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AUSTRALIAN DOLLAR PRICE SHOCKS AND THE AUSTRALIAN STOCK MARKET

Ramzi E.N. Tarazi

Submitted in fulfilment of the requirement for the Degree of Doctor of Philosophy of Finance

School of Business

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Dedication

To my parents

Elias Tarazi and Samia Tarazi

Who taught me to dream about this work

Statement of Authentication

I hereby declare that the work presented in this thesis is, to the best of my knowledge and belief, original except as acknowledged in the text, I also declare that I have not submitted this material, either in full or in part, for any degree at the University of Notre Dame Australia or any other institution.

Ramzi Tarazi

March 2018

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Most importantly, big loving thanks to my parents and my brothers. They have been my rock through these years, they were so patient and tolerant.

LIST OF ABBREVIATIONS

AIC	Akaike Information Criterion
ADF	Augmented Dickey Fuller
APT	Arbitrage Pricing Theory
ASX	Australian Securities Exchange
ARCH	Autoregressive Conditional Heteroskedasticity
CAPM	Capital Asset Pricing Model
CCC	Constant Conditional Correlation
GARCH	Generalised Autoregressive Conditional Heteroskedasticity
EGARCH	Exponential Generalised Autoregressive Conditional Heteroskedastic
TGARCH	Threshold GARCH
PGARCH	Periodic GARCH
GFC	Global Financial Crisis
GICS	Global Industry Classification Standard
GLS	Generalised Least Squares
JB	Jarque-Bera
KPSS	Kwiatkowski–Phillips–Schmidt–Shin
OLS	Ordinary Least Squares
PP	Phillips–Perron
SBC	Schwarz’s Bayesian Criterion
S&P	Standard & Poor's
VAR	Vector autoregression
DCC	Dynamic Conditional Correlation

PREFACE

Tarazi R, & Hasan Z. (2015). The financial crisis and the dynamic dependency between five international currencies volatility with sectors volatility: Evidence from Six Australian Sectors. *4th Global Accounting, Finance and Economics Conference*, 26 May 2015, Melbourne, ISBN: 978-1-922069-76-4.

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Honours & Awards

International Fee Remission Research Scholarships (IFRRS).

Australian Government Research Training Program (RTP) Scholarships.

The paper entitled "Financial Crisis and dynamic the dependency between six international currencies volatility with sectors volatility: Evidence from six Australian sectors" earned the best paper award in the International Review of Business Research Papers.

ABSTRACT

This thesis presents three studies on the Australian dollar price shocks and the Australian stock market. In this thesis, we study the volatility of the major currencies, identify the effect of the Australian dollar return and volatility on six sectors of the Australian stock market, evaluate volatility from the Australian dollar to the big four banks' shares volatility in Australia, and finally identify the risk factors for the real estate market in Australia at the fundamental factors and macroeconomies level.

In chapter two, we investigate the influence of volatility of the foreign exchange rate of the US, the UK, Euro-zone, Japan, and Singapore on the volatility of the six Australian sectors within the investigated period, controlling for the time period's global financial crisis 2007-2008. The volatility in this study was estimated by using GARCH (1,1) models. Daily data was collected for a period of 2002 to 2014. The dataset is divided into three sub-periods: before GFC (July 2002 to July 2007), during GFC (July 2007 to July 2009) and after GFC (July 2009 to July 2014). The estimated results find a strong relationship between exchange rates for the five countries with volatility of the six Australian sectors, except the health care sectors during GFC. The same relationship is evident before the GFC, except in the banks sector. The statistically significant impact of these foreign exchanges on the five Australian sectors continues after the GFC, except that the materials sector is weakly

significant. This result is important for the investors and other market participants to understand the risk factors related to the sectors of the Australian stock market.

In chapter three, we examine the volatility of the Australian dollar return and the big four Australian banks, using unique high-frequency-hourly-data from September 2012 to September 2016. This study applies an extended version of the generalised autoregressive conditional heteroskedasticity (GARCH) specifications. The GARCH variants specification includes the basic GARCH (1,1), TGARCH (1,1), EGARCH (1,1) and PARCH (1,1) models. This chapter varies from the previous Australian research studies in that detached hourly returns are used over a four-year sample period. The findings show that the volatility of the Australian dollar positively affects the big four banks in Australia in the four models and the short-term interest rate volatility negatively affects the big four banks' volatility. The outcomes show that significant ARCH term and GARCH term impacts are present in the data, and that the standard error of PARCH model defines the volatility process better than the other three models for Commonwealth Bank (CBA), Westpac and National Australia Bank (NAB). In addition, the best model to describe the volatility for the Australia and New Zealand Banking Group (ANZ) is the TARCH model. This study is important to the market participants and investors, who want to understand the risk factor of Australian dollar volatility on the big four banks in Australia.

Chapter four incorporates two objectives of the Australian real estate market. First, this research investigates the effect of TWI return on the Australian REITs volatility from 2009 to 2016 by using monthly panel data. We use fixed and random effect models. In the second objective, we examine the linkage between the fundamental factors and the real estate market for three major states in Australia at unit price and house price. These states are New South Wales (NSW), Victoria (VIC), and Queensland (QLD). This research uses monthly data covering the period from 2009 to 2016 by applying the VAR model. This research is important for investors, investment managers and operational decision makers to get a better understanding of how they can manage their investments more effectively during times of any changing macroeconomics factor. The findings of this research will help the real estate investment and Australians funds to reduce macroeconomics exposure. The panel fixed, and random effect models analysis concludes that there is a positive and significant relationship between the market risk and TWI with the Australian REITs, hence the hypothesis of a positive connection was accepted. The Vector Autoregressive Model (VAR) indicated that there is a positive relationship between the NSW real estate market and rental yield, while it is negative with auction clearance rate at a 5% level of significance. For Victoria, the real estate price has a positive significant effect on the Victorian rental yield and average stock on the market, while the auction clearance rate is negative. In Queensland, there is a negative relationship between the auction clearance rate and the average stock on the market with Queensland's real-estate price. The results of this chapter help portfolio managers to reduce exposure to interest rate risks inherent in property investments by choosing externally managed REITs with low levels of debt.

The topic of this thesis is timely, and the outcomes provide significant information to various groups of market participants, such as portfolio managers, policy makers and

risk managers, and to market participants who wish to understand the volatility of major currencies. Since the exchange rates and the stock market are considered as two important markers of financial markets, the outcomes of this thesis provide guidance on how investors and the market participants construct their portfolios. When the Australian dollar shocks are imminent, investors and market participants can adjust or rebalance their portfolios by looking at the sensitivity of each sector to oil price shocks and adjusting accordingly.

Keywords: GARCH models, Exchange rate, Returns, Volatility, Australian Banks. Australian Sector, Global Financial Crisis.

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CHAPTER ONE

SCOPE AND FRAMEWORK OF THIS STUDY

1.1 Introduction

Volatility plays a significant role in the marketplace, in the willingness and ability of financial institutions and portfolio managers to make the right investment decision. Volatility refers to the tendency of the asset price to change over time. It is usually measured by the standard deviation from the expectation. The volatility in stock price movements is the influence of the new information. Thus, the degree of volatility will indicate the liquidity, returns, how much economic stability and the risk of the financial market (Schwert, 1990). Besides, the movement of financial volatility in the passage of time across the assets or markets will ultimately lead to financial assets' volatility.

Moving further, the interaction between the stock markets and foreign exchange (FX) markets has significantly increased in recent years with the integration of national economic policies through international trade, capital flows, foreign direct investment (FDI) and also with the spread of technology. Financial economists generally believe that the exchange rate risk should matter for asset pricing. That is, stock returns should be sensitive to exchange rate movements, and the exchange rate risk should be a priced factor. Adler and Dumas (1984) argue that US corporations, including those with no foreign operations and no foreign currency assets, liabilities, or transactions, are generally exposed to foreign currency risk. Foreign exchange exposure can be due to direct effects of exchange rate movements on firms' cash flows (through its influence on the demand for firms' goods/services or the cost of imported capital and other imported inputs), and its indirect effects through foreign competition and competition for factors of production between traded and non-traded sectors. Solnik (1974), Sercu (1980), and Adler and Dumas (1983) developed the international capital asset pricing model (ICAPM) in which exchange rate risk is a priced factor. A vast literature has investigated the link between interest rate differentials and exchange rates across countries. However, little is known about the similarly important relationship between exchange rates and equity returns. Hau and Rey (2006) shed some light on this issue and provide a theoretical benchmark to evaluate the joint dynamics of risky assets in international markets. They show theoretically that, under the assumptions of risk averse investors and incomplete hedging of foreign exchange (FX) risk, when foreign equity markets are expected to outperform domestic equity markets, the domestic currency is expected to appreciate (Hau & Rey, 2006, p. 296). More precisely, in expectation, exchange rates and equity return differentials (in local currency) are perfectly negatively correlated.

So, the volatility of financial markets and foreign exchange (FX) markets plays a significant role in the trading, hedging, and regulatory strategies within as well as across the markets. Hence, the understanding of market interdependence is imperative in determining international diversification of investments (Shamsuddin & Kim, 2003, 2007). Both markets' volatility are important to allow individuals, companies, and governments to access more opportunities in different countries to borrow or invest, which in turn reduces risk. The theory is that not all markets will experience contractions at the same time. And the integration between the two markets is important for strategic asset allocation users; it makes little sense because we know valuation is the biggest determinant of your long-term investment returns. Once you are empowered with the knowledge from fundamental value analysis and have mapped out your risk management plan, you can choose an appropriate asset allocation in these two markets.

In recent years, a growing interest has arisen to investigate the determinants of the Australian stock market's volatility and foreign exchange market volatility. Previous studies have stressed transmission across international stock markets, foreign exchange market effects and GDP growth as significant factors influencing volatility spillovers across different markets. Specifically, this thesis will focus on the interaction between the Australian stock market and foreign exchange market in terms of volatility during the global financial crisis and oil price effects.

First, concerning foreign exchange market volatility effects, the foreign exchange market became more volatile when the Bretton Woods system in 1971 broke down, where the currencies of major industrial countries were allowed to float freely in 1973. So, to be parallel with the others, the Australian government allowed its currency to float in December 1983. The floating currency is an additional source of volatility for the Australian market. In addition, globalisation has increased the exposure of exchange rate risk amongst Australian firms.

There are two basic frameworks to investigate between the stock market and foreign exchange market from the micro and macroeconomic perspectives. From the microeconomic perspective, most recent studies argue that the connection runs mostly from exchange rates to stock prices (Aggarwal & Harper, 2010; Carrieri et al., 2006; Chue & Cook, 2008; Choi & Jiang, 2009; Kolari et al., 2008). The explanations are as follows: on the one hand, multinational companies are severely affected by foreign exchange risk due to the transaction, economic exposure (Chaieb & Mazzotta, 2013; Jongen et al., 2012; Kolari et al., 2008). The consolidated financial statements of the Company existing in foreign countries are affected by the changes in foreign exchange rates. In other words, if a company has outstanding obligations denominated in foreign exchange rates, it will be affected by local foreign exchange rates significantly; when the exchange rate drops, it makes selling prices denominated in foreign currencies cheaper and thus affects future corporate cash flows and prices of shares. Even for local businesses, the fluctuations in foreign exchange rates affect the value of the inputs through import and competition (Aggarwal & Harper, 2010; Bodnar et al., 2003; Choi & Jiang, 2009; Hutson & Stevenson, 2010). Changes in a firm’s stock price are too tiny to lead the fluctuation in foreign exchange rates. It is assumed that the interconnection runs mostly from exchange rates to stock prices.

Meanwhile, from a macroeconomic view, periods of expansion may cause the increase of the stock market and inflation rising rapidly by increasing the money supply. The monetary policies will respond to cool up the overheated economy, by increasing the interest rates, by selling the treasury bills, and by an increase in banks' reserve ratio responses. With those mechanisms, the home currency will strengthen. An appreciation of the local currency will attract more international funds to the market. Therefore, the international funds and hot money may also target the stock market, which will result in forcing up the stock price by the theory of supply and demand. When the economy is contracting, the stock market tends to go down. Furthermore, the central bank may try to reduce the interest rate to decrease the raising funds cost, it also buys government T-bills. These activities will impact the exchange rate negatively. From both mentioned perspectives, we may expect some lag in the relationship between the exchange rate volatility with stock price volatility. The exchange rate volatility will impact on trade departments and the capital account of the balance of payment in the country, which leads to a change in local stock prices.

Early empirical research tests the relationship between the exchange rate and stock market volatility. Dornbusch and Fischer (1980) find some connection between the exchange rate risks and the stock return. Other previous research has confirmed similar findings to the above, such as Baur (2012), Chan et al. (2011), Dimitriou et al. (2013), Frankel (1987), Hussain and Bashir (2013), Kanas (2000), Kontonikas (2012), Kenourgios and Padhi (2012) and Smith (1992).

Another significant influence on stock returns and volatility is the commodity price volatility. In economics term, the evolution of commodity prices is an imperative issue since it can affect in one way or another the economy of a country. Many of the things that are used every day are related to raw materials such as the gasoline that powers the ships and trucks that transport products. Commodity price volatility is important for economies dependent on commodities. This is not because raw materials represent a significant proportion of the total exports, which can lead to increased vulnerability of these countries in terms of trade shocks. In fact, the commodities price plays a significant role in government financial stability. Some governments, perhaps on the assumption that a surge in prices will be permanent, increase expenses more than proportionally. Once high government spending and the effects of the boom have faded, it may be very difficult to reduce it. Hence, commodity price booms and busts can result in pro-cyclical government spending.

On the other side, in financial terms, the trading of the commodity has seen significant growth in exchanges in recent years. The nominal values of outstanding products decreased by about 20% in 2014 to 2012. The energy and commodity prices are very important for both producers and buyers due to the unique characteristics of the kind of detail and trading. In practice, the global commodity volatility can also be used to hedge risk market potential, trading strategies, speculators and increase firms' performance. Building on the practical links between commodity and stock markets, recent literature has emerged regarding the impact of commodity volatility on stock price volatility. According to Gorton and Rouwenhorst (2006), there is a negative correlation between the commodity prices and the stock price. Buyuksahin and Robe (2014) reported that the associations between equities and commodities increased amid greater participation by speculators. Other previous research, specifically on oil and coal price, by Kilian and Park (2009) shows that the equity prices to oil price shocks depends on the nature of the shocks. Aydogan and Berk (2015) examine the relationship between oil prices and Turkish stock market returns.

Therefore, the purpose of this thesis is to focus on these three issues to identify and quantify varying implications on the Australian stock market volatility through the application of advanced econometric techniques. In this regard, the current thesis uses hourly, daily and monthly data from the Australian stock market and two other markets, namely, the foreign exchange market and commodity markets during the thirteen years from 2002 to 2015.

In addition, to the best of our knowledge, no study has conducted a comprehensive analysis and used the approach taken in this thesis to examine the effects of volatility, foreign exchange market, economic activities, and energy market influence on the Australian stock market. According to Heaton et al. (2011), there are very few studies that investigate the relationship between the foreign exchange market and Australian firms.

This thesis will examine the relationship between the Australian sectors' volatility and foreign exchange rate volatility located in the US, the UK, Eurozone, Japan, and Singapore. Second, it will investigate the effect of the foreign exchange market shocks on the big four banks in Australia. Third, this research will investigate the impact of exchange rate volatility on REIT stock return volatility in the Australian market from fundamental factors and company factors.

The Australian stock market is of particular interest in this thesis as it is one of the major financial markets in the Asia Pacific region. According to the Australian stock exchange[1], ASX is a world leader in raising capital, consistently ranking among the top five exchanges globally. With a total market capitalisation of around $1.5 trillion, ASX is home to some of the world's leading resource, finance and technology companies. The banking sector is of particular interest; Australia ranks 12th in the world in terms of bank assets as rated by the Banker. It has the second largest project finance market in Asia-Pacific after India, the second largest free-floating stock market in the Asian-Pacific region, and the financial sector is the largest contributor to Australia national output, generating more than 10 per cent of Australian output. In addition, the Australian interest rate derivatives market is the largest in Asia and the biggest in the world. The real estate sector is also of particular interest; Australia has the highest proportion of securitised property relative to other markets and is the leading investor in direct global property. The US now comprises 54%, while Australia comprises 15% of the global REIT market. However, as of July 2014, the Australian public real estate sector consists of a total market capitalisation of almost au$95 billion.

Thus, the findings of this thesis will be important for local and foreign investors when allocating their funds on portfolio diversification across these markets. Kroner and Ng (1998) report that it is less risky to invest in two assets that are less correlated, while if both assets are highly positively correlated then two assets are risky. In addition, this thesis will help the Australian policy makers and macroeconomists to understand risk factors in the wake of the information flow during the global financial crisis and economic turmoil. Thus, policy makers may take relevant policy actions to reduce the possible risks that affect the Australian stock market volatility.

[1] http://www.asx.com.au/about/corporate-overview.htm

1.2 Objective of the thesis

The main objective of this research is to help the investor and other market participants to understand the foreign exchange rate risk factor in the Australian stock market. The Australian stock market is examined at the sectoral level and the company level.

This thesis has three objectives related to the Australian stock market volatility: consider the volatility of the major currency components of USD, EUR, GBP, JPY, and SGD; identification of the impact of five currencies' volatility and the Australian sectors volatility. The second objective is to test the volatility of Australian dollar rates on the big four banks' shares volatility. These banks are Commonwealth Bank (CBA), National Australian Bank (NAB), Australia and New Zealand Banking Group (ANZ) and Westpac Corporation (WPC). The third objective is to incorporate two aims of the Australian real estate market. First, this research investigates the effect of TWI return on the Australian REITs volatility from 2009 to 2016 by using monthly panel data. We use fixed and random effect models. In the second objective, we examine the linkage between the fundamental factors and real estate market for three major states in Australia at unit price and house price. The four real estate factors are average rental yield (ARY), average auction clearance rate (AAC), and average stock on market (ASM). These states are New South Wales (NSW), Victoria (VIC), and Queensland (QLD). This research uses monthly data covering the period from 2009 to 2016 by applying the VAR model.

Table 1.1 lists each chapter with its corresponding research objective, including the main objective and sub-objectives. The foreign exchange market is the primary interest, and we seek to establish the relationship between the foreign exchange market and the Australian stock market, including the aggregate market and sectors market.

Table 1. 1 List of chapters and objectives

Chapters	Research Objectives
Chapter Two: Financial crisis and the dynamic dependency between five international currencies' volatility with sectors volatility "Evidence from six Australian sectors''	Examine the impact of the volatility of USD, EUR, GBP, JPY, and SGD on the Australian stock market sectors' volatility. Measure the effect of the foreign exchange market return volatility on the variance equation of sectors return. Evaluate the trade-off between the risk and Australian stock market sectors' return volatility
Chapter Three: Modelling of intraday stock return of the Australian banking stocks	Examine the exchange rate risk factors and the big four banks' shares volatility in the Australian market by using four different GARCH models, namely GARCH (1,1), TARCH (1,1), EGARCH (1,1), and PARCH (1,1)
Chapter Four: The effect of economic and fundamental factors on the Australian property return	The effect of TWI return on the Australian REITs volatility from 2009 to 2016 by using monthly panel data. We use fixed and random effect models. Examine the linkage between the fundamental factors and real estate market for three major states in Australia at unit level and house price level. These states are New South Wales (NSW), Victoria (VIC), and Queensland (QLD). This research uses monthly data covering the period from 2009 to 2016 by applying VAR

1.3 Contribution of the thesis to literature

This thesis incorporates three individual studies on the Australian stock market. Each study makes numerous distinguished contributions to the literature on the financial market. In the first study, we examine the effect of shocks of the foreign exchange risk on sectors of the Australian stock market. This study is essentially for the industry level. According to the literature on the FX market return volatility, the majority of studies concentrate on the large open economy and only a few focus on the small open economy, such as the Australian economy. Lima (2011) concentrates on USD, JPY, EUR, Chinese yuan with ten Australian sectors by weekly data applied from 1990 to 2010. Some research has focused on one currency (USD) with individual sectors, such as Wing and Nguyen (2012), who study the resources sector, and Shamsuddin (2009), who studies the Australian banking sector. This research focuses on the market index level and the sectoral level. The previous research used market index level, which may hide the impressive impact of the fluctuations of the FX market at the sectors level. This research focuses on the sectoral level; it also has great importance for understanding market behaviour and market risk. There is no study focusing on the top five traders' partner currencies by using daily data and the six Australian sectors. This chapter investigates the financial crisis and the dynamic dependency between the five international currencies' volatility and the Australian stock market sectors' volatility. This study investigates the effect of the global financial crisis 2008 on the Australian dollar volatility and the Australian sectors' volatilities.

The second study measures the impact of Australian dollar volatility on the big four banks' shares volatility by using high frequency data. This study is imperative, as no study focuses on exchange rate volatility, and it impacts on the big four banks' shares in Australia. There are a few studies, including Chi et al. (2010), Harper and Scheit (1992), Ryan and Worthington (2004), Shamsuddin (2009), and Vaz et al. (2008), that focus on the Australian banking volatility. The work of Harper and Scheit (1992) does not consider the big four Australian banks' volatility and the high frequency data. The study of Ryan and Worthington (2004) considers the Australian banking sector volatility with the trade-weighted foreign exchange index. However, they do not focus on the individual bank volatility. Work by Chi et al. (2010), Shamsuddin (2009), and Vaz et al. (2008) does not focus on five currencies, and they also do not consider high-frequency data. No research classifies the effect of exchange rates and the short- and long-term interest rate on the major Australian banks shares by using high-frequency data (hourly). The main reason that high-frequency data can greatly improve the forecast accuracy is simply that volatility is highly persistent, so that a more accurate measure of current volatility, which high-frequency data provides, is valuable for forecasting future volatility. Regarding the methodology of Ryan and Worthington (2004) Shamsuddin (2009), Vaz et al. (2008) and Jain et al. (2011), none of these studies used TGARCH methodology and compared between three methods, including GARCH (1,1), EGARCH, TGARCH. According to Lu et al. (2010) Higgs and Worthington (2005), Worthington et al. (2005) and Thomas and Mitchell (2005), they have used half hourly data for the Australian electricity market by using GARCH family models.

The findings of this chapter will be used as an indicator for investment decision making in the banking industry. It also provides excellent and useful information for the Australian Reserve Bank (RBA) and other market participants to understand the effect of the foreign exchange market volatility on the Australian banking sector.

The final study measures the linkage between the volatility of Trade-Weighted Indexes (TWI) and Australian Real estate shares. The TWI is often used as one indicator of Australia's international competitiveness and is a useful gauge of the value of the Australian dollar when bilateral exchange rates exhibit diverging trends. The literature finds some studies on volatility foreign exchange rate with Australian real estate sectors. However, no study has examined the effect of the volatility of TWI with the Australian real estate sector on the fundamental level and the company level. To the best of our knowledge, the papers by Yong et al. (2009), Newell and MacIntosh (2007) and Newell and Webb (1996) are similar to our study, however, this research is different from previous research in that the independent variable represented the exchange rate risk. Those researchers only consider the relationship between the Australian dollars against US dollar volatility with the volatility of the Australian real estate stock, while, in this study, we examine the volatility of TWI to the Australian real estate sectors at the company level. At the fundamental factor, this investigates the effect of the fundamental variables on the real estate house price for three major states in Australia. The six real estate factors are average house (HP) price, average unit price (UP), average rental yield (ARY), average auction clearance rate (AAC), and average stock on market (ASM). These states are NSW, VIC and QLD.

The findings of this study provide important information for Australian market participants to understand the hedge strategy for the FX market with the Australian real estate sectors. In other words, this research also sheds light on whether investors could use TWI as part of a hedging strategy against fluctuations in the Australian real estate stock market.

1.4 Thesis structure

Chapter two examines the impact of five currencies on the Australian sectors return volatility. These five currencies are the US dollar, the UK pound, Euro, Japanese yen, and Singaporean dollar. We also consider in this study six Australian sectors. We divide the covering period from 2002 to 2014 into three sum periods: before the GFC (July 2002 to July 2007), during the GFC (July 2007 to July 2009) and after the GFC (July 2009 to July 2014) to estimate the impact of the financial global crisis (GFC) on the return, volatility of the FX prices and the Australian stock market sectors' volatility. The volatility in this chapter will be estimated by GARCH (1,1) model. The volatility model is an important aspect of risk management and hedging strategies for the local and foreign investors and other participants to make the right decisions.

Chapter three discovers the effect of exchange rate on the big four banks' shares in Australia. We consider four major banks listed on the Australian stock market. These banks are Commonwealth Bank (CBA), National Australian Bank (NAB), Australia and New Zealand Banking Group (ANZ) and Westpac Corporation (WPC). In this chapter, we use high-frequency data (hourly) for periods 2012 to 2016. This research considers four of the volatility models in the GARCH family, namely GARCH (1,1), TGARCH (1,1), EGARCH (1,1), and PARCH (1,1) modelling techniques. We concurrently estimate the influence of the FX market return and return volatility and the banking shares' volatility and classify the risk factors engagement of the banking shares by using four modelling techniques. The findings of this research are very important for the policy makers and the Australian Reserve Bank to assume the impacts of the volatility of the Australian dollar on banking shares, and also help them to make the right decisions to stabilise the Australian banking system and stabilise speculation.

Chapter four investigates the influence of the Australian Trade-Weighted Index (TWI) on REITs stock return in Australia by using panel data. The Trade Weighted Index (TWI) is a weighted average of a basket of currencies that reflects the importance of the sum of Australia's exports and imports of goods by country. This study considers 22 real estate companies listed on the Australian stock market. To estimate the important determinants of the real estate share returns, we employ a multi-factor arbitrage pricing theory (APT) model using the panel data. In this APT model, we assume that the property shares return links with real estate index, TWI return and other factors related to real estate market by using monthly panel data covering the period from 2009 to 2016. And we use the vector autoregression (VAR model) to examine the fundamental factor level on the Australian housing price for three states, namely New South Wales (NSW), Victoria (VIC), Queensland (QLD) by using monthly data from 2009 to 2016. This research is important to help market participants to better understand the foreign exchange rate risk factor. This study also provides an excellent information for hedge fund managers and portfolio managers to develop hedging strategies to deal with foreign exchange market shock with the Australian real estate sectors.

The outcomes of this research are imperative to local and foreign investors, pension funds, risk management, the portfolio managers, policy makers and other market participants. In general, for everyone who diversifies their portfolio through the Australian stock market, commodity markets and foreign exchange market. More specifically, for those who need to understand the returns, volatilities and the dependency between the foreign exchange market and the Australian stock market from the sectors and company perspective. Domestic and foreign investors will be able to formulate strategies to reduce risks through the use of portfolio diversification, risk management, and hedging. It is also vital for investors to maintain confidence and the expected price movement.

The foreign exchange market is one of the largest asset markets, and efficient pricing of currencies requires reliable estimation and an understanding of volatility. Since the foreign exchange market and the stock market are considered two significant markets in the global financial market, the results of this thesis will inform policy makers on the micro and macro level and be helpful in developing efficient hedging strategies to deal with foreign exchange market shocks with the Australian stock market. To hedge against foreign exchange market shocks, investors can invest in the Australian stock market or Australian firms. Lastly, the findings of this study provide direction on how investors can build their portfolio; it is helpful them to evolve their portfolio strategies.

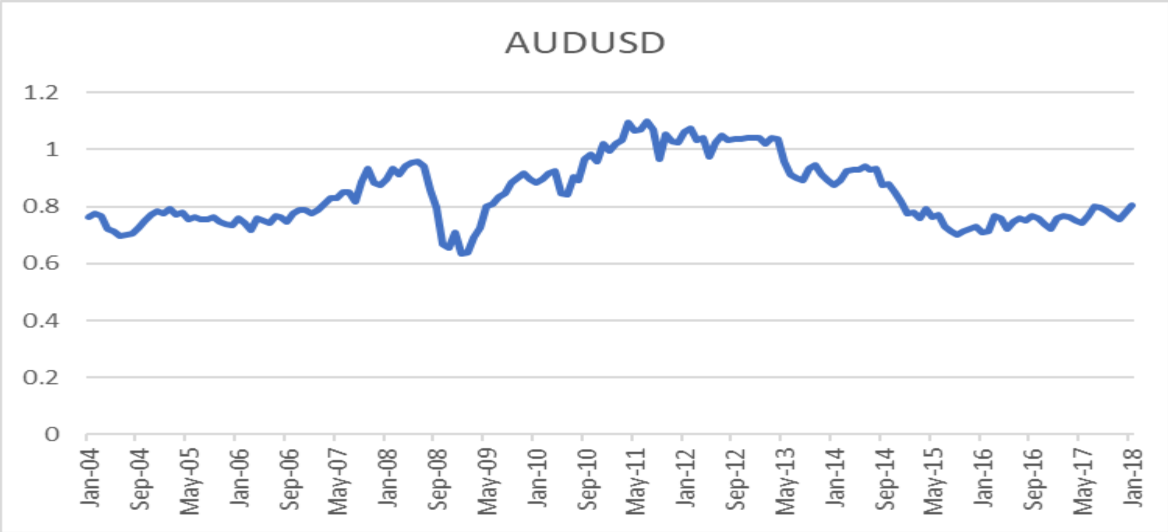
CHAPTER TWO

FINANCIAL CRISIS AND THE DYNAMIC DEPENDENCY BETWEEN FIVE INTERNATIONAL CURRENCIES' VOLATILITY WITH SECTORS VOLATILITY: "EVIDENCE FROM SIX AUSTRALIAN SECTORS"

2.1 Introduction

For the last two decades, Australia has experienced several crises, including the Mexican currency crisis in 1994, the Asian currency crisis in July 1997 and the subprime crisis in 2007 and 2008. As an impact, especially from the Asian and the US subprime crises, not only the stock of foreign direct investment had crashed but, according to the Australian trade commission, the Australian exchange rate has also crashed as a result. Theoretically, an exchange rate is the relative value of a foreign country's currency in terms of the home country's currency. The exchange rate affects the domestic economy greatly, especially when the investment is denominated in foreign currency. Meanwhile, a stock market can reflect a country's economic development, and the market prices (indices) can reflect the whole stock market, which can be regarded as the barometer of a country's economic situation and shareholder wealth. According to Kim (2003), the growing degree of the world trade capital movement has made the exchange rate one of the main determinants of business profitability and equity prices. It is important to note that when studying the dynamic behaviour of shareholder wealth, the effect of the exchange rate market cannot be neglected.

Figure 2. 1 The Australian dollar price performance from 2004-2018



According to economic theory, exchange rate changes and stock market volatility have a strong relationship with each other (Frankel, 1987; Smith, 1992; Kanas, 2000; Chan et al., 2011; Kenourgios & Padhi, 2012; Dimitriou et al., 2013; Hussain & Bashir, 2013). The Mexican financial crisis of 1994, the Asian financial crisis in 1997, and the global financial crisis have all showed the coupling effect of the foreign exchange market and the stock market. These strong relationships between the exchange rate volatility and financial market volatility will also affect the shareholder wealth.

This research is the study of volatility of returns of Australian sectors to the variation in exchange rates. Previous researchers have mainly focused on a single currency and a group of micro/macroeconomic variables (Chan et al., 2011; Kenourgios & Padhi, 2012; Dimitriou et al., 2013). In this study we consider five currencies to understand the individual impact of each currency on sectors of the Australian stock market. The previous research ignored the financial crisis period from 2007-2008. The dataset of this research is divided into three subperiod sample data to examine the financial crisis impact on the Australian stock market. Examining the financial crisis period will help the investors and the market participants to understand the effects of financial crisis on the Australian stock market and help them to build up a hedging strategy to avoid high risk as result of high volatility in the market during any financial crisis in the future.

This research aims to add to the knowledge in the existing literature in a number of ways. Firstly, these five exchange rates are the top five foreign direct investment countries in Australia, namely USA, UK, Europen union, Japan, and Singapore. In the previous research, these countries' currencies have not been examined (Liow et al., 2006; Kontonikas, 2012; Baur, 2012; Chan et al., 2011; Guo et al., 2011; Kenourgios & Padhi, 2012; Dimitriou et al., 2013). Secondly, the sample data used in our research includes the period of the global financial crisis 2007-2008, which significantly affected the performance of the financial market, foreign direct investment, and the exchange rate.

In this research, the advanced econometric technique used in this study, the GARCH (1,1) model, is applied. Joseph and Vezos (2006), Adjasi (2009), Tai (2010) and Brooks et al. (2010) have employed GARCH (1,1). In addition, this research will help investors know the trends in stock markets, and how they are affected by exchange rates, and therefore how to invest accordingly, and foreign investors can invalidate the exchange rate risk.

2.2 The foreign exchange rate exposure

The subject of exchange rate exposure has long been of interest to academic researchers. Standard finance theory argues that changes in exchange rate carry transaction and economic exposures on a firm's expected future cash flows, which in turn affect the firm value. An extension of the theory further suggests that the foreign exchange effect may also be asymmetric. Sources of the asymmetric exposures include pricing to market behaviour (Froot

& Klemperer, 1989; Marston, 1990; Knetter, 1994), hysteresis (Ljungqvist, 1994; Christophe, 1997), and asymmetric hedging (Booth, 1996).

According to Adler and Dumas (1984), exposure refers to the sensitivity of the value of the item at risk. Exposure indicates the value sensitivity of the item risk. The exchange rate risk definition is the change in the exchange rate. Exposure to the foreign exchange rate risk is described as the local currency value sensitivity of items, which would denominate in foreign currency (e.g., assets, liabilities, and cash flows), to unexpected changes in the exchange rate (Adler & Dumas, 1984). This study will use the term of the exchange rate risk exposure. According to Jacque (1981), there are three different types of exchange rate risk exposure. These are transaction, translation and operating (economic) exposure.

First, transaction exposure is the sensitivity of the local exchange rate value of a firm's contractual cash flows, denominated in foreign exchange rate, to unexpected exchange rate volatility. In other words, it results from the deals transactions; it is the loss or gain relative to the business transaction settlement, the currency changes between now and the future transaction settlement, as known the currency is changing randomly. According to Eiteman (2007), the foreign exchange rate cash flows value is associated with this volatility, leading the exchange rate loss or gains. According to Eiteman (2007), there are three possibilities through which the exposure of transaction may appear. The first is when the price of the product link is in foreign exchange rate and the company would like to purchase or sell the product. The second is when the firms are lending or borrowing funds while the repayment is in foreign exchange rate. The third is when incurring liabilities or acquiring assets that are denominated in foreign currencies.

Second, translation exposure appears when the foreign subsidiary financial statement is translated into the firm's local exchange rate for consolidating the financial report purpose. The liabilities, revenue, and expenses of the local corporation are affected by foreign exchange rate volatility. This usually results in foreign exchange 'gains' or 'losses' in the financial statements. So, translation risk does not affect actual cash flows. It is only recorded in the group accounts when the foreign currency asset or liability is revalued in the reporting currency using the current exchange rate. For example, the value of the loan in a foreign currency may change with exchange rates, but there is no immediate cash-flow effect. This is translation risk. However, any interest payments that have to be made and any repayment of the loan will be actual cash flows and become transaction risk.

For prospective investors, investors and shareholders use consolidated financial statements to understand the value of the overall company. For multinational corporations with subsidiaries operating in different currencies, the group's capitalisation and profitability are affected by foreign currency movements, as the financial statements are prepared in one currency. The finance function needs to decide how much impact trying to manage translation risk will have on other activities within the group. Although many investors look at the headline results first, prudent investors and analysts still concentrate on the underlying performance of the business. They try to understand the company's exposure to currency risk. Nonetheless, transaction risk can have an impact on the share price, particularly when there are large movements attributed to variations in exchange rates.

Third, economic exposure indicates the unexpected currency movement's impact on expected cash flows of firms (Eiteman et al., 2004). This exposure appears because of the exchange rate volatility, it can also affect the future revenues and cost of the firms. The future cash flow can be classified into cash flow from obligations of contractual and cash flow from the future transaction. The transaction exposure can be as part of economic exposure. Economic exposure appears when a multinational corporation incurs costs denominated in one currency and generates sales denominated in another. In this case, the currency volatility can affect the firm’s competitive position, for instance, if the country’s currency where the firms are producing services or goods appreciates against the country’s exchange rate where the company is selling these services. The profit generated may decrease. Of course, various other factors may impact on the firm’s future cash flow, such as the political crisis in the country, which can affect the sales level.

Eun and Resnick (2004) show that economic exposure can be divided into assets exposure and the operating exposure: the assets exposure indicates the future local exchange rate value sensitivity of the company assets and liabilities to random volatility in the currency. Operating exposure measures the extent to which the firms present value is affected by any change in the firm’s future cash flow, generated by unproductive movement in the exchange rate. Eun and Resnick (2004) suggest that, because of the difficulty of measuring the exposure arising from operating cash flows, it is important that the firm properly manages it. Handling the company economic exposure needs a long-term plan, viewing the company as an ongoing concern with operations whose costs, prices, and competitiveness can be affected by unanticipated currency changes.

Research interest in economic exposure is concentrated on the estimated effect of exchange rate changes on accounting profits (Dumas, 1978). Each line of a firm’s income statement and balance sheet was separated and the effect of an increase or decrease in exchange rates on each item was analysed. This was due to the recognition that foreign exchange rate exposure arose from the practical need to consolidate the financial statements of foreign operations. The possibility of acquiring accounting gains or losses on receivables and payables denominated in foreign currencies (transaction exposure) was also recognised. However, firms are simultaneously exposed to multiple uncertain environment contingencies and the dimensions of economic exposure are difficult to estimate using a model designed to measure accounting exposure.

Although the accounting concepts of translation and transaction exposures have been codified in accounting standards, no such standard exists for economic exposure. One point of confusion in the existing discussions has focussed on the choice of the dependent variable used to model this type of exposure. An accounting earnings sensitivity approach has been a poor performer in presenting a measure of economic exposure, and two main alternative approaches have been developed: the cash flow approach and the capital market approach (Miller, 1998).

The cash flow approach measures the sensitivity of firm value, by the firm's discounted future cash flows, to changes in exchange rates (Shapiro, 1975, 1977, 1984; Cornell, 1980; Wihlborg, 1980; Lewent & Kearney, 1990; Martin & Meuer, 2005). However, many difficulties arise in terms of using this approach to measure economic exposure, including the choices of an appropriate discount rate and time horizon for a firm's operations. As a result, researchers have developed an alternative, capital market approach to measure economic exposure.

If capital markets are assumed to have the capability of ascertaining the underlying value of a firm's competitive positions, the market value of the firm's equity can be used as the dependent variable in a regression on exchange rate changes (Adler & Dumas, 1984; Jorion, 1990). According to Adler (1986), approaches measures the stock return with several exchange rates, investigating for a significant relationship. His methodology may create some statistical problems when other macroeconomics variables are included. Therefore, Jorion (1990) modifies the model, using the exchange rate residual movement against other explanatory variables, making the exposure of exchange rate orthogonal to the other depended variables. Economic exchange rate exposure could thus be measured as the relevant slope coefficient. A few research studies have followed Adler and Dumas' (1984) and Jorion's (1990) approach, which uses stock market returns as a proxy for firm value (Jorion, 1990, 1991; Loudon, 1993a, 1993b; Bodnar & Gentry, 1993; Bartov & Bodnar; 1994; He & Ng, 1998; Di Iorio & Faff, 2001, 2002; El-Masry, 2006).

2.3 The theoretical and empirical model

2.3.1 The firm

The company is an organisation that transforms input into the output and earns the difference between revenues and costs. The aim of most firms is to maximise their profits or equivalently minimise their losses. A firm's profit is given by Carlton and Perloff (2005) as:

$$\pi = p * f[L,K,X] - wL - rK - qX \qquad (2.1)$$

Where π is the profit, p is the price, L is labour, K is capital, X is other inputs such as oil, W is the wage, r is the interest rate and q is the cost of other inputs.

$$P=P*Ex \qquad (2.2)$$

Where, the price P is influenced by the currency exchange rate. Thus, Ex is expressed as for exchange rates.

Firms constantly make strategic behaviour in order to impact the market environment and increase their profits. Thus, a firm produces only if it is beneficial to produce. The market environment encompasses several factors that might be manipulated by a firm to increase its value and avoid losses. These factors influence the market outcome, such as prices, quantities, and profits (Carlton & Perloff, 2005). According to Ross (2005) and others, there are four main macroeconomic factors that play a significant role in explaining the return on a stock, including inflation, GDP, investor confidence and shifts in the yield curve.

However, other literature shows that macroeconomic variables such as the crude oil price and the exchange rate are also to be considered, especially for companies operating abroad. It has been proved that the GDP of the foreign country where the goods are exported has an impact on the price of the goods. Thus, the GDP is reflected in the price. Since the stock market index measures a stock market for a given country, the changes in the price are captured in the stock market index. This leads us to the mathematical function:

$$\pi = p * Ex * f[L, K, X] - wL - rK - qX \qquad (2.3)$$

Where π is the profit, p*Ex is influenced by the currency exchange rate, L is labour, K is capital, X is other inputs such as oil, w is the wage, r is the interest rate and q is the cost of other inputs.

To analyse more closely how the exchange rate influences stock returns, empirically, the Arbitrage Pricing Theory (APT) and the capital asset pricing model (CAPM) are among the most influential theories of stock and asset pricing today.

Traditionally, the CAPM was developed by Sharp (1964). The CAPM relates the expected return on an asset to the expected return on the market and to the risk-free rate. This model is restricted since it only allows one variable in the function. The model is as follows,

$$\text{CAPM:} \quad R_{it} = r_f + \beta_{im}\,(r_m - r_f) \qquad (2.4)$$

Where R_{it} is the expected return of asset i, $R_m$is the expected return on the market portfolio, $R_f$is a return on the risk-free asset, and B_i represent the systematic risk of asset i.

The main attention of investors when evaluating an investment portfolio is the total risk exposure estimated by the standard deviation of the portfolio return. The CAPM classifies two kinds of risk: systematic risk and unsystematic risk. According to Fletcher (2007), only systematic risk is rewarded as unsystematic is diversifiable. Unsystematic risk is also the firm or industry specific risk, which can be utilised in the form of strikes, or natural disaster hitting specific industries. For example, bad weather could be an industry specific risk for farmers, hence, according to the CAPM theory, firm specific risk is not included in the return of the stock and thus not rewarded. This risk can be diversified through portfolio management. Systematic risk, however, cannot be diversified according to Moffett et al. (2005) and is related to the risk of the market portfolio. Identifying the type of risk, which exchange rate is derived from, does in principle appear important for investors, at least according to the capital asset pricing model.

Other models including more variables have been developed, such as the multiple factor model of King (1966) and the arbitrage pricing theory by Ross (1976). The APT was also originally a one-period testing, which assumes that stochastic properties of assets return are correlated with a factor structure. This means that the expected assets return is approximately linear to the betas (Fama & French, 2004). Therefore, the APT model modifies the assumption of the CAPM theory, defining a linear relationship between the asset beta and expected asset returns, to an interrelationship between various securities. It means the CAPM measures the systematic risk of an underlying equilibrium argument. The APT does not have the underlying assumption, but it uses the underlying factors as variables to explain the asset returns, these factors must be chosen from empirical ground research. The APT model can be illustrated as follows:

$$R_i = \beta_0 + \sum_{j=1}^{n} \delta_j \beta_i + \varepsilon_i \qquad (2.5)$$

Where, R_i is the return of company i, β_0 is constant, β_i is the coefficients of the macro-economic variables, δ_j is the factor included in the model, ε_i residual terms.

The APT is commonly put forward as a superior alternative to the criticised but widely used CAPM model. The supposed weakness of the CAPM, its baggage of “unrealistic assumptions” and its empirical shortcomings, are well known. Tests of the CAPM model typically display poor explanatory power as well as overestimating the risk-free rate and underestimating the market risk premium. The main criticism is particularly the use of betas to predict an asset's return – returns on high-beta stocks will tend to be overestimated and vice versa for low-beta stocks. (Groenewold & Fraser, 1997).

For this research, we chose to use the APT model framework, as it is less restrictive in its assumptions and includes several factors. According to the APT, the expected return on an asset is a function of many factors and the sensitivity of the stock to these factors. The APT model incorporates variables that are expected to have an impact on the expected stock return meaning that if the variables move, the expected stock return will also move, thus affecting the value of the investor. Therefore, a stock return is affected by a number of independent factors. The APT model states that there is a linear relationship between stock market returns and a number of factors.

2.4 Literature review

In the early stages, previous studies were mostly conducted in the US and European countries. After the financial crisis in 2008, the focus has shifted to the financial market of the world's countries. Furthermore, studies on the volatility of exchange rates and stock market volatility are widely conducted in both developed and developing countries because of the increasing degree of the integration of the world financial market. The asset market approach to determine the exchange rate is supposed to run causality from stock prices to exchange rate changes as expectations regarding the movements of financial asset prices affect the dynamics of exchange rates (Mundell, 1963, 1964; Dornbusch & Fisher, 1980; Branson, 1983; Frankel, 1987).

A number of researchers have focused on the extent to which the volatility from FX markets to other markets, such as the stock market because of the increasing degree of the integration of the world financial markets. The early empirical research is on the interaction of the exchange rate return to the stock exchange. Soenen and Hennigar (1988) examine the effect of the US dollar on US stock price. They find negative a significant correlation between the US currency return and the US stock market return. They observe that appreciation of the US dollar led to decrease in the US stock price. This result is contradictory with some of the previous research that notes that the investment will be more engaging as the home exchange rate value appreciates. Soenen and Hennigar (1988) also argue that higher cost of imports will affect the country's balance of payment account after the decrease of the home exchange rate. Jorion (1990) investigates the exchange rate sensitivities for the US multinational companies from 1971-1987. He finds that currency has a major effect on 5% only of the total multinational companies in his sample. Diermeier and Solnik (2001) analyse the domestic stock firms' factor with international firm's factor; they observe that the exchange rate is significant on international companies and the ratio of foreign sales. This outcome is consistent with theoretical arguments. In this regard, the FX markets have more influence on the international companies' profitability than local firms. Fang and Loo (1996) investigate how exchange rate changes affect stock return for US, Canada, England, and Japan. They used the multi-factors arbitrage pricing theory model. Their result contends that the exchange rate risk will impact on stock price for the three countries. Fang and Loo (1996) also indicate that the exchange rate plays a critical role in investor's decisions, and those decisions will impact on the supply funds invested in the share market. Kroon and Veen (2004) examine whether there is a linkage between the foreign exchange rates risk with the 24 stock markets. They are decisions the global stock price has exchange rate effects. Yang and Doong (2004) investigate the dependency among stock price and foreign exchange markets for the G-7 countries. They find evidence from stock returns to exchange rate changes for France, Italy, Japan and the US Similar results have been obtained for Latin American countries by Diamandis and Drakos (2011), who observe that the global financial and currency crisis (2007-2008) was affected by the stability of that relationship. Kutty (2010) investigates the association between foreign exchange rates and the Mexican stock market for the period 1989 to 2006. His empirical results show that there is a significant relationship in a short period and the opposite is not true.

Previous studies examine the exchange rate return impact on stock market performance. They investigate the relationship between the volatility of the exchange rate return and stock market return volatility by examining the issue of price volatility modelling using GARCH-Class models. From the perspective of developing countries, Kanas (2000) investigates the dependency between exchange rate volatility for six countries and the volatility of stock price. He observes an effect of the exchange rate volatility in discovering stock price return. A similar market is examined by Bianconi and Cai (2014) who investigate whether there is any link between the exchange rate and S&P return. They assume that the exchange rate shocks are reflected in the S&P500 index return. They observe the adverse effect of exchange rate volatility on S&P500 returns. El-Masry (2007) examines the linkage among the exchange rate exposures on UK industries. The outcomes show that non-finance corporates in the UK are more exposed to the volatility of exchange rates than those analysed in previous research. In general, this result shows a stronger support for the suggested equally weighted rate as an economic variable, which affects firms' stock returns. El-Masry (2007) expected a rise in the company stock price from the strong UK exchange rate. Subhani et al. (2011) perform a similar study in eight countries and find that the exchange rate has a significant effect on stock price volatility. In recent studies, Dumitrescu and Rosca (2015) investigate the effect of four currencies' volatility on four eastern European shares. The findings show a strong relationship. From a recent US paper, Nitschka and Atanasov (2015) applied empirical approximation of the intertemporal capital asset pricing model (ICAPM) to show that cross-sectional dispersion in currency returns can be rationalised by differences in currency excess returns' sensitivities to the market return's cash-flow news component. They find the presence of a common source of systematic risk in stock and foreign currency returns that is reflected in the market return's cash-flow news component.

The empirical research shows that a number of articles investigate the effect of volatility of the exchange rate on the Asian stock market. Ajayi et al. (1998) investigate the impact of exchange rate volatility and return volatility on the seven developed markets and eight Asian emerging markets. They find a unidirectional relationship from stock volatility to the exchange rate in all the developed markets, while no relationship for the four Asian countries, and one emerging country has a bi-directional relationship to the exchange rate. The summary of their findings shows that foreign exchange risk and the stock market are well integrated into developed markets but not in the emerging Asian market. Ajayi, Friedman and Mehdian argue that the big market size, the higher access to foreign investors, and the higher compression in Asian markets is due to various relation results. Lee et al. (2011) examine the interaction between stock prices and exchange rates of several Asia-Pacific countries. Their empirical results indicate that the correlation between stock and foreign exchange markets becomes higher when stock market volatility increases. Yau and Nieh (2009) find the long-term balance and causal association between unequal stock prices and exchange rates for Taiwan and Japan. Jayasinghe, Tsui and Zhang (2014) examine the effect of exchange rate on the Japanese industrial sectors. Jayasinghe, Tsui and Zhang (2014) find significant evidence of such exchange rate exposure that is not captured by the conventional measure. From a

Chinese perspective, Zhao (2010) analyses the dynamic relationship between the real effective exchange rate and the Chinese stock price. The results show that there is no stable long run relationship between the exchange rate with the Chinese stock market. His justification for his result is that China's exchange rate is being controlled by government authorities. China's central bank manages the value of the renminbi. Interesting results by Liu and Shrestha (2008) investigate the relationship between the Chinese market and macroeconomic variables. A lower Chinese exchange rate will increase the Chinese stock market. They also find that the Chinese market has a negative association with the US and other developed countries.

Despite extensive work to investigate the relationship between foreign exchange rate volatility and the volatility of the financial market for European countries and the US, the influence of exchange rate shocks can be examined on different sectors level. From an Australian market perspective, there are a few studies that examine the relationship between foreign exchange rate volatility and Australian sectors volatility. In an early study, Subbarao et al. (1993) examines the exchange rate return with the 24 Australian industry indices. The results show that the firms hedging of foreign exchange rate risk may not add profitability. Lim (2011) studied the effect of the four currencies' volatility on ten Australian sectors. The ten sector indices included are basic materials, consumer goods, consumer services, health care, financials, industrials, oil & gas, technology, telecommunication, and utilities. Lim (2011) applied weekly data over the period from 1990 to 2011. The findings suggest significant exchange rate effects on Australian market returns for all five exchange rate series with asymmetric exposure to the Chinese yuan. At the sector level, domestic market return is found to have more significant influence than exchange rate risk on all sector returns. Of all 10 sectors, the four sectors that do not have any exchange rate exposure are consumer goods, technology, telecommunications and utilities. The six sectors that have significant asymmetric exposure to at least one currency are basic materials, consumer services, financials, health care, industrials, and oil & gas. Of the six sectors, basic materials would benefit from the appreciation of the Australian dollar while the other five sectors would benefit from the depreciation of domestic currency. Lorio and Faff (2001) investigate the relationship between three currency options with twenty-four industry indices represented in the Australian stock market. They find strong results with daily data. Lorio and Faff (2001) report that the previous research in this area has been relatively weak. Noel and Simpson (2009) examine the relationship between the Australian dollar and Australian stock market index (ASX500) from 2003 to 2006. Their outcomes show a unidirectional causal relationship between the exchange rate and the Australian stock market index. For Australian manufacturing, resources and banking sectors, Swift (2006) observes that a higher Australian dollar by 10% leads to lower total investment within the channel of export share over the period by 8%. Wing and Nguyen (2012) examine the sensitive movement between the exchange rate risk with Australian resource shares for a period 2006 to 2009. They find that the foreign currency derivative is more effective in alleviating exchange rate exposures during the crisis as opposed to the pre-crisis period. For banking sectors, Shamsuddin (2009) tests the effect of US dollar and interest rates on individual bank stocks from 1994 to 2007 by using weekly returns. His results show that the FX market affects the small banks only. Chi et al. (2010) explain the effect of exchange rate on four major banks in Australia. Chi et al. (2010) find that there is no significant relationship between the Australian banks and the exchange rate.

From an Australian aggregate stock market perspective, Brooks et al. (1998) consider the influence of macroeconomics on the Australian stock market. They find that the exchange rate has an impact on Australian stock returns. Dissimilar results by Kearney and Daly (1998) observe that there is no relationship between the US dollar and the Australian stock market. Faff and Nguyen (2003) find that the exchange rate derivatives of the short period seem to be negatively connected with a firm's price-earnings ratio. In the present two papers, Imams et al. (2011) investigate the impact of US dollar in ASX 200 for the period 1991 to 2011. Daily data is used in this study and is estimated by a linear forecast model compared with the nonlinear and ensemble-based intelligent system models. Their results show that the change in USD effect immediately on ASX 200. Raghavan and Dark (2008) investigate the effects among the US dollar and the Australian Ordinaries Index for daily data from 1995 to 2004. The BEKK GARCH (1,1) model was applied to this research. Raghavan and Dark (2008) find the effects from the Australian exchange rate to the Australian Ordinaries Index. Baur and Miyakawa (2014) examine the effect of the exchange rate movement on the Australian stock price listed on the S&P-ASX 100 index from 1980 to 2010 using daily data. The findings show that a positive relationship exists between the exchange rate and Australian stock price return.

Table 2.1 provides a summary of the existing literature reviews on the volatility of global and Australian financial stock markets. Most of the current research has concentrated on large open economies such as the US or Europe, or emerging markets in Asia. There are not many studies that examine small open developed economies such as Australia in detail. The nature of the Australian economy makes it distinct from the US and other Asian countries. These countries have been already studied, while the US population is about 13 times that of Australia, the US gross domestic product (GDP) is more than 20 times that of the Australian total GDP. It is usually believed that Australia's international trade is above a verage, it is much lower than the total trade for Canada and the United Kingdom. However, ASX is a world leader in raising capital, consistently ranking among the top five exchanges globally, as documented by Friberg and Nydahl (1999) and Gavin (1989), the connection between FX market and equity market exists in a small economy. This result is confirmed by Books et al. (1998), Imams et al. (2011) Raghavan, and MV and Dark (2008). They focus on USD, JPY, EUR, the Chinese yuan with stock market index and the aggregate market of Australian stock market. However, in this study, we focus on five international currencies for the top five trading partners and we also consider Australian sectors, which will provide relevant information for market participants to understand whether the Australian industries have sensitivity to fluctuations of foreign exchange markets.

The previous studies examine the relationship between the oil shocks and the Australian stock market (Kerans & Pagan, 1993; McSweeney & Worthington, 2008). Hasan and Ratti (2012) investigate the relationship between the oil shocks and the Australian sectors market. They used daily data for 10 sectors in Australian markets from 2000-2010. The findings show a positive relationship between the oil price return, material sectors and the financial sector. Some studies have absorbed on foreign exchange market shocks with individual Australian sectors, such as Swift's (2006) studies of the manufacturing sector, Wing and Nguyen's (2012) study of the resources sector and Shamsuddin's (2009) investigation of the Australian banking sector. But we focus on Australian sectors[2]. Whereas, a few studies have mainly focused on FX market shocks with all Australian stock market sectors volatility, Lima (2011) concentrates on USD, JPY, EUR, and the Chinese yuan with ten Australian sectors by weekly data applied from 1990 to 2010.

[2] The twelve sector indices included are basic A-REIT index, consumer discretionary index, consumer staples index, energy, financial index, health care, industrials, information technology index, materials index, banks, telecommunication, and utilities.

In this research, we focus on five international currencies with six sectors by using daily data from 2001 to 2014. We also divide the covering period to three sum periods: before the GFC (July 2002 to July 2007), during the GFC (July 2007 to July 2009) and after the GFC (July 2009 to July 2014) to provide greater insight into the nature of the estimation of foreign exchange market risk in Australian stock market sectors before, after and during the GFC. Lorio and Faff (2001) deliberate on the Fama-French factors, and also applied the Fama-French approach augmented by USD exchange rate factor. But, we use a different approach to examining the volatility by applying the GARCH (1.1) approach. We also focus on five currencies. Then, our choice of instigating is motivated by the evidence that previous empirical research has been undertaken in a CAPM framework by using low-frequency data applied by Lorio and Faff (2001) and focused on three currencies only applied by Lima (2011) and the summary of empirical evidence has been relatively weak. In conclusion, this research aims to fill the void by examining the interaction between the five currencies' shocks and volatility, and six sectors of the Australian stock market. The results of this research will help the investors and the market participants to understand whether a more volatile five currencies movement has asymmetrically affected return on the Australian sectors of the stock market and will help the portfolio manager to take the right action to minimise the foreign exchange rate risk.

Table 2. 1 Empirical Evidence on the foreign exchange rates volatility effect in the US, the UK, and European stock market volatility

Author	Econometric Model	Data	Findings
Nitschka and Atanasov (2015)	VAR model	Monthly data for U. S	The relationship between the six exchange rates and S&P500
Mun (2007)	EGARCH model	Weekly data for UK, France, Germany, Italy, Australia, Hong Kong, Japan, and Singapore from 1990 to 2003	Significant relationship between UK, France, Germany, Italy, Australia, Hong Kong, Japan, and Singapore
Soenen and Hennigar (1988)	Augmented Granger model	Testing 12, 18, 24, 36 months	Appreciation of US dollar resulted in decrease in the US stock price
Subhani et al. (2011)	GARCH (1,1)	The data frequency is monthly	The relationship between the volatility of the two variables.
Kroon and Veen (2004)	APT model	24 countries for the period 1996 to 2002	The global stock price has exchange rate effects
Kutty (2010)	GARCH (1,1) model	Weekly data for the period 1989 to 2006, Mexican stock market	Significant relationship
Masry (2007)	EGARCH-M model	402 UK non-financial firms from 31 industries over the period 1990 to 2006	Exchange rate exposure effect on the UK stock

Author	Econometric Model	Data	Findings
Aydemir and Demirhan (2009)	Augmented Granger causality model	Data from 2001 to 2008 four sectors, namely services, financials, industrials, and technology indices in Turkey	The negative causal relationship between exchange rate to all stock market indices
Bianconi and Cai (2014)	GARCH (1,1) model	Quarterly data for a period 2001 to 2013	The negative effect of exchange rate volatility on S&P500 returns.
Dumitrescu and Rosca (2015)	GARCH (1,1) model	Daily data	Find a strong relationship between four currencies' volatility and four eastern European countries
Diamandis and Drakos (2011)	Multivariate Granger Causality tests.	Monthly data for four Latin America countries from a period 1980-. 2005	The relationship between the Latin America countries stock market with the foreign exchange rate
Hsing and Loo (1996)	Arbitrage pricing theory model	Monthly data for US, Canada, England and Japan.	The exchange rate will impact on stock price for the three countries
Kanas (2000)	GARCH (1,1) model	US, the UK, Japan, Germany, France and Canada	Significant evidence in all the countries except Germany

Table 2. 2 Empirical evidence on the foreign exchange rate volatility effect in the Asian stock market volatility

Author	Econometric Model	Data	Findings
Jayasinghe, Tsui and Zhang (2014)	BGJR-GARCH model	The Japanese industrial sectors for the period 1992 to 2000 and contain 2240 observations	Significant evidence of such exchange rate exposure that is not captured by the conventional measure
Lee et al. (2011)	STCC–GARCH model	Weekly data from 2000 to 2008 for Asia-Pacific countries	Foreign exchange markets become higher when stock market volatility increases
Liu and Shrestha (2008)	GARCH model	Chinese stock market indices macroeconomic variables	Finds negative relationship between the stock price and the exchange rate
Yang et al. (2014)	Least square (LS) estimation.	Nine Asian markets over the period 1 January 1997 to 16 August 2010	The exchange rate impact on 9 Asian countries
Yau and Nieh (2009)	Threshold error-correction model (TECM)	Monthly from 1991 to 2008 for Japan and Taiwan	The causal association between unequal stock prices and exchange
Zhao (2010)	Multivariate GARCH model.	Monthly data from January 1991 to June 2009 for the Chinese market	There is no stable long run symmetry relationship between the two financial markets

Table 2. 3 Empirical evidence on the foreign exchange rate volatility effect on the Australian stock market volatility

Author	Econometric Model	Data	Findings
Baur and Miyakawa (2014)	Two-factor regression model	Daily, weekly, monthly and quarterly returns for the period 1980 to 2010	The exchange rate exposure of Australian firms is dependent on the appreciation or depreciation trajectory of the Australian dollar and on the sample frequencies used.
Brooks et al. (1998)	ARIMA model	Daily data from 1989 to 1993	The exchange rate has an impact on Australian stock returns.
Chi et al. (2010)	The traditional capital market model	Quarterly data from January 1997 to March 2007	No significant relationships between Australian bank stock returns and foreign exchange rates
Faff and Nguyen (2003)	The generalised method of moments (GMM)	Monthly data for the period from January 1997 to December 1999	Australian firms are generally exposed to foreign exchange risks in the long run
Imams et al. (2011)	A linear forecast model	Daily data for the period 1991 to 2011	The change in USD effect immediately on ASX 200.

Author	Econometric Model	Data	Findings
Lim (2011)	GARCH (1,1) model	Weekly data over the period from January 1990 to June 2011	The impact of the exchange rate is significant with six out of ten Australian sectors
Subbarao et al. (1993)	Multiple regression model	Monthly data from 1980 to 1991	The firms hedging of foreign exchange rate risk may not add profitability
Lorio and Faff (2001)	The Fama-French three-factor model	Both daily data and monthly data from 30 April 1996 to 30 September 1998.1	Daily data provides stronger results than monthly data
Noel and Simpson (2009)	Granger causality	Daily data for the period 2003to 2006	A short-term positive relationship between the Australian dollar exchange rate and stock prices during the sample period
Raghavan and Dark (2008)	BEKK GARCH (1,1) model	Daily data from 1995 to 2004	The effects from Australian exchange rate to Australian ordinaries index.
Shamsuddin (2009)	GARCH-M model	Weekly data from 1994 to 2007	The FX market affects the small banks only
Swift (2003)	Optimising adjustment-cost model	Quarterly data for Australian manufacturing industry between 1988 and 2001.	Positively with export share of sales and negatively with the share of imported inputs into production
Wing and Nguyen (2012)	Augmented market model	Monthly stock return data over the period 2006 to 2009	Strong evidence that Australian resources firms on average are sensitive to exchange rate movement
Kearney and Daly (1998)	GLS estimation procedure	Monthly data from 1970 to 1994	There is no relationship between the USD and the Australian market

2.5 The methodology and model

2.5.1 GARCH Model

A generalised autoregressive conditional heteroskedasticity (GARCH) model is used to investigate the generated measures of conditional variance to serve as approximations for the exchange rate and stock market return volatility. This model allows the researcher to estimate the conditional volatility by modelling the stock return and exchange rate together as suggested by Joseph and Vezos (2006). According to Engle (1982), the GARCH (1,1) is the simplest volatility model. The model is modifiable. The GARCH model is a generalised form of GARCH (1, 1) with added lag terms, used for longer spans of data (daily or hourly). Various researchers have employed GARCH and its modifications in modelling financial time series data exhibiting time-varying volatility, particularly on stock returns and various microeconomic and macroeconomic variables (Joseph & Vezos, 2006; Adjasi, 2009; Tai, 2010; Brooks et al., 2010; Aloui et al., 2013).

Each model has its own strengths and weaknesses and having at hand such a large number of models, all designed to serve to the same scope, it is important to correctly distinguish between various models in order to find the one which provides the most accurate predictions. According to Matei (2009) GARCH is the most appropriate model to use when one has to evaluate the volatility of the returns of groups of stocks with large amounts (thousands) of observations. The appropriateness of the model is seen through a unidirectional perspective of the quality of volatility forecast provided by GARCH when compared to any other alternative model. In this context, the quality of the results is seen as the chosen model's ability to comprehend the relationship between the exogenous variables and the endogenous ones, by taking into account the autocorrelations and interaction effects that may exist within the data. Bollerslev et al. (1992) suggest that GARCH models and the GARCH (1,1) model are appropriate for data series in which the autocorrelation problem will die out moderately. According to Sadorsky (1999) and Aloui et al. (2013) the calculated volatility from GARCH (1,1) is well fitted to study the link between exchange rate shocks and stock returns. Hansen and Lunde (2001) used intra-day estimated measures of volatility to compare volatility models. Their objective was to evaluate whether the evolution of volatility measures has led to better forecasts of volatility when compared to the first "species" of volatility models. They compared two different time series, daily exchange rate data and stock prices. Their findings show that the more advanced models did not provide better forecasts than the GARCH (1,1) model.

GARCH models help to describe financial markets in which volatility can change, becoming more volatile during periods of financial crises or world events and less volatile during periods of relative calm and steady economic growth. On a plot of returns, for example, stock returns may look relatively uniform for the years leading up to a financial crisis, such as the one in 2007. In the time following the onset of a crisis, however, returns may swing wildly from negative to positive territory. Moreover, the increased volatility may be predictive of volatility going forward. Volatility may then return to levels resembling that of pre-crisis levels or be more uniform going forward. A simple regression model does not account for this variation in volatility exhibited in financial markets. GARCH aims to minimise errors in forecasting by accounting for errors in prior forecasting, enhancing the accuracy of ongoing predictions. In addition, The GARCH process is often preferred by financial modelling professionals because it provides a more real-world context than other forms when trying to predict the prices and rates of financial instruments.

The model of this research contains two equations: (i) the main equation, and (ii) the variance equation, which consists of two terms: (i) the ARCH term (lag of squared residuals), and (ii) the GARCH term (previous period's volatility). Both ARCH and GARCH coefficients must be positive. However, if the coefficients are negative, they indicate the presence of leverage effects. The sum of the ARCH and GARCH coefficients determines the extent of perseverance in shocks to volatility. Persistence holds if the sum is less than or equal to unity.

(i) The mean equation

$$r_{i,t} = c + \delta_1 r_{m,t} + \delta_2 r_{fx,t} + \varepsilon_{it} \qquad (2.6)$$

Where, $r_{i,t}$ is the six Australian sectors return i at time t, C is constant, $\delta_1 r_{m,t}$ is the market return, $r_{fx,t}$ is the Australian dollar against five currencies return, namely, US dollar, UK pound, European euro, Japanese yen, and Singaporean dollar.

(ii) Variance equation

The esidual derived from mean equation 2.6 is used in making variance equation 2.7.

$$h_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}^2 + \rho\sigma_{fx,t}^2 + \varepsilon_{t-1}^2 \qquad (2.7)$$

Where, h_t^2 is the variance of the residual derived from equation 2.6. It is also known as the current day's variance or volatility of Australian sectors (ASR), h_{t-1}^2 is the previous day's residual variance, known as the GARCH term, ε_{t-1}^2 is the previous period's squared residual derived from equation (2.6), also called the previous day's sector return information about volatility. $\sigma^2_{fx,t}$ is the Australian dollar against five currencies' return, namely, US dollar, UK pound, European euro, Japanese yen, and Singaporean dollar.

2.5.2 The data

This research uses daily data covering the period from July 2002 to July 2014, extracted from the Data Stream and external trade statistics from the RBA and Australian trade commission. This study attempts to investigate the influence of volatility of foreign exchange rate risk, namely US dollar, UK pound, Euro, Japanese Yen, and Singaporean dollar to the volatility of the six Australian sectors within the investigated period controlling for the time period of the global financial crisis 2007-2008. The dataset covering the period is divided into three sub-periods; the first is from July 2002 to July 2007. The second is during the global financial crisis, which is from July 2007 to July 2009. The third is after the global financial crisis period, that is from July 2009 to July 2014. The reason for dividing the sample into three samples is to provide greater insight into the nature of the estimation of the foreign exchange rate risk in the Australian industry sectors market before and after the crisis.

On the other hand, we expect the Australian sectors to be more exposed to exchange rate fluctuations in both the pre- and post-GFC periods. In the post-GFC period, due to increased market uncertainty arising from the crisis, we expect that more sectors will be highly exposed to exchange rate volatility. The Australian sectors' return is expressed as a percentage computed by multiplying the first difference of the logarithm of Australian industry sectors value by 100.

$$r_i = \ln\left(\frac{P_t}{P_{t-1}}\right) \tag{2.8}$$

Where r_i are daily continuously compounded sectors returns of the Australian stock market P_t are the daily ending sectors value of the Australian stock market P_{t-1} are the daily beginning sectors value of the Australian stock market.

Figures 2.1, 2.3, and 2.5 display daily returns of five currencies namely USD, JPY, EUR, SGD, and GBP for three sub-periods, the first is from July 2002 to July 2007; the second is during the global financial crisis, which is from July 2007 to July 2009. The third is after the global financial crisis period, that is from July 2009 to July 2014. In general, the five currencies have a consistent level of volatility, but during the global financial crisis show a high level of volatility. Figures 2.2, 2.4, and 2.6 show the daily return volatility of six Australian sectoral indexes, namely the financial sector, materials sector, health care sector, utility sector, IT sector, and the telecommunication sector. The graph shows that the daily Australian financial sector volatility is the highest level of volatility compared with the rest of the Australian sectors.

Figure 2. 2 Daily five currencies volatilities before the global financial crisis 2007-2009

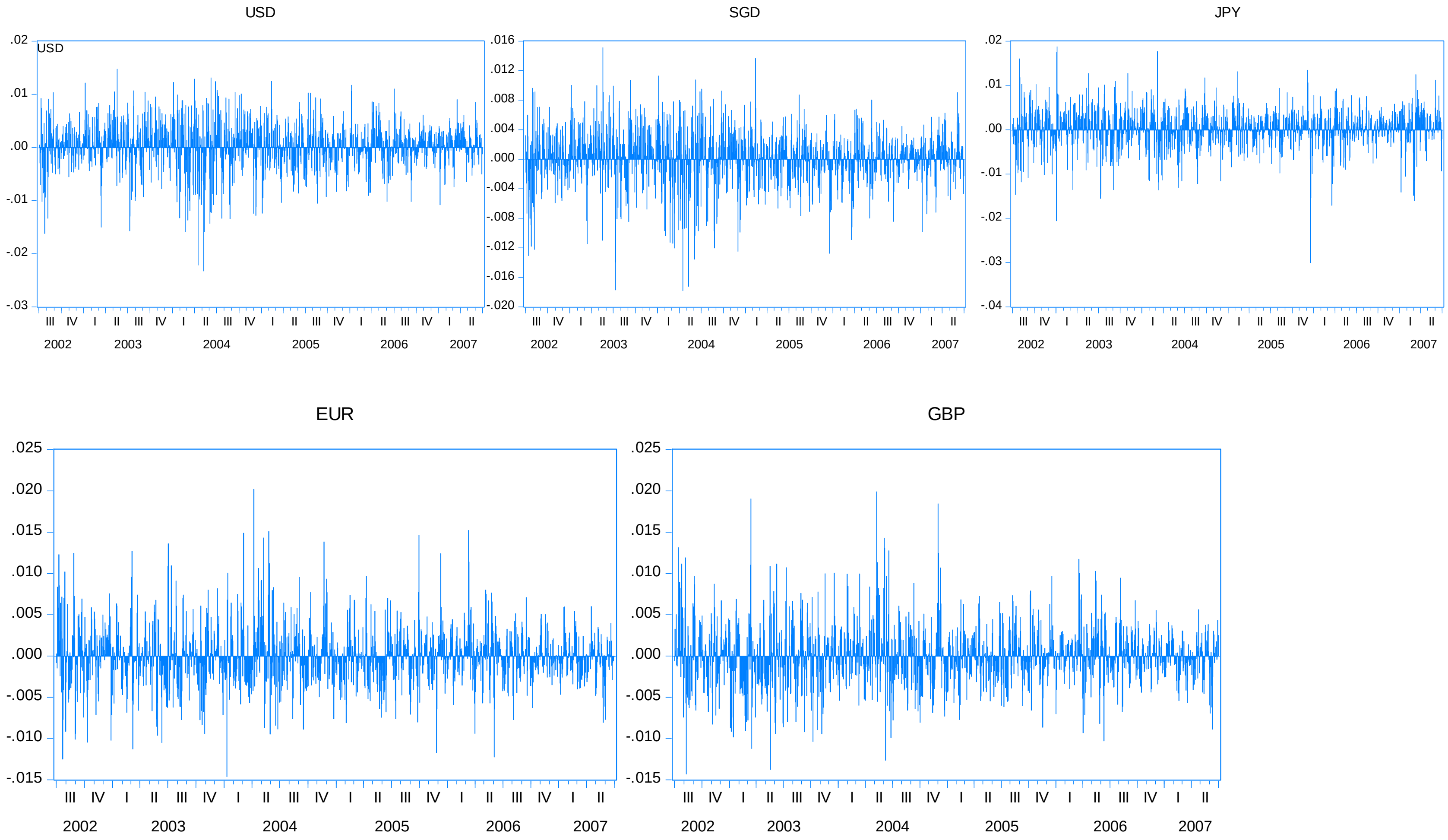


Figure 2. 3 Daily six sector volatilities before the global financial crisis 2007-2009

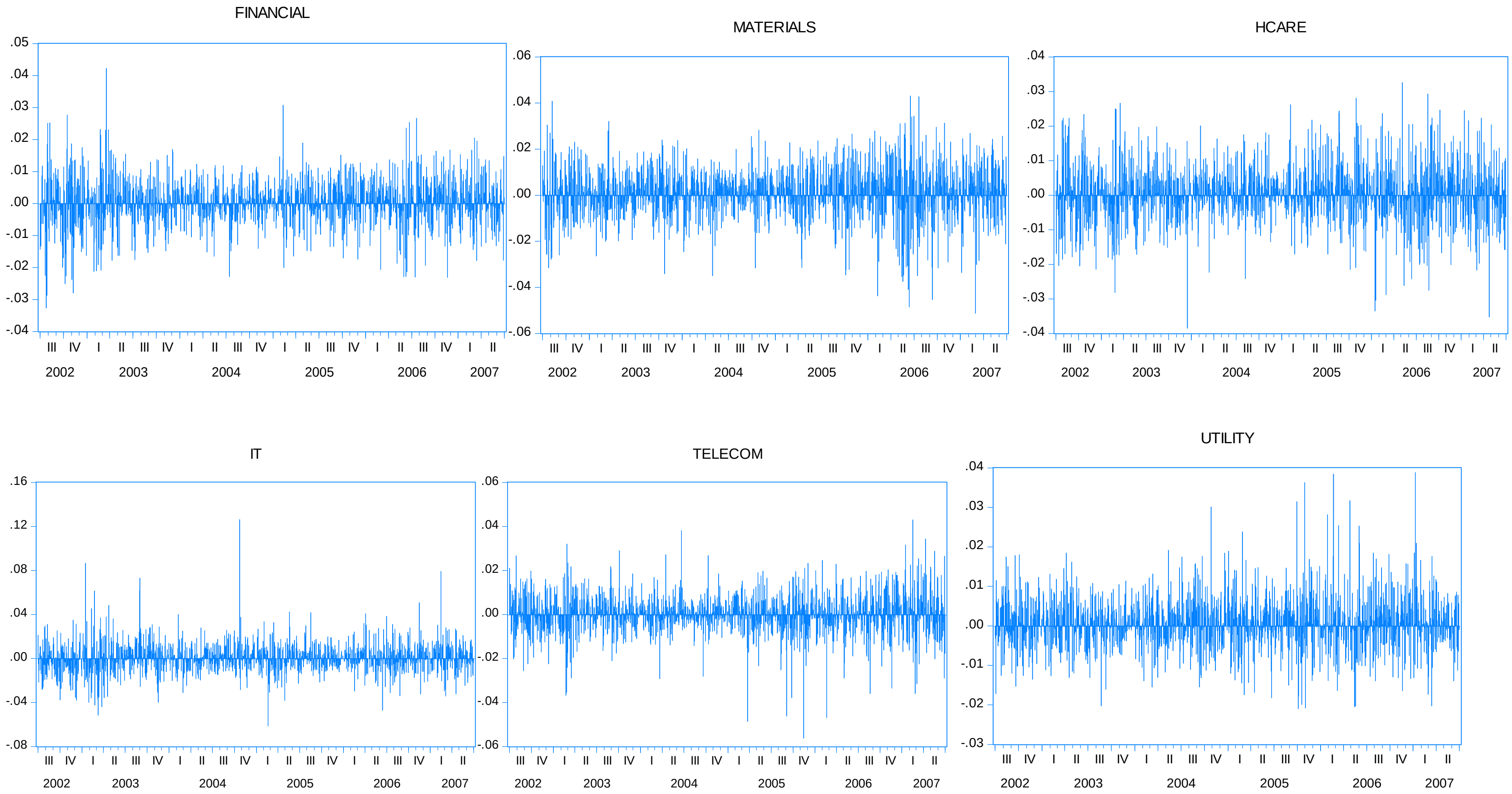


Figure 2. 4 Daily five currencies volatilities during the global financial crisis 2007-2009

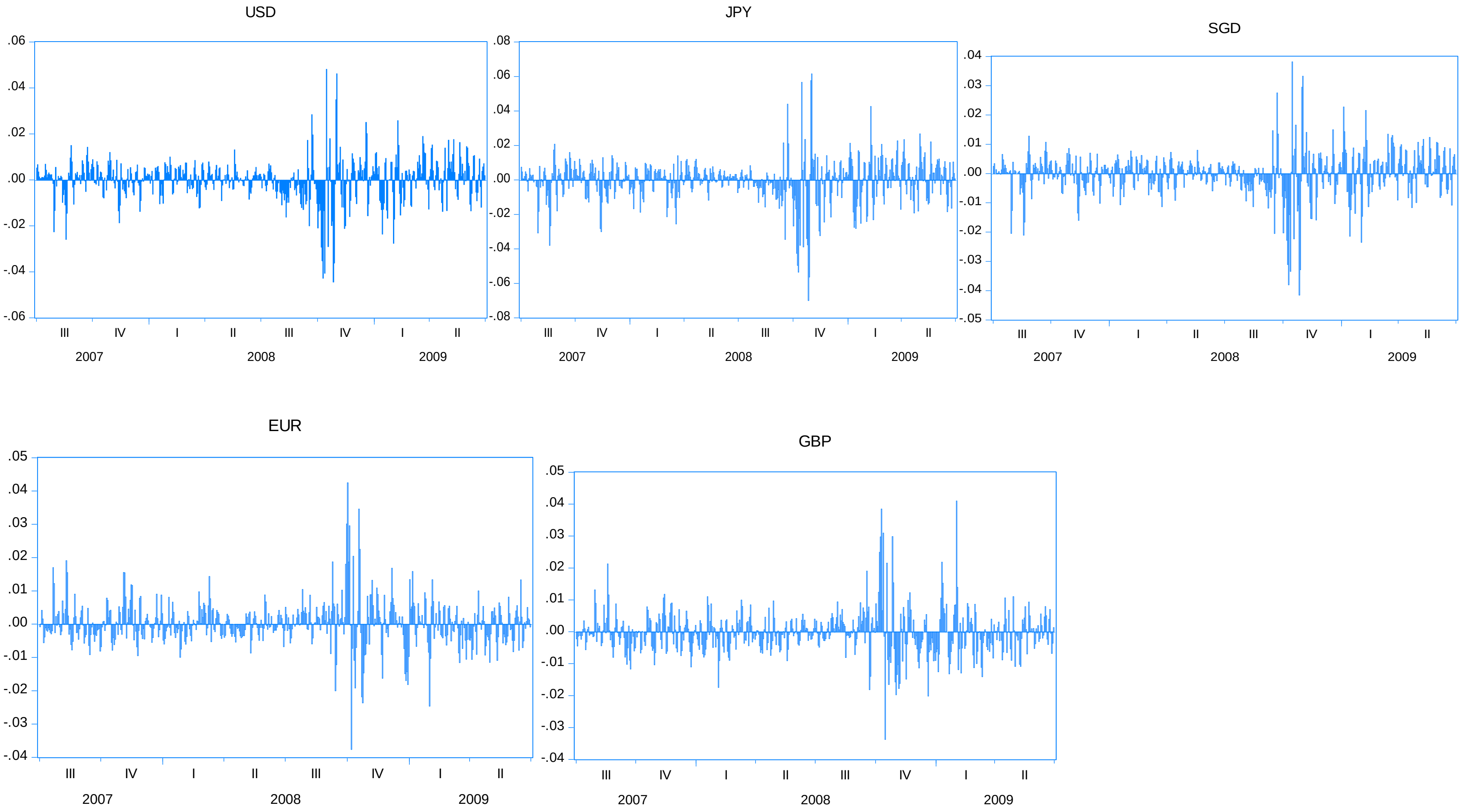


Figure 2. 5 Daily six sector volatilities during the global financial crisis 2007-2009

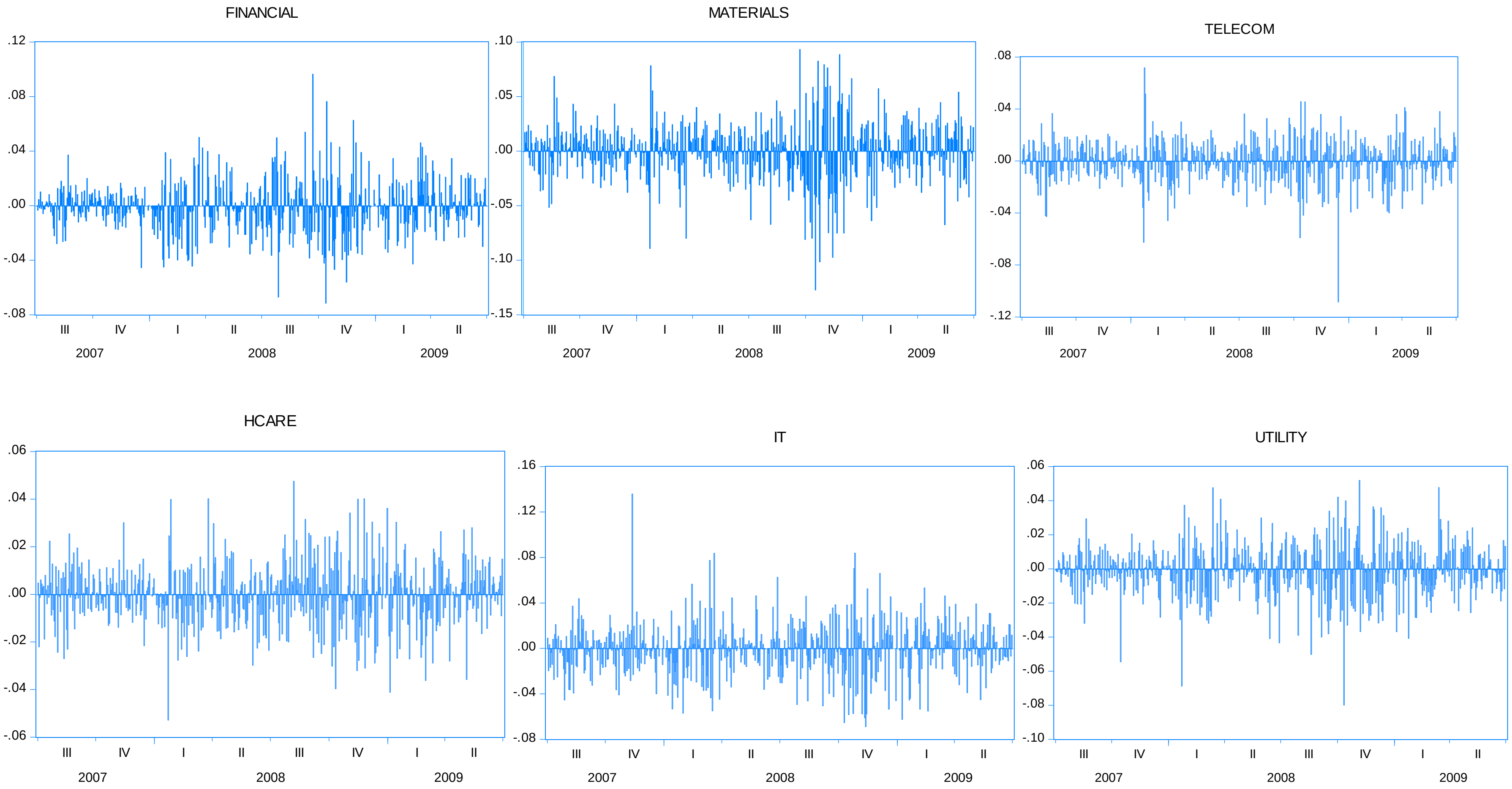


Figure 2. 6 Daily five currencies volatilities after the global financial crisis 2007-2009

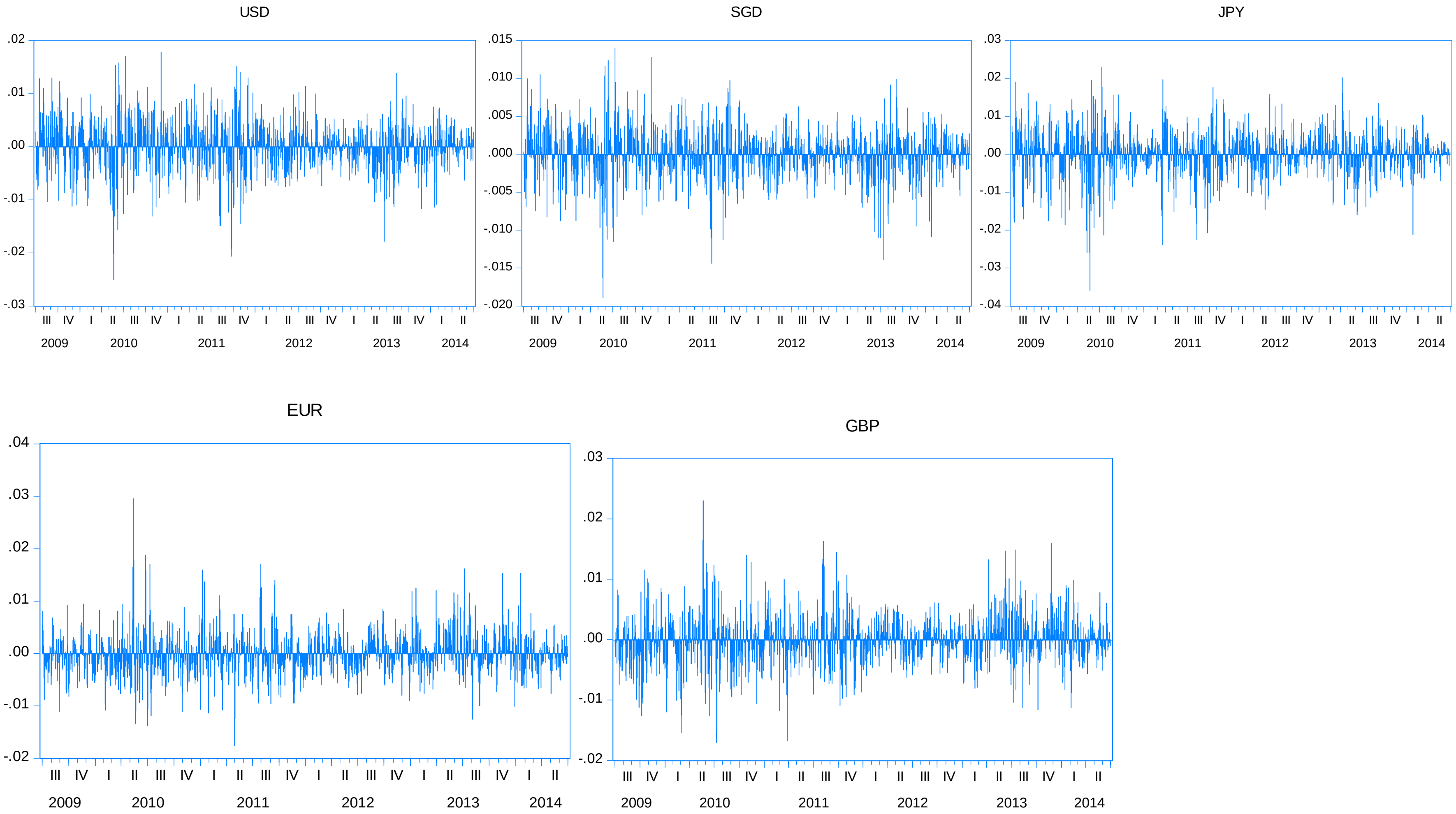
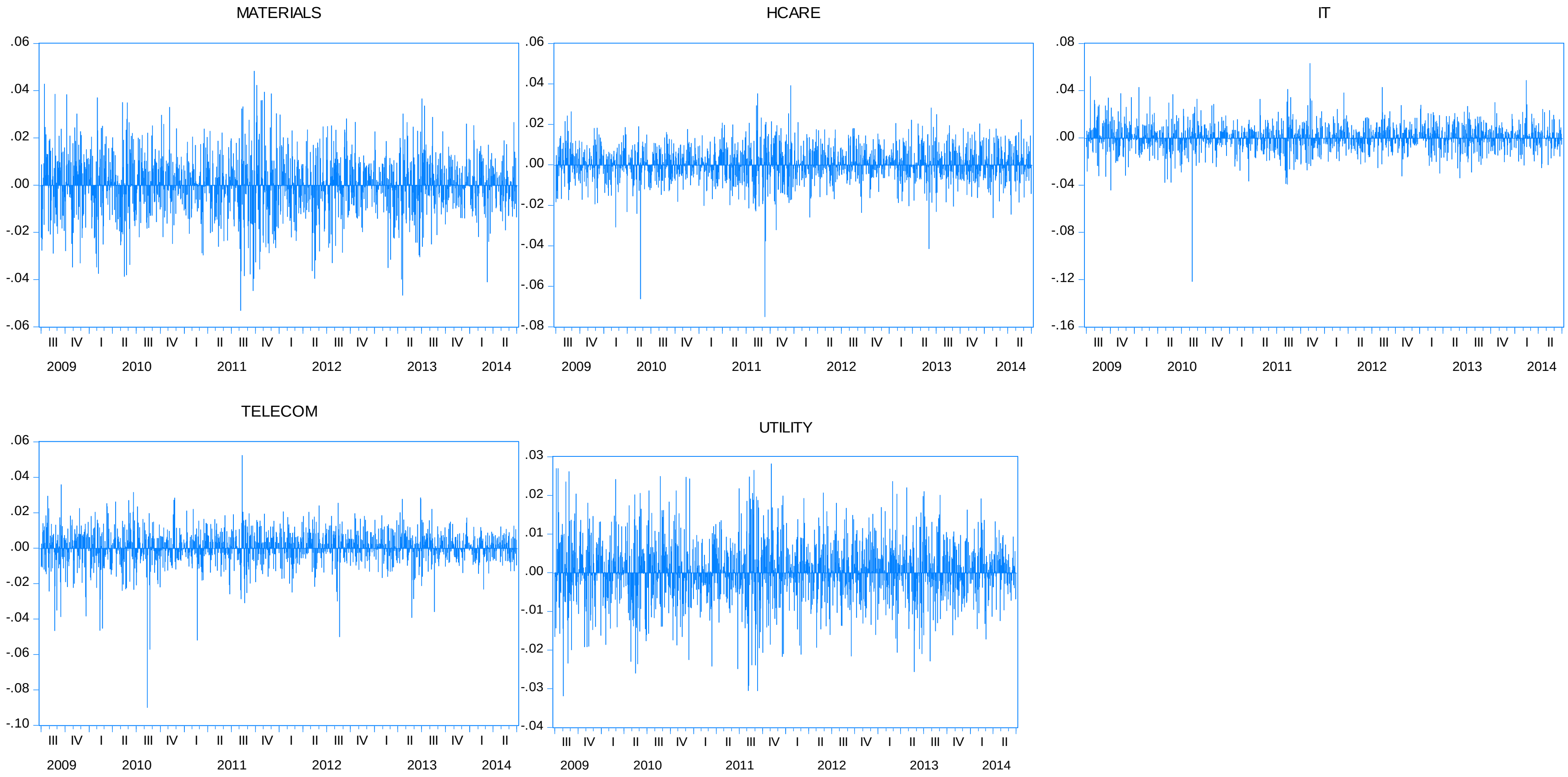


Figure 2. 7 Daily six sector volatilities after the global financial crisis 2007-2009



2.5.3 Descriptive Statistics

The descriptive statistics of the six Australian sectors' returns and foreign exchange rate data of five countries, namely the US, the UK, Europe, Singapore, and Japan for a period of July 2002 to June 2014 are presented in Table 2.4.

During the overall sample period, the mean Australian sectors return of the six series is positive and ranges from 0.00149 (telecom sector) to 0.012087 (healthcare sector). With regard to volatility measured by standard deviation, the materials sector has a higher standard deviation than other sectors and exchange rate return. Also, the average returns of all variables are smaller than their standard deviation, which means that the return series is not normally distributed. Based on the skewness, most of the variables return series indicate negative skewness. Only EUR, GBP, banks, and IT sector return series are negatively skewed. With regard to kurtosis, the value of this is greater than 3.0 for the six Australian sectors' returns and five exchange rates. This means a typical leptokurtic distribution. Additionally, these non-normal distributions of the data are confirmed by the skewness, kurtosis, standard deviation, and the Jarque-Bera statistics.

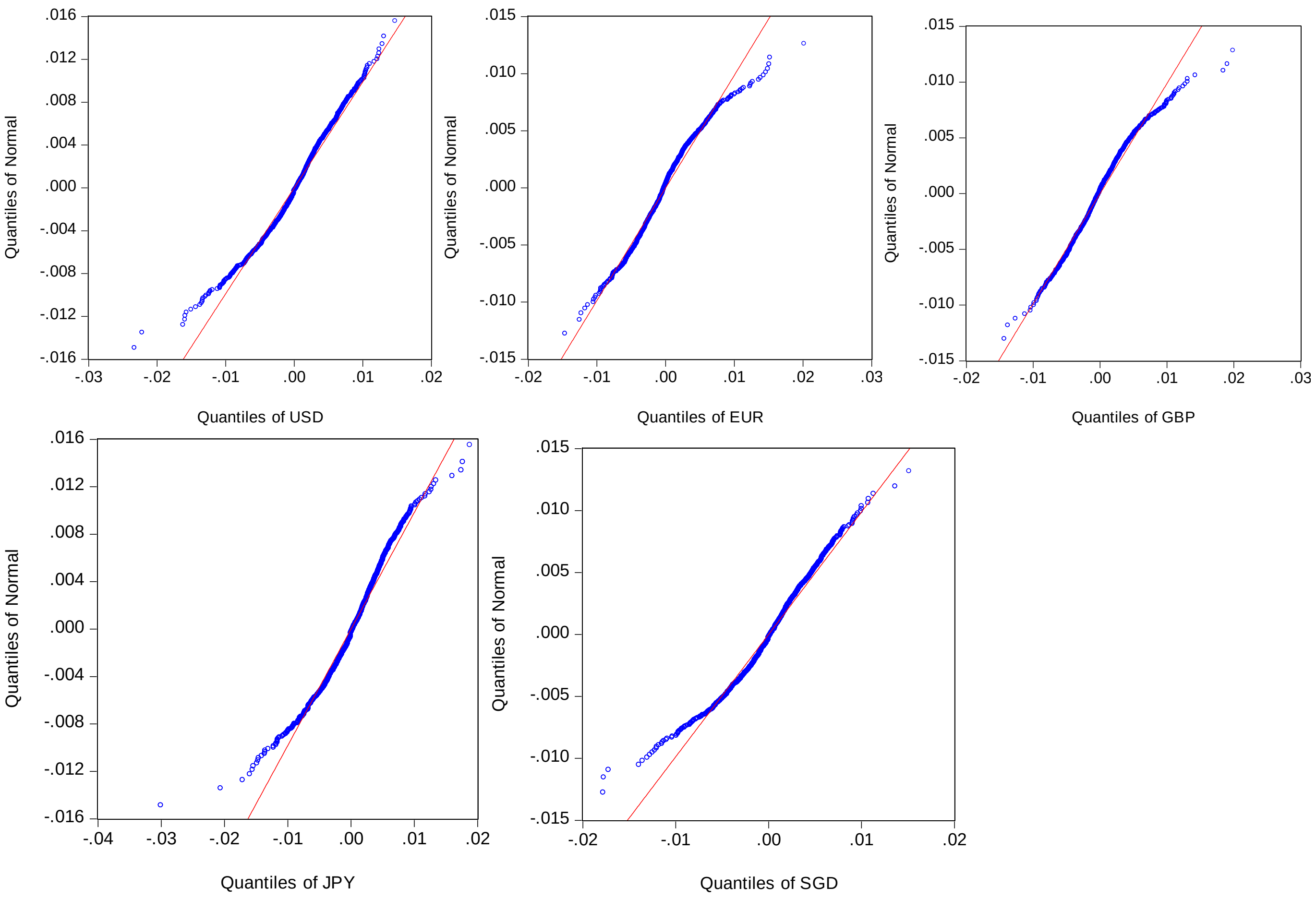
We used a QQ plot test to help us assess if a data set plausibly came from some theoretical distribution, such as normal or exponential. Also, the QQ test allows us to see at-a-glance if our assumption is plausible, and if not, how the assumption is violated and what data points contribute to the violation. Based on figures 2.8, 2.9 and 2.10, the return series of 11 variables are not normally distributed. Finally, the previous findings show that the ARCH and GARCH family is appropriate in this research**.**

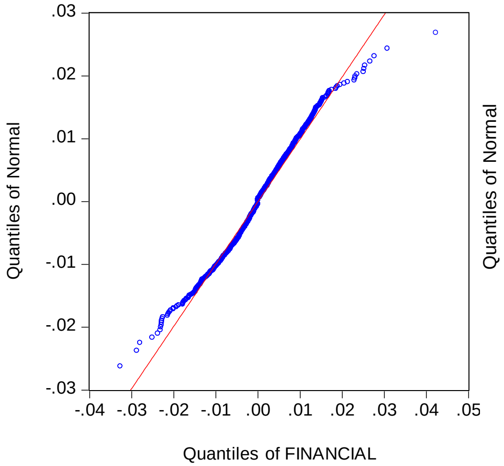
2.5.4 Unit Root Test

Unit root statistics is used to determine whether all data are stationary. In order to make strong conclusions about the time series properties of the time-series data, this study uses the unit root tests of the ADF, the PP, and the KPSS. These were introduced by Dickey-Fuller (1979) and Phillips and Perron (1988). This research measures the unit root of the five currencies and the six Australian sectors' returns in level and in first difference.

The results in Table 2.5 suggest that the null hypothesis of the series, being a unit root process, is rejected for the first differences of the series at 1% significance level for all markets for the ADF and PP test. The ADF and PP test results suggest that all variables are stationary for the first difference, both with and without a trend parameter present. Estimations show no trace of autocorrelation in the residuals; however, heteroskedasticity and non-normality of the residuals are evident. Although insignificant, the negative sign for the trend parameter could indicate a slow decline in variables value relative to trading over the period. Another possible explanation could be due to biased parameter estimates, caused by an unknown structural-break in the series. In the case of the KPSS test, most of the variables are stationary for the first difference. This does mean that we accept the null hypothesis of the series. In summary, the previous findings show that the ARCH and GARCH family is suitable for this research.

Figure 2. 8 QQ plot of five currencies' returns and six sectors' returns for daily data from 2002-2007




Quantiles of Normal
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.01
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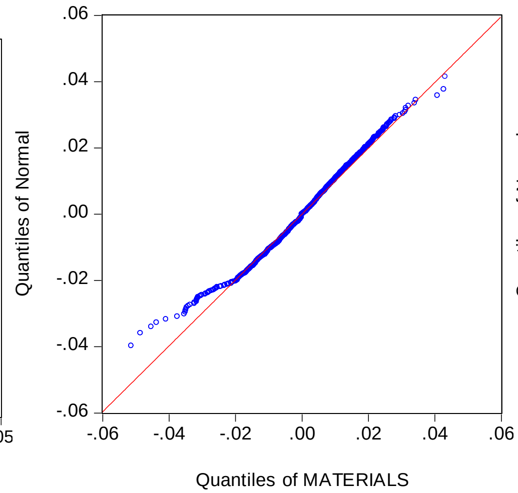
-.02
-.03
-.04 -.03 -.02 -.01 .00 .01 .02 .03 .04 .05
Quantiles of FINANCIAL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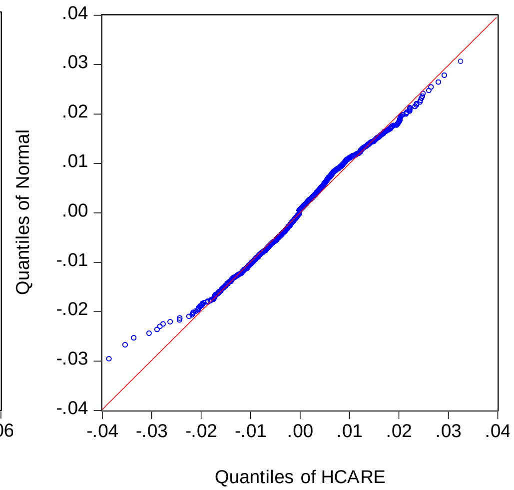
-.04
-.06
-.06 -.04 -.02 .00 .02 .04 .06
Quantiles of MATERIALS


Quantiles of Normal
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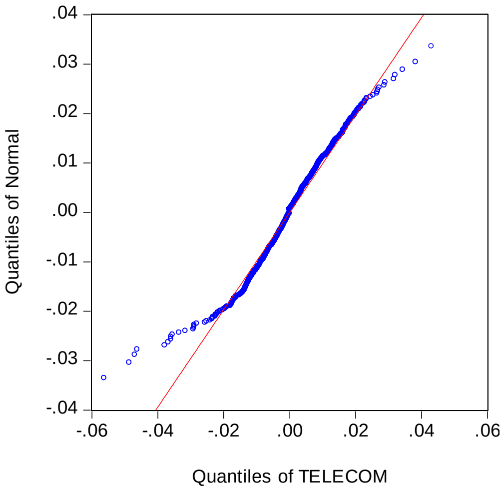
-.03
-.04
-.04 -.03 -.02 -.01 .00 .01 .02 .03 .04
Quantiles of HCARE


Quantiles of Normal
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-.01
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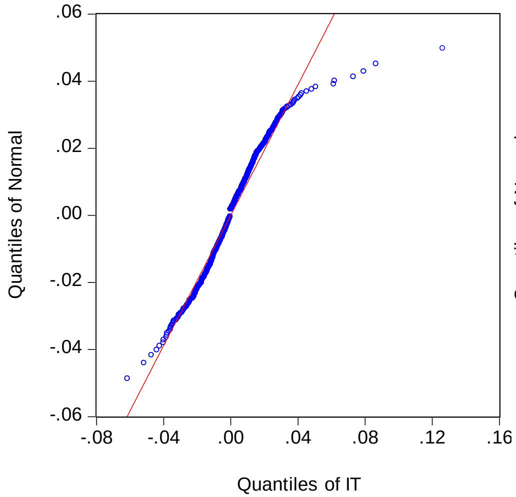
-.03
-.04
-.06 -.04 -.02 .00 .02 .04 .06
Quantiles of TELECOM


Quantiles of Normal
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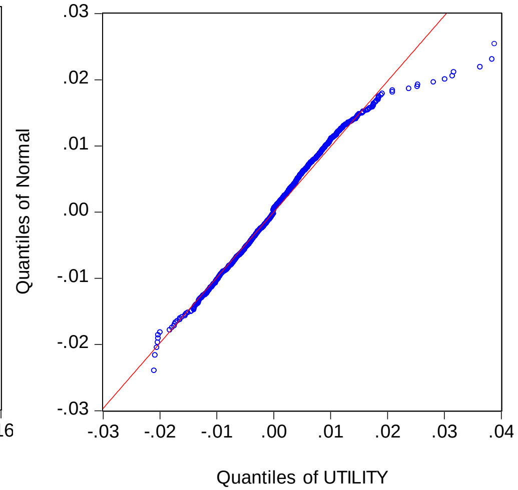
-.08 -.04 .00 .04 .08 .12 .16
Quantiles of IT


Quantiles of Normal
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.02
.01
.00
-.01
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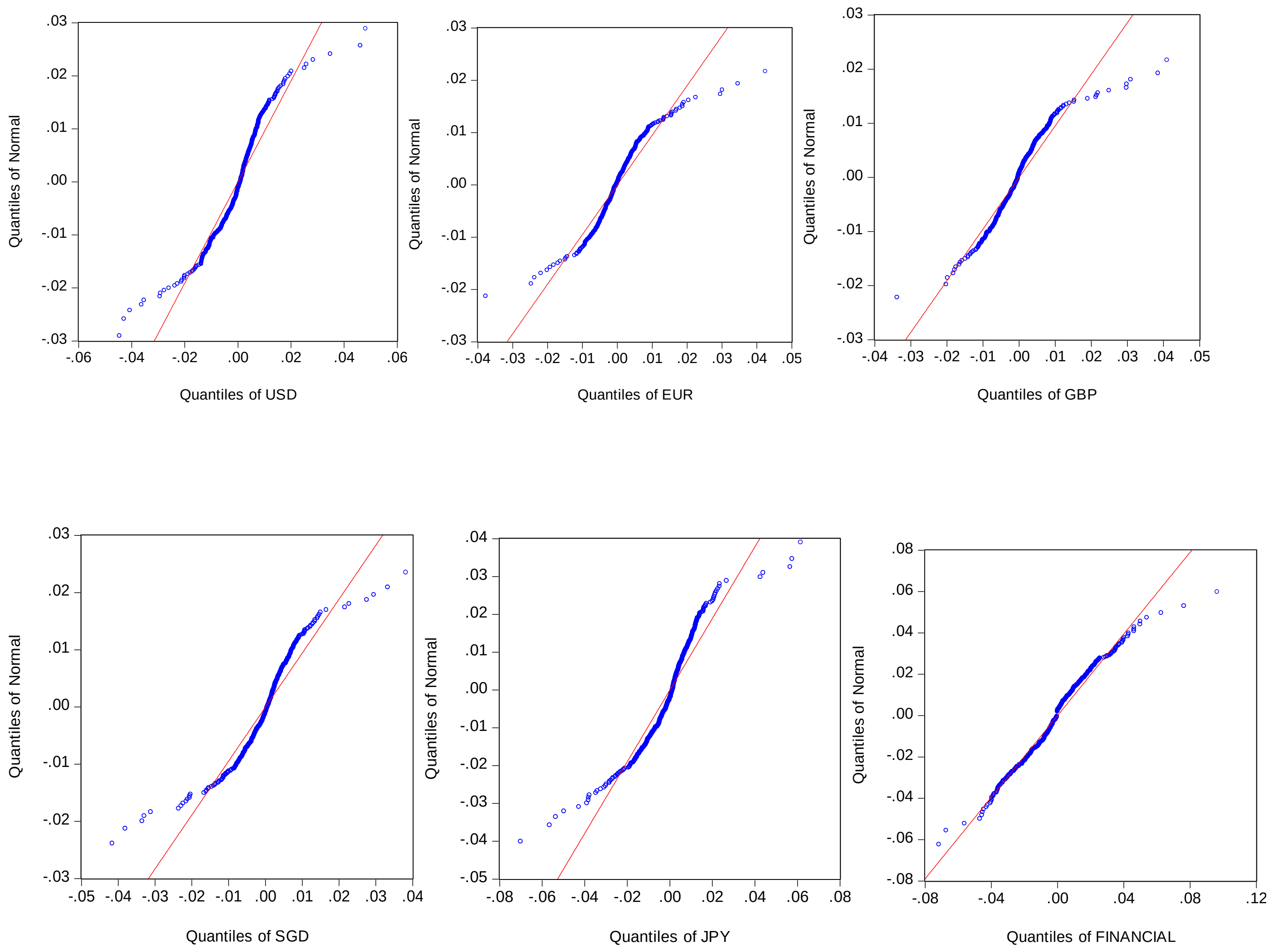
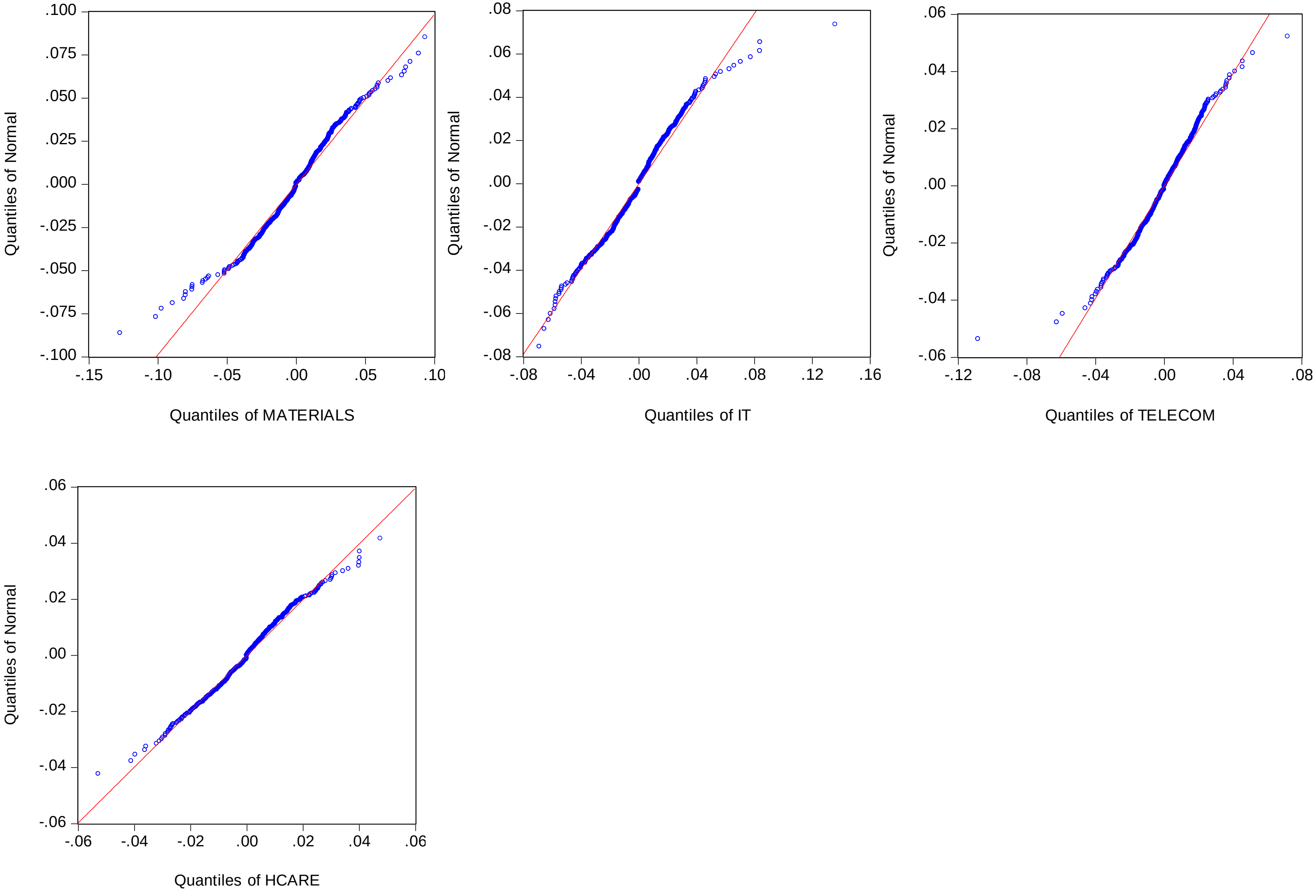
-.03
-.03 -.02 -.01 .00 .01 .02 .03 .04
Quantiles of UTILITY

Figure 2. 9 QQ plot of five currencies' returns and six sectors' returns for daily data from 2007-2009




Quantiles of Normal
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.025
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-.025
-.050
-.075
-.100
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-.10
-.05
.00
.05
.10
Quantiles of MATERIALS
Quantiles of Normal
.08
.06
.04
.02
.00
-.02
-.04
-.06
-.08
-.08
-.04
.00
.04
.08
.12
.16
Quantiles of IT
Quantiles of Normal
.06
.04
.02
.00
-.02
-.04
-.06
-.12
-.08
-.04
.00
.04
.08
Quantiles of TELECOM
Quantiles of Normal
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.02
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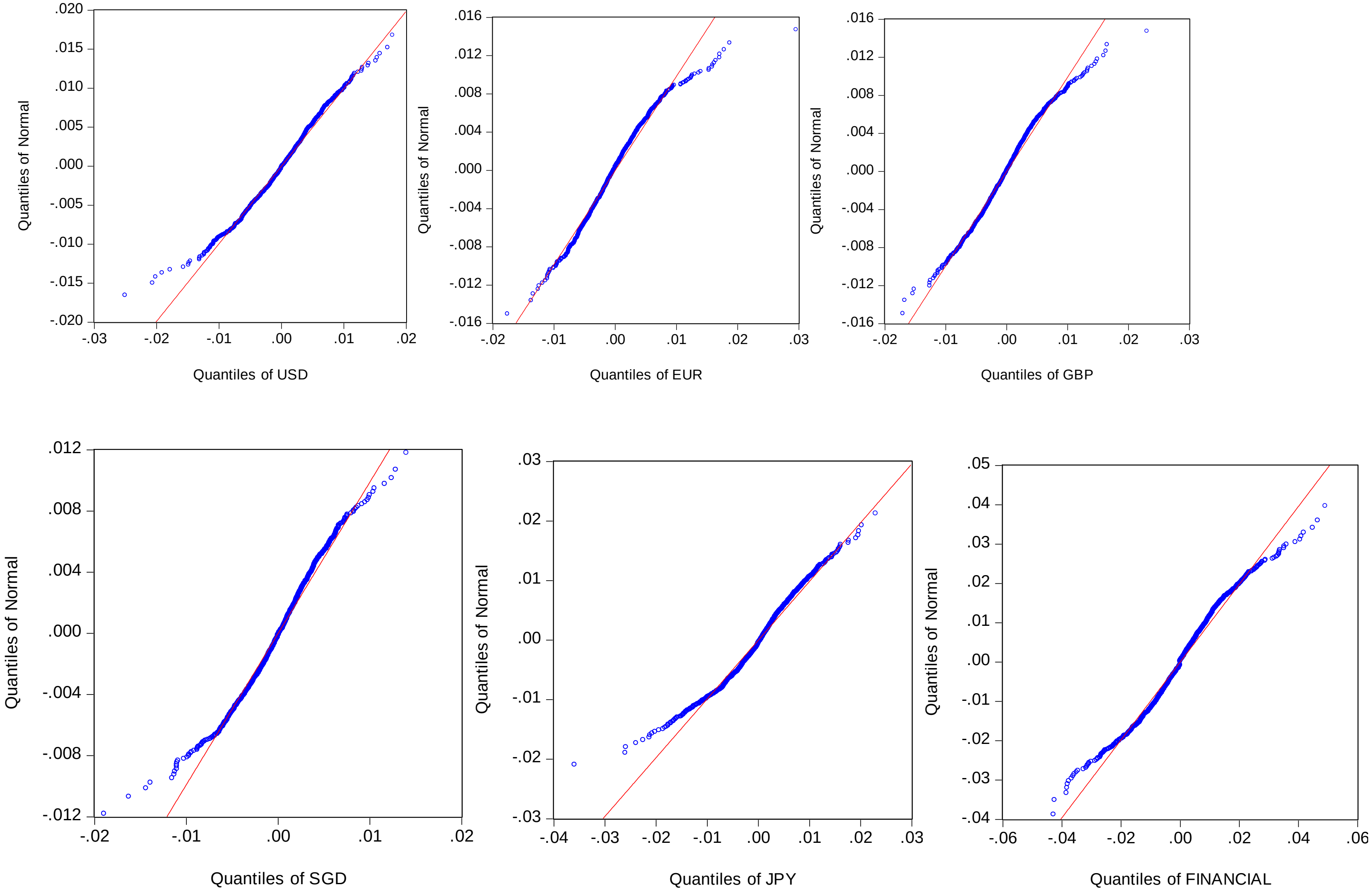
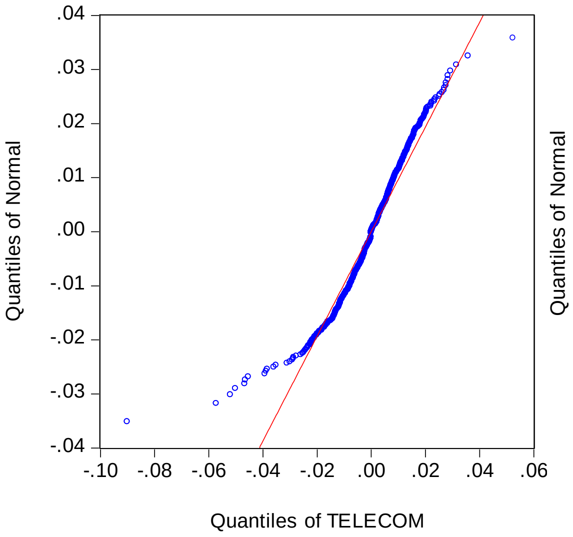
-.02
-.04
-.06
-.06
-.04
-.02
.00
.02
.04
.06
Quantiles of HCARE

Figure 2. 10 QQ plot of five currencies returns' and six sectors' returns for daily data from 2009-2014

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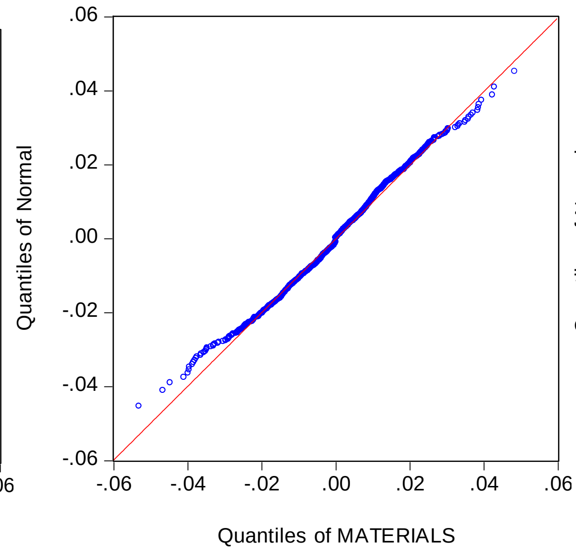
-.10 -.08 -.06 -.04 -.02 .00 .02 .04 .06
Quantiles of TELECOM


Quantiles of Normal
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-.04
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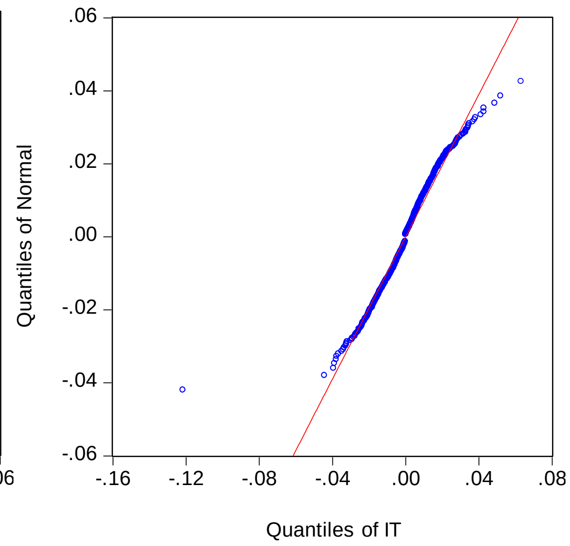
-.06 -.04 -.02 .00 .02 .04 .06
Quantiles of MATERIALS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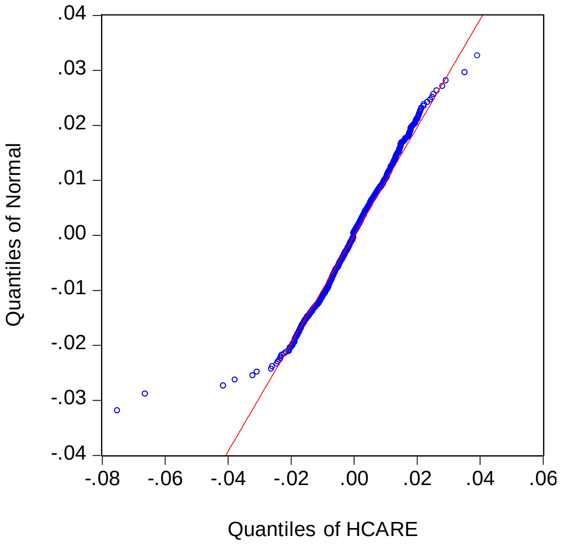
-.04
-.06
-.16 -.12 -.08 -.04 .00 .04 .08
Quantiles of IT


Quantiles of Normal
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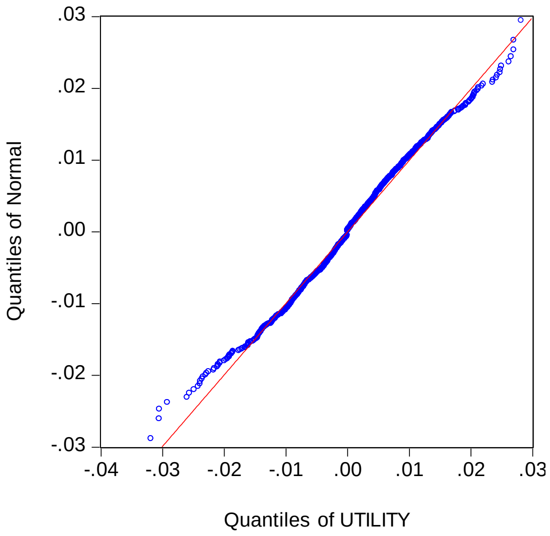
Quantiles of HCARE


Quantiles of Normal
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-.04 -.03 -.02 -.01 .00 .01 .02 .03
Quantiles of UTILITY

Table 2. 4 The descriptive statistics of daily six sectors' returns and five currencies' returns

	USD	SGD	EUR	JPY	GBP	ASX20	FINANCIA	HCARE	IT	MATERIAL	TELECO
Mean	0.007179	0.002324	-0.00252	0.004908	-0.00562	0.0074	0.007599	0.01208	0.00859	0.01091	0.00149
Median	0.021655	0.011955	-0.0127	0.027142	-0.00977	0.0138	0.0000	0.0000	0.0000	0.012449	0.0000
Maximum	2.091866	1.658463	1.845138	2.673679	1.781214	2.3277	4.208286	2.06213	5.90247	4.051158	3.118786
Minimum	-1.93366	-1.80559	-1.63683	-3.04275	-1.46628	-3.7178	-3.69835	-3.25973	-5.28169	-5.5333	-4.71175
Std. Dev.	0.250721	0.199227	0.203833	0.313379	0.206465	0.4254	0.581035	0.43089	0.68306	0.704872	0.507206
Skewness	-0.49953	-0.72797	0.700116	-0.77501	0.724781	-0.5579	0.155332	-0.27406	0.34782	-0.41546	-0.71345
Kurtosis	11.44495	14.00412	10.72851	16.11777	9.945769	9.3456	9.0645	5.78878	9.48662	8.268292	9.090369
Jarque-Bera	9425.097	16058.43	8040.33	22740.36	6561.623	5406.9	4805.999	1050.6	554.573	3707.374	5099.764

The table reports the summary of the return of five exchange rates and six Australian sectors: US dollar, Singaporean dollar, EUR, Japanese yen, and UK pound, financial sector, health care sector, IT, materials sector, telecommunication and utilities sectors

Table 2. 5 The unit roots analysis of the five currencies and Australian sectors' returns of daily data

	ADF		PP		KPSS	
	C	**C & T**	**C**	**C & T**	**C**	**C & T**
lnUSD	-1.995229	-2.389600	-1.949934	-2.354715	5.353123***	0.246192***
ΔUSD	-24.85155***	-24.84754***	-203.1990***	-203.1321***	0.015220	0.014747
lnSGD	-2.871127	-2.646566	-2.757303	-2.541185	0.918406***	0.324098***
ΔlnSGD	-26.67335***	-26.69982***	-30.20205***	-30.18320***	0.169183	0.054185
lnEUR	-1.562614	-2.019167	-1.585181	-2.122225	4.128922***	0.542235***
ΔlnEUR	-27.99747***	-27.99430***	-28.31454***	-28.30645***	0.074597	0.071717
lnJPY	-2.530460	-2.623867	-2.394742	-2.482604	1.056849***	0.500815***
ΔlnJPY	-26.59919***	-26.59647***	-28.07463***	-28.06608***	0.058427	0.052279
lnGBP	-1.480001	-1.808124	-1.415790	-1.822171	6.432256***	0.527044***
ΔlnGBP	-26.59468***	-26.60349***	-29.68751***	-29.66265***	0.138736	0.102862
LnASX200	-1.643411	-1.701821	-1.589189	-1.634190	2.030961***	0.893295***
ΔlnASX200	-56.70972***	-56.70366***	-56.76310***	-56.75770***	0.129897	0.098023
lnFINAN	-1.096770	-1.939201	-0.964270	-1.814540	2.636158***	0.506658***
ΔlnFINAN	-54.54231***	-54.53834***	-54.72304***	-54.72399***	0.087289	0.061599
lnHCARE	-0.614084	-1.612020	-0.473075	-1.485646	4.277996***	0.745968***
ΔlnHCAR	-59.11295***	-59.10359***	-59.34548***	-59.33567***	0.102618	0.104252
lnIT	-1.132915	-2.929253	-1.033629	-2.810457	5.200446***	0.637978***
ΔlnIT	-58.13400***	-58.12579***	-58.13400***	-58.12579***	0.073192	0.077318
lnMATER	-1.997969	-1.764446	-1.924863	-1.627859	3.440921***	1.265374***
ΔlnMATER	-56.43486***	-56.45672***	-56.80289***	-56.86791***	0.302755	0.043616
lnTELEC	-1.503010	-1.200676	-1.423703	-1.095371	1.996564***	0.845697***
ΔlnTELEC	-41.16065***	-41.17617***	-54.99237***	-55.01755***	0.213003	0.100232
lnUTILI	-1.638170	-1.560444	-1.533011	-1.432356	1.101169***	0.904766***
ΔlnUTILI	-21.89811***	-21.89457***	-853.6940***	-853.2242***	0.037772	032422

This table presents three measures of unit root tests for daily data, five exchange rates and six Australian sectors: US dollar, Singaporean dollar, EUR, Japanese yen, and UK pound, financial sector, health care sector, IT, materials sector, telecommunication and utilities sectors. The tests are considered both at level and at first difference level. The null hypothesis of ADF and PP tests is that the series has a unit root, while the null hypothesis of the KPSS test is that the series is stationary. The series of the first difference is reported by Δ. Also, two specifications of intercept (C) and intercept and trend (C&T) are considered. Here ***, **, * represent significance at the 1%, 5%, and 10 % levels respectively.

2.6 Empirical findings

The models are estimated using GARCH (1,1) to examine the six Australian sectors' returns and five foreign currencies across three periods i.e. pre-GFC, during GFC, and post-GFC periods. The results are provided in Tables 2.6 to 2.11. The result of each sector is presented in each table.

For the financial sector, based on Table 2.6, the findings of the mean equation show that the five currencies return is nonsignificant with financial sector in the pre-GFC period. GBP return only is positive significantly with the financial sector during the GFC period. For the post-GFC period, we find a positively significant relationship between the JPY and the financial sector. The volatility of the five currencies is included in the variance equations to understand its effect on the sector for the three sub-periods. Based on the pre-GFC period, the USD return volatility significantly affects the financial sector return volatility at the 10% level of significance, while the SGD return volatility significantly and positively affects the financial sector return volatility at the 5% level of confidence. The EUR volatility of return is strongly and positively related to the financial sector at 1% level of significance. During the GFC period, the five foreign exchange rates' return volatility does not have a significant impact on the financial sector. Ryan and Worthington (2004) found that the foreign exchange rate does not appear to be significant in the Australian banking return. For the post-GFC period, the JPY and the EUR return volatility significantly affects the financial sector return volatility at the 10% and 1% level, respectively.

The positive and significant relationship between the three foregoing exchange rates' return volatility and the financial sectors' volatility may be anticipated to be related to companies with significant exposure to the three foreign exchange fluctuations. The ARCH parameter, α is equal to 0.1484 and the GARCH coefficient, β is 0.6874 are both statistically significant at 1%. The sum of these coefficients is 0.8358, which approaches unity. This implies that shocks to the conditional variance will be highly persistent. Based on during and post-GFC periods, we have the GARCH coefficient at 0.9473 and 0.92540, respectively, and the ARCH parameter is 0.0501 and 0.06342, respectively. So, the sum of these coefficients is 0.9974 and 0.988, respectively. These imply that shocks to the conditional's variance will be highly persistent at the 1% significance level. Our findings correspond with results of Shamsuddin (2009). He tested the relationship between the USD and interest rate. His results showed that the FX market affects only the small Australian banks.

Table 2. 6 Financial sector return and conditional variance equation: GARCH (1,1) estimates using daily data 2002 to 2014

	USD	JPY	SGD	EUR	GBP
Mean					
C	-5.81E-05	-7.86E-05	-5.71E-05	-4.34E-05	-6.48E-05
δ_1	0.8723***	0.8741***	0.8725***	0.8718***	0.8732***
δ_2	0.0002	0.0215	5.37E-05	-0.012534	0.0174
Variance					
α	0.1484***	0.1435***	0.1479***	0.1456***	0.1471***
β	0.6874***	0.6936***	0.6830***	0.6469***	0.6719***
ρ	0.0496*	-0.0312	0.0913**	0.3030***	0.05673
Mean			**During GFC**		
C	0.0001	9.13E-05	0.0001	0.0001	0.0001
δ_1	0.9836***	0.9829***	0.9816***	0.9836***	0.9809***
δ_2	-0.1133*	-0.0438	-0.1061	0.0599	0.1814***
Variance					
α	0.0501***	0.0500***	0.0510***	0.0517***	0.0504***
β	0.9473***	0.9474***	0.9454***	0.9445***	0.9470***
ρ	0.0014	0.0005	0.0100	0.0220	0.0032
Mean			**After GFC**		
C	0.0002	0.0002	0.0002	0.0002	0.0002
δ_1	1.077***	1.0785***	1.0772***	1.0763***	1.0755***
δ_2	-0.0185	-0.0404**	1.0772	-0.0304	-0.0193
Variance					
α	0.0634***	0.0640***	0.0582***	0.0715***	0.0692***
β	0.9254***	0.9157***	0.9345***	0.9095***	0.9168***
ρ	-0.0007	0.0113**	-0.0184	0.0538***	0.0081

GARCH (1,1) model is estimated by equations (2.1), and (2.2) respectively for five exchange rates and financial sector. ARACH is the non-heteroskedasticity statistic. Here ***, **, * represent significance at the 1%, 5%, and 10 % levels respectively.

For the materials sector, in equation one the coefficient identifies the impact of the five currencies' return on the materials sector. The USD and SGD returns are positive significantly with the materials sector in the three sub-periods. The rest of the five currencies' returns are non-significant with the materials sector. The market return is significant with the materials sector for the three sub-periods.

The finding of the pre-GFC period for the variance equation shows that the USD and SGD volatility of return significantly and negatively affects the Australian materials sector at 1% and EUR volatility of return significantly and negatively affects the Australian materials at 10% level, while the GBP volatility of return significantly and positively affects the materials sector at 1% level. This means that depreciation of the British pound against the Australian dollar has a negative impact on the materials sector.

Our results agree with the results of Brooks et al. (2010), who found strong evidence of a negative exposure to the Australian materials sector. The data used in their analysis is the daily return data for the period from 2001 to 2005. Based on during and post-GFC periods, we find a non-significant relationship between the five foreign exchange rates' volatility of return and the materials sector. ARCH and GARCH are statistically significant in the three sub-periods. The sum of these coefficients is 0.98 for each period, which specifies that shocks to fickleness have a permanent effect.

Table 2. 7 Materials sector return and conditional variance equation: GARCH (1,1) estimates using daily data 2002 to 2014

	USD	JPY	SGD	EUR	GBP
Mean					
C	6.29E-05	6.54E-05	7.71E-05	8.36E-05	8.16E-05
δ_1	1.5445***	1.5443***	1.5434***	1.5447***	1.5371***
δ_2	0.1146***	0.0054	0.0944**	-0.0272	-0.0887*
Variance					
α	0.0400***	0.0426***	0.0415***	0.0419***	0.0371***
β	0.9087***	0.9085***	0.9087***	0.9145***	0.9240***
ρ	-0.0405***	-0.0188	-0.0585 ***	-0.0607*	-0.0669***
Mean			**During GFC**		
C	0.0008	0.00091	0.000889	0.0008	0.0008
δ_1	1.3784***	1.3835***	1.38210***	1.3855***	1.3808***
δ_2	0.1293**	0.0457	0.13048*	-0.1176	-0.1664*
Variance					
α	0.0736***	0.0720***	0.0752***	0.0806***	0.0800***
β	0.9241***	0.9153***	0.9226***	0.9153***	0.9150***
ρ	0.0044	-0.0027	0.0063	0.0416	0.0331
Mean			**After GFC**		
C	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002
δ_1	1.3161***	1.3168***	1.3161***	1.3179***	1.3174***
δ_2	0.0606**	0.0180	0.0732**	-0.0121	-0.0005
Variance					
α	0.0548***	0.0002***	0.0619***	0.0686***	0.0711***
β	0.9273***	1.3168***	0.91554***	0.8987***	0.8945***
ρ	-0.0190***	0.0180	-0.0161	0.0545	0.0261

GARCH (1,1) model is estimated by equations (2.1), and (2.2) respectively for five exchange rates and materials sector. ARACH is the non-heteroskedasticity statistic. Here ***, **, * represent significance at the 1%, 5%, and 10 % levels respectively.

In the mean equation for the health sector, Table 2.8 shows that the five currencies, except JPY and AUD, have a negatively significant effect on the health sector for the three sub-periods. The market return has a positively significant effect on the Health sector. Regarding the variance equation, the results of the pre-GFC period indicate a negative relationship between JPY, SGD, and USD return volatility and the return of the healthcare sector at 1%, 5%, and 10% levels of confidence, respectively.

During the GFC period, we find a non-significant relationship between the five-foreign exchange rate volatility of return and the Australian health care sector. For the post-GFC period, we find a significant positive relationship between the two Asian currencies' volatility of return and the return of the Australian health sector.

In the variance equation, the high value of the measure of shock persistence, $\alpha + \beta$ is an indication that the effects of five currency volatility are highly durable. Our outcomes match the results of Brooks et al. (2010), who found a negative link between the exchange rate return volatility and the Australian health sector. The data used in their analysis is the daily return data for the period from 2001 to 2005. Lim (2011) found that the health sector has a significant asymmetric exposure to exchange rates return.

Table 2. 8 Health sector return and conditional variance equation: GARCH (1,1) estimates using daily data 2002 to 2014

	USD	JPY	SGD	EUR	GBP
Mean					
C	7.12E-05	3.24E-05	4.85E-05	8.91E-06	2.55E-05
δ_1	0.8430***	0.8426***	0.841***	0.8375***	0.8390***
δ_2	-0.1512***	-0.0935*	-0.1119*	-0.0357	0.068491
Variance					
α	0.0717***	0.0646***	0.0710***	0.0728***	0.0682***
β	0.6964***	0.7457***	0.7105***	0.7015***	0.7548***
ρ	-0.1239*	-0.1103***	-0.1498**	-0.1388	-0.0756
Mean			**During GFC**		
C	6.08E-05	-4.02E-05	-9.25E-06	-3.34E-05	9.35E-05
δ_1	0.5366***	0.5380***	0.5325***	0.5306***	0.5291***
δ_2	-0.2282***	-0.158***	-0.2662***	0.0661	0.2271***
Variance					
α	0.0529***	0.0523***	0.0516***	0.0592***	0.0503***
β	0.9262***	0.9312***	0.9302***	0.9056***	0.926***
ρ	0.0111	0.0023	0.0114	0.0442	0.0268
Mean			**After GFC**		
C	0.0001	0.0002	0.0001	0.000278	0.0001
δ_1	0.6314***	0.6253***	0.6242***	0.60419***	0.6224***
δ_2	-0.1480***	-0.0373	-0.1594***	0.051991	0.0712
Variance					
α	0.0492***	0.0334	0.0475***	0.03303***	0.0483***
β	0.8528***	0.3701	0.8050***	0.62158***	0.8626***
ρ	0.0886	0.4636***	0.3941**	1.0712***	0.0784

GARCH (1,1) model is estimated by equations (2.1), and (2.2) respectively for five exchange rates and health sector. ARACH is the non-heteroskedasticity statistic. Here ***, **, * represent significance at the 1%, 5%, and 10 % levels respectively.

Based on the pre-GFC period, Table 2.9 shows that the ARCH parameter equal to α is 0.0664 and the GARCH coefficient, β, is 0.829 at the 1% level. The sum of these coefficients is 0.899, which approaches unity. This indicates that shocks to the conditional variance will be highly persistent. In equation one, the coefficient of the three Asian currencies is positive and statistically significant at the 1% level for pre- and post-GFC periods, while during the GFC, it is negative and significant at the 1% level. The GBP is negatively significant with the IT sector.

For the variance, the positive and significant relationship between the JPY return volatility and the Australian IT sector is at the 1% level of confidence, while the SGD return volatility significantly and negatively affects the IT sector at the 5% level of confidence. During the GFC period, the outcomes show that the EUR and GBP volatility of return positively and significantly impacts the Australian IT sector at the 1% level of confidence.

For the post-GFC period, the USD, JPY and SGD volatility of return significantly and positively affect the IT sector at the 1% level of confidence, while GBP is significant at the 5% level. The GARCH coefficient is 0.048675, and the ARCH parameter is 0.0904. So, the sum of these coefficients is 0.13867. This indicates that shocks to the conditional's variance have no continual effect on the post-GFC period at the 1% significance level.

Table 2. 9 IT sector return and conditional variance equation: GARCH (1, 1) estimates using daily data 2002 to 2014

	USD	JPY	SGD	EUR	GBP
Mean					
C	0.0005	0.0004	0.0005	0.0005	0.0005
δ_1	0.1125*	0.1141*	0.1087*	0.1135*	0.0901
δ_2	0.2326***	0.2138**	0.2497***	-0.1844**	-0.3997***
Variance					
α	0.0664***	0.0699***	0.0685***	0.075***	0.0663***
β	0.829***	0.794***	0.8336***	0.8246***	0.8526***
ρ	-0.2879	0.6434***	-0.3348**	-0.3078	-0.0555
Mean			**During GFC**		
C	-0.0004	-0.0005	-0.0004	-0.0003	-0.00047
δ_1	0.5288***	0.5158***	0.5277***	0.5128***	0.5134***
δ_2	-0.268***	-0.1227**	-0.3487***	0.0475	0.1787
Variance					
α	0.0699	0.0226***	0.0554	0.0108	0.0226
β	0.0304	0.7385***	0.0314	0.7854***	0.7688***
ρ	2.6358	2.5426	4.8412	2.2491***	11.0243***
Mean			**After GFC**		
C	0.0001	0.0001	0.0002	0.000212	0.0001
δ_1	0.2340***	0.2321***	0.2456***	0.29833***	0.2663***
δ_2	0.5159***	0.4639***	0.6607***	0.13187*	-0.383***
Variance					
α	0.0905***	0.07444	0.0886	0.114436	0.0886
β	0.04867	0.09991	0.0641	0.075784	0.0775
ρ	3.2158***	1.3239***	7.9733***	0.872117	4.4410***

GARCH (1,1) model is estimated by equations (2.1), and (2.2) respectively for five exchange rates and IT sector. ARACH is the non-heteroskedasticity statistic. Here ***, **, * represent significance at the 1%, 5%, and 10 % levels respectively.

In the telecommunication sector, increasing the EUR significantly raises returns in the telecommunication sector for the pre-GFC period, while SGD reduces it during the GFC period and post-GFC period. The Australian stock market index return has a positive effect on the telecommunication sector for the three sub-periods, except the pre-GFC period. In the variance equation, the four-foreign exchange rate volatility of return significantly influences the telecommunication sector's volatility of returns at the 1% level of confidence for the pre-GFC period. An increase in the USD, JPY SGD, and GBP volatility significantly reduces the Australian telecommunication sector volatility.

Table 2.10 results are consistent with the results of Brooks et al. (2010), who found a negative relationship between the exchange rate return and the Australian telecommunication sector volatility. During the GFC period, there is a positive and weak significant relationship between the two Asian currencies' returns volatility and the Australian telecommunication sector at the 10% level of confidence, while the five currencies' volatility of return positively and significantly impacts the Australian telecommunication sector volatility for the post-GFC period.

The ARCH parameter equal to α is 0.026 and the GARCH coefficient, β, is 0.9244. The sum of ARCH and GARCH equals to 1, which approaches unity. Both ARCH and GARCH parameters are statistically significant at the 1% significance level, which means that the FX parameter and the persistence coefficient are significant. The outcomes for the post-GFC period are similar to the ones obtained above.

Table 2. 10 Telecommunication sector return and conditional variance equation: GARCH (1, 1) estimates using daily data 2002 to 2014

	USD	JPY	SGD	EUR	GBP
Mean					
C	-0.0002	-0.0002	-0.0002	-0.0002	0.0004
δ_1	0.6026***	0.6028***	0.6042***	0.598***	0.4904***
δ_2	-0.0179	-0.03261	-0.0293	0.0016***	0.0526
Variance					
α	0.026***	0.0349***	0.0260***	0.0382***	0.0288***
β	0.9244***	0.9181***	0.9218***	0.8718***	0.9447***
ρ	-0.0658***	-0.04967	-0.1131***	-0.26264	-0.0055
Mean			**During GFC**		
C	0.0001	4.15E-05	6.11E-05	0.0001	-0.00085
δ_1	0.4872***	0.4881***	0.4872***	0.467***	0.6369***
δ_2	-0.1630*	-0.0950*	-0.2082***	0.1565	0.1028
Variance					
α	0.0910***	0.0838***	0.0791***	0.0977***	-0.0104***
β	0.8765***	0.8813***	0.8859***	0.8731***	1.0111***
ρ	0.0951	0.0504*	0.1743*	0.1344	-0.0258
Mean			**After GFC**		
C	0.0004	0.000449	0.0004	0.0004	0.0002
δ_1	0.5214***	0.52419***	0.5112***	0.51485***	0.6030***
δ_2	-0.12609*	-0.1259***	-0.194***	-0.0228	0.03727
Variance					
α	0.0874***	0.05827***	0.0876***	0.0598***	0.0478***
β	0.8398***	0.88097***	0.850***	0.9165***	0.8989***
ρ	0.3709***	0.15896***	0.6558***	0.3707***	0.048*

GARCH (1,1) model is estimated by equations (2.1), and (2.2) respectively for five exchange rates and telecommunication sector. ARACH is the non-heteroskedasticity statistic. Here ***, **, * represent significance at the 1%, 5%, and 10 % levels respectively.

For the utility sector, the coefficient of the two Asian currencies is negatively significant on the utility sector for the during-GFC period, while USD is negatively significant for the post-GFC period. The ASX200 return is statistically significant with the utility sector for the three sub-periods. The findings from during the GFC period in the variance equation show that the coefficient of USD and JPY is strong and significant. This indicates a negative relationship with the Australian utility sector at the 1% level of confidence, while for the pre- and post-GFC periods, there is no relationship between the five currencies and the Australian utility sector.

For the three sub-periods, the two coefficients in the variance equation, the intercept ARCH, the first lag of squared return, and GARCH, the first lag of the conditional variance show that the coefficients sum up to a number less than one, which is required to have a mean reverting variance process. Since the sum is very close to one and both the ARCH and GARCH parameters are statistically significant at the 1% significance level, this means that the foreign exchange parameter and the persistence coefficient are significant. So, this indicates that shocks to the conditionals variance have a continual effect.

This result is inconsistent with the results of Lim (2011) in which the study says there is no significant exposure of the exchange rate towards the Australian utility sector for the given period of 1990 to 2011. The said discrepancy could be due to the time interval used, where our data was taken on the daily basis for the three sub-periods, while he has used the weekly based data for one period mentioned. Our study concludes that two out of the five currencies are negatively significant with the utility sector during the GFC period

Table 2. 11 Utilities sector return and conditional variance equation: GARCH (1, 1) estimates using daily data 2002 to 2014

	USD	JPY	SGD	EUR	GBP
Mean					
C	0.0004	0.0004	0.0004	0.0004	0.0004
δ_1	0.4890***	0.492***	0.4889***	0.4898**	0.4904***
δ_2	-0.0323	-0.0774*	-0.02155	-0.0387	0.0526
Variance					
α	0.0284***	0.02936***	0.028***	0.0288**	0.0288***
β	0.9490***	0.9428***	0.945***	0.9479**	0.9447***
ρ	0.0037	-0.0135	2.62E-05	0.0145	-0.0053
Mean			**During GFC**		
C	-0.0008	-0.00075	-0.0008	-0.0008	-0.0008
δ_1	0.6442***	0.6488***	0.64636***	0.6407***	0.6369***
δ_2	-0.1243*	-0.0987***	-0.1793***	-0.0594	0.1028
Variance					
α	0.012***	0.0101***	0.0130***	0.0182***	-0.0104***
β	1.0115***	1.0102***	0.9799***	0.9731***	1.0111***
ρ	-0.0143***	-0.007***	-0.0095	-0.01490	-0.0250
Mean			**After GFC**		
C	0.0002	0.0001	0.0002	0.0002	0.00021
δ_1	0.6084***	0.60811***	0.6047***	0.6027***	0.6038***
δ_2	-0.1000**	-0.0768*	-0.082	-0.0272	0.0372
Variance					
α	0.0519***	0.0369***	0.0553***	0.0329***	0.0472***
β	0.8847***	0.9109***	0.87***	0.9360***	0.8989***
ρ	0.0482	0.0266*	0.1465*	0.0373	0.0482*

GARCH (1,1) model is estimated by equations (2.1), and (2.2) respectively for five exchange rates and utilities sector. ARACH is the non-heteroskedasticity statistic. Here ***, **, * represent significance at the 1%, 5%, and 10 % levels respectively.

2.7 Conclusions

The main objective of this research is to understand the effect of the five-foreign exchange return and return volatility on the six sectors of Australian stock market return and volatility based on the GARCH (1,1) approach. The dataset is divided into three sub-periods: before GFC, during GFC, and after GFC. The empirical analysis shows the effects of USD, SGD, EUR, JPY, and GBP on the Australian sectors.

Finance theory argues that exchange rate return carries economic exposures on expected future cash flows of a firm, which, in turn, affects the firm's value. An extension of the theory further suggests that a foreign exchange influence may also be asymmetric. Empirical studies that have identified the effect of exchange rate changes on stock returns do not provide conclusive evidence.

The findings of this study demonstrate that the exchange rates of the five currencies affect the six Australian sectors' volatility before the GFC period, except for the financial sector. The same relationship is weakly evident during the GFC period, except for the IT sector. The five foreign exchange rates volatility have a strong impact on the six Australian sectors volatility in the post-GFC period, except for the materials sector.

The results obtained from this research are of potential interest to investors and other market participants to understand the risk factors related to the sectors of the Australian stock market. When foreign exchange rates shocks are imminent, investors and market participants can adjust their portfolios to shocks of different sectors. For future studies, researchers can use spillover based on MGARCH and VAR approaches.

CHAPTER THREE

MODELLING OF INTRADAY STOCK RETURN OF THE AUSTRALIAN BANKING STOCKS

3.1 Introduction

In an open economy, the exchange rate is the relative price level of the main economy, which helps to maintain a balance on both sides of the financial and the real economy. Most importantly, any movements in the exchange rate play a critical role in the banking sector, both directly and, indirectly. From the direct perspective, the direct effect comes from the banks' holdings of assets (or liabilities) with the current debt net denominated in a foreign currency. Foreign exchange rates' volatilities are in the local currencies of these asset values. This source of currencies is the easiest to classify risks, and this is the most easily hedged. From the indirect perspective, a bank without foreign assets or foreign liabilities can be exposed to exchange rate risk because the currency can impact the domestic banking operations income. For instance, consider the bank loan value to the Australian exporter. The Australian dollar's depreciation might make it easier for the Australian exporter to compete against foreign companies; while the Australian dollar's appreciation might make it harder for them. If the appreciation thereby declines the profitability of the exporters, it also declines the timely loan payment and the bank profitability. In this matter, the bank is exposed to currency risk: the dollar's strength is decreasing the bank's profitability. In reality, the bank is selling the Australians dollars against the foreign exchange rate, at any time the currency value is related to foreign competition to the loan demand, so it also will affect the local bank profitability.

The bank profitability may be related to other types of risk, like interest rate risk. When the interest rates to depositors decrease and, due to that, if spread increases, then it will discourage savings and, on the other hand, if interest rates to depositors increase, then it will badly affect investment. That is why there is an important implication of these changes in interest rates on the economy. In the banking system, the impact of interest rate exchange on profitability has been a significant issue, as compared to other institutions. Banks are more sensitive to the change in the interest rates, the investment crisis and saving. The experience of the bank to interest rate risk has been argued to be a significant issue. Interest rates act as an incentive for those who sacrifice their consumption and lend money to others. If interest has been eliminated from the whole framework, then no one would lend the amount of money available. When a borrower borrows the amount, he or she pays interest as fees for utilising the fund. Interest rates and exchange rates often move together. So, the indirect effect of interest rates position on the overall banks' profitability. Theoretically, according to economic exposure theory, the exchange rate affects firms' profitability, firm stock becomes riskier, which in turn increases the stock price volatility.

During the last decades, the relationship between exchange rate, stock price and the banking firms remains a critical point for risk management and portfolio management. The linkage between the two factors has had significant attention from researchers and economists, for academic and practical reasons, as they play a significant role in influencing stock prices. Additionally, the financial market liberalisation and the advance of technology have upgraded the linkage between the exchange rate and the stock returns. The linkage between the two factors in the banking sectors has provided a lot of research activity over the last two decades. In the early papers, Garmmatikos et al. (1986) use the exchange rate factor in explaining stock return in the US banking sector. Jorion (1991) examines the pricing of exchange rate risk in the US stock market. Choi et al. (1992) find that the exchange rate is negatively related to the bank sector. Chamberlain et al. (1997) identify the influence of exchange rates with bank stocks by comparing both US and Japanese firms. They find a positive relationship between the exchange rates and the US and Japanese banks. In contrast, Tai (2000) finds no significant effect between the exchange rate and the Japanese banks. Haham (2004) investigates the relationship between the exchange rate and Korean financial institutions. He observes that the Korean commercial banks and merchant banking corporations have significant exposure to both risk factors. Beirne et al. (2009) show that interest rates and exchange rates have a significant effect in 16 different countries. Kasman et al. (2011) find a significant relationship between both factors. Papadamoua and Siriopoulos (2013) investigate the effect of the interest rate risk on banks and life insurance companies from the UK. They find that the exchange rate affects the banking share prices.

Previous researchers have studied the effect of exchange rate risk on the Australian stock market, include Lorio and Faff (2000), who examine the effect of exchange rate exposure on the Australian stock markets. They find a strong relationship between the exchange rate and the Australian stock market. Cagliarini and McKibbin (2009) study the impact of the foreign shocks on the Australian market. In a similar spirit, Richards, Simpson and Evans (2007) investigate the interaction between the stock price and exchange rate. The findings show a positive co-integrating relationship between the Australian stock price and the Australian dollar. According to Jain et al. (2011), there are only a few studies on Australian bank stock return. This statement is confirmed by Chi et al. (2010), Harper and Scheit (1992), Ryan and Worthington (2004), and Vaz et al. (2008). Shamsuddin (2009) examines the impact of the exchange exposure on the Australian banks. This study contributes to the finance literature by documenting the effect of the exchange rate shocks on individual banks, which are an important source of macroeconomic volatility for small open economies. This research complements other papers that describe the effect of the exchange rate movement on the Australian market.

In this chapter, we study the effect of exchange rate return and exchange rates' volatility on the return, and the volatility of different banks stocks in the Australian stock market. We estimate four econometric models using high-frequency adjusted data at hourly frequency for the period 2012 to 2016. The models are GARCH (1,1), TARCH (1,1) EGARCH (1,1) and PARCH (1,1). This study seeks to identify the superior model in capturing the characteristics of the Australian banks stock. Apart from this, this research also seeks to investigate whether exchange rate can influence the big four banks' stock movement in Australia. The literature considers the effect of the exchange rate shock on stock market returns, but few studies focus on the effect of the exchange rate volatility and big four banks' share volatility in Australia. The majority of the studies of the effect on the exchange rates shocks focus on the US and European countries' indexes. The results for index may mask the interesting effect of the exchange rates shocks at the individual shares.

3.2 Theoretical linkage and empirical studies

The world experienced a significant floating exchange rate in 1973; researchers set out to estimate and understand the nature of price movement and volatility on the exchange rate and other financial assets. At the theoretical level, there are three theories that explain the effect of the foreign exchange rate on banking performance. The three theories are as follows.

The modern portfolio theory (MPT) was developed in 1952 by Markowitz. This theory helps investors to maximise the expected return on different volatility levels. The investor who diversifies would reduce the elements of the systematic risk, even if the average yield of the assets in other countries does not exceed those of the local market. If the two markets have a correlation less than 1, the offset of risk from diversification can contribute more regular returns in the portfolio, also if the average revenue settles the same (Gastineau, 1995).

The second theory, the capital asset pricing model (CAPM) was developed by Mossin (1966) Sharpe (1967) and Lintner (1969). CAPM presents an equilibrium model of the relationship between risk and return that describes the beta of assets expected return with the market portfolio. There are three hypotheses for the capital asset pricing model. The first hypothesis is that investors can borrow money to trade in the financial market risk-free. The second hypothesis is that investors choose the portfolio that has the maximum expected return on a different level of volatility (efficient portfolio). The market portfolio is equal to the efficient portfolio. The third hypothesis is that investors have a similar perspective as regards volatility, return, and correlation. The International Asset-Pricing Model (ICAPM) extended by Solnik (1974), focusses on exchange rate risk and the tools that can help investors to minimise risk. This means that investors can be neutral among choosing the best portfolio from the asset portfolio on the one hand, and hedging exchange rate portfolio. MPT and CAMP/ICAPM show that internationally diversified portfolios essentially exceed local portfolios. However, international portfolios are constructed by using historical risk and return data in a time of relatively stable exchange rates. It is natural to investigate the impact of the exchange rate risk on asset prices in an international context. Exchange rate risk may be at least partially diversifiable internationally. Moreover, international asset pricing models show a close link between inflation risk, exchange rate risk and equity risk. However, the extant literature on international asset pricing commonly assumes inflation rates to be constant. In this research, we apply the international asset-pricing model (ICAPM) to investigate the theoretical linkage between the Australian dollar volatility and the big four banks' stock in Australia.

Exchange rate volatility decreases the profit of international diversification, which makes financial asset investment riskier. To a large extent, there is a high positive correlation between the changes in exchange rates. As the outcome, when fundamental factors affect currency, they will affect other currencies and the stock market. In the overall risk, the portfolio risks rise. According to Eun and Resnick (1988), investors can improve their profit from hedging strategies. The majority of hedging strategies are developed to include the exchange rate risk. This displays better performance than unhedged strategies. Eun and Resnick (1988) also find a strong significant relationship between the dollar volatility with the large European countries' markets. In a hedging strategy, it is more important to include the exchange rate risk in the banking sector portfolio than the other sectors, because the banking sector operations deal with different banking in different countries with multi-currencies. In fact, the banking sector's portfolio might be riskier than the other sector's portfolio.

The literature has far less research on the relationship between the exchange rates and banking stock. In early studies, it only concentrated on either the sensitivity of exchange rate or bank stock return. The first study for banking stocks and exchange rate was conducted by Garmmatikos et al. (1986). Their outcomes suggest that the exchange rate may affect US bank stock return. This means that banks have correctly hedged their overall asset position in individual foreign exchange rates. Jorion (1991) uses two factor and multi-factor arbitrage pricing models to investigate the pricing of exchange rate risk in the US stock market. The findings do not suggest that the exchange rate risk impacts on the stock market, which means that active hedging policies by financial managers cannot affect the cost of capital and other reasons must explain why firms decide to hedge. Choi et al. (1992) examine the exchange rate risk and interest rate risk with US bank sector return; they employ a multi-factor index model. The outcomes show that the exchange rate is a negative relationship with the bank sector before 1979, while significantly positive after 1979. Diirio et al. (2013) investigate the relationship between the exchange rate and Eurozone bank sectors. Their findings suggest that the banks are more sensitive for short term interest rate and a weak relationship with exchange rate exposure.

From the volatility perspective, the asymmetrical aspect of volatility is initially observed in stock return volatility by Black (1976) and Christie (1982). In the stock market, the symmetric volatility phenomenon is a market dynamic that shows that there are higher market volatility levels in market downswings than in market upswings. Factors that cause this phenomenon have been attributed to several possible sources, such as the effects of leverage in the markets, volatility feedback and psychological investment factors related to the perceived risk/reward balance at different market levels. In the financial literature, Chamberlain et al. (1997) examine the effect of the exchange rate risk on the banks' stock in the Japanese market and the US market. They suggest that the sensitivity of the exchange rate can provide a benchmark for assessing US banking and the Japanese stock market. Elyasiani and Mansur (1998) apply the GARCH-M model to explain the interest rate and exchange rate on US bank stock return. Their results show that there is a direct relationship with the banks sector. They also find that the interest rate volatility affects risk indirectly. Similar research focussing on US banks by Tai (2000) explores the sensitivity of US bank stock returns to the market, interest rate, and foreign exchange rate. Tai (2000) finds that volatility is an important factor determining bank stock returns but that long-term interest rates and the foreign exchange rate are insignificant. Papadamoua and Siriopoulos (2014) investigate the effect of the interest rate risk on banks and life insurance companies from the UK. The results show that volatility of interest rates significantly affects the banking sector index stock returns. Beirne et al. (2009) analyse the dependency between macroeconomic variables and stock returns in three financial sectors (banking, financial services and insurance) in 16 different countries. Their results show that interest rates and exchange rates have a significant effect. Kasman et al. (2011) investigate the effect of the interest rate and exchange rate on the Turkish banks' stock. Kasman et al. (2011) find that interest rate and volatility of exchange rate are significant with bank stock return volatility.

Diiorio et al. (2013) examine the European financial sector return sensitivity to the exchange rate and interest rates. They find that exchange rate exposure evidence is weak cross European countries. Chowdhurya and Wheeler (2015) investigate the effect of exchange rate shocks and fixed investment in four countries. They find the exchange rate volatility has no significant effect on fixed investment in Canada, Germany, the United Kingdom and the United Statas. Verma (2016) examines the relationship between the exchange rate volatility and the interest rate volatility with the US banks. Results indicate mean and volatility from short-term interest rates and exchange rates and long-term interest rates and exchange rates to three bank portfolios.

From the Asian countries' perspective, Haham (2004) investigates the relationship between the interest rate and the exchange rate with Korean financial institutions by using a multivariate factor model. He observes that the Korean commercial banks and merchant banking corporations had significant exposure to both risk factors in the pre-crisis period. Walid et al. (2011) examine the influence of foreign exchange on stock price volatility by using the EGARCH model for Hong Kong, Singapore, Malaysia, and Mexico, over the period 1994-2009. They provide strong evidence of the relationship between stock and foreign exchange markets. Sukcharoensin (2013) investigates the interest rate and exchange rate risk sensitivity of Thailand bank stocks. He finds that the exchange rate risk is relevant for small banks, whereas large and medium banks may have adequately hedged their foreign exchange rate exposure throughout the sample period. Zaman et al. (2013) show that there is a relationship between the interest rate and the commercial banks in Pakistan. Shahzad et al. (2014) study the impact of the volatility of exchange rate and interest rate volatility on Pakistani banks’ stock volatility by using GARCH (1,1). Their evidence shows that bank volatility is significantly related to interest rate and foreign exchange rate risk. Moussa (2014) uses multivariate GARCH modelling to describe the relationship between the systematic risk and the stock return in the banking industry in Thailand, Malaysia, Korea, Indonesia and Philippines. Verma (2016) examines the volatility of exchange rate and interest rate with the US banks. The outcomes show the response from the interest rate and exchange rate volatility to three banks portfolios.

Despite those researches in the US and other countries, there are relatively few studies on the relationship between exchange rate volatility and Australian bank stock return. In an early study, Harper and Scheit (1992) investigate the impact of the foreign exchange market on three major Australian banks – ANZ Bank, National Australia Bank, and Westpac Banking Corporation – by using monthly data. They observed that there is no direct relationship between the three banks and the foreign exchange market. Ryan and Worthington (2004) discovered the linkage between the short, medium and long-term interest rates, and a trade-weighted foreign exchange index and the Australian bank sector return. Their results show that the TWI index and long run interest rate do not appear to have any relationship with Australian stock return. Vaz et al. (2008) examine the exchange in the interest rate with Australian banks by using the GARCH approach. Their outcomes show no negative effect on Australian bank stock return after announced increases in interest rates, in comparison to banks in the US. Shamsuddin (2009) tested the relationship between the USD and interest rate. His results show that the foreign exchange market affects the small banks only.

Chi et al. (2010) explain the effect of exchange rate on four major banks in Australia. Chi et al. (2010) use the capital market approach to investigate the relationship between exchange rate risk and the Australian bank sector by using quarterly data from 1997 to 2007. They find no significant association between the Australian banks and the exchange rate. Jain et al. (2011) consider the effect of the exchange rate and interest rate on Australian bank stock return. They show strong evidence that when the Australian dollar appreciates, the bank's return is increased. Moreover, they find that interest rate has a negative impact on the Australian bank stock return.

Table 3.1 shows the studies regarding the effect of foreign exchange rate risk on the banking sector from the global financial market. The previous studies mainly reflect the experiences from the US, UK and European banks, which have different bank regulations, trading partner's countries and economic situation from those predominant in Australia. There are a few studies that investigate the Oceania countries, such as Australia. According to The Banker (2016), Australia ranks 12th in the world in terms of bank assets as rated by the Banker, Top 1000 World Banks. It is the second largest project finance market in the Asia-Pacific after India, the second largest free-floating stock market in the Asian-Pacific region, and the financial sector is the largest contributor to Australia national output, generating more than 10 per cent of Australian output. On the other side, Australia is the world's seventh largest foreign exchange market with total FX turnover averaging 192 billion dollars per day. Chi et al. (2010), Harper and Scheit (1992), Ryan and Worthington (2004), Shamsuddin (2009), and Vaz et al. (2008) consider three Australian banks' stock volatility. However, a few of the previous studies focus on the Australian banks. These include Commonwealth Bank, Macquarie Bank, National Australian Bank and Westpac Bank. Ryan and Worthington (2004) investigate the relationship between the TWI index volatility with Australian bank stock volatility. From a data-frequency perspective, Chi et al. (2010), Shamsuddin (2009), and Vaz et al. (2008) use low-frequency data, including monthly, weekly and daily data. However, this study focusses on high-frequency hourly data. The previous Australian research typically confines its use to low-frequency data over daily data. This study considers a much larger data frequency that is broader in scope than the previous papers, covering a four-year sample of higher-frequency hourly data across the big four banks in Australia. We believe the use of a very much larger data set better characterises the volatility process. The findings with high-frequency data are very important for the hedge funds, portfolio managers and high-frequency traders. It also helps them to maximise the profit and minimise the exchange rate risk in Australian bank stock. This study compares the various GARCH models to investigate the underlying volatility process without the noise contributed by these effects.

Finally, this research aims to fill the gap by investigating the relationship between the exchange rates' volatility and the four major Australian banks. The results from this study will help the high-frequency traders and Australian reserve banks to assume the effect of the volatility of Australian dollar on Australian banks' stock and help the hedge fund and portfolio managers to maximise the profit by understanding the exchange rate shocks and volatility.

Table 3. 1 Empirical evidence from the US, UK, and European bank sector

Author	Econometric Model	Data	Findings
Choi et al. (1992)	Multi-factor model and ARIMA model	Monthly data divided into two sample periods: before 1979 and after 1979	The exchange rate had a negative relationship with the bank sector before 1979, while significantly positive after 1979
Calvet et al. (1995)	GARCH (1,1) model	Monthly data for the period 1976-1991 from Canadian banking sector.	There is a relationship between the interest volatility and exchange rate volatility with a Canadian Bank
Chamberlian et al. (1997)	Multi-factor model	Daily and monthly data from 1986 to 1992 stocks by comparing both US and Japanese firms	They find US bank stock moving with foreign exchange market while Japanese's firms' relationship with the foreign exchange market are insignificant
Elyasian and Mansur (1998)	GARCH-M model	Monthly data for the period 1970 to 1992 from US bank	There is a direct relationship with the bank's sector
Tai (2000)	GARCH-M model	Weekly data ranges from 1987 to 1998 for US bank	Long-term interest rates and the foreign exchange rate are insignificant.
Beirne et al. (2009)	GARCH model	Daily data for 1986 to 2006	A significant mixed effect on stock prices
Kasman et al. (2011)	GARCH model	Daily data used from 1999 to 2009	Interest rate and volatility of exchange rate are significant bank stock return volatility
Siriopoulos (2013)	GARCH-M model	Monthly data for the period January 1989 to December 2012	The volatility of interest rates significantly affected the banking sector index stock returns.
Diirio et al. (2013)	Augmented market model	Daily from 1991 to 2004	The findings suggest that the banks are more sensitive for short

			term interest rate and have a weak relationship with exchange rate exposure.
Verma (2016)	EGARCH model	Daily data from 1997 to 2003	Results indicate mean and volatility from short-term interest rates and exchange rates and long-term interest rates and exchange rates to three bank portfolios
Haham (2004)	Multifactor model	Monthly data from 1990 to 1997.	Have significant exposure to both risk factors in the pre-crisis period
Walid et al. (2011)	EGARCH model	Quarterly data over the period 1994–2009	Significant relationship between the volatility of exchange rate with stock price
Sukcharoensin (2013)	GARCH-M model	Daily banks stock return from 2005 to 2012	Significantly relationship
Shahzad et al. (2014)	GARCH (1.1)	Daily data for a period 2005 to 2012	Bank volatility is significantly related to interest rate and foreign exchange rate risk

Table 3. 2 Empirical Evidence from the Australian Bank Sector

Author	Econometric Model	Data	Findings
Harper and Scheit (1992)	CAPM, market model	Monthly data from 1974 to 1989	There is no relationship between the three banks with foreign exchange market
Ryan and Worthington (2004)	GARCH-M approach	Daily data from 1996 to 2001	TWI index and long run interest rate do not appear any relationship with Australian stock return.
Vaz et al. (2008)	GARCH approach	Weekly data applied for this research from 1990 to 2005	No negative effect on Australian bank stock
Shamsuddin (2009)	GARCH-M model	Weekly data from 1994 to 2007	The foreign exchange market affects the small banks only
Chi et al. (2010)	Capital market approach	Quarterly data from 1997 to 2007	Find there is no significant relationship between the exchange rate with Australian banks stock and interest rate level
Jain et al. (2011)	EGARCH Model	Monthly data from 1992 to 2007	A positive relationship between the Australian bank sector and the exchange rate, while negative with interest rate level

3.3 Overview of Australian banking industry

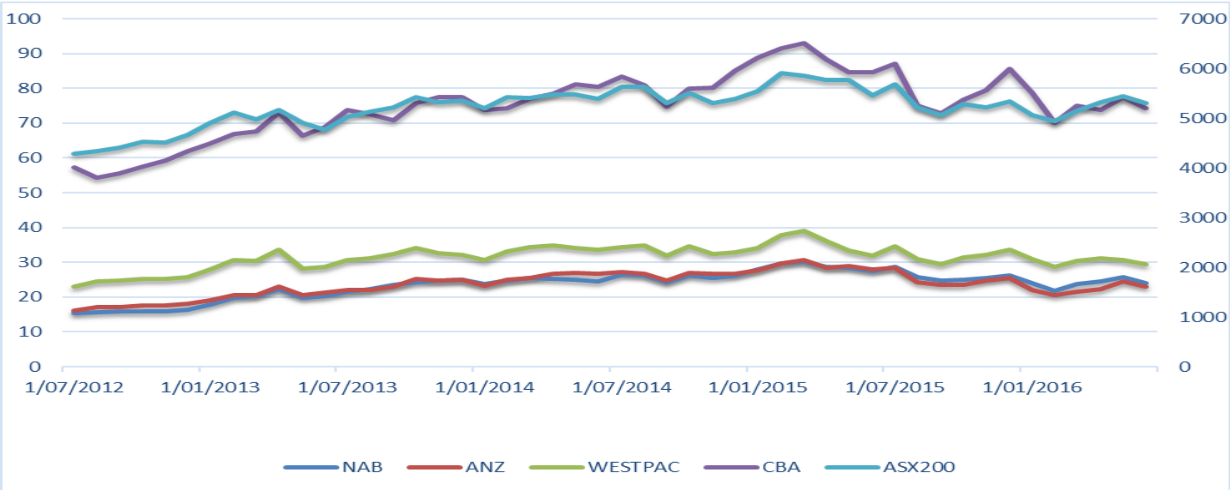
The Australian commercial banking industry began operating in 1817 under the banner of the 'Bank of New South Wales', with the first savings bank being opened in 1819 under the banner 'New South Wales Savings Bank'. In the mid-1830s, many English banks, such as the Bank of Australasia and the Union Bank of Australia, opened up for operations in Australia (Marwick, 1985). The English banks brought a huge amount of capital which helped establish the foreign exchange market and encouraged interest rate competition, thus laying the foundations for modern-day banking.

In the 1850s, the discovery of gold in Victoria led to Australian banks trading gold directly, as gold trading was very profitable at this time. From 1850 to 1890, many new banks started operating in Australia. However, in the 1890s the Australian banking industry faced a major crisis as a result of the real estate crash (Marwick, 1985). Many banks went bankrupt as they incurred huge losses by speculating on land prices and thus closed down. This called for more stringent supervision (Marwick, 1985) and from the start of the nineteenth century until the early 1980s, the banks were highly regulated by the Australian government. By the 1960s, the banks had been allowed to venture into more diversified activities, such as credit cards, travel services, etc. This allowed banks to earn more income and in 1982, through the Campbell Report, the banking industry was further deregulated. The Campbell committee also approved selected foreign banks to operate in Australia.

In short, over the past few decades, according to The Banker (2016), Australia ranks 12th in the world in terms of bank assets as rated by the Banker, Top 1000 World Banks. It is second the largest finance market in the Asia-Pacific after India and the second largest free-floating stock market in the Asia-Pacific region. The Australian financial sector is the largest contributor to Australian national output, generating more than 10 per cent of Australian output. In addition, the Australian interest rate derivatives market is the largest in Asia and among the biggest in the world. Specifically, the four banks are the four largest listed companies in Australia. According to ASIC (2016), the financial sector amounts to around half of the Australian stock market capitalisation. The vast majority of the sector is comprised of banks and "diversified" banks. The remainder is insurance and real estate

Figure 3.1 displays the four major banks' value in Australia from 2012-2016. The Commonwealth Bank (CBA) is run over 95% from the middle of 2012 to 2016, peaking at $96.17 on March 2015. The stock has since fallen 30% and returned to an average of $75. Westpac Banking Corporation's (WBC) run from under $20 in May 2012 to March 2016 was no coincidence, because of cutting of the interest rate in Australia. National Australia Bank Limited (NAB) is ran over 75% from March 2012 to March 2015, peaking at 37.15 on March 2016. In summary, the CBA shows the bigger movements from 2012 to 2016, while the other three banks are relatively stable.

Figure 3. 1 Major Banks' Performances and ASX 200 Performances from 2012 to 2016



3.4 Models specification

This section describes four models applied to investigate the effect of the Australian dollar volatility on the big four banks in Australia. The GARCH methodology involves modelling variance in the error terms of the mean equation. In this research, the mean equation takes the Australian banking share price, the Australian stock market index (ASX 200), the Australian dollar against US dollar, and T-bills and autoregressive of the big four Australian banking share prices. The mean equation has the following form:

$$r_{i,t} = c + \delta_1 r_{m,t} + \delta_2 r_{usd} + \delta_3 r_{tbills} + \delta_4 r_{i-1} + \varepsilon_{it} \qquad (3.1)$$

Where $r_{i,}$ is the Australian banking shares prices, r_{usd} is the Australian dollar against the US dollar , r_{tbills} is short term Australian interest rate, and ε_{it} is error term in the mean equation at time t.

In this research, we apply four models: GARCH (1,1), TARCH, EGARCH and PARCH. The purpose of this study is to compare the hourly conditional variance forecasting of four GARCH-family models. This study investigates which one is the better to use for prediction of future volatility for Australian banks' stock. We consider the same mean equation for the four models, however, the specification of conditional variance will be according to the model structure.

3.4.1 GARCH (1,1)

This model structure was provided by Bollerslev (1986) and allows the researcher to estimate conditional volatility by modelling the stock return and exchange rate together, by Joseph and Vezos (2006) Adjasi (2009), Tai (2010), and Brooks et al. (2010). The model becomes:

$$h_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}^2 + \rho\sigma_{fx,t}^2 + \varepsilon_{t-1}^2 \qquad (3.2)$$

Where h_t^2 is a variance of the residual derived from equation 3.2, it is also known as current hourly variance or volatility of the four banks' share price. h_{t-1}^2 is the previous day's residual variance, known as the GARCH term, ε_{t-1}^2 is the previous period's squared residual derived from equation (3.1), known as the ARCH term.

3.4.2 Threshold ARCH model (TARCH)

The TARCH model introduced by Glosten et al. (1993) and Zakoian (1994) is used to examine this asymmetric news impact. This is described as the leverage effect. The TARCH model adds one variable to the variance equation, called the multiplicative dummy variable. The main objective of this model is to find whether negative news has more impact on the volatility of return than positive news, or the negative return of our variables has more impact on the volatility of return than positive returns. The basic GARCH model equation is comprehensive to include a threshold term $\gamma\varepsilon_{t-1}^2 d_{t-1}$. The conditional variance of the TARCH model is given by:

$$h_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}^2 + \gamma\varepsilon_{t-1}^2 d_{t-1} + \varepsilon_{t-1}^2 \qquad (3.3)$$

Where here, h_t^2 is a variance of the residual derived from equation 3.2, it is also known as current hourly variance or volatility of the four banks' share price, βh_{t-1}^2 is the previous day's residual variance, known as the GARCH term, $\alpha\varepsilon_{t-1}^2$ is the previous period's squared residual derived from equation (3.2), known as the ARCH term. $\gamma\varepsilon_{t-1}^2 d_{t-1}$ captures the asymmetry effect of banks' price volatility. If γ is zero, the asymmetry effect of lagged volatility shock is present. If $\gamma > 0$, a negative shock augment more than lagged positive shock, which means, the good news can have more impact on the conditional variance than the bad news. If $\gamma < 0$, a positive shock augment more than lagged negative shock, which means the bad news can have more impact on the conditional variance than the good news, or the positive shocks of Australian bank return increase the volatility by more than the negative shocks.

3.4.3 Exponential GARCH (EGARCH)

The Exponential GARCH (EGARCH) by Nelson (1991) is a simple extension of GARCH that considers the logarithm of conditional variance. EGARCH is used to test for the leverage effect. According to Francq et al. (2010), EGARCH is a model that is used to examine the volatility of the stock return. The model takes the following form:

$$\ln(h_t^2) = \omega + \alpha\left[\left|\frac{\varepsilon_{t-1}}{h_{t-1}^2}\right|\right]\varepsilon_{t-1}^2 + \gamma\frac{\varepsilon_{t-1}}{h_{t-1}^2} + \beta\ln(h_{t-1}^2) + \varepsilon_{t-1}^2 \qquad (3.4)$$

The explanation of parameters α , β and γ is like those of the TARCH model. When γ is less than zero, it means that the negative shocks have higher implication than the positive shocks for raising the volatility and vice versa. In other words, the higher leverage occurs due to negative return which is translated to low equity prices meaning a higher debt to equity ratio, which means the higher the leverage effect, the greater the risk or volatility of firms.

According to Narayan and Narayan (2007), the advantage of the EGARCH model is that there is no restriction on the parameters to be positive. Therefore, we expect the negative sign in the coefficient of γ .

3.4.4 Power ARCH (PARCH)

The PARCH specification allows for modelling the conditional standard deviation rather than the conditional variance. The model could be written as follows (Ding et al., 1993):

$$h_t^{\delta} = \omega + \sum_{i=1}^{p} \alpha_i \left(\left| \varepsilon_{t-1} \right| - \gamma_i \varepsilon_{t-i} \right)^{\delta} + \sum_{j=1}^{q} \beta_j h_{t-j}^{\delta} + \varepsilon_{t-1}^{2} \qquad (3.5)$$

Where, δ is the power parameter of the standard deviation and γ parameters capture the asymmetry up to order τ.

3.5 The data and the descriptive statistics

3.5.1 The data

The availability of high-frequency data has a beneficial effect on financial market research in many areas. First, high-frequency data (HFD) provides more information about the daytime transactions and can significantly expand the accuracy in forecasting of volatility. And, more and more studies begin to use high-frequency data, not only as a volatility measure but directly in model estimation and forecasting (Anderson et al. 1998).

Second, high-frequency data analysis provides the understanding of asset prices and financial market behaviour, particularly at times around information arrival during trading hours. It also better examines information announcement impact to be isolated from the impact of other factors that might otherwise contaminate the analysis (Dacorogna et al., 2001). Therefore, the high-frequency data will be able to capture the rapid movements of the prices during the day (Andersen et al., 2001, Brownlees & Gallo, 2006, O'Hara, 1996). For institutional investors, for instance, knowing the prices rapid movement during the day is important to make quick investment decisions. Knowing the price rapid movements prices is important for regulators of the market to detect irregularities or behaviours or manipulation in the market (Aggarwal & Wu, 2006; Öğüt et al., 2009).

Third, HFD can greatly increase the forecast accuracy as it basically provides beneficial information about future market volatility and provides the investors with a good understanding of volatility movements and the market behaviour. For instance, high-frequency data have enabled a news announcement analysis and the effect of news announcements on the financial market volatility. High-frequency data realised measures can help and improve the complex volatility models' estimation, such as continuous time volatility models. The subsequent reduction in the parameter uncertainty will expand predictions based on such models.

Table 3.3 shows the raw dataset including the big four Australian banks' price, which is the most liquid and the most well-known banks in Australia, short-term interest rate, and the Australian dollar giants the US dollar. All datasets are from 10:00 am on 3 September 2012 to 4:00 pm on 30 September without covering the observation on Saturday and Sunday, as well as some major holidays in Australia. High frequency data is used, specifically, hour by hour data for all trades. The bank raw data is provided by Adest Ltd. Adest Ltd is a database that provides the stock tick price, adjusted price and trading volume, while the hourly exchange rate raw dataset is extracted from FXDD[3] brokerage firm based in New York, USA.

[3] FX Direct Dealer, LLC is a provider of foreign exchange trading for retail and institutional clients.

The raw data from Adest Ltd and FXDD database are filtered to segregate the stock closing price, adjusted price, and the short-term interest rate. All trades that are not correct or cancelled by ASC are excluded. Then, trades with zero volume are filtered out. Trades are filtered out if zero return or both the second-hours closing price is equal to first-hours closing price. All the trades out of 10:00 am and 4:00 pm are not very dynamic; then, trades before 10:00 am and trades after 4:00 pm are discarded. Moreover, trading days with less than 6 consecutive trading hours, such as the day before Christmas Day and New Years' Day are replaced to previous tick. Furthermore, whenever there is no observed price attached to a specific time, the "previous tick" method is used to replace the missing price. According to Boehmer et al. (2009), there are some unusual and irregular values in the raw dataset. For instance, the return may have values near thousands of per cent. So irregular values are filtered out after the measures are calculated; this is consistent with the literature (Boehmer et al. 2009). If the return is less or more than [-0.03, 0.03] range are discarded which is the normal practice. After this process, Figure 3.4 shows the dataset is within the reasonable range. The four banks are Commonwealth Bank (CBA), Westpac (WBC), National Australia Bank (NAB) and Australia and New Zealand Banking Group (ANZ). The return of a stock is calculated as log first difference of stock price. Three factors are market risk measured as the log first difference of ASX200 index, an interest rate risk measured as the log first difference of two-year treasury bills, and the exchange rate risk measured as the log first difference of Australian dollar against the US dollar. The equation is as follows:

$$\mathrm{SR_i} = \ln\left(\frac{P_t}{P_{t-1}}\right) \tag{3.6}$$

Table 3. 3 Number of observations and number of trading days

The table reports the details of the number of trading days for each year, and the numbers of observations for each variable.

	2012-2013		2013-2014		2014-2015		2015-2016	
	Trading days	No. observations	Trading days	No. observations	Trading days	No. observations	Trading days	No. observations
AUD/USD	250 days	1500	249 days	1494	251 days	1506	251 days	1506
ASX200	250 days	1500	249 days	1494	251 days	1506	251 days	1506
CBA	250 days	1500	249 days	1494	251 days	1506	251 days	1506
Westpac	250 days	1500	249 days	1494	251 days	1506	251 days	1506
NAB	250 days	1500	249 days	1494	251 days	1506	251 days	1506
ANZ	250 days	1500	249 days	1494	251 days	1506	251 days	1506

Table 3. 4 Summary of irregular returns for each variable

Table 3.4 reported the number of unusual returns such as more than .03 returns or less than -.03 returns.

Variable	Less than -.03 Return	More than .03 Return
USD	0	0
ASX 200	0	0
CBA	1	0
WBC	5	1
ANZ	3	1
NAB	6	1
T-Bills	0	0
Total	15	3

3.5.2 The descriptive statistics

Table 3.5 shows descriptive statistics for the big four Australian banks' returns and foreign exchange rate data of the US dollar for the period of September 2012 to September 2016. For the overall sample period, most of the variables return series have a positive hourly mean return, except USD has a negative mean (-4.88E-05). Based on the standard deviation, the T-bills have lower standard deviation than other series. The average returns of all variables are smaller than their standard deviation. For skewness, most of the variables return series are less than zero, it is negatively skewed (a nonsymmetric distribution), which for investors can mean a greater chance of extremely negative outcomes.

Based on kurtosis, the value of the variables return series is greater than 3.0 for the big four Australian banks' returns and Australian dollar. This means a typical leptokurtic distribution (meaning fatter tails and lesser risk of extreme outcomes). As part of the measurements of skewness and kurtosis, statistics also reject the null hypothesis of normality in the distribution of the sample return series. These data are non-normal distributions confirmed by the skewness, kurtosis, and the Jarque-Bera statistics.

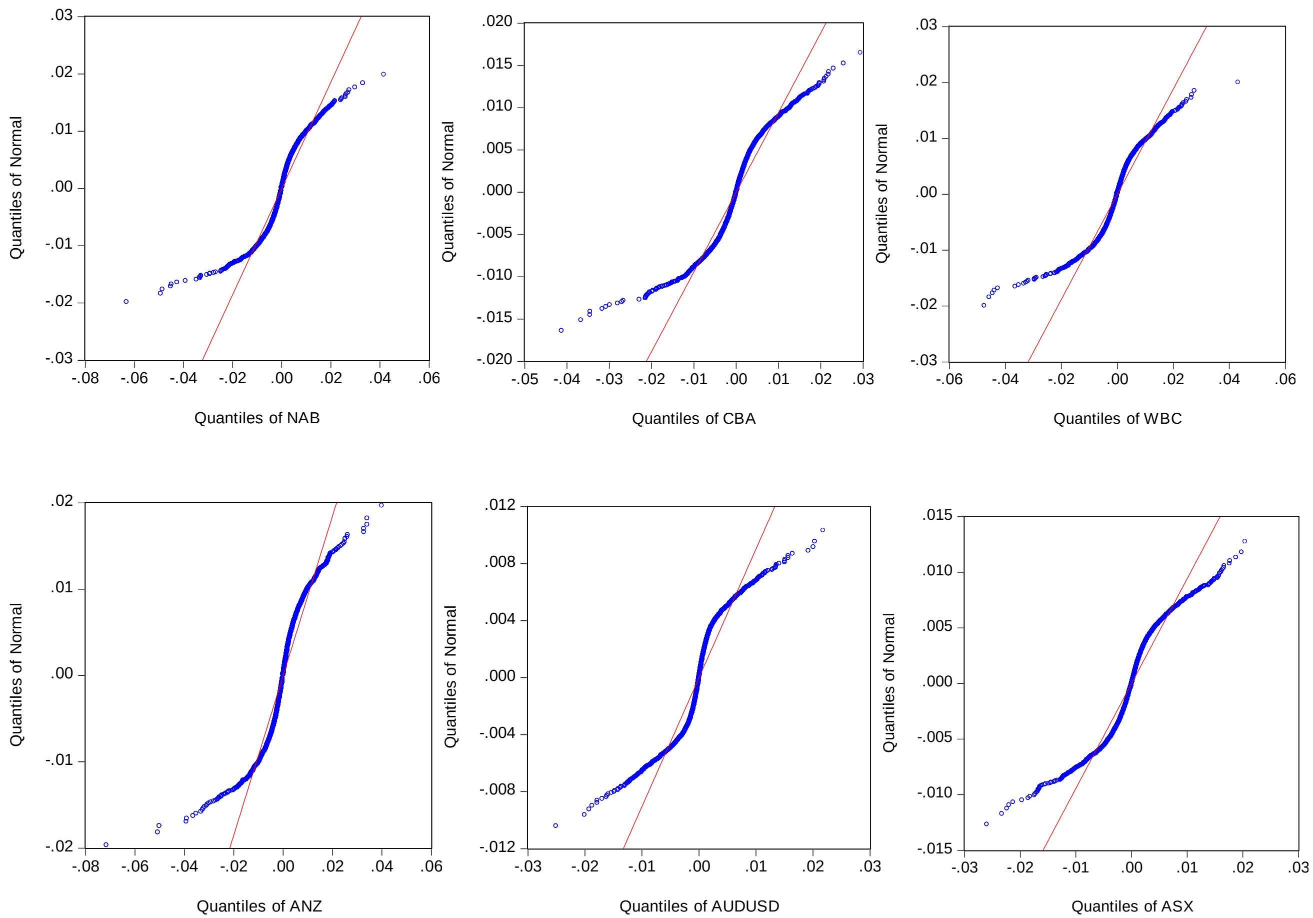
We use a QQ plot test to help us assess if a set data plausibly came from some theoretical distribution, such as a normal or exponential. Also, the QQ test allows us to see at-a-glance if our assumption is plausible, and if not, how the assumption is violated and what data points contribute to the violation. Based on figure 3.2, the return series of six variables are not normally distributed. Based on skewness, kurtosis and the QQ test, the previous findings show that the ARCH and GARCH family is appropriate in this research.

Table 3. 5 The descriptive statistics of hourly big four banks returns, exchange rate

	ANZ	CBA	NAB	WBC	ASX	AUD	T-bills
Mean	1.47E-05	4.61E-05	1.42E-05	2.96E-05	3.89E-05	-4.88E-05	1.86E-06
Median	0.0000	0.0001	0.0000	0.0000	7.61E-05	1.12E-05	0.0000
Maximum	0.0400	0.0294	0.0416	0.0431	0.0204	0.0218	0.0019
Minimum	-0.0715	-0.0412	-0.0631	-0.0474	-0.0259	-0.0250	-0.0022
Std. Dev.	0.0052	0.0043	0.0052	0.0053	0.0033	0.0027	0.0002
Skewness	-0.9981	-0.5787	-0.9997	-0.6883	-0.1926	-0.3639	-0.1942
Kurtosis	19.393	12.289	17.174	12.741	10.171	14.143	14.110
Jarque-Bera	68782.73	22103.79	51678.88	24409.64	13007.64	31452.72	31172.23
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sum	0.0887	0.2791	0.0857	0.1794	0.2357	-0.2956	0.0112
Sum Sq. Dev.	0.1650	0.1151	0.1681	0.1702	0.0689	0.0458	0.0003
Observations	6053	6053	6053	6053	6053	6053	6053

The table reports summary statistics of the return of four banks and exchange rate return: Australia and New Zealand Banking Group (ANZ), Commonwealth Bank (CBA), National Australia Bank (NAB Westpac (WBC) and foreign exchange rate located to USD

Figure 3. 2 QQ plot of six variables returns for hourly data from 2012-2016



3.5.3 The unit roots

Unit root tests are conducted to determine if the series are non-stationary in the levels or if they are stationary in the first differences. The evidence of non-stationary implies a stochastic trend, meaning they do not revert to long-run or average value. If a series has a unit root, the shocks have permanent effect, and this is an important consideration in modelling volatility. In this case, we measure the unit roots of the Australian market index (ASX) and big four banks in Australia: Commonwealth Bank (CBA), Westpac Bank (WBC), National Australia Bank (NAB), and Australia and New Zealand Banking Group (ANZ).

The ADF, PP and KPSS test were developed by Dicky-Fuller (1979), Nelson and Plosser (1982) and Philips and Perron (1988). In statistics, unit roots tests show whether the time serious variables are non-stationary and possess unit roots. Generally, the null hypothesis is defending as the presence of a unit root and alternative hypothesis is either stationary or trend stationary.

Table 3.6 shows the unit roots test for the big four banks in Australia, Australian dollar against the US dollar and the Australian T-bills at level or at the first difference. The ADF and PP tests outcomes show the null hypothesis is rejected for the first different at 1% significance level, which means that the variables are stationary. Regarding the KPSS test, the results show that we accept the null hypothesis for all variables. This means that all the variables are stationary.

Table 3. 6 The unit roots analysis of the big four banks and Australian dollar

	ADF		PP		KPSS	
	C	C&T	C	C&T	C	C&T
Ln AUDUSD	-1.0895	-1.9871	-1.0505	-1.7923	9.4586***	0.5504***
ΔLnAUDUSD	-77.985***	-77.981***	-78.284***	-78.282***	0.1036	0.0813
LnASX200	-2.7830	-2.6886	-2.8168	-2.7450	3.7108***	1.6539***
ΔLn ASX200	-78.167***	-78.168***	-78.186***	-78.189***	0.1240	0.0353
Ln CBA	-2.5764	-1.9552	-2.6060	-2.0510	4.8819***	1.8680***
ΔLn CBA	-77.638***	-77.664***	-77.727***	-77.742***	0.2779	0.0192
Ln NAB	-1.7927	-1.8504	-1.8860	-1.9376	2.0089***	1.9917***
ΔLn NAB	-81.120***	-81.140***	-81.059***	-81.075***	0.2508	0.0339
Ln WBC	-2.6368	-2.3640	-2.6747	-2.4124	2.6290***	1.7716***
ΔLn WBC	-79.831***	-79.844***	-79.817***	-79.828***	0.1733	0.0185
Ln ANZ	-1.7739		-1.9011	-1.8409	-1.9599	2.2605***
ΔLn ANZ	-79.394***	-79.403***	-79.450***	-79.452***	0.1905	0.0449
Ln INT	-0.6504	-2.3246	-0.6597	-2.3312	6.1809***	1.4524***
ΔLn INT	-77.936***	-77.958***	-77.936***	-77.959***	0.2584	0.0430

This table presents three measures of unit root tests for hourly data of the market (ASX), Australian dollar, and the big four banks in Australia: Commonwealth Bank (CBA), Westpac Bank (WBC), National Australia Bank (NAB), and Australia and New Zealand Banking Group (ANZ). The tests are considered both at level and at first difference level. The null hypothesis of ADF and PP test is that the series have a unit root, while the null hypothesis of the KPSS test is that the series is stationary. The series of the first difference is reported by Δ. Also, two specifications with intercept (C) and intercept and trend (C&T) are considered. Here ***, **, * represent significance at the 1%, 5%, and 10 % levels respectively.

3.6 Empirical Results

In this study, the GARCH (1,1), EGARCH (1,1), TGRARH (1,1), and PARCH (1,1) models are used to test the relationship between the big four banks' volatility of return in Australia and the Australian dollar's return volatility by using intraday data for the period from September 2012 to September 2016, presented in Tables 3.7, 3.8, 3.9 and 3.10 respectively.

Table 3. 7 Estimation outcomes of different GARCH models for Commonwealth Bank (CBA)

	GARCH (1,1)		TARCH(1,1)		EGARCH(1,1)		PARCH(1,1)	
	Coeff	**P-Val**	**Coeff.**	**P-Val**	**Coeff.**	**P-Val**	**Coeff.**	**P-Val**
Mean								
ω	0.0001	0.0177	0.0001	0.0286	7.56E-5	0.1121	6.6E-05	0.1512
δ_1	0.0399	0.0192	0.0401	0.0187	0.0360	0.0307	0.0337	0.0390
δ_2	0.0607	0.0000	0.0600	0.0000	0.0656	0.0000	0.07127	0.0000
δ_3	-1.5000	0.0000	-1.4677	0.0000	-1.5491	0.0000	-1.5809	0.0000
δ_4	-0.0470	0.0137	-0.0440	0.0130	-0.0475	0.0060	-0.0475	0.0050
Variance								
ω	3.11E-8	0.000	3.5608	0.0000	0.0597	0.0000	2.5E-05	0.0095
α	0.01628	0.000	0.0128	0.0000	0.0452	0.0000	0.0235	0.0000
β	0.98261	0.000	0.0068	0.0000	-0.0203	0.0000	0.4910	0.0000
γ			0.9821	0.0000	0.99732	0.0000	0.9820	0.0000
δ							0.8357	0.0000
AIC	-8.1755		-8.1761		-8.1900		-8.1904	
SBC	-8.1678		-8.1672		-8.1811		-8.1804	
ARCH TEST	0.1058		0.0950		0.0739		0.0756	
Log likelihood	24755.12		24757.48		24799.6		24801.8	
DW-stat	2.0578		2.0580		2.0543		2.0523	
R-squared	0.00938		0.0094		0.0094		0.0092	

GARCH, TGARCH, EGARCH, PARCH models are estimated by equations (3.1), (3.2), (3.3), (3.4), and (3.5) respectively for Australian dollar and Commonwealth Bank (CBA) ARACH is the non-heteroskedasticity statistics.

Outcomes of Commonwealth Bank (CBA) return volatility for the full sample are provided in Table 3.7. The mean equation of the four models shows that there is a positively significant relationship between the CBA price return with USD return and the Australian market index at the 1% confidence level, while it is negative significantly with the short-term interest rate at the 1% confidence level. It means that an increase in the short-term interest rate level of one point would decrease the CBA share price by only 1.5 percentage points.

According to the variance equation, the ARCH term and the GARCH term are statistically significant for the GARCH (1, 1) model. The sum of these coefficients is 0.998, which specifies that shocks to fickleness have a permanent effect. In the TARCH model, the coefficient of ARCH and GARCH are statistically significant, similar to the GARCH (1.1). This means that the lagged residual and lagged conditional variances are significant in describing conditional volatility. The coefficient of β is positive and significant. This means that there is a leverage effect, which means the negative return on CBA has more impact on the volatility of return than positive return. Regarding the EGARCH model, the coefficient of β is negative and significant. This means that the negative correlation between the past return and future volatility of return or positive shock has less effect on the conditional variance compared to a negative shock.

The ARCH parameter (α), and GARCH parameter (β) in the PARCH model are positive and significant, and the power coefficient δ of the standard deviation process in the PARCH model is significantly different from unity, indicating it is more appropriate to model the conditional standard deviation of foreign exchange markets in a non-linear form.

Based on the Durbin-Watson statistic, the null hypothesis is that the residuals from an ordinary least-squares regression are not autocorrelated against the alternative that the residuals are autocorrelated. The Durbin-Watson statistic is more than 2, meaning that there is no autocorrelation in the sample for our models. Comparing the four models, based on AIS and SBC, indicates that the GARCH (1,1) model is the best model. For the ARCH-LM test, it is not significant for four models, indicating that heteroskedasticity has been accounted for by all four models; the ARCH test suggests that the GARCH (1,1) may be taking better account for the ARCH effect. Based on log likelihood ratio asymmetric, GARCH models are mostly preferred. The PARCH model is preferred in most cases followed by the EGARCH models.

Table 3. 8 Estimation outcomes of different GARCH models for Westpac (WBC)

	GARCH (1,1)		TARCH(1,1)		EGARCH(1,1)		PARCH(1,1)	
	Coeff.	**P-Val**	**Coeff.**	**P-Val**	**Coef**	**P-Val**	**Coef**	**P-Val**
Mean								
ω	7.1E-05	0.2698	7.8E-05	0.2745	3.8E-05	0.5695	2.1E-05	0.5620
δ_1	0.1289	0.0000	0.1282	0.0000	0.1139	0.0000	0.1426	0.0000
δ_2	0.0892	0.0000	0.0888	0.0000	0.1082	0.0000	0.0837	0.0000
δ_3	-2.7744	0.0000	-2.7837	0.0000	-2.5547	0.0000	-2.6617	0.0000
δ_4	-0.0858	0.0000	-0.0854	0.0000	-0.0843	0.0000	-0.0739	0.0000
Variance								
ω	4.3E-08	0.0000	4.7E-08	0.0000	-10.3951	0.0000	0.0001	0.0114
α	0.0081	0.0000	0.0076	0.0000	0.0853	0.0000	0.0153	0.0000
β	0.9903	0.0000	0.0011	0.2081	-0.0448	0.0000	0.6937	0.0000
γ			0.9901	0.0000	0.0154	0.9110	0.9875	0.0000
δ							0.459	0.0000
AIC	-7.7377		-7.7375		-7.6618		-7.7596	
SBC	-7.7289		-7.7275		-7.6518		-7.7485	
ARCH TEST	0.6453		0.6337		0.7075		0.6233	
DW-Stat	2.0838		2.0927		2.0845		2.105	
Log likelihood	23426.43		23426.61		23197.52		23494.46	
R-squared	0.0195		0.0195		0.0197		0.018	

GARCH, TGARCH, EGARCH, PARCH models are estimated by equations (3.1), (3.2), (3.3), (3.4), and (3.5) respectively for Australian dollar and Westpac (WBC). ARACH is the non-heteroskedasticity statistics.

Based on Table 3.8, the Westpac (WBC) results show that USD return and the market are strongly positively significant with WBC returns in the four GARCH models, while the short interest rates return is negatively significant with Westpac return at the 1% significance level. In terms of the variance equation, the ARCH term and the GARCH term are statistically significant for the GARCH (1.1) model. The sum of these coefficients is 0.998, which specifies that shocks to fickleness have a permanent effect. Based on the TARCH model, the coefficient of the GARCH term is not statistically significant. This means that the lagged conditional variances and lagged residual are not significant in describing conditional volatility. Regarding the EGARCH model, the coefficient of β is negatively significant at the 1% significance level. The positive shock has less effect on the conditional variance compared to a negative shock.

Both the ARCH parameter (α), and the GARCH parameter (β) are positively significant in the PARCH model and the power coefficient of the standard deviation process in the PARCH model is significantly different from unity. Based on the Durbin-Watson statistic, the null hypothesis is that the residuals from an ordinary least-squares regression are not autocorrelated against the alternative, that the residuals are autocorrelated. The Durbin-Watson statistic is more than 2, meaning that there is no autocorrelation in the sample for our models. Comparing the four models, based on AIS and SBC, the EGARCH (1,1) model is the best model. The ARCH-LM test is not significant for four models, indicating that heteroskedasticity has been accounted for by all four models. The ARCH test suggests that the EGARCH (1,1) may be taking better account for the ARCH effect. Based on log likelihood ratio, PARCH is the best model in regard to log likelihood ratio.

Table 3.9 shows that the market risk and currency risk are significantly positive at the 1% level for TARCH and EGARCH and PARCH models, suggesting that when the market index and exchange rate increase by one point, this would increase the NAB return by one percentage. In terms of the short-term interest rate, it is negatively significant at the 1% confidence level for four models. The negative interest rate exposure suggests that Australian banks suffer from increasing the interest rate. Regarding the variance equation, consider the estimated parameter for conditional variance. The elements in the vectors α and β are significant at the 1% level. The β coefficient is negative in both TARCH and EGARCH, suggesting that positive shocks have a higher impact on the net period of conditional volatility of National Australia Bank (NAB) returns than negative shocks. Based on the Durbin-Watson statistic, the null hypothesis is that the residuals from an ordinary least-squares regression are not autocorrelated against the alternative that the residuals are autocorrelated. The Durbin-Watson statistic is more than 2, meaning that there is no autocorrelation in the sample for our models. In terms of PARCH, both the ARCH parameter (α), and the GARCH parameter (β) are positively significant in the PARCH model and the power coefficient δ of the standard deviation process in the PARCH model is significant at the 1% level. Comparing by Akaike Information (AIC) and Schwartz Bayesian Criteria (SBC) favours the EGARCH model over the other three models. The ARCH-LM test is significant for all the models except the GARCH (1,1) model, indicating that the PARCH model may be taking better account of the ARCH effects.

Table 3. 9 Estimation results of different GARCH models for National Australia Bank (NAB)

	GARCH (1,1)		TARCH (1,1)		EGARCH (1,1)		PARCH (1,1)	
	Coeff.	**P-Val**	**Coeff.**	**P-Val**	**Coef**	**P-Val**	**Coef**	**P-Val**
Mean								
ω	3.7E-05	0.5469	8.9E-05	0.1625	8.2E-06	0.9025	6.47E-0	0.8815
δ_1	0.0188	0.3483	0.0823	0.0037	0.0581	0.0355	0.1427	0.0000
δ_2	0.0434	0.0102	0.0706	0.0000	0.1277	0.0000	0.1045	0.0000
δ_3	-2.9930	0.0000	-2.5786	0.0000	-2.4935	0.0000	-2.0744	0.0000
δ_4	-0.1001	0.0000	-0.0396	0.0000	-0.1085	0.0000	-0.0935	0.0000
Variance								
ω	5.1E-05	0.0000	7.7E-08	0.0000	-10.3338	0.0000	0.0003	0.0004
α	0.0015	0.0000	0.0175	0.0000	0.2037	0.0000	0.0232	0.0000
β	0.9970	0.0000	-0.0069	0.0000	-0.0394	0.0001	0.5902	0.0000
γ			0.9840	0.0000	0.0296	0.6226	0.9797	0.0000
δ							0.5107	0.0000
AIC	-7.7586		-7.7726		-7.6767		-7.8064	
SBC	-7.7498		-7.7626		-7.6667		-7.7955	
ARCH TEST	0.0059		0.5058		0.3111		0.6643	
DW-Stat	2.0961		2.1281		2.1250		2.1452	
Log likelihood	23541.12		23532.89		23242.7		23636.37	
R-squared	0.0154		0.01981		0.0190		0.0192	

GARCH, TGARCH, EGARCH, PARCH models are estimated by equations (3.1), (3.2), (3.3), (3.4), and (3.5) respectively for Australian dollar and NAB. ARACH is the non-heteroskedasticity statistics.

Table 3.10 reports the relationship between the exchange rate return, market risk, and interest rate risk with Australia and New Zealand Banking Group (ANZ) returns for the overall period September 2012 to September 2016.

The exchange rate and market risk variables are positively correlated with the Australia and New Zealand Banking Group return, although significantly. The short interest rate returns are negatively significant with the change in Australia and New Zealand Banking Group for the four GARCH models. The negative sign indicates that when Australian interest rates increase, the Australia and New Zealand Banking Group return (the value of Australia and New Zealand Banking Group stock price decreases). The variance equation shows that the sum of α and β value is equal to or greater than 1 in the GARCH (1,1) and EGARCH (1,1) models (summing to 1 and 1.01, respectively) indicating that ARCH process. The, β and γ values for the TARCH (1,1) is less than 1. The α, β and γ values are insignificant suggesting that the presence of ARCH and GARCH has no effect on the returns.

Based on the Durbin-Watson statistic, the null hypothesis is that the residuals from an ordinary least-squares regression are not autocorrelated against the alternative that the residuals are autocorrelated. The Durbin-Watson statistic is more than 2, meaning that there is no autocorrelation in the sample for our models. Based on AIS and SBC, the TARCH model is slightly preferred. For the ARCH-LM test, the P-value for the ARCH-LM test statistic is markedly larger for TARCH model than other models.

Table 3. 10 Estimation results of different GARCH models for Australia and New Zealand Banking Group (ANZ)

	GARCH (1,1)		TARCH (1,1)		EGARCH (1,1)		PARCH (1,1)	
	Coeff.	**P-Val**	**Coeff.**	**P-Val**	**Coef**	**P-Val**	**Coef**	**P-Val**
Mean								
ω	5.7E-05	0.3860	1.4E-06	0.9852	4.3E-05	0.4718	2.1E-05	0.7530
δ_1	0.1037	0.0001	0.0513	0.0722	0.1047	0.0001	0.0440	0.0835
δ_2	0.0795	0.0000	0.0968	0.0000	0.0704	0.0002	0.0854	0.0000
δ_3	-2.3890	0.0000	-2.6397	0.0000	-2.3227	0.0000	-2.6731	0.0000
δ_4	-0.0703	0.0002	-0.0419	0.0181	-0.0702	0.0001	-0.0304	0.0603
Variance								
ω	2.3E-08	0.0000	1.8E-05	0.0001	-0.0240	0.0000	2.1E-05	0.5154
α	0.0061	0.0000	-0.0191	0.0000	0.0208	0.0000	-0.0089	0.1826
β	0.9931	0.0000	0.01583	0.0052	-0.0062	0.0000	-0.4999	0.2430
γ			0.4131	0.0060	0.9989	0.0000	0.3703	0.0186
δ							1.9266	0.0000
AIC	-7.7975		-7.6815		-7.8095		-7.6883	
SBC	-7.7886		-7.6714		-7.7995		-7.6772	
ARCH TEST	0.5266		0.6052		0.5366		0.7810	
DW-Stat	2.0672		2.0877		2.0712		2.0676	
Log likelihood	23607.21		23257.3		23644.52		23278.66	
R-squared	0.0175		0.0177		0.0174		0.0176	

GARCH, TGARCH, EGARCH, PARCH models are estimated by equations (3.1), (3.2), (3.3), (3.4), and (3.5) respectively for Australian dollar and Australia and New Zealand Banking Group (ANZ). ARACH is the non-heteroskedasticity statistic.

3.6 Conclusion

This chapter estimates the volatility of the Australian dollar and the big four banks in Australia. The main objectives of this study are to examine the relationship between the volatility of the big four banks in Australia with the Australian dollar volatility and to investigate the efficacy of the four different GARCH methodologies in relating the underlying intraday return volatility on the banking sector. Four GARCH methodologies, GARCH (1,1), Threshold ARCH (TARCH), Exponential GARCH (EGARCH) and Power-ARCH (PARCH) models are applied to hourly volatility returns for the period 3 September 2012 to 3 September 2016. This research finding is important for investors and relevant market participants to understand how the long shock persists in the volatility of the big four banks in Australia. This will help the market participant to build the right risk management strategies, and the shocks findings are important for generating volatility by helping the market participant to determine the direction of shocks (positive or negative).

The findings show that a positive significant Australian dollar effect on the big four banks in Australia in the four models and the short-term interest rate volatility negatively affect the big four banks volatility. The outcomes show that significant ARCH term and GARCH term impacts are present in the data and that the PARCH model used to the standard error defines the volatility process better than the other three models for Commonwealth Bank (CBA), Westpac and National Australia Bank (NAB). In addition, the best model describing the volatility for the Australia and New Zealand Banking Group (ANZ) is the TARCH model.

This study can be extended further by considering more Australian banking shares or the Asian stock market and other important Australian sectors, such as the mining sector. A possible extension to this research might be to apply other ARCH models and higher frequency data, such as 5 min data or tick by tick data.

This study is imperative to the market participant and investors and hedge funds and risk managers who want to understand the risk factor of Australian dollar volatility on the big four banks in Australia. The Australian banking sector is one of the largest sectors in the Australian stock market.

Figure 3. 3 Hourly raw return of big four banks and the Australian dollar returns 2012 to 2016

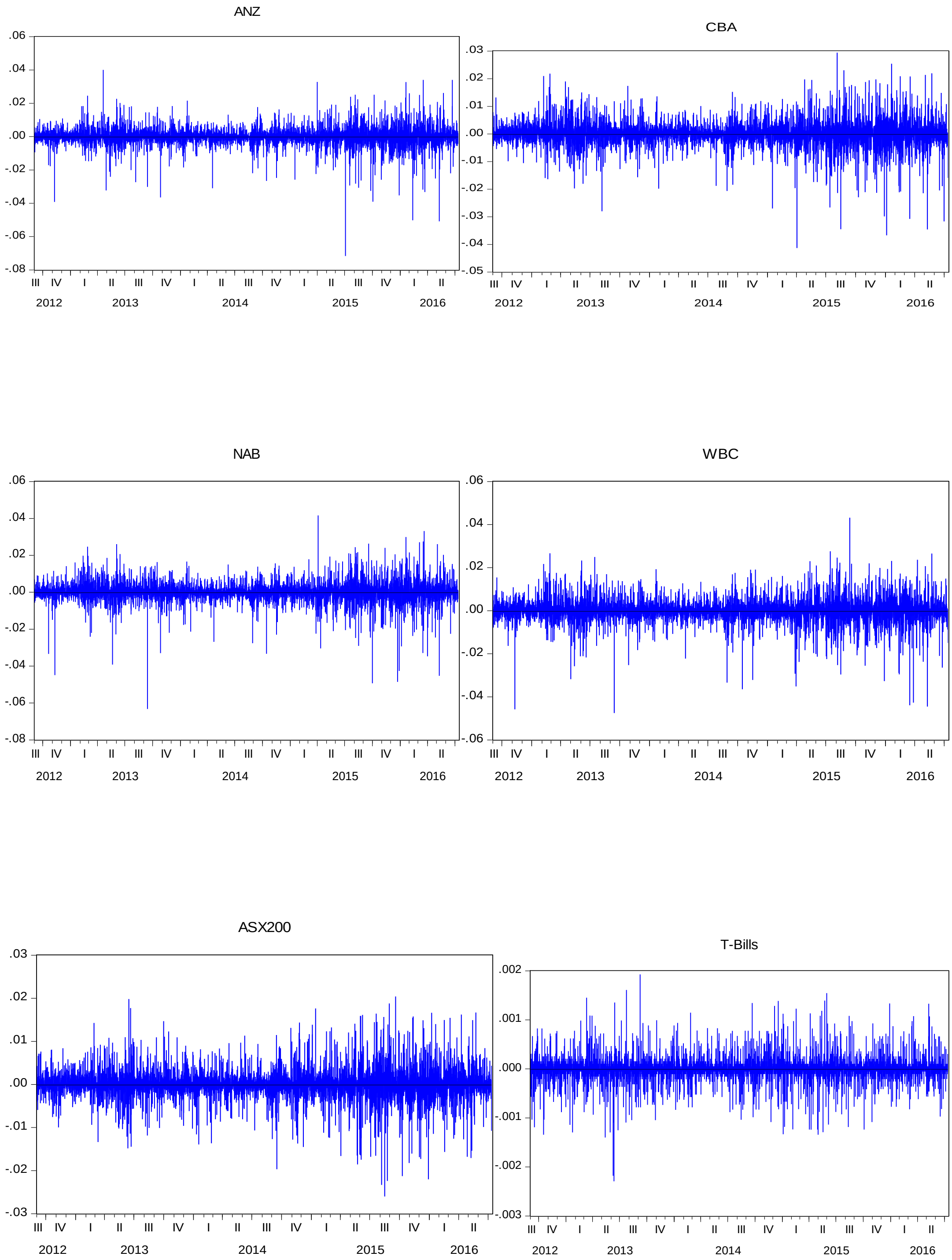


Figure 3. 4 Hourly return of big four banks and the Australian dollar returns 2012 to 2016

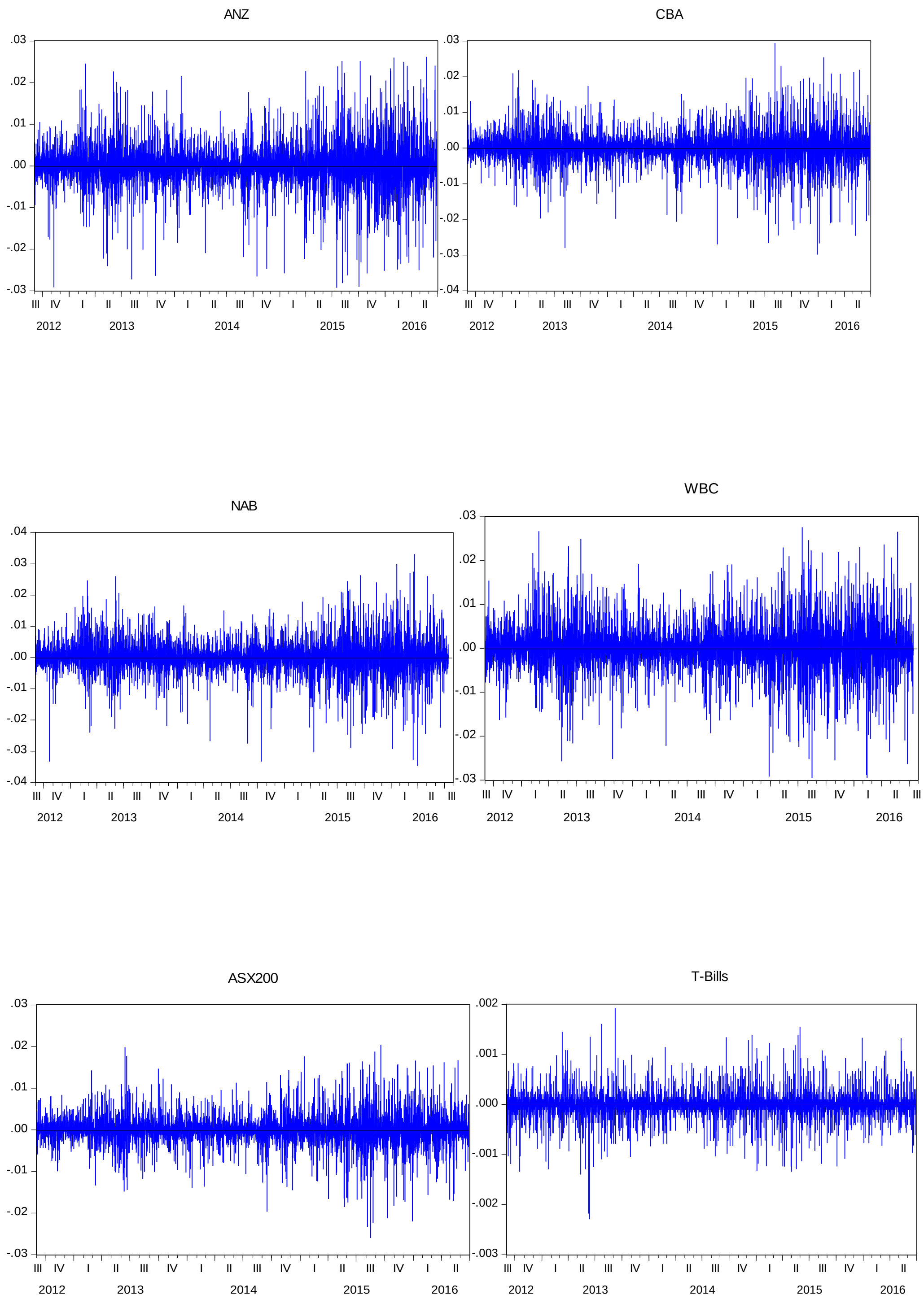


Figure 3. 5 Daily return of big four banks and the Australian dollar returns 2012 to 2016

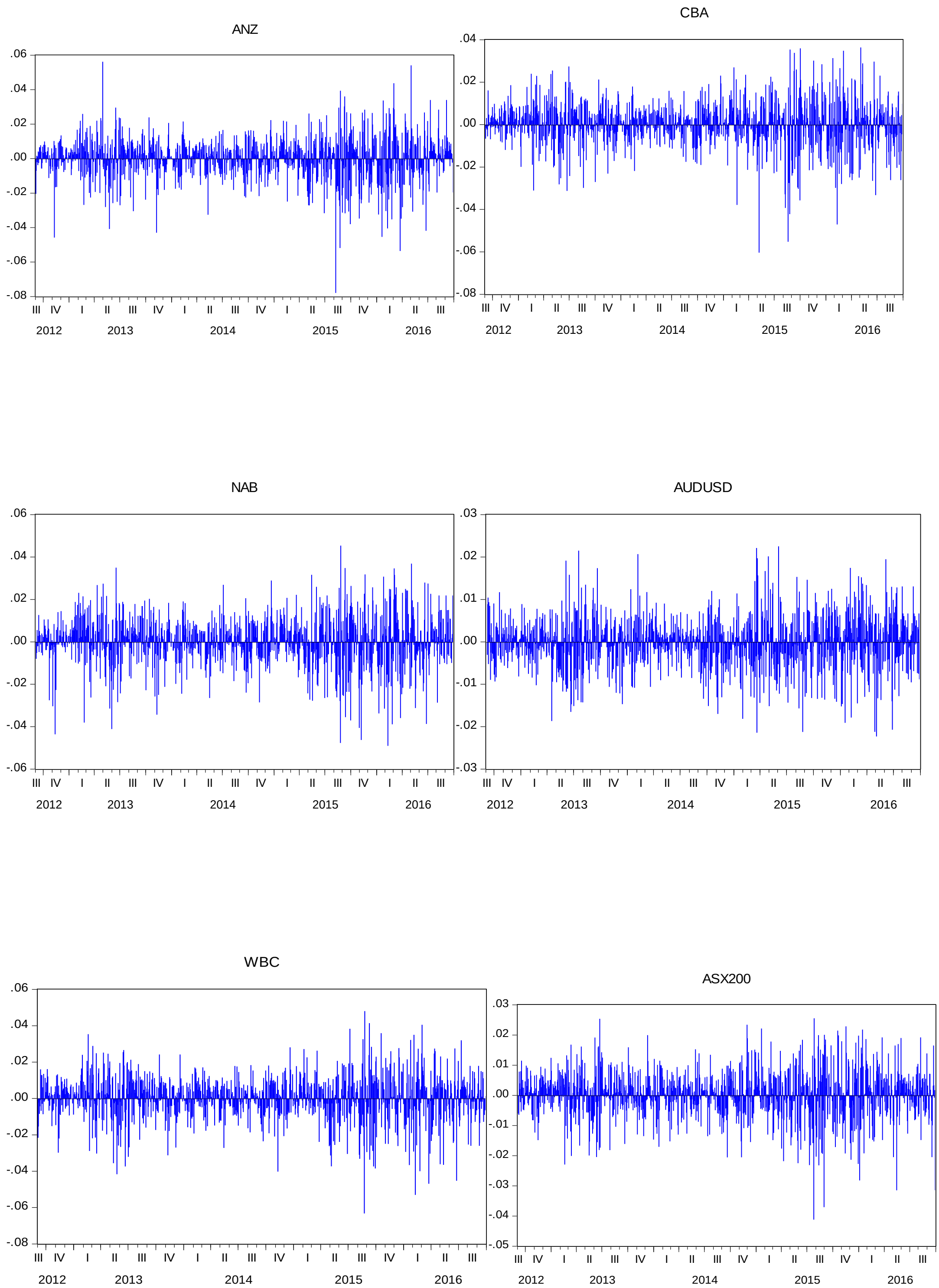
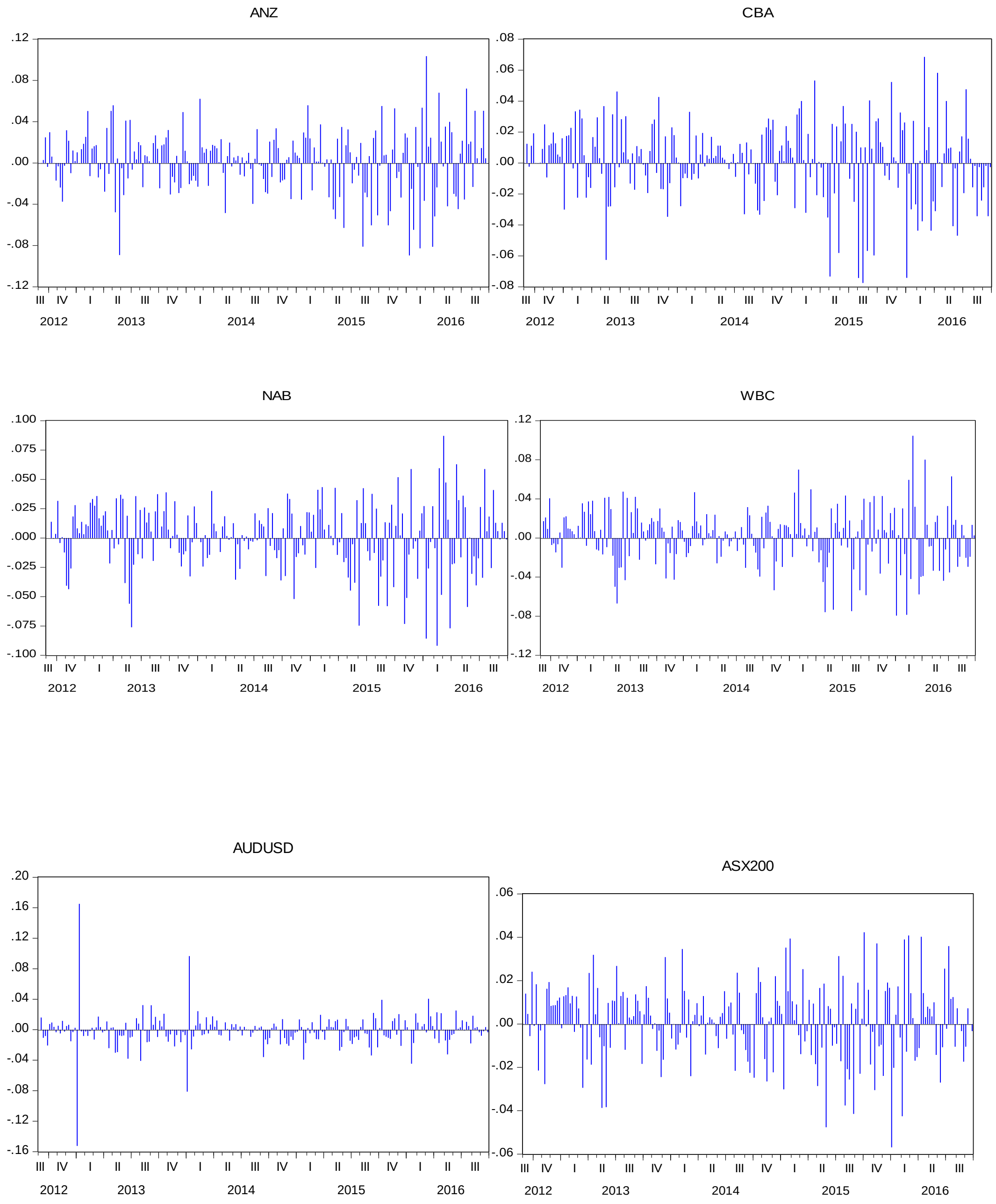


Figure 3. 6 Weekly return of big four banks and the Australian dollar returns 2012 to 2016



CHAPTER FOUR
THE EFFECT OF ECONOMIC AND FUNDAMENTAL FACTORS ON THE AUSTRALIAN PROPERTY PERFORMANCE

4.1 Introduction

Globally, the commercial real estate market has experienced important fluctuations since the 1960s (Yong & Singh, 2014). The commercial real estate market is booming all over the world since 2009. This is due to the fact that real estate market indicators, such as the house price level and commercial real estate price level, have doubled in many developed countries, such as the United States, the United Kingdom and Canada, and other developing countries, particularly Australia. The World Livability Index ranks three Australian capital cities – Melbourne, Adelaide and Perth – in the top ten most livable cities in the world for 2016 (The Economist Intelligence Unit, 2016). Sydney also ranks highly, dropping just outside of the top ten ranking for 2016. Sydney ranked third of the four Australian cities in the top ten most livable cities for 2015 (Economist Intelligence Unit, 2015).

The real estate and equity markets and lagged values of these markets between peaks and troughs in the economy can also be expected to be inversely related. Lizieri and Satchell (1997) state that if profitability decreases in the industrial sector, investors will switch capital into the real estate market in pursuit of higher profits. In the equity market, the adjustments should be faster than in the direct, non-exchange traded market. For instance, a switch of capital into the real estate market will reduce capitalisation rates and hence increase capital values. Indication of this will only materialise after completion of sales. In turn, this will be shown in the published net asset value of property companies only after revaluation. In addition, conflicting results have been obtained from such research as some conclude that the real estate and stock markets are segmented, and this implies that there is no co-movement between the two markets while the other strand of studies finds that these two markets are integrated, implying a significant positive contemporaneous co-movement (Gyourko & Keirn, 1992).

Over the last decade, house prices in Australian capital cities have increased dramatically. This occurrence has led many interested parties, like industry groups and academics, to investigate the effect of the economic factors and fundamental factors on the Australian real estate market. Yong and Singh (2013) undertook research aimed at determining whether the overall stock market and interest rates have consistent effects on REITs return and the impact of borrowing and management structure in a sample period which includes the GFC and subsequent recovery of the REIT sector. Their study examines three variables: interest rate, market return and inflation. Wong and Reddy (2017) conduct a similar study aimed at examining the impact of the interest rate on the Australian REITs by using the ICAPM model. They conclude that the stock market returns, real GDP, and the interest rate are the key drivers of the Australian REITs. Ratcliffe and Dimowski (2007) also note that the defensive characteristics of REITs as a property investment against market risk have decreased. REITs have a significantly negative relationship with long-term interest rates but an insignificantly positive relationship with short-term rates. Newell and Tan (2005) find strong correlation between the REITs and the Australian stock market. Liu and Mei (1998) find a strong relationship between the exchange rate and the Australian real estate market.

The combined findings of Chan et al. (1992), Lizieri and Satchell (1997), and Brooks and Tuskacus (1999) is that the macroeconomic variables the real treasury bill rate, the short-term nominal interest rate, the interest rate structure and the unexpected inflation have a systematic impact on the returns of the real estate market. McCue and Kling (1994) study the relationship between the macroeconomic factors and the US REITs returns. The results show that the change in interest rate is affected by the US REITs returns. Koop et al. (1996) and Pesaran and Shin (1998) determine how subsector REIT returns respond to unexpected shocks to the macro-state variables.

Previous studies examine the effect of macroeconomic variables and fundamental variables on the Australian real estate market, including Yong and Singh (2013), Wong and Reddy (2017), Newell and Tan (2005) and Ratcliffe and Dimowski (2007), who examine the effect of the interest rate on the Australian REITs. But in this study, we examine the relationship between the TWI and the Australian REITs. And we consider the real estate market at the state level. Yong and Singh (2013), Wong and Reddy (2017), Newell and Tan (2005) and Ratcliffe and Dimowski (2007) use quarterly and yearly data. None of the previous studies uses panel data. According to the best of our knowledge, none of the previous researchers use TWI and examine the relationship between the fundamental factors and the real estate market at the house price level and the unit price level. The study shall also assist in narrowing the gap of the Australian academic literature in the field of REITs and macroeconomics.

This chapter incorporates two aims of the Australian real estate market. First, this research investigates the effect of TWI[4] return on the Australian REITs volatility from 2009 to 2016 by using monthly panel data. We will use fixed and random effect models. In the second aim, we examine the linkage between the fundamental factors and the real estate market for three major states in Australia at unit level and house price level. The four real estate factors are average house (HP) price, average unit price (UP), average rental yield (ARY), average

[4] The Trade Weighted Index (TWI) is a weighted average of a basket of currencies that reflects the importance of the sum of Australia's exports and imports of goods by country.

auction clearance rate (AAC), and average stock on market (ASM). The states are New South Wales (NSW), Victoria (VIC), and Queensland (QLD). This research uses monthly data covering the period from 2009 to 2016 by applying the VAR model. This research is important for investors, investment managers and operational decision makers to get a better understanding of how they can manage their investments more effectively during times of any change happening in macroeconomic factors. The findings of this research will help real estate investment and Australian funds to reduce macroeconomics exposure.

4.2 Empirical Studies

A vast literature on real estate markets has focussed on the linkage between the real estate market and the equity market instead of the linkages between the REITs and macroeconomics. Examples of such studies include Schnare and Struyk (1976), Rosen (1985), Miles et al. (1990), Liu et al. (1992), Okunev and Wilson (1997), Geltner and Goetzmann (2000), Okunev et al. (2000) and Yang et al. (2005). The linkages between the real estate market and equity market arise from the twofold nature of property as a financial asset in capital markets and as a factor of production in the space or industrial markets (Hakfoort, 1994). A study by Fisher (1992) suggests that the rental income stream generated in the space market is a cashflow valued in the capital market. Corporate growth in profitability (expected or actual) results in business expansion as well as increasing rental levels given the inelastic short-run supply in the real estate market. An increase in rental rates results in high capital values in the capital market (both through increased income and reduced capitalisation rates). This ultimately increases net asset values and prices for property companies, property unit trusts, and real estate investment trusts (REITs) (Lizieri & Satchell, 1997).

Global demand for REITs has led to a significant body of academic literature that explores the risk and return characteristics of REITs. In the literature, most of the studies are associated with the US market. Chan et al. (1992) analyse monthly returns of 23 equities in the US market. They examine the relationship between the macroeconomic factors and the REITs. The findings show that REITs do not offer a superior risk-adjusted return and are not a hedge against unexpected inflation. A similar study by McCue and Kling (1994) tests the relationship between the macroeconomic factors and the US REITs returns. The dataset uses daily returns from 1972-1992. The results show that prices, nominal rates, output and investment all directly influence the US real estate market. Nominal interest rates, moreover, explain most of the variation in the real estate series. Koop et al. (1996) and Pesaran and Shin (1998) examine the relationship between macroeconomic shocks and the US REITs. They find a strong relationship between the interest rate and the US REITs. Wilson and Zurbruegg (2001) find US economic forces affect international real estate markets. They find the US GDP and the US term structure of interest rates and inflation have a flow-through effect on the securitised property markets of Australia, Japan, and the UK. Allen et al. (2000) study the linkage between the interest rate and the REITs. The findings show a negative association between both variables.

A study by Payne (2003) identifies the response of REIT excess returns to unexpected changes in the broader stock market, real output growth, inflation, term structure of interest rates, default risk, and the federal funds rate using the generalised impulse response analysis. Friday and Howton (2000) and Hoesli and Moreno (2007) find the variance and performance of securitised real estate are explained by the variance of the stock market or the state of the market as a bull market. Liow et al. (2003) examine the effect of the interest rate on the Japanese and US real estate market performances. They find a strong positive relationship between the interest rate and real estate market for both countries. Simpson, Ramchander and Webb (2007) find a positive relationship between US REITs returns and inflation. The findings are consistent with the Fama and Schwert (1977) hypothesis. Xu and Yang (2011) investigate the effect of the US monetary policy surprises on securitised real estate markets in 18 countries. The outcomes show that most international REITs have significantly positive responses to surprise decreases in current or future expected federal fund rates, though such responses vary greatly across countries. For example, Yunus (2012) investigates the linkage between macroeconomic factors and REITs for North America, Europe, Australia, and Asia. The results indicate that each property market is co-integrated with its respective stock market and macroeconomic factors in the long run and is also influenced by the overall economy in the short run. Chou and Chen (2014) examine the effect of monetary policy on the US market. The results contrast with the empirical evidence of asymmetry relating to output and stock returns, indicating that REITs' responses to monetary policy shocks are very different compared with stock returns. Zhao et al. (2014) examine how the correlation structure between REITs and general stocks changes when macroeconomic conditions change. They find strong correlation between equity REITs and the general stock market over the short term. This is because equity REITs provide limited diversification potential for short-term investment horizons, particularly during periods of high stock market volatility.

There are a few studies that investigate the relationship between the exchange rate exposure and US REITs. Ngo (2017) examines the effect of the exchange rate on the US REITs. She obtains monthly returns data of all REITs companies in the US stock market from 1990 to 2013. Her final sample includes 371 companies listed on the REITs index in US stock market. The findings show that the exchange rate exposures, however, vary significantly among the REIT types and REITs property. US dollar appreciation adversely affects equity

REITs returns. To the best of her knowledge, Ngo's (2017) research is the first paper that examines the exchange rate exposures of REITs in the US market.

A number of studies examine the linkage between the macroeconomic factors and the European REITs. For interest rate, Kofoedpihl (2009) finds that economic variables have had significant impact on commercial property return to the UK. Another study by Goslings and Petri (1992) finds REITs performance is relatively stable during economic crisis. This is probably due to the 'lag effect' experienced by the property and construction sectors during the economic cycle transitions. The spillover effect of economic recession is most likely experienced by property sectors in the post-crisis period. Bouchouicha and Ftit (2012) examine the relationship between the interest rate return and the UK REITs performance. The findings show that rising interest rates do not negatively impact REITs performance. This is probably because commercial real estate has the pricing power to cover the rising costs by increasing the rents during the high interest period. Increasing interest rates is always associated with economic expansion, which rental and cash flow would increase while the real estate value would appreciate. This is also consistent with a study on the property market in Hong Kong, Japan, Singapore and UK by Mueller and Pauley (1995). Except Singapore, the other three nations show significant positive correlation at 1% and 10% significance levels between interest rates and REITs performance. However, for Swedish and Swiss markets, Bernardi and Rodenholm (2013) found that the correlation between these variables disappeared in the crisis period. A negative relationship exists in the pre-crisis period, to then become almost insignificant in the crisis period. The responsiveness of the Swiss labour market to the real estate stock market seems to be more consistent compared to Sweden, possibly due to the political structure of the Swiss economy that is based on liberal labour politics.

In spite of those studies in the US and other countries, there are few studies on the Asia-Pacific and Australasian REITs. For Asian countries, Chui and Chau (2005) suggest that there is no relationship between GDP and real estate investment in Hong Kong. This contradicts the outcomes of similar previous studies in other markets. The lack of relationship is due to the significant variation in the project's duration in Hong Kong. Similar research focussing on the Hong Kong market by Liu et al. (2012) show that expected property stock excess returns are positively correlated with the conditional variances of GDP growth, industrial production output growth, unexpected inflation and exchange rate, and negatively correlated with the conditional variances of interest rate and money supply.

A study by Newell et al. (2010) shows that the REITs were only moderately correlated with property stocks in Hong Kong. For Thai and Taiwanese markets, research by Pham (2011) studies the Thai REITs market from 2003 to 2010 by using daily data. He investigates the dynamic correlations between REITs and other investment factors and determines the diversification potential of Thai-REITs in a mixed-asset portfolio. His results show that pre-GFC and during the GFC, Thai-REITs only played a minor role in the mixed-asset portfolio at low risk levels due to their poor risk-adjusted performance. He suggests that Thai-REITs offer a low-risk investment option and a better portfolio optimiser than property companies for shares investors. Peng and Newell (2012) provided portfolio diversification benefits, with enhanced risk-adjusted returns, enhanced diversification benefits and a significant role in the mixed-asset portfolio in the post-GFC period.

There is a considerable volume of research on US and other countries-based REITs, although less attention has been devoted to the Australian REITs. Newell (1996) examines the relationship between inflation and Australian commercial property. He uses quarterly data from 1984 to 1995. The outcomes show that investors can use Australian real estate investments to hedge against actual, expected and unexpected inflation. Liu et al. (1997), Newell (2005) and Newell and Peng (2007) examine the relationship between the REITs and interest rates. Newell (2005) finds a negative relationship between the REITs and the Australian interest rate. Newell and Peng (2009) find that higher levels of gearing in A-REITs are a key factor in the sector's underperformance against other sectors. Wilson and Zurbruegg (2008) investigate the linkage between the real estate stock market and 10-year government bond yields in Australia and the UK. The results show that real estate in Australia is influenced by the stock market in the long- and short-run, while the bond market only affects REITs in short term. West and Worthington (2006) suggest that employment growth in various industries signals higher property prices as they are proxies for increased demand for commercial space.

A conference paper by Yong et al. (2011) examines the linkages between commercial property and A-REITs using cointegration analysis with industrial production and various employment indices. In a recent paper, Yong and Singh (2013) show that REITs are only negatively affected by changes to short-term interest rates at the lowest 5% quantile of returns. Changes to long-term interest rates have an adverse effect on REITs only at the upper 75% and 95% quantiles. Wong and Reddy (2017) apply intertemporal capital asset pricing model (ICAPM) by using monthly data from 1995 to 2015. The outcomes show that rising short-term interest rates contribute to positive returns while rising long-term interest rates result in lower returns. Wong (2017) investigates the linkage between the macroeconomic risk factors and the Australian REITs performance. His study includes REITs listed on the

Australian Stock Exchange (ASX) between 1995 and 2015. The findings show there is linkage between the interest rate risk and the Australian REITs.

Table 4.1 shows the studies investigating the effect of macroeconomics risk factors on the REITs sector from the global financial market. The previous studies mainly reflect the experiences from US, UK, European and Asian-specific countries, which have different regulations, investor behaviours, and economic situations from those predominant in Australia. There are a few studies investigating the Oceanian countries such as Australia. According to Wong and Reddy (2017), the A$125 billion Australian real estate investment trusts (A-REITs) is the second largest global listed property sector, behind the United States. A-REITs were formally known as Listed Property Trusts (LPTs) that have a long-established history in the Australian stock market since 1971. A-REITs are popular investment options for both institutional and retail investors seeking regular income and capital growth. Liu et al. (1997), Newell and Tan (2005), Newell and Peng (2009), Wilson and Zurbruegg (2008), Yong et al. (2011), Yong and Singh (2013) and Wong and Reddy (2017) study the relationship between the interest rate and the Australian REITs. However, none of the of the previous research focusses on the TWI variable. From a data perspective, the previous researchers focus on quarterly data and real estate companies only. However, this study incorporates two kinds of data. First, this study focusses on monthly data to examine the effect of TWI, interest rate, and Australian REITs. Second, this research uses three major states in Australia at unit price and house price. These states are New South Wales (NSW), Victoria (VIC), and Queensland (QLD). To the best of our knowledge, this research is the first paper that examines the exchange rate exposures of REITs in Australia and investigates the effect of the fundamental risk factors on three major states in Australia at unit price and house price.

Finally, this research aims to fill the gap by investigating the relationship between the exchange exposure volatility and Australian real estate market. This study shall provide valuable insight into the effects that macroeconomic factor movements are likely to have on REITs based in Australia. It shall give investors, investment managers and operational decision makers a better understanding of how they can manage their investments more effectively during times of any change happening in macroeconomic factors. The study will also assist in narrowing the gap of the Australian academic literature in the field of REITs and macroeconomics. The outcome of this study will mainly benefit the academic as well as the real estate investment and Australians funds. Moreover, it will reveal practical solutions for reducing macroeconomics exposure while at the same time enhancing REITs investments.

Table 4. 1 Empirical evidence from real estate Sector

Author	Econometric Model	Data	Findings
Chan et al. (1992)	Multifactor Model	US market by using monthly data.	The findings show that REITs do not offer a superior risk-adjusted return and are not a hedge against unexpected inflation.
McCue and Kling (1994)	Non-limiting VAR Model	US REITs returns are used as daily return from 1972-1992.	Nominal rates, output and investment all directly influence the real estate.
Chatrath, and Liang (1998)	Regression analysis model	Monthly data over the 1972-1995 period.	The findings show that REITs provide a long run inflation hedge.
Liu and Mei (1992)	Multifactor latent variable model	Monthly data.	The outcomes show that the risk premiums of equity REITs resemble small cap stocks. Therefore, these studies suggest that REITs possess similar risk factors to those of traditional stock.
Glascock et al. (2002)	A vector error correction model.	Monthly data.	The findings show a negative relationship between the REITs returns and inflation.

Table 4.1Continued…

Author	Econometric Model	Data	Findings
Simpson, Ramchander and Webb (2007)	ARIMA model	Monthly data over 1981 to 2002	Find a positive relationship between real estate securities returns and inflation in the US
Xu and Yang (2011)	Two-factor model	The differences between the federal funds futures rate 10 min prior to the monetary policy announcements and 20 min after the announcements	The outcomes show that most international REIs have significantly positive responses to surprise decrease in current or future. expected federal funds rates
Bredin et al. (2011)	Baseline regression model	Frequency is daily and runs from January 1996 to March 2005.	Monetary policy surprises consistently have an impact on REIT returns
Yunus et al. (2012)	A VAR model	Annual frequency data over 1989 to 2008	They found that REITS and direct real estate exhibit similar response to market shocks and that I-REIT sector return is neither influenced by common stock nor direct real estate markets
Chou and Chen (2014)	A Markov-switching model	Monthly data over the period 1992 to 2010	The results indicate that each property market is co-integrated with its respective stock market and with key macroeconomic factors in the long run and is also influenced by the overall economy in the short run
Akimov et al. (2015)	Nelson-Siegel model	Daily data	The results confirm the time-sensitive nature of the exposure and sensitivity to interest rates and highlight the importance of

			considering the entire term structure of interest rates.
KofoedPihl (2009)	Regression model	Quarterly real estate data from 1984-2008	Find that economic variables have had significant impact on commercial property return to the UK
Bouchouicha and Ftiti (2012)	DCF model	Quarterly real estate data from 1990-2010	Find that raising interest rates does not negatively impact REITs' performance.
Pham (2011)	Regression model	Daily data from 2003 to 2010	The results show that pre-GFC and during the GFC, Thai-REITs only played a minor role in the mixed-asset portfolio at low risk levels due to their poor risk-adjusted performance.
Bernardi and Rodenholm (2013)	A univariate and bivariate analysis	Quarterly data is applied. The sample period is from January 2003 to December 2012	A negative relationship exists in the pre-crisis period, to then become almost insignificant in the crisis period.
Liu et al. (2012)	DCC-GARCH model	Monthly data	REIT correlations rise with increases in the interaction of national inflation rates and with higher global equity market uncertainty.
Newell et al. (2012)	Regression model	Monthly data from 2005-2011.	They provided portfolio diversification benefits, with enhanced risk-adjusted returns, enhanced diversification benefits and a significant role in the mixed-asset portfolio in the post-GFC period.

Author	Econometric Model	Data	Findings
Newell (1996)	Multi-factor model	Quarterly data from 1984 to 1995	The outcomes show that the investors can use Australian real estate investments to hedge against actual, expected and unexpected inflation.
Newell and Tan (2005)	Multi-factor model	Daily data over 1996-2006	The results show a steady increase of correlations between stapled A-REITs and the general stock market since 2003 and during the GFC. Though stapled A-REITs provide higher returns
Newell and Peng (2009)	Regression analysis model	Monthly total returns over 1996-2008	Find that higher levels of gearing in A-REITs were a key factor in the sector's underperformance against stocks
Wilson and Zurbruegg (2008).	Cointegration Tests model	Quarterly data from 1986 to 2007	The results show that real estate in Australia is influenced by the stock market in the long- and short-run.
West and Worthington (2006)	(GARCH-M) model	Quarterly data from 1985 to 2002	Suggest that employment growth in various industries signals higher property prices as they are proxies for increased demand for commercial space.
Yong et al. (2013)	Cointegration tests and Vector Error Correction Models	Monthly data from 2000 to 2012	The main empirical results from this study reveal that stapled AREITs are consistent representatives of commercial real estate, and provide an efficient hedge against inflation

4.3 Model specifications

This section explains two methodologies applied in this chapter. These two methodologies are the fixed effect and random effect model and the vector autoregression model (VAR). For the fixed effect and random effect model, the aim of this methodology is to examine the effect of the macroeconomic variables on the Australian REITs companies. For the vector autoregression model (VAR), the aim of this methodology is to examine the relationship between the fundamental factors and the real estate market for three states in Australia.

The fixed effect and random effect model is applied to investigate the effect of the macroeconomic variables on the Australian REITs return. According to Bruce’s (2016) panel data, it makes conceptual contrasting assumptions about effects as either random or fixed. The fixed effects model is just a standard regression model and can be estimated by OLS as follows:

$$r_{sr,t} = \alpha + \beta_1 r_{m,t} + \beta_2 r_{ir,t} + \beta_3 r_{twi,,t} + \beta_4 r_{oil,,t} + \varepsilon_{it} \quad (4.1)$$

Where $r_{sr,t}$ is REITs return, $r_{m,t}$ is the Australian stock market index (ASX200), $r_{ir,t}$ is the long term Australian interest rate, $r_{twi,t}$ is the Australian Trade Weighted Index (TWI), $r_{oil,t}$ is the oil price return.

According to Taoulaou and Burchuladze (2016), the random effects model, which is equivalent to the generalised least square (GLS), needs to follow some severe restrictions in order to be applied in our regression. According to this method, the subtraction of the necessary mean value seems to be a better and more advanced solution than subtracting the whole mean value over all the cross-section units. Therefore, using the random effect model we do not lose any degrees of freedom, since we do not use more variables, we just make transformations, so it is more efficient than the fixed test. The random effect equation is as follows:

$$r_{sr,t} = \alpha + \beta_1 r_{m,t} + \beta_2 r_{ir,t} + \beta_3 r_{twi,t} + \beta_4 r_{oil,t} + \omega_{it} \qquad (4.2)$$

Where $\omega_{it} = \epsilon_i + v_{it}$, $\epsilon_i \sim IDD(0, \sigma_\varepsilon^2)$ and $v_{it} \sim IDD\ (0, \sigma_v^2)$

The vector autoregression model (VAR) is useful to study the effect of the real estate fundamental factors on the Australian house and unit price for three states, namely New South Wales (NSW), Victoria (VIC), and Queensland (QLD). According to Basci and Karaca (2013), vector autoregression (VAR) is a stochastic process model used to capture the linear interdependencies among multiple time series. VAR models generalise the univariate autoregressive model (AR model) by allowing for more than one evolving variable. The VAR model is one of the most successful, flexible and easy to use models for the analysis of multivariate time series. It is a natural extension of the univariate autoregressive model to dynamic multivariate time series. The VAR model has proven to be especially useful for describing the dynamic behaviour of economic and financial time series and for forecasting. It often provides superior forecasts to those from univariate time series models and elaborate theory-based simultaneous equations models. Forecasts from VAR models are quite flexible because they can be made conditional on the potential future paths of specified variables in the model. The VAR equation is as follows:

$$HP_t = \alpha_1 + \beta_{1,i} HP_{t-1} + \beta_{3,i} HP_{t-2} + \beta_{3,i} ARY_{t-1} + \beta_{4,i} ARY_{t-2} + \beta_{5,i} AAC_{t-1} + \beta_{6,i} AAC_{t-2} + \beta_{7,i} ASM_{t-1} + \beta_{8,i} ASM_{t-2} + \mathcal{U}_{1,i} \qquad (4.3)$$

$$ARY_{t,i} = \alpha_2 + \beta_{9,i}ARY_{t-1} + \beta_{10,i}ARY_{t-2} + \beta_{11,i}HP_{t-1} + \beta_{12,i}HP_{t-2} + \beta_{13,i}AAC_{t-1} + \beta_{14,i}AAC_{t-2} + \beta_{15,i}ASM_{t-1} + \beta_{16,i}ASM_{t-2} + \mathcal{U}_{2,i} \quad (4.4)$$

$$AAC_{t,i} = \alpha_3 + \beta_{17,i}AAC_{t-1} + \beta_{18,i}AAC_{t-2} + \beta_{19,i}ARY_{t-1} + \beta_{20,i}ARY_{t-2} + \beta_{21,i}HP_{t-1} + \beta_{22,i}HP_{t-2} + \beta_{23,i}ASM_{t-1} + \beta_{24,i}ASM_{t-2} + \mathcal{U}_{3,i} \quad (4.5)$$

$$ASM_{t,i} = \alpha_3 + \beta_{25,i}ASM_{t-1} + \beta_{26,i}ASM_{t-2} + \beta_{27,i}AAC_{t-1} + \beta_{28,i}AAC_{t-2} + \beta_{29,i}ARY_{t-1} + \beta_{30,i}ARY_{t-2} + \beta_{31,i}HP_{t-1} + \beta_{32,i}HP_{t-2} + \mathcal{U}_{3,i} \quad (4.6)$$

Where HP_i is house price return and unit price for three states, ARY_i is Average Rental Yield (ARY) for house price and unit price for three states, ACC_i is Average Auction Clearance Rate (AAC) house price and unit price for three states, ASM_i is Average Stock on market (ASM) for house price and unit price for three states. $\beta_{t,i}$ is the parameters to be estimated. $\mathcal{U}_{1,i}$, $\mathcal{U}_{2,i}$ and $\mathcal{U}_{3,i}$ are white noise disturbance terms with $E(\mathcal{U}_{it}) = 0, (i = 1,2)$, $E(\mathcal{U}_{1,i}$, $\mathcal{U}_{2,i}) = 0$.

4.4 The data and the descriptive statistics

4.4.1 The data

This study includes the monthly data of price value of 22 REITs that are listed on the Australian stock market, six real estate's factors for three Australian states, trade weight index (TWI), Australian 90-days bank accepted bills and oil prices. The study period starts from January 2009 to 31 December 2016. The six real estate factors are average house price (HP), average unit price (UP), average rental yield (ARY), average auction clearance rate (AAC), and average stock on market (ASM). The three Australian states are New South Wales (NSW), Victoria (VIC), and Queensland (QLD). These states are the major states in Australia with a population of more than 65% the Australian total. New South Wales (NSW) is Australia's largest state economy, with 33% of the nation's GDP in 2016–17. The next largest state, Victoria, with its capital, Melbourne, contributes 22%.

For oil price, we consider the one-month future price of TWI. Sadorsky (2003) suggests future price should be used rather than spot price because spot prices are more affected by short run price movement caused by temporary shortages and supplies. Most studies related to oil price use future price since they are perceived as the efficient price and the trading of crude oil futures is popular. In the model, oil data are used at lag on. The monthly data of oil price value is collected from Datastream.

In this chapter, panel data is used to analyse the impact of macroeconomic variables on REITs. We use panel data because it increases the degrees of freedom, deals with the collinearity issue among the explanatory variables (decreases it), and consequently allows for more efficient estimates. Both fixed and random effect panel data analyses are applied to deal with the firm heterogeneity, which may be caused by characteristics that differ among firms but are invariant over time. Problems such as heteroskedasticity and multicollinearity are also taken into consideration. Moreover, our variables are non-stationary and co-integrated.[5]

[5] We confirmed the non-stationarity using unit root tests on the individual series and panel unit root tests. Co-integration tests suggested that the variables are co-integrated. Of course, this is not surprising, as consumption functions are the classic example for co-integration analysis.

We consider two methodologies to evaluate the real estate market in Australia. First, real estate investment trust (REITs) is usually used as an estimator of property price changes. For example, the studies of Okunev et al. (2000) and Gyourko and Keim (1992) use excess REITs returns data in their study of real estate and macroeconomic variables. REITs and stocks have similar characteristics. REITs are traded on the stock exchange, they offer a relatively high liquidity and high return. This could be an explanation to why the REIT is closer related to movements in the stock market than other estimators of real estate prices (Eichholtz & Hartzell, 1996). According to Firstenberg et al. (1988), the volatility of REITs is larger compared to real estate prices. Second, the average sales price methodology is another common approach for measuring house prices. For example, the studies of Okunev et al. (2000), Gyourko and Keim (1992) and Case et al. (1991) use excess average house price data in their studies. Finally, these two methodologies are suitable for answering the hypotheses for this chapter.

The return of a stock is calculated as log first difference of stock price. Three factors are market risk measured as the log first difference of ASX200 index, an interest rate risk measured as the log first difference of Australian 90-days bank accepted bills, and trade weighted index risk measured as the log first difference of and trade weighted index risk. The equation is as follows:

$$SR_i = \ln\left(\frac{P_t}{P_{t-1}}\right) \quad (4.7)$$

4.4.2 The descriptive statistics

The descriptive statistics of 22 REITs monthly companies return (SR), Australian 90-days bank accepted bills (IR), and trade weighted index (TWI), and Australian stock market index (ASX) are reported in Table 4.2.

Based on Table 4.2, most of the variables return have a positive monthly mean, median and maximum, except that the interest rate has a negative mean. The skewness shows that the variables have a negative skew, except the REITs return. Based on kurtosis, the variables value return series is higher than 3.0 for the five variables, except the Australian market index, which means that the variables show a typical leptokurtic distribution. As part of the measurements of skewness and kurtosis, statistics also reject the null hypothesis of normality in the distribution of the sample return series. These data are non-normal distributions confirmed by the skewness, kurtosis, standard deviation, and the Jarque-Bera statistics. We use the QQ plot test to help us assess if a set data plausibly came from some theoretical distribution, such as a normal or exponential. Also, the QQ graph[6] test allows us to see at-a-glance if our assumption is plausible.

The QQ plot used when there are two data samples, it is often desirable to know if the assumption of a common distribution is justified. If so, then location and scale estimators can pool both data sets to obtain estimates of the common location and scale. If two samples do differ, it is also useful to gain some understanding of the differences. The q-q plot can provide more insight into the nature of the difference than analytical methods such as the chi-square and Kolmogorov. Based on figures 4.4, 4.5, 4.7, and 4.9, the return series of six variables are not normally distributed. Based on skewness, kurtosis and the QQ test, the findings show variables are not normally distributed. Figure 4.1, 4.2, and 4.3 display the three states real estate price movement in Australia. The NSW real estate price shows the bigger movements, while other states are relatively stable.

[6] The QQ graph is a way to determine whether data are normally distributed. The QQ graph is a scatter plot with the quantiles of the scores on the horizontal axis and the expected normal scores on the vertical axis

Figure 4. 1 The house price performance for NSW, VIC and QLD from 2009-2016

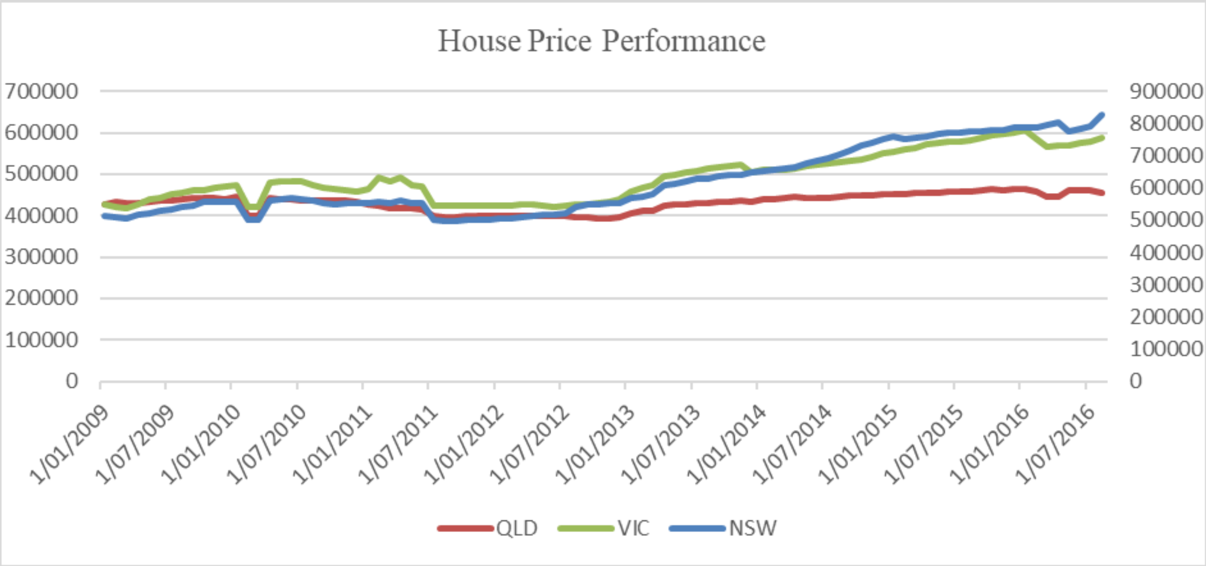


Figure 4. 2 The unit price performance for NSW, VIC and QLD from 2009-2016

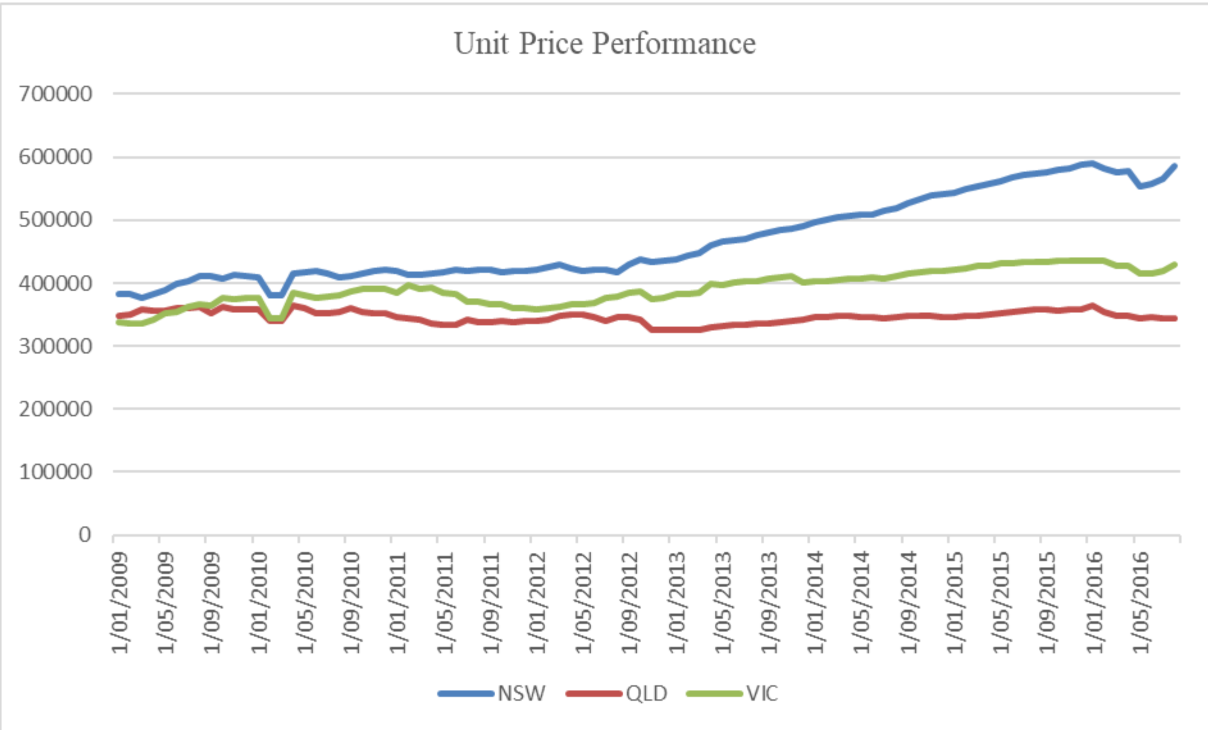


Figure 4. 3 The real estate returns for NSW, VIC and QLD from 2009-2016

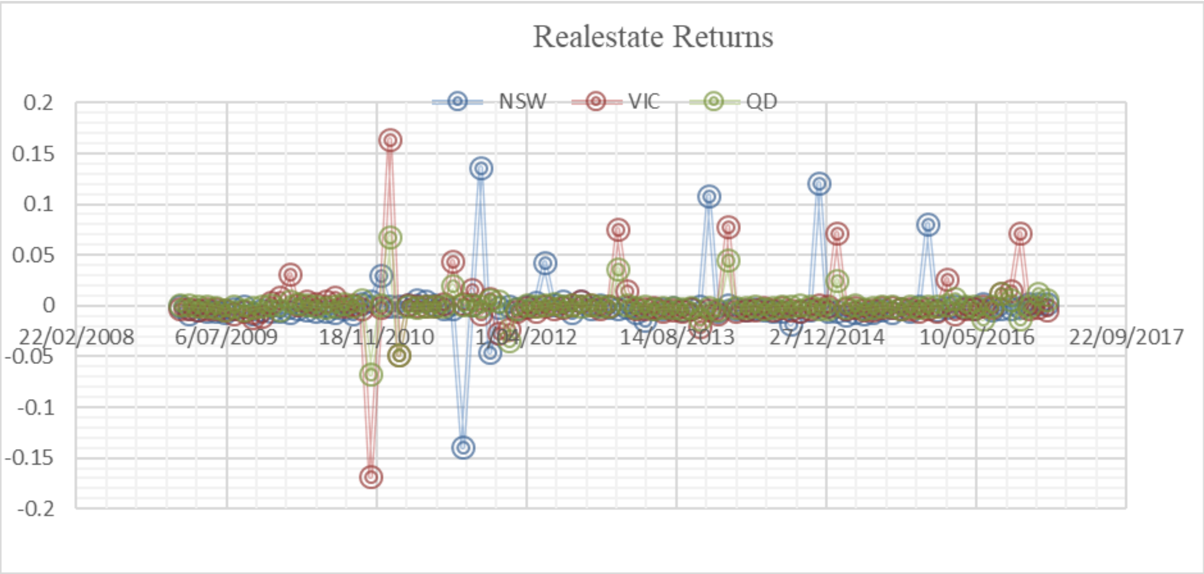


Table 4. 2 The descriptive statistics of monthly data for REITs, ASX, interest rate, Trade-Weighted Index (TWI) of the Australian dollar and oil price

	SR	ASX	IR	TWI	OIL
Mean	0.006483	0.002238	-0.001648	0.000856	0.001275
Median	0.004766	0.003692	0.001993	0.001788	0.004853
Maximum	0.301030	0.030640	0.078373	0.026188	0.112988
Minimum	-0.204120	-0.039226	-0.105194	-0.031034	-0.101093
Std. Dev.	0.033658	0.016520	0.029114	0.011168	0.037611
Skewness	0.910814	-0.421210	-0.215789	-0.233224	-0.176256
Kurtosis	12.43952	2.443133	4.135798	3.052387	3.806465
Jarque-Bera	8121.662	89.61246	129.7294	19.36040	68.07245
Probability	0.000000	0.000000	0.000000	0.000063	0.000000
Sum	13.67338	4.720313	-3.476293	1.804764	2.688538
Sum Sq. Dev.	2.388001	0.575273	1.786759	0.262904	2.981930
Observations	2109	2109	2109	2109	2109

The table reports summary statistics of the return of stock return (SR), Australian stock market (ASX), the Australian 90-days bank accept bills (IR), trade weight index (TWI) and oil price (OIL).

Figure 4. 4 QQ plot of macroeconomic variables and REITs returns for monthly data from 2009-2016

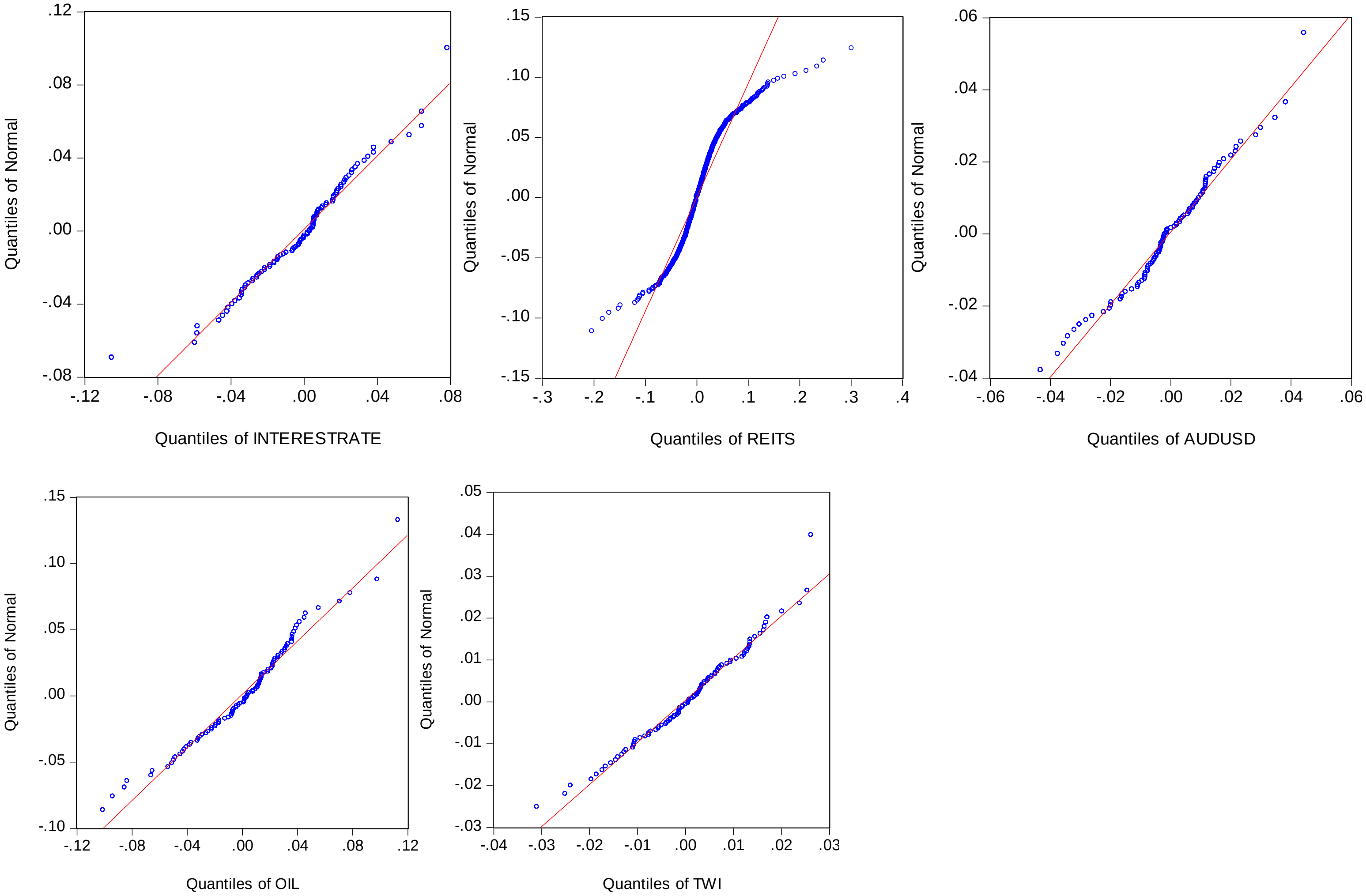


Figure 4. 5 QQ plot of real estate fundamental variables returns for NSW monthly data from 2009-2016

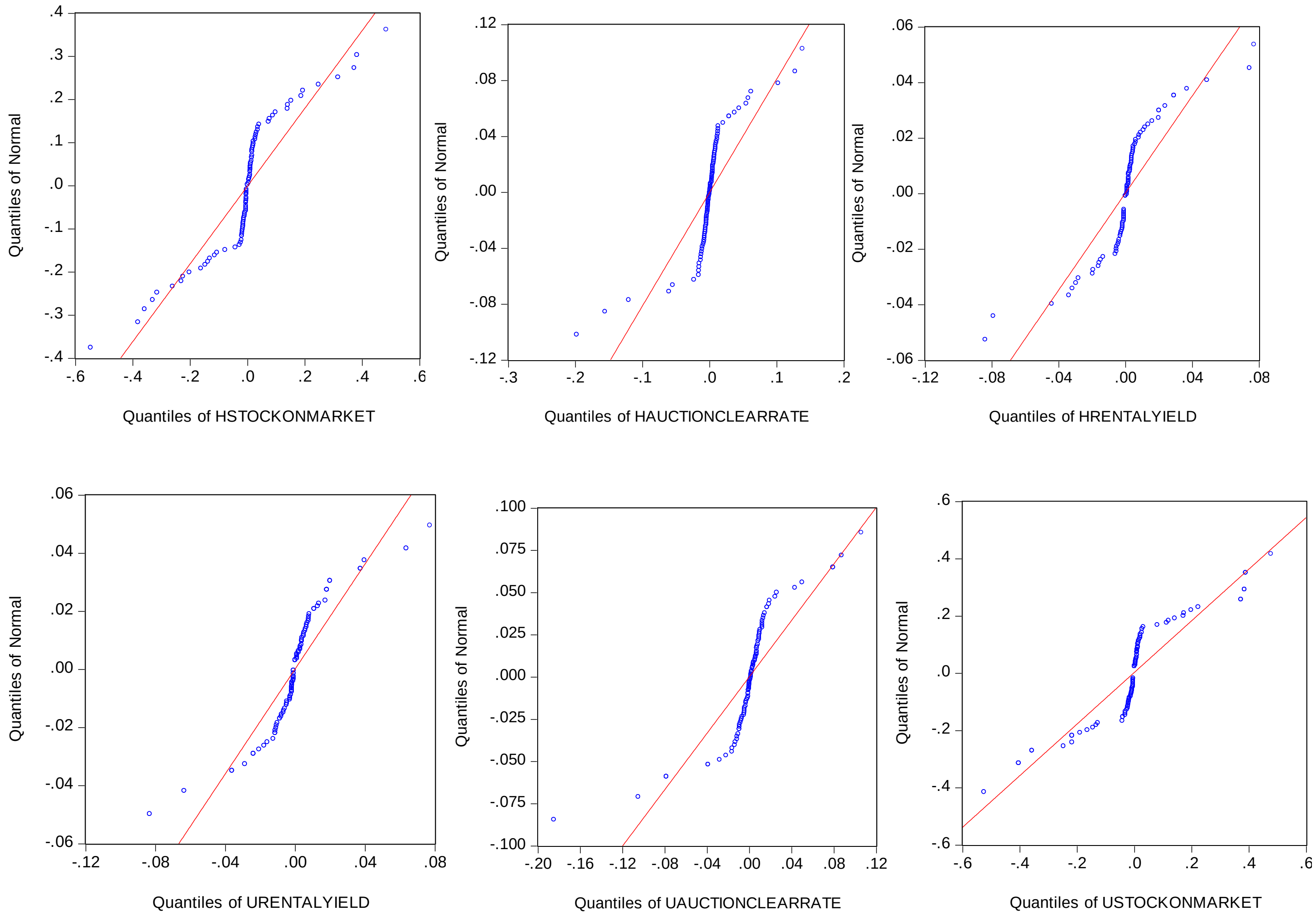


Figure 4. 6 Monthly return of NSW real estate from 2009 to 2016

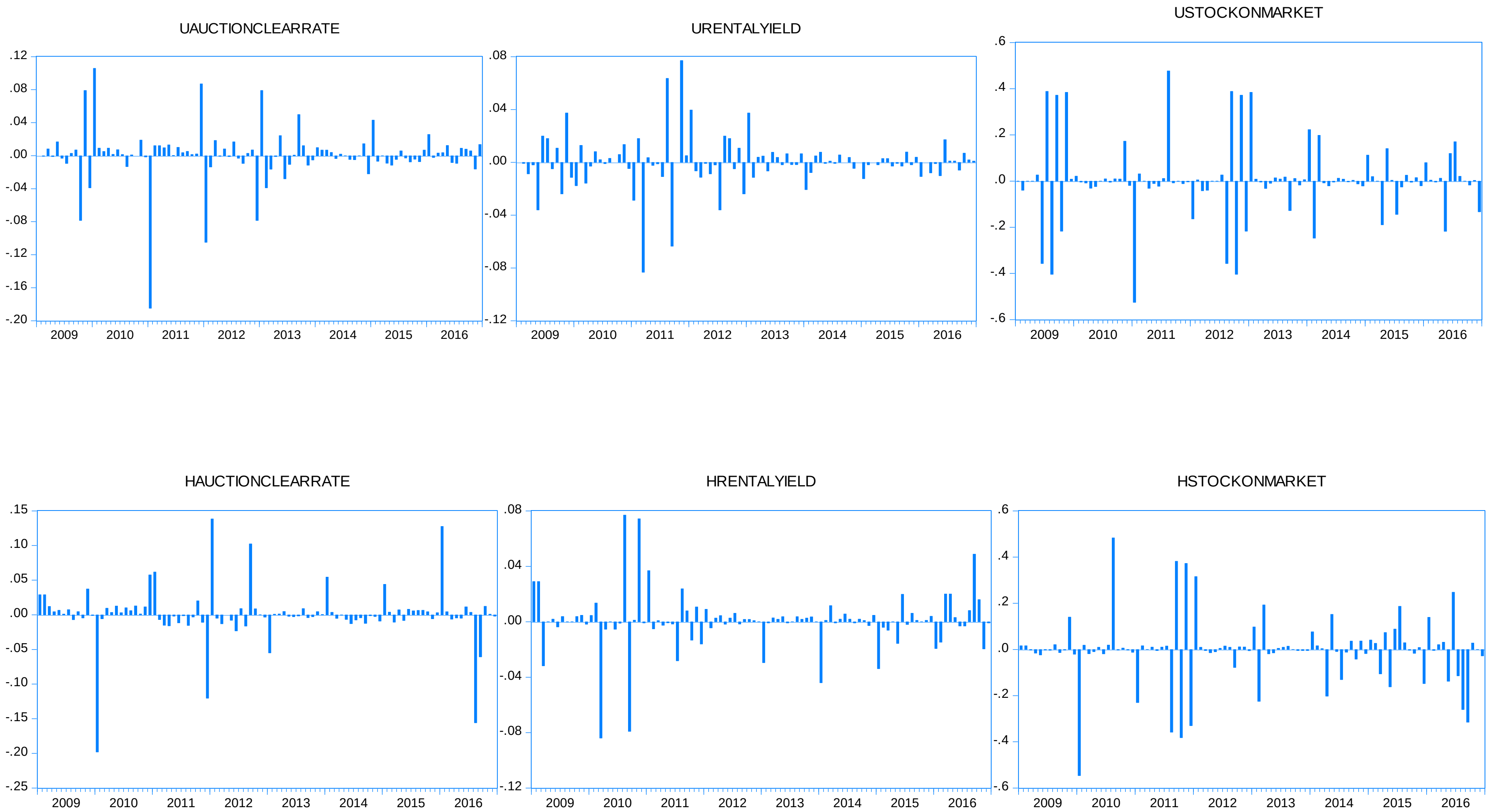


Figure 4. 7 QQ plot of real estate fundamental variables returns for VIC monthly data from 2009-2016

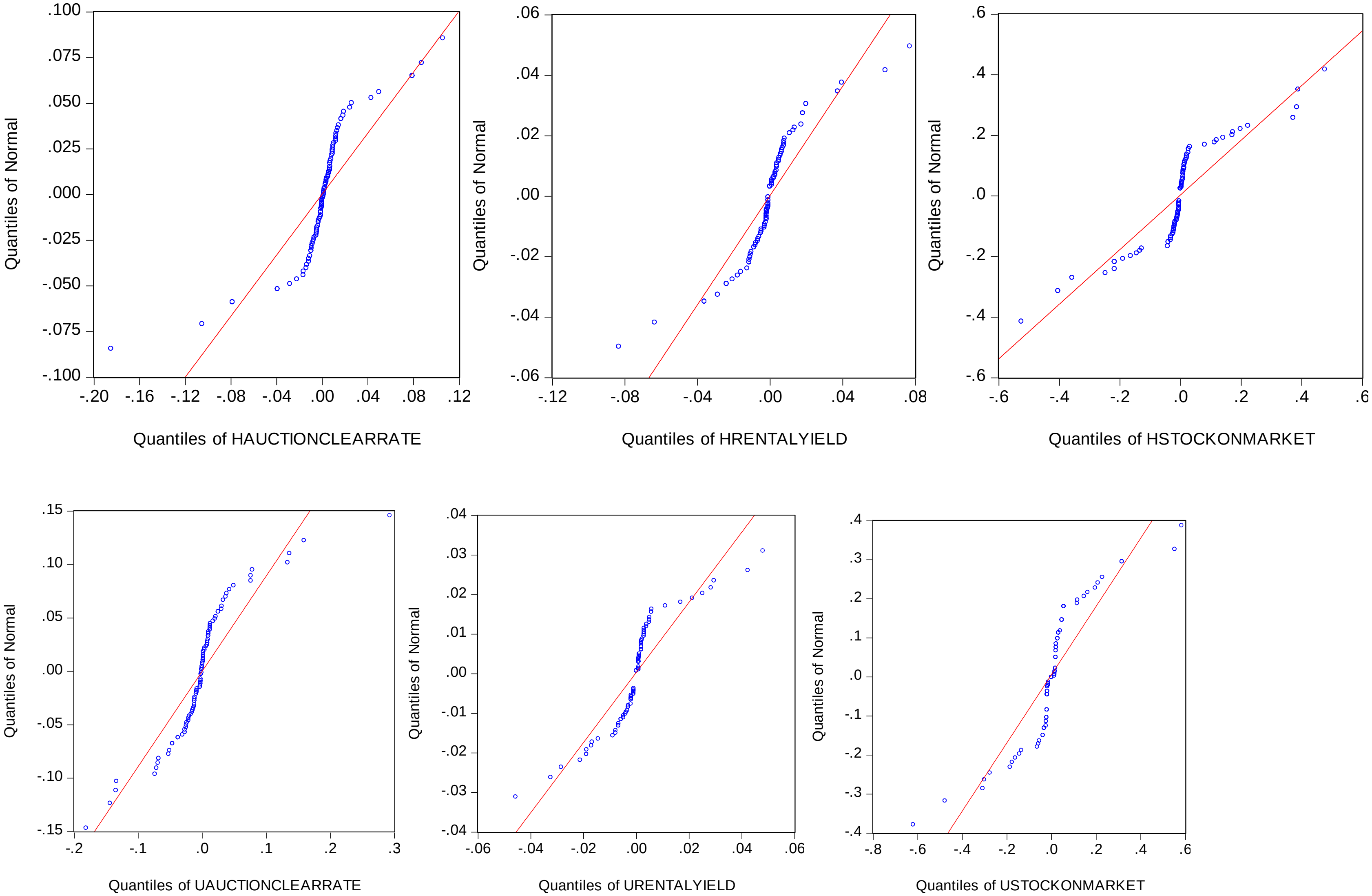


Figure 4. 8 Monthly return of VIC real estate from 2009 to 2016

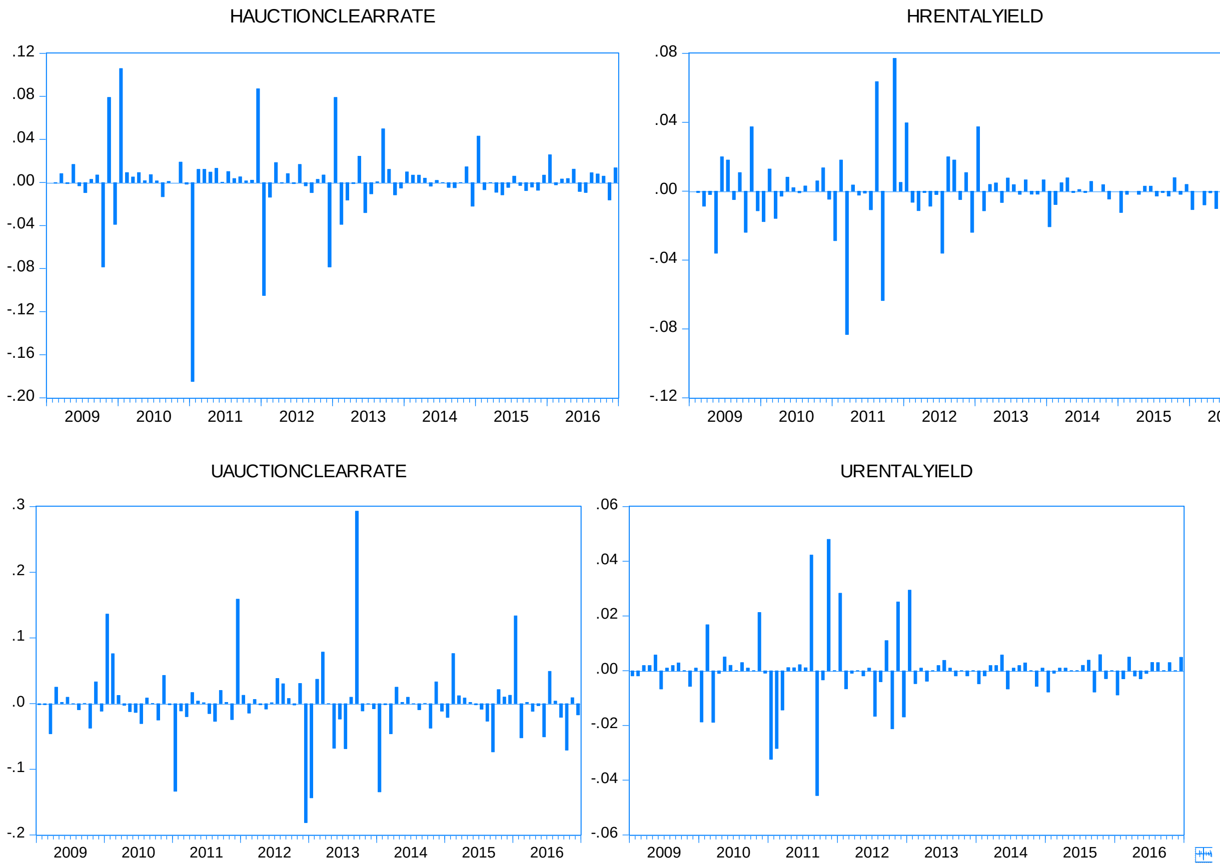


Figure 4. 9 QQ plot of real estate fundamental variables returns for QLD monthly data from 2009-2016

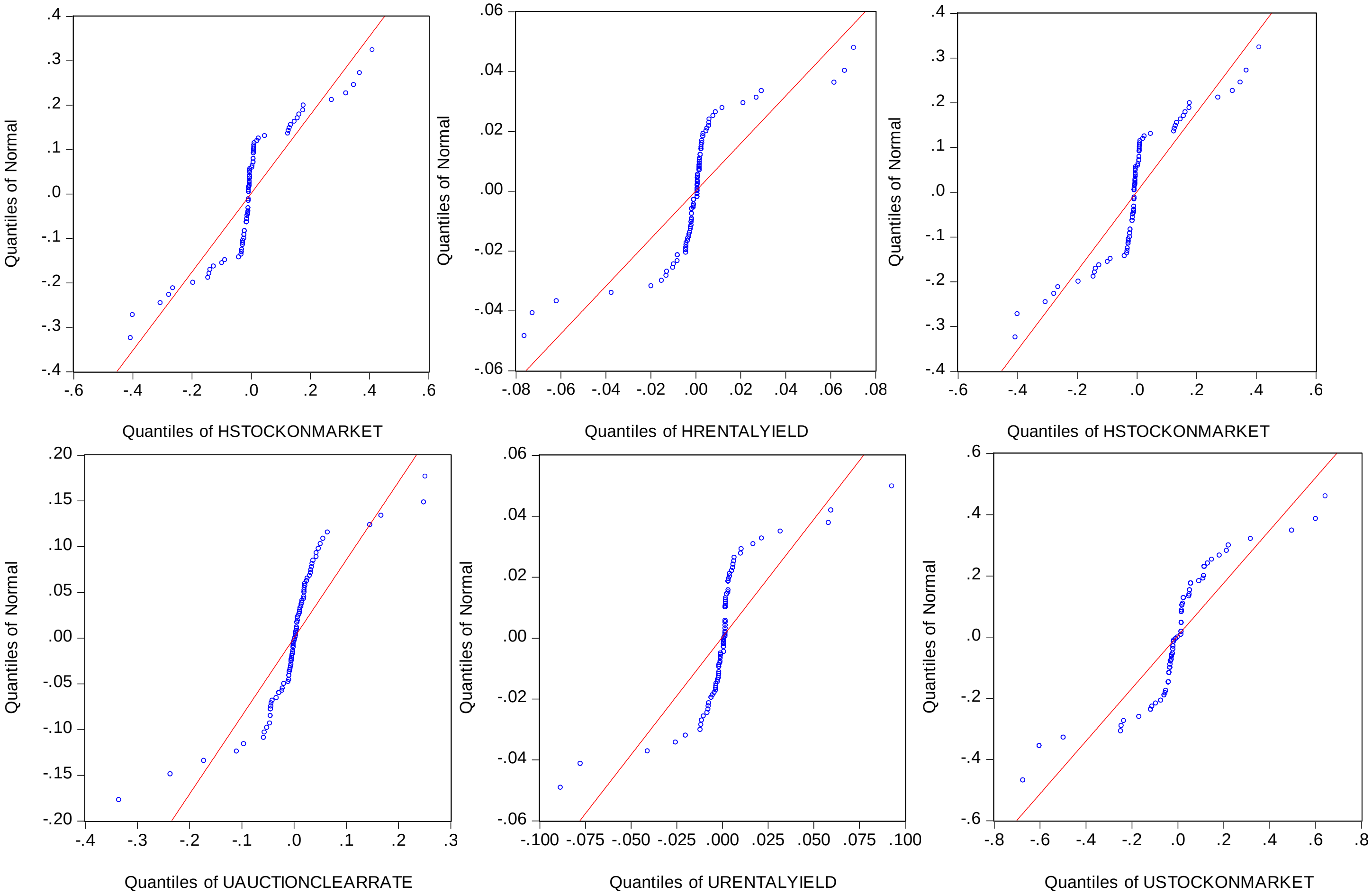
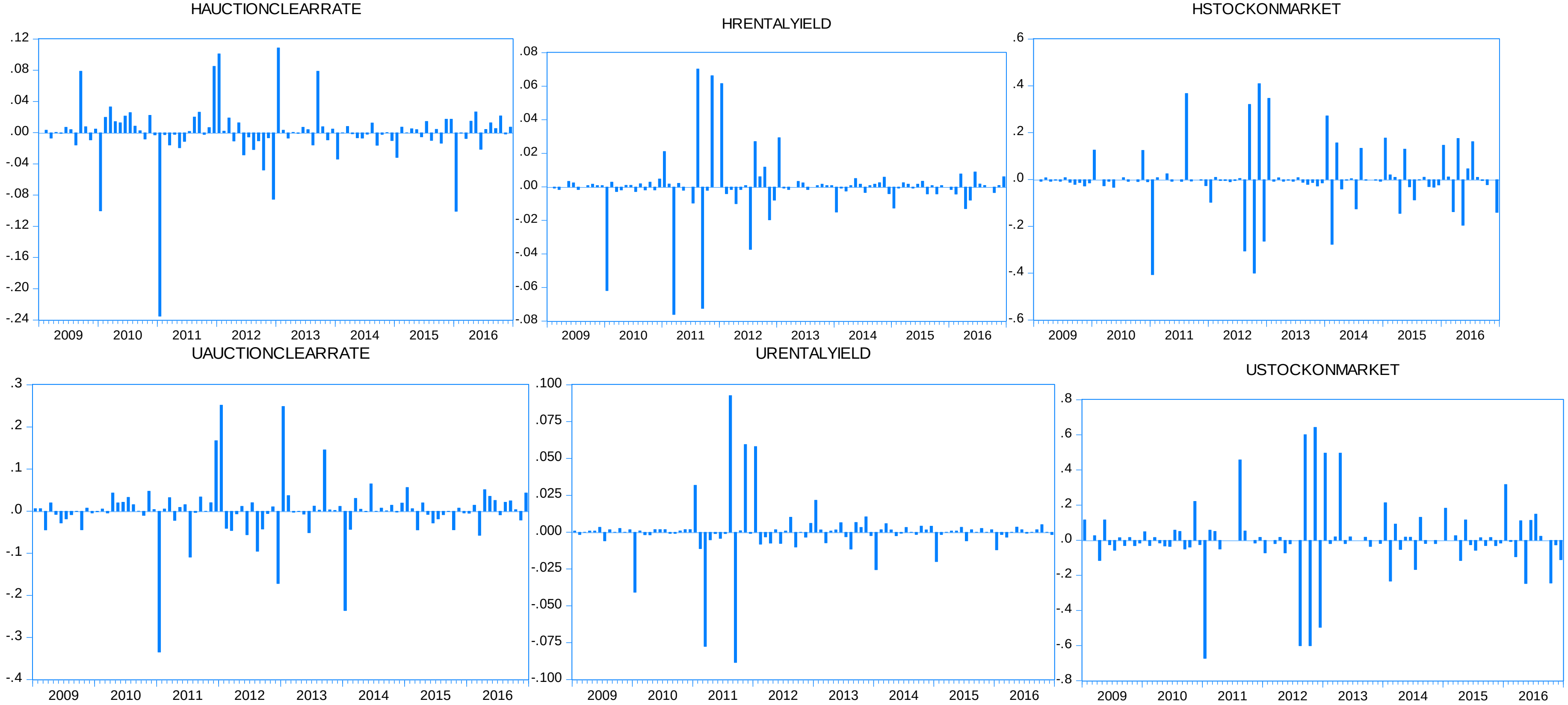


Figure 4. 10 Monthly return of QLD real estate from 2009 to 2016



4.5 Empirical Results

This study contains two individual findings related to real estate market return in Australia: the findings of the effect of the real estate fundamental variables on the housing and unit price for three major states in Australia by using monthly data from 2009 to 2016 are presented in Tables 4.3, 4.4, and 4.5 respectively. We use a VAR model. Second findings, in this study we use the fixed effect and random effect model to examine the relationship between the REITs and the macroeconomic variables by using monthly panel data from 2009 to 2016, as presented in Tables 4.6 and 4.7.

Table 4.3 represents VAR model findings; this estimation is examining the dynamic structure of the real estate variables at house price and unit price for NSW. Table 4.3 reveals that the lagged value (-2) of NSW house price is significant at the 1% level for NSW house price, while the lagged value of average stock on the market is significant at the 1% level and 10% with rental yield. This suggests that there is causation from rental yield to NSW housing auction clearance rates. For house auction clearance rates, there is no significant relationship between the auction clearance rate and the lagged value of the three variables. Table 4.3 shows that there is causality from the auction clearance rate to the stock on the market.

For NSW units, the outcomes show that there is a negative relationship between the NSW unit price return and the lagged value (-2) of unit price at the 1% level, while it is positive with rental yield return at the 5% level of significance. The lagged value (-2) of the rental yield is positively significant at the 1% level. For auction clearance rate for NSW units, the results show that the rental yield lagged (-1) is positively significant at the 1%, which means that when the rental yield goes up, the auction clearance rate will increase. For the average stock on the market for NSW units, the unit price and average auction clearance impact negatively on the stock on the market.

Overall, the average rental yield impacts positively on the average NSW real estate price and auction clearance rate, which means that the rental yield makes buyers more confident to invest their money in the NSW real estate market.

Table 4.3 VAR model estimation for NSW real estate from 2009 to 2016

	NHP	ARY	AAC	ASM		NUP	ARY	AAC	ASM
NHP(-1)	-0.093582	0.003171	0.049335	-0.000628	NUP(-1)	-0.026669	-0.012859	0.147050	0.002652
	(0.1029)	(0.0061)	(0.1452)	(0.0085)		(0.1047)	(0.0087)	(0.1767)	(0.0021)
	[-0.9599]	[0.4745]	[0.3303]	[-0.0732]		[-0.2556]	[-1.8749]	[0.8324]	[1.2301]
	0.3656	0.6369	0.7348	0.9416		0.7992	0.2670	0.2602	0.215
NHP(-2)	-0.268945	-0.010689	0.108961	0.002393	NUP(-2)	-0.361019	0.001378	-0.474340	-0.010380
	(0.1022)	(0.0069)	(0.1400)	(0.0854)		(0.1022)	(0.0090)	(0.1771)	(0.0017)
	[-2.6132]	[-1.5913]	[0.7545]	[0.2804]		[-3.4304]	[0.1976]	[-2.6718]	[-4.7926]
	0.0094***	0.1109	0.4529	0.7794		0.0007***	0.0620*	0.2602	0.00***
ARY(-1)	2.098990	0.695575	0.244852	0.047467	ARY(-1)	-0.861395	0.702590	1.136582	-0.019524
	(1.5028)	(0.0976)	(2.1124)	(0.1265)		(1.6219)	(0.1067)	(2.7306)	(0.0337)
	[1.3966]	[7.1222]	[0.1156]	[0.380]		[-0.5310]	[6.616]	[0.4156]	[-0.5859]
	0.1634	0.0000***	0.9080	0.7036		0.5956	0.8418	0.007***	0.59
ARY(-2)	-1.472383	0.102723	-1.414409	-0.173777	ARY(-2)	1.757970	0.177508	-2.773549	0.003364
	(1.5119)	(0.0985)	(2.1299)	(0.1240)		(1.6556)	(0.1026)	(2.7861)	(0.0339)
	[-0.9738]	[1.0455]	[-0.6646]	[-1.3883]		[1.0643]	[1.6399]	[-0.9949]	[0.0989]
	0.3308	0.2965	0.5071	0.1667		0.287	0.0000***	0.6780	0.9212
AAC(-1)	-0.038194	-0.005675	0.983321	0.013655	AAC(-1)	0.012952	0.003466	0.785031	0.001208
	(0.0572)	(0.0057)	(0.1207)	(0.0071)		(0.0392)	(0.0019)	(0.1083)	(0.0012)
	[-0.4457]	[-1.0186]	[8.1475]	[1.9069]		[0.2064]	[0.8727]	[7.2804]	[0.851]
	0.6562	0.3090	0.0000***	0.0556		0.2879	0.1020	0.3202	‘’0.3590
AAC(-2)	0.038080	0.005086	-0.141529	-0.017083	AAC(-2)	0.013434	-0.001126	0.010415	-0.002477
	(0.0852)	(0.0055)	(0.1201)	(0.0070)		(0.0644)	(0.0042)	(0.1086)	(0.0013)
	[0.4469]	[0.9178]	[-1.1786]	[-2.4144]		[0.2080]	[-0.2667]	[0.0956]	[-1.8690]
	0.6555	0.3593	0.2396	0.0162		0.8395	0.4087	0.0000	‘’0.0625’’
ASM(-1)	1.397955	-0.152865	-1.447285	0.425273	ASM(-1)	4.373779	0.107646	-12.38144	0.519337
	(1.3914)	(0.0992)	(1.9110)	(0.1104)		(4.8705)	(0.3124)	(8.1611)	(0.1024)
	[0.9915]	[-1.6818]	[-0.7345]	[3.6644]		[0.8904]	[0.3379]	[-1.5097]	[5.1800]
	0.3184	0.0936*	0.4633	0.0003***		0.8349	0.7898	0.9237	‘‘0.0000’’
ASM(-2)	-1.584994	0.274620	0.361623	0.244992	ASM(-2)	-2.639703	0.339425	5.726302	0.152595
	(1.3812)	(0.0874)	(1.9556)	(0.1154)		(4.8108)	(0.3162)	(8.2286)	(0.0910)

	[-1.1770]	[3.0004]	[0.1887]	[2.1390]		[-0.5482]	[1.0752]	[0.7046]	[1.5379]
	0.2519	0.0024***	0.8527	0.0332		0.3698	0.7362	0.1327	0.1245
C	-0.025612	0.008382	0.131915	0.010094	C	-0.055421	0.003685	0.183126	0.001999
	(0.0546)	(0.0036)	(0.0715)	(0.0054)		(0.0484)	(0.0027)	(0.0848)	(0.0010)
	[-0.4671]	[2.3545]	[1.7096]	[2.2224]		[-1.1193]	[1.1277]	[2.1794]	[1.9484]
R-squared	0.113371	0.682779	0.745825	0.441542	R-squared	0.137479	0.711853	0.666245	0.521047
Adj. R-squared	0.029923	0.652923	0.721903	0.388981	Adj. R-squared	0.056301	0.684733	0.634832	0.475970
Sum sq. resids	0.068833	0.000291	0.136612	0.000474	Sum sq. resids	0.053015	0.000228	0.150872	2.25E-05
S.E. equation	0.028457	0.001849	0.040090	0.002360	S.E. equation	0.024974	0.001637	0.042130	0.000514
F-statistic	1.358587	22.86903	31.17692	8.400603	F-statistic	1.693544	26.24854	21.20971	11.55883
Log likelihood	205.9302	462.8897	173.7133	439.9563	Log likelihood	218.2022	474.3488	169.0468	583.2387

The VAR model is estimated by equation 4.4 for house price (HP), unit price (UP), average rental yield (ARY), average auction clearance rate (AAC) and average stock on market (ASM). () and [] denote standard error and t-statistics respectively. ***, **, * denote the significance of the coefficients at 1%, 5% and 10%.

Table 4.4 shows the results of the Victorian real estate fundamental variables covering the period starting from 2009 to 2016 by the applied vector autoregression (VAR) model. The outcomes indicate the auction clearance rate is negatively affected by the Victorian house price at the 5% level of significance. While the lagged value (-2) of the stock on the market is affected positively by the Victoria house rental yield at the 5% significance level. For the auction clearance rate, the both house price lagged value is negatively significant on the auction clearance rate at the 5% level of significance.

This result is consistent with our previous results. The previous results show that there is a negative relationship between the auction clearance rate and the Victorian house price. Table 4.5 indicates that the house price is negatively affected by the average stock on the market.

For Victorian unit fundamental variables, the results display that there is no relationship between the five fundamental variables and the unit price volatility. The outcomes show that the Victorian house price is negatively significant with unit rental yield at the 5% level of significance. For auction clearance rate, the lagged value of the unit price volatility is negatively significant at the 5% level of significance. While stock on the market is negatively significant at the 5% significance level. For the stock on the market, Table 4.6 indicates that there is a negative relationship between the average unit price volatility and the stock on the market at the 5% significance level. This result is consistent with Victorian house price outcomes.

In summary, the Victorian real estate price negatively effects the rental yield and the auction clearance rate, which means that when the Victorian real estate price increases, the average rental yield and the auction clearance rate decrease.

Table 4. 4 VAR model estimation for VIC real estate from 2009 to 2016

	VHP	ARY	AAC	ASM		VUP	ARY	AAC	ASM
VHP(-1)	-0.087034	-0.009756	-0.359878	-0.017444	VUP(-1)	-0.069376	-0.010786	-0.335282	-0.005555
	(0.10658)	(0.00592)	(0.11014)	(0.00785)		(0.10023)	(0.00370)	(0.20354)	(0.00229)
	[-0.81659]	[-1.64723]	[-3.26748]	[-2.22072]		[-0.69215]	[-2.91649]	[-1.64724]	[-2.42806]
	0.4147	0.1004	0.0012**	0.0270**		0.4893	0.8893	0.0020	0.4876
VHP(-2)	-0.375843	-0.002227	-0.223312	-0.003285	VUP(-2)	-0.301770	-0.007529	0.100822	-0.001296
	(0.11290)	(0.00627)	(0.11667)	(0.00832)		(0.08424)	(0.00311)	(0.17106)	(0.00192)
	[-3.32889]	[-0.35503]	[-1.91402]	[-0.39483]		[-3.58232]	[-2.42253]	[0.58939]	[-0.67377]
	0.0010**	0.7228	0.0565*	0.6932		0.0004**	0.0038	0.1004*	0.0157
ARY(-1)	-1.285013	0.616526	-2.246522	0.127182	ARY(-1)	-0.606603	0.646369	2.810824	0.005746
	(1.89836)	(0.10549)	(1.96172)	(0.13991)		(2.80686)	(0.10356)	(5.69982)	(0.06407)
	[-0.67691]	[5.84433]	[-1.14518]	[0.90906]		[-0.21611]	[6.24132]	[0.49314]	[0.08967]
	0.4989	0.0000***	0.2529	0.3640		0.8290	0.0159	0.5560	0.5009
ARY(-2)	0.222185	0.122819	-0.182756	-0.198131	ARY(-2)	0.318485	0.148631	-2.035524	-0.013534
	(1.87088)	(0.10396)	(1.93332)	(0.13788)		(2.78457)	(0.10274)	(5.65456)	(0.06356)
	[0.11876]	[1.18135]	[-0.09453]	[-1.43698]		[0.11437]	[1.44667]	[-0.35998]	[-0.21292]
	0.9055	0.2383	0.9247	0.1516		0.9090	0.0000***	0.6222	0.9286
AAC(-1)	-0.251419	0.004444	0.569750	0.001097	AAC(-1)	-0.071601	0.000375	0.949649	5.36E-06
	(0.11237)	(0.00624)	(0.11612)	(0.00828)		(0.05212)	(0.00192)	(0.10585)	(0.00119)
	[-2.23737]	[0.71173]	[4.90644]	[0.13241]		[-1.37366]	[0.19523]	[8.97187]	[0.00450]
	0.0259**	0.4771	0.0000***	0.8947		0.1705	0.1489	0.7191	0.8315
AAC(-2)	0.164109	-0.004624	0.146043	-0.005108	AAC(-2)	0.066870	-0.001232	-0.219009	-0.000754
	(0.10996)	(0.00611)	(0.11363)	(0.00810)		(0.05192)	(0.00192)	(0.10543)	(0.00119)
	[1.49238]	[-0.75668]	[1.28520]	[-0.63034]		[1.28796]	[-0.64318]	[-2.07725]	[-0.63656]
	0.1365	0.4498	0.1996	0.5289		0.1986	0.8453	0.0000***	0.9964
ASM(-1)	2.563592	-0.141673	1.101366	0.487849	ASM(-1)	5.596446	-0.240752	-8.537645	0.542233
	(1.67109)	(0.09286)	(1.72686)	(0.12316)		(4.65121)	(0.17161)	(9.44510)	(0.10617)
	[1.53409]	[-1.52563]	[0.63779]	[3.96122]		[1.20322]	[-1.40288]	[-0.90392]	[5.10713]
	0.1259	0.1280	0.5240	0.0001**		0.2297	0.5205	0.0385	0.5248
ASM(-2)	-0.980202	0.291061	1.534384	0.287399	ASM(-2)	-3.907503	0.292624	-0.849675	0.234251
	(1.69291)	(0.09407)	(1.74941)	(0.12476)		(4.65189)	(0.17164)	(9.44649)	(0.10619)
	[-0.57900]	[3.09394]	[0.87709]	[2.30353]		[-0.83998]	[1.70489]	[-0.08995]	[2.20601]
	0.5630	0.0021**	0.3811	0.0219**		0.2297	0.1616	0.3667	0.0000***

C	0.074542	0.010215	0.212270	0.006929	C	0.011264	0.009272	0.114080	0.001225
	(0.06884)	(0.00383)	(0.07114)	(0.00507)		(0.08084)	(0.00298)	(0.16416)	(0.00185)
	[1.08282]	[2.67021]	[2.98393]	[1.36576]		[0.13934]	[3.10851]	[0.69491]	[0.66369]
R-squared	0.157533	0.631714	0.613528	0.447451	R-squared	0.161735	0.671855	0.657107	0.553128
Adj. R-squared	0.078242	0.597052	0.577154	0.395446	Adj. R-squared	0.082839	0.640971	0.624834	0.511070
Sum sq. resids	0.073048	0.000226	0.078005	0.000397	Sum sq. resids	0.070530	9.60E-05	0.290840	3.68E-05
S.E. equation	0.029315	0.001629	0.030294	0.002160	S.E. equation	0.028806	0.001063	0.058495	0.000658
F-statistic	1.986773	18.22488	16.86731	8.604065	F-statistic	2.049987	21.75401	20.36131	13.15139
Log likelihood	203.1366	474.8076	200.0506	448.2677	Log likelihood	204.7855	514.9519	138.1988	560.0889

The VAR model is estimated by equation 4.4 for house price (HP), unit price (UP), average rental yield (ARY), average auction clearance rate (AAC) and average stock on market (ASM). () and [] denote standard error and t-statistics respectively. ***, **, * denote the significance of the coefficients at 1%, 5% and 10%.

Table 4.5 exemplifies the vector autoregression (VAR) model outcomes. The results demonstrate that there is a negative relationship between the auction clearance rate and the Queensland house prices for the period from 2009 to 2016, while the average clearance rate is not significant with Queensland unit prices return.

For Queensland rental yield, the average auction clearance lag value is positively significant at the 1% level of significance, while it is insignificant with Queensland unit rental yield. The Queensland auction clearance outcomes show that the lag value of Queensland house and unit prices returns negatively effects the Queensland auction clearance at the 5% level of significance, which means that when the house price goes up, the Queensland auction clearance rate drops down.

Table 4.5 displays that there is a positive relationship between the Queensland house and unit prices returns and the average stock on the market. The lag value of Queensland average stock on the market significantly effects the average stock on the market at the 5% significance level.

Table 4. 5 VAR model estimation for QLD real estate from 2009 to 2016

	QHP	ARY	AAC	ASM		QUP	ARY	AAC	ASM
QHP(-1)	-0.277977	0.023990	-0.653789	-0.027903	QUP(-1)	-0.180327	0.010294	-0.989016	-0.021652
	(0.10553)	(0.01532)	(0.18861)	(0.01892)		(0.10566)	(0.02000)	(0.38283)	(0.00718)
	[-2.63422]	[1.56594]	[-3.46641]	[-1.47466]		[-1.70667]	[0.51470]	[-2.58346]	[-3.01474]
	0.0088***	0.9036	0.0148	0.1412		0.0888	0.6071	0.0039***	0.0028***
QHP(-2)	-0.434913	0.017943	-0.152038	-0.021954	QUP(-2)	-0.247969	0.015541	-0.012031	-0.006369
	(0.10940)	(0.01588)	(0.19552)	(0.01962)		(0.07232)	(0.01369)	(0.26204)	(0.00492)
	[-3.97559]	[1.12980]	[-0.77759]	[-1.11920]		[-3.42854]	[1.13518]	[-0.04591]	[-1.29547]
	0.0001***	0.9036	0.0006***	0.2638		0.0007	0.2571	0.0102**	0.1960
ARY(-1)	0.569172	0.656021	0.442634	0.147074	ARY(-1)	0.133696	0.631225	1.331438	0.017892
	(0.74265)	(0.10781)	(1.32735)	(0.13316)		(0.58448)	(0.11064)	(2.11768)	(0.03973)
	[0.76640]	[6.08471]	[0.33347]	[1.10447]		[0.22874]	[5.70542]	[0.62872]	[0.45034]
	0.4440	0.1183	0.4374	0.7166		0.8192	0.0000***	0.9634	0.6528
ARY(-2)	-0.275050	0.151241	-0.210274	-0.048236	ARY(-2)	-0.064568	0.124270	0.600443	0.010776
	(0.74045)	(0.10750)	(1.32342)	(0.13277)		(0.57507)	(0.10885)	(2.08359)	(0.03909)
	[-0.37146]	[1.40696]	[-0.15889]	[-0.36331]		[-0.11228]	[1.14161]	[0.28818]	[0.27568]
	0.7105	0.2594	0.7390	0.4802		0.9107	0.2571	0.9634	0.7830
AAC(-1)	-0.146923	0.010578	0.921334	-0.007913	AAC(-1)	-0.030489	0.007276	0.813425	-0.001194
	(0.06243)	(0.00906)	(0.11159)	(0.01119)		(0.03043)	(0.00576)	(0.11024)	(0.00207)
	[-2.35324]	[1.16700]	[8.25641]	[-0.70681]		[-1.00210]	[1.26346]	[7.37900]	[-0.57717]
	0.0192	0.0000	0.8739	0.6465		0.3170	0.2073	0.5300	0.5642
AAC(-2)	0.095085	-0.006712	-0.125931	-0.005130	AAC(-2)	0.038470	-0.001052	-0.180128	-0.000906
	(0.06233)	(0.00905)	(0.11141)	(0.01118)		(0.03025)	(0.00573)	(0.10961)	(0.00206)
	[1.52545]	[-0.74171]	[-1.13036]	[-0.45897]		[1.27169]	[-0.18371]	[-1.64342]	[-0.44056]
	0.1281	0.1604	0.0000***	0.0001***		0.2044	0.8544	0.7734	0.6598
ASM(-1)	0.140545	-0.079676	0.471425	0.438046	ASM(-1)	1.542315	-0.126706	1.209701	0.576157
	(0.61516)	(0.08931)	(1.09949)	(0.11030)		(1.57124)	(0.29742)	(5.69287)	(0.10680)
	[0.22847]	[-0.89216]	[0.42877]	[3.97128]		[0.98159]	[-0.42602]	[0.21249]	[5.39452]
	0.8194	0.2440	0.2591	0.0001		0.3270	0.6704	0.0000***	0.0000***
ASM(-2)	-0.330149	0.193232	0.162443	0.322856	ASM(-2)	-0.304750	0.325718	4.349879	0.255911
	(0.61810)	(0.08973)	(1.10474)	(0.11083)		(1.54839)	(0.29309)	(5.61008)	(0.10525)
	[-0.53413]	[2.15341]	[0.14704]	[2.91306]		[-0.19682]	[1.11131]	[0.77537]	[2.43144]
	0.5936	0.4588	0.6684	0.0038***		0.8441	0.2672	0.1012	0.0156**

C	0.002448	0.007178	0.039086	0.001408	C	-0.008644	0.010039	-0.013662	-0.000451
	(0.02019)	(0.00293)	(0.03609)	(0.00362)		(0.01823)	(0.00345)	(0.06604)	(0.00124)
	[0.12125]	[2.44855]	[1.08304]	[0.38884]		[-0.47423]	[2.90941]	[-0.20686]	[-0.36363]
R-squared	0.228012	0.725423	0.739401	0.530311	R-squared	0.168458	0.665725	0.617922	0.585358
Adj. R-squared	0.155354	0.699580	0.714874	0.486105	Adj. R-squared	0.090195	0.634264	0.581962	0.546333
Sum sq. resids	0.014072	0.000297	0.044952	0.000452	Sum sq. resids	0.009196	0.000330	0.120725	4.25E-05
S.E. equation	0.012867	0.001868	0.022997	0.002307	S.E. equation	0.010402	0.001969	0.037687	0.000707
F-statistic	3.138165	28.07084	30.14638	11.99635	F-statistic	2.152469	21.16022	17.18348	14.99952
Log likelihood	280.5429	461.9453	225.9557	442.0962	Log likelihood	300.5347	456.9962	179.5240	553.2656
Akaike AIC	-5.777508	-9.637135	-4.616079	-9.214812	Akaike AIC	-6.202866	-9.531834	-3.628170	-11.58012

The VAR model is estimated by equation 4.4 for house price (HP), unit price (UP), average rental yield (ARY), average auction clearance rate (AAC) and average stock on market (ASM). () and [] denote standard error and t-statistics respectively. ***, **, * denote the significance of the coefficients at 1%, 5% and 10%.

Table 4. 6 reports the Hausman's test to compare the fixed effect model and the random effect model

Correlated Random Effects – Hausman Test Equation: Untitled Test cross-section random effects				
Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random		0.368905	4	0.9849
Cross-section random effects test comparisons:				
Variable	Fixed	Random	Var(Diff.)	Prob.
ASX	0.669344	0.669533	0.000000	0.5436
IR	-0.025477	-0.025531	0.000000	0.5436
TWI	0.344843	0.344819	0.000000	0.5436
OIL	-0.051974	-0.052098	0.000000	0.5436

We compared the random effect model to the fixed effect model by using Hausman's test, the outcomes show that we reject the ALT hypotheses: the fixed effect model is appropriate, and we accept the null hypothesis which means that the random effect variable is appropriate to our study.

Table 4. 7 Estimation outcomes of fixed and random effects models

Variables	**Fixed Effect Model**		**Random Effect Model**	
	coefficient	**P-Value**	**Coefficient**	**P-Value**
ASX	0.669344	0.0000	0.669533	0.0000
IR	-0.025477	0.3658	-0.025531	0.3648
TWI	0.344843	0.0000	0.344819	0.0000
OIL	-0.051974	0.0237	-0.052098	0.0234
R-squared	0.127012		0.116926	

Fixed and random effect models are estimated by equations 4.2 and 4.3 respectively for Australian stock market index (ASX), Australian 90-day bank accepted bills (IR), trade weight index (TWI), oil price (OIL). ***, **, * denote the significance of the coefficients at 1%, 5% and 10% respectively.

Based on Hausman's test, in order to test whether the cross-section random effects model is well specified, we ran the hausman test. The results show that the random effect model is appropriate in this study. Table 4.7 shows that the market risk is significantly positive at the 1% level for both models, suggesting that when the market index goes up by one point, this would increase the REITs companies return by one percentage. According to Table 4.7, which presents the random effect model, it can be observed that the oil price is statistically significant at the 2% significance level while the TWI is positively significant at the 1% level of significance. The interest rate is negatively insignificant with Australian REITs companies. This result is consistent with Lee (1997). He tried to forecast excess returns on the Standard and Poor 500 index with short term interest rate, but he found that there is no relationship between the two variables.

4.6 Conclusion

This study incorporates two individual aims, each of which make several distinct contributions to the literature review of finance. In the first aim, we investigate the effect of macroeconomic variables on the Australian REITs return from 2006 to 2016 by using monthly panel data. In the second aim, we examine the linkage between the fundamental factors and real estate market for three major states in Australia at unit level and house price level. These states are New South Wales (NSW), Victoria (VIC), and Queensland (QLD). This research uses monthly data covering the period from 2009 to 2016 by applying the VAR model. The topic is important to highlight since stocks and houses are large components of the Australian wealth. A connection could have a significant impact on the health of the general economy.

Panel monthly data of the REITS, housing market and macroeconomic variables from 2009 to 2016 are applied. The panel fixed, and random effect models analysis concluded that a positive and significant relationship exists between the market risk and TWI with the Australian REITs, hence the hypothesis of a positive connection was accepted. A vector autoregressive model (VAR) indicated that there is a positive relationship between the NSW real estate market and rental yield, while it is negative with auction clearance rate at the 5% level of significance. For Victoria, the real estate price has a positively significant effect on the Victoria rental yield and average stock on the market, while the auction clearance rate is negative.

For Queensland, there is a negative relationship between the auction clearance rate and the average stock on the market with Queensland's real estate price. The results of this chapter help portfolio managers to reduce exposures to interest rate risks inherent in property investments and they should choose externally managed REITs with low levels of debt. Internally managed REITs with high levels of debt have compounded benefits during extremely favourable market conditions, but also expose investors to extreme losses during market reversals. Investors looking to replicate direct real estate investments in their portfolios should select externally managed REITs or stapled ones with less borrowing.

For further research and improvements, the researchers can develop some of the more common and important factors such as expectation of future house prices, unexpected inflation, expected inflation. This study can be extended further by considering more Asian stock markets and including other important countries.

CHAPTER FIVE
CONCLUSION

5.1 Introduction

Foreign exchange rate price shocks and their volatility have a profound impact on the Australian stock market. Frequent jumps in price increase uncertainty, which creates an adverse environment for investors, market participants and policymakers. this thesis focuses on such foreign exchange shocks and evaluates their effect on the Australian stock market. In this research, we study the volatility of the major foreign exchange components of the Australian dollar, European EUR, and US dollar, and identify the effect of foreign exchange rate returns and volatility on each sector of the Australian stock market, evaluate volatility from the foreign exchange rate on the big four Australian banking, and finally identify the risk factors for the real estate market in Australia.

This thesis is timely, and the outcomes of thesis provide significant information to various groups of people, such as risk managers, portfolio managers, policy makers and market participants, who wish to understand the volatility of major foreign exchange markets. This thesis fills some gaps in the literature of financial economics which are specifically mentioned in each chapter. The foreign exchange market is one of the largest financial markets and efficient pricing requires accurate estimation of volatility.

The foreign exchange and the stock markets are considered two important sectors of the financial market, the findings of this thesis provide guidance on how investors can construct their portfolio. Not all the Australian sectors are equally sensitive to foreign exchange rate. This implies that risk diversification across industries is a possibility. When foreign exchange shocks are imminent, investors and market participants can adjust or rebalance their portfolio by looking at the sensitivity of each sector to the exchange rate shock and adjusting accordingly.

5.2 Overview and the major findings of the thesis

In chapter two, we estimate the volatility of five foreign exchange rate components: the US dollar, European euro, Japanese yen, and Singaporean dollar and the volatility of the six Australian sectors. This chapter investigates the influence of the volatility of five exchange rates' volatility on the six Australian sectors' volatility. The volatility in this chapter was estimated by using GARCH (1,1) models. In this study, daily data was collected for the period of 2002 to 2014. The dataset is divided into three sub-periods: before GFC (July 2002 to July 2007), during GFC (July 2007 to July 2009), and after GFC (July 2009 to July 2014).

The findings of this study demonstrate that the exchange rates of the five currencies affect the six Australian sectors' volatility before the GFC period, except for the financial sector. The same relationship is weakly evident during the GFC period, except for the IT sector. The five foreign exchange rates' volatility have a strong impact on the six Australian sectors volatility in the post-GFC period, except for the materials sector. The results obtained from this research are of potential interest to investors and other market participants to understand the risk factors related to the sectors of the Australian stock market. When foreign exchange rate shocks are imminent, investors and market participants can adjust their portfolios to shocks of different sectors.

In chapter three, we examine the volatility of the exchange rate return and the big four Australian banks, using unique high-frequency dataset- hourly data from September 2012 to September 2016. This study applies an extended version of the generalised autoregressive conditional heteroskedasticity specifications. The GARCH variants specification includes the basic GARCH, TGARCH, EGARCH and PARCH models. This study varies from the previous Australian research studies in that detached hourly returns are used over a four-year sample period.

The results from chapter three find that the Australian dollar volatility positively affects the big four banks in Australia in the four models and the short-term interest rate volatility negatively affects the big four banks volatility. The outcomes show that significant ARCH term and GARCH term impacts are present in the data and that the PARCH model used to the standard error defines the volatility process better than the other three models for the Commonwealth Bank (CBA), Westpac and National Australia Bank (NAB). In addition, the best model to describe the volatility for the Australia and New Zealand Banking Group (ANZ) is the TARCH model. This research finding is important for investors and relevant market participants to determine how long the shock persists in the volatility of the big four banks in Australia. This will help the market participant to build the right risk management strategies, and the shocks findings are important for generating volatility by helping the market participant to determine the direction of shocks (positive or negative).

Chapter four incorporates two aims of the Australian real estate market. First, this research investigates the effect of TWI[7] return on the Australian REITs volatility from 2006 to 2016 by using monthly panel data. We use fixed and random effect models. In the second aim, we examine the linkage between the fundamental factors and real estate market for three major states in Australia. Unit price and house price are employed in this chapter. These states are New South Wales (NSW), Victoria (VIC), and Queensland (QLD). This research uses monthly data covering the period from 2019 to 2016 by applying the VAR model.

The estimated results from chapter four reveal that the oil price is statistically significant at the 2% significance level, while the TWI is positively significant at the 1% level of significance. The interest rate is negatively insignificant with Australian REITs companies. A vector autoregressive model (VAR) indicated that there is a positive relationship between the NSW real estate market and rental yield, while it is negative with the auction clearance rate at the 5% level of significance. For Victoria, the real estate price has a positively significant effect on the Victoria rental yield and average stock on the market, while the auction clearance rate is negative. Based on Queensland, there is a negative relationship between the auction clearance rate and the average stock on the market with Queensland’s real estate price. The results of this chapter help portfolio managers to reduce exposures to interest rate risks inherent in property investments; they should choose externally managed REITs with low levels of debt. Internally managed REITs with high levels of debt have compounded benefits during extremely favourable market conditions, but also

[7] The Trade Weighted Index (TWI) is a weighted average of a basket of currencies that reflects the importance of the sum of Australia's exports and imports of goods by country.

expose investors to extreme losses during market reversals. Investors looking to replicate direct real estate investments in their portfolios should select externally managed REITs or stapled ones with less borrowing.

This study is important to provide valuable insights into the effects that macroeconomic factor movements are likely to have on REITs based in Australia. It shall give investors, investment managers and operational decision makers a better understanding of how they can manage their investments more effectively during times of any change happening in macroeconomics factors.

5.3 Future research and limitations

This thesis has some limitations, mainly in outcomes appropriate foreign exchange rate price series and in the analytical techniques used. In chapter two, GARCH models often fail to fully capture the tails observed in asset return series. Heteroskedasticity explains some of the tail behaviours, but typically not all of them. Tail distributions, such as student-t, have been applied in GARCH modelling, but often the choice of distribution is a matter of trial and error. Future research should consider applying n MGARCH and VAR approaches. The final suggestion is for future studies to add technical indicators like price momentum, moving average convergence-divergence (MACD), and relative strength index (RSI).

Chapter three is limited to the big four banks in Australia and the foreign exchange rate of Australia. In contrast, similar studies have compared other financial markets, such as the bond market (Andersen et al., 2007; Brenner et al., 2009; Kim, S-J &

Nguyen, 2008), or futures market (McCredie et al., 2013; Smales, 2012a). Evident by the low explanatory power of the models within this study, there are obviously factors other than foreign exchange rate influencing equity prices. Thus, the absence of other macroeconomic variables such as employment or GDP is a limitation. For further research, as the financial markets are becoming more globalised, it is important to take into account the shocks of Australia's major trading partners. Further analysis of the spillover effect from the US and other major economies, as well as domestic shocks, would improve the scope of this research (Kim & In, 2002). Thus, testing could include comparisons across countries or regions. For chapter four, one possible area for future research is to allow for multivariate time series models that would take correlations between different property types into account. For example, instead of modelling each property type individually, a multivariate model can model the price behaviour for the two property types simultaneously, allowing for the correlations between property types to be used in the modelling process.

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APPENDICES A 1

REITS NAME	ASX SYMBOL
1- 360 Capital Industrial Fund	TIX
2- 360 Capital Group	TGP
3- 360 Capital Office Fund	TOF
4- Abacus Property	ABP
5- ALE Property Group	LEP
6- Apn Property Group	APD
7- Arena REIT	ARF
8- Asia Pacific Data	AJD
9- Aspen Group	APZ
10- Astro Jap Property	AJA
11- Aventus Retail Fund	AVN
12- BWP Trust	BWP
13- Carindale Property	CDP
14- Centuria Metro REIT	CMA
15- Charter Hall Group	CHC
16- Charter Hall Retail	CQR
17- Cromwell	CMW
18- Dexus Property Group	DXS
19- Elanor Investors	ENN
20- Folkestone Education	FET
21- Folkestone Limited	FLK
22- Galileo Japan Trust	GJT

23- Goodman Group	GMG
24- Growthpoint Property	GOZ
25- Hotel Property	HPI
26- Industria REIT	IDR
27- Ingenia Group	INA
28- Investa Office Fund	IOF
29- Lendlease Group	LLC
30- Lifestyle Communities	LIC
31- Mantra Group	MTR
32- Mirvac Group	MGR
33- National Storage	NSR
34- Rural Funds Group	RFF
35- SCA Property Group	SCP
36- Scentre Grp	SCG
37- Stockland	SGP
38- Sunland Group Ltd	SDG
39- Villa World Ltd.	VLW