *(0.57)*
Q(18)	21.03 *(0.28)*	18.96 *(0.39)*	15.34 *(0.64)*
Q(19)	21.04 *(0.34)*	19.96 *(0.40)*	15.34 *(0.70)*
Q(20)	22.47 *(0.32)*	20.31 *(0.44)*	15.51 *(0.75)*
Q(21)	22.81 *(0.35)*	20.40 *(0.50)*	15.55 *(0.80)*
Q(22)	23.18 *(0.39)*	21.33 *(0.50)*	15.97 *(0.82)*
Q(23)	24.92 *(0.35)*	21.43 *(0.56)*	25.02 *(0.35)*
Q(24)	28.33 *(0.25)*	28.56 *(0.24)*	26.43 *(0.33)*

Note: *Q(n)* is the n^{th} lag Ljung–Box test statistics. Probabilities are given in parentheses.

6. CONCLUSIONS

This research uses the univariate GARCH model to identify the magnitude of exchange rate exposure on Australian stock returns, as well as volatility. Thus, in analysing exchange rate exposure, the current paper finds that there are significant lag influences on stock returns and volatility from exchange rates and unanticipated shocks arising in the foreign exchange market. However, the variance of exchange rates is only significant on Australian stock market volatility. The results also indicate that investors reflect on the immediate fluctuations of exchange rates when making portfolio decisions, confirming short time lags where information is available to investors. Furthermore, the findings from this study indicate that currencies from larger economies can have a positive influence on Australian stock returns, while this influence is negative for currencies from smaller economies. Future research could examine whether investors from smaller economies tend to decrease their level of investment in Australian stocks when their currency depreciates.

Although this study evaluates exchange rate influences on stock returns using univariate models, due to globalisation's effects and thus the increased interconnectedness of financial markets, it would be interesting to evaluate the interaction across various currency rates and stock markets simultaneously. This would enable, firstly, the identification of the effect of shocks and volatility spillovers of one currency towards another currency and, secondly, the influence on the stock returns and their volatility. Therefore, in terms of the agenda for future research, it would be interesting to utilise multivariate methodology to evaluate the shocks and volatility spillovers across these series simultaneously. However, given the number of exchange rate series, the number of estimated parameters of the multivariate GARCH modelling framework would increase geometrically in the mean, variance and covariance equations leading to a complex estimation process as well as complicating the interpretation of results. Thus, it would be an interesting approach to utilise alternative multivariate modelling methodologies.

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NOTES

1. Several definitions of exchange rate risks are found in the literature. For example, Walker (1978) argues that foreign exchange risk is defined as unexpected changes in exchange rates and is short term, while Adler and Dumas (1984) claim that foreign exchange risk comprises the sensitivity or correlation of the value of an asset or liability to a change in exchange rates.
2. The descriptions of other notations, which are common to all models, are listed at the end of the 'Methodology' section.
3. Model (2) in this study generates exchange rate residuals and exchange rate variances for exchange rates between foreign currency *j*/Australian dollar for all seven currencies. Therefore, this paper has not reported on the results from both the mean and variance equations, but they are available from the author upon request.

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