The reaction of the Australian stock market to monetary policy announcements from the RBA

Alexandra Brown

December 2014

Disclaimer and Copyright

The views and opinions expressed in this report are solely that of the author's and do not reflect the views and opinions of the Australian Prudential Regulation Authority.

Any errors in this report are the responsibility of the author. The material in this report is copyright.

The reaction of the Australian stock market to monetary policy announcements from the RBA

Alexandra Brown

Flinders University of South Australia

Acknowledgement of support provided by the Australian Prudential Regulation Authority and the Brian Gray Scholarship in writing this report

Principal Supervisor: Dr Sigitas Karpavicius

Associate Supervisor: Professor Sarath Delpachitra

December 2014

ABSTRACT

How interest rates flow through financial markets and the economy is an important topic for academics, policy makers and market participants. Of particular importance is how monetary policy decisions are transmitted to the equity market. The aim of this thesis is to explore the effect of monetary policy decisions by the Reserve Bank of Australia (RBA) on the Australian stock market. Represented by the All Ordinaries index, this research utilises Ordinary Least Squares and Robust Standard Errors methodology to ascertain market reaction to target cash rate announcements. The research provides a unique perspective by investigating what proportion of the change in the Australian stock market may be attributed to unexpected policy announcements.

Having determined market expectation of the cash rate using 30-day interbank futures contracts, this study finds that decomposing the raw cash rate change improves the statistical significance of results, but results offer only a small fraction of explanation for the overall variability of stock returns. The release of RBA Board meeting explanatory minutes provides a small but positive effect on 1-day returns when considering the associated cash rate change, but the overall response is statistically insignificant. Moreover, there is weak evidence that the improved communication practices of the RBA from December 2007 have made a significant impact on the variability of returns.

Asset prices play a fundamental role in several channels throughout the economy, thus it is important to gain a wider understanding of the transmission mechanism and identify the link between monetary policy and equities.

TABLE OF CONTENTS

FIGURES

TABLES

Section 1 Introduction

This thesis explores the effect of monetary policy decisions by the Reserve Bank of Australia (RBA) on the Australian stock market. Understanding the impact of RBA announcements on equity prices will assist with both policy-maker and investor decisions. To gain insight, this research investigates many factors surrounding policy decisions that may contribute to a change in stock prices. Factors explored include the expected and surprise components of a policy decision, magnitude of the rate change, directional influence and the effect of a new policy communication regime.

1.1 Background to the Research

1.1.1 Monetary policy and the Reserve Bank of Australia

The RBA is Australia's central bank and responsible for monetary policy. Monetary policy meetings of the RBA Board are held eleven times per year on the first Tuesday of each month, except January. Monetary policy decisions are expressed in terms of a target for the cash rate, which is the overnight money market interest rate. The RBA sets interest rate targets with the aim of maintaining currency stability and full employment within Australia as well as preserving the economic prosperity and welfare of Australians (RBA, 2013).

1.1.2 Monetary transmission mechanism

How interest rates flow through financial markets and the economy is an important topic for academics, policy makers and market participants. Referred to as the transmission mechanism, it is the process through which monetary policy decisions are transmitted into changes in real GDP and inflation (Taylor, 1995). Monetary transmission operates mainly through the effects that

monetary policy has on interest rates, exchange rates, asset prices and banks' willingness to supply funds. This thesis focuses on asset prices in the form of publicly listed equities, using the All Ordinaries market index (All Ords) as a benchmark for Australian equity prices.

1.2 Justification for the research

Asset prices play a fundamental role in several channels throughout the economy, thus it is important to gain a wider understanding of the transmission mechanism and identify the link between monetary policy and equities (Bernanke & Kuttner, 2005; Laeven & Tong, 2012; Rosa, 2011).

1.2.1 Policy makers can affect stock prices

There is an ongoing debate in monetary policy rules literature between the proactive (using changes in interest rates to steer the economy or to control stock price bubbles, based on future expectation), and reactive approach (making interest rate decisions according to economic data). Both approaches rely on the assumption that policy makers can affect stock prices (Ioannidis & Kontonikas, 2008). Thus, establishing quantitatively the existence of a stock market response to monetary policy changes provides a deeper understanding of the potential economic impact of policy actions or inactions (Ioannidis & Kontonikas, 2008; Kurov, 2012; Rigobon & Sack, 2004).

1.2.2 Monetary policy affects decision making

The significance of research into the monetary transmission mechanism is widely mentioned in the literature and focuses on the needs of two important groups; policy makers and market participants. To conduct monetary policy effectively, central banks need to understand their

influence on markets via their control over interest rates as well as the influence of market expectation and how market participants adjust their views in response to a given decision (Kim, S-J & Nguyen, 2008; Smales, 2012a). Stock market participants should be aware of this relation to manage portfolios and to formulate effective investment and risk management strategies (Rigobon & Sack, 2004).

1.2.3 Limited Australian literature

This study will also fill a gap in Australian literature relating to this topic. Being a small economy in comparison to the US or Europe has meant less research on the announcements of the RBA and a lack of focus on the Australian stock market. However, understanding the transmission mechanism is important for not only the Australian economy, policy makers and market participants, but for international decision makers due to the global nature of financial markets.

1.3 Research Problem

The objective of this study is to support the decision making of policy makers, investors and also businesses and consumers, by determining how RBA monetary policy decisions impact the Australian stock market.

This thesis seeks to answer two main research problems. Firstly, by looking at the returns on the All Ords, it will investigate the impact of the RBA's monetary policy decisions on the level of stock returns. Secondly, this study will determine if the stock market reacts only to unanticipated rate decisions. This research takes on a quantitative approach; testing hypotheses through statistical inference.

1.3.1 Research Question #1

How does the Australian stock market, represented by the All Ordinaries index, react to interest rate announcements by the RBA?

To investigate this research question, multiple models are developed and tested using regression analysis. Independent variables include the raw cash rate change, positive, negative and large rate change dummies as well as interaction variables to determine if a change in monetary policy communication from 2008 affects the results.

To test if there is a significant impact on All Ords returns at the time of each RBA policy decision, an announcement dummy variable is used. The announcement of the policy decision may reveal new information not previously incorporated into asset prices and volatility is likely to rise while market participants process the newly received information (Bomfim, 2003; Harju & Hussain, 2011; Kim, S-J & Nguyen, 2008; Kim, S & In, 2002).

Directional analysis will consider the impact on stock returns if the cash rate is increased, decreased or kept on hold by the RBA. There is opposing literature on the asymmetric news effect of policy changes and many consider the differences to be associated with economic business cycles (Bomfim, 2003; Brenner, Pasquariello & Subrahmanyam, 2009; Kim, S-J & Nguyen, 2008; Smales, 2012a). Thus, directional influence models will include interaction variables to test if the surprise component is significant in periods of contraction or expansion within the Australian economy.

Previous research has found that the impact on stock returns' volatility is expected to be greater when the state of the economy is in a contraction, so the reaction of the Australian stock market is tested for state dependence by testing for the impact on returns before and after January 2008.

The state of the economy was contracting prior to 2008 due to global economic collapse surrounding the GFC. In 2009, markets were recovering and economies were expanding in comparison. Therefore, models are tested for a difference pre-2008 and post-2008.

This period approximately coincides with when the RBA changed its communication policies. In December 2007, the RBA implemented a new regime whereby meeting decisions became announced on the day and explanatory meeting minutes started to be released two weeks after each announcement(RBA, 2007). Therefore, testing is expected to show that the impact on stock returns is reduced with the introduction of more transparent communication practices.

1.3.2 Research Question #2

Using 30-day Interbank futures as a proxy for the market's anticipated rate changes, what proportion of the change in the Australian stock market may be attributed to unexpected policy announcements?

This research seeks to isolate the 'surprise' component of policy decisions using short-term interest rate futures data as a proxy for anticipated rate changes. This is accomplished using the method introduced by Kuttner (2001) and widely used in similar studies (Bernanke & Kuttner, 2005; Kim, S-J & Nguyen, 2008; Laeven & Tong, 2012; McCredie et al., 2013; Smales, 2012a). It is expected that there will be a significant impact on All Ords returns with unexpected RBA decisions.

The unexpected portion of market reaction is calculated using 30-day interbank futures contracts. The change in price of the interbank futures, relative to the day prior of the policy action, is scaled according to the day of the month and then subtracted from the actual change in the cash rate. Because financial market participants adjust their portfolios based upon their expectations

of the coming monetary policy announcements, if the actual target rate announced is different from that already priced, markets react to this surprise (or news) component accordingly (Kim, S-J & Nguyen, 2008).

To explore this research question, various regressions are estimated using a combination of independent variables. These include expected change, surprise change, actual change and announcement dummy, as well as interaction terms to gain a complete understanding of the impact of this surprise element. One reason for isolating the unanticipated component of the announcements is described in research by Bomfim (2003). Results from models used in this study, that failed to distinguish unanticipated news, report that announcements have only a small effect on stock market volatility. However, the news effect nearly doubled when the surprise component was isolated.

The research presented here is an empirical study of the relationship between monetary policy and the Australian equity market. Section 2 provides a critical overview of previous studies within this topic including both Australian and international literature. The methodology is outlined in Section 3 covering research design, data collection, hypotheses tested and the development of regression models. This section also provides a brief introduction into the statistical software environment 'R' used in the analysis. Section 4 contains detailed results tables and analysis for the fourteen regression models used as well as explanatory figures and scatterplots. The final part of this report, Section 5, provides a summary of findings, limitations of the study and recommendations based on the results.

Section 2 Literature Review

2.1 Introduction

The Australian and international literature outlined in this section will contribute to understanding the concepts, hypotheses, findings and relationships within this study.

There has been extensive research conducted on the effect of monetary policy on financial markets, the majority of which has focused on equity markets and US policy actions (Bernanke & Kuttner, 2005; Bomfim, 2003; Rigobon & Sack, 2004). The research covers multiple hypotheses as to the effect of interest rate decisions. Throughout international literature, there exists a general agreement that interest rate increases (cuts) result in a fall (rise) in equity returns (Bernanke & Kuttner, 2005; Bomfim, 2003; Ioannidis & Kontonikas, 2008; Kim, S & In, 2002; Rigobon & Sack, 2004).

A major influence regarding this study is research by Bernanke and Kuttner (2005), *What Explains the Stock Market's Reaction to Federal Reserve Policy?* This paper looks at the effects of unanticipated monetary policy actions on the equity market, finding that they account for the largest part of the response of stock prices. An in depth research paper, using Capital Asset Pricing Models (CAPM) and industry portfolios to dissect equity returns, findings show that monetary policy surprises impact stock prices either through the effects on expected future excess returns or dividends. It improves upon earlier research (prior to the introduction of Kuttner's model in 2000) by using futures data which isolates the unanticipated element of policy actions.

2.2 Surprise component of monetary policy decisions

It has been found that the surprise component in monetary policy announcements boost stock market volatility significantly in the short run (Bomfim, 2003). The majority of works use an adaptation of the approach by Kuttner (2001) in determining the surprise component, using futures pricing to isolate market expectations of interest rates (Bernanke & Kuttner, 2005; Kim, S-J & Nguyen, 2008; Laeven & Tong, 2012; McCredie et al., 2013; Smales, 2012a).

Futures contracts provide a good indication for market anticipation because a change in the target rate has an immediate impact on other short-term interest rates and the futures market may respond more quickly than the stock market (Kim, S-J & Nguyen, 2008). Financial market participants adjust their portfolios based upon their expectations of the coming monetary policy announcements and this expected component can be observed immediately prior to the announcement. If the actual target rate announced is different from that already priced, markets react to this surprise (or news) component accordingly (Kim, S-J & Nguyen, 2008).

Other methods have been used for separating market expectation including the utilisation of market surveys (Brenner, Pasquariello & Subrahmanyam, 2009; Kim, S-J & Nguyen, 2008) and the conversion of monetary policy statements into a wording indicator variable based on positive, negative or neutral language (Rosa, 2011). Kim, S-J and Nguyen (2008) use financial press reports to calculate market consensus forecasts; a database of press reports based on a few days before and after the RBA's scheduled announcements. This data was tested and found to be unbiased.

The importance for isolating the unanticipated component of the announcements is highlighted in research by Bomfim (2003). Models used within this study that fail to distinguish unanticipated

news, find that announcements have only a small effect on stock market volatility. However, the news effect nearly doubles when the surprise component is isolated.

Smales (2012a) disaggregates the surprise component even further by dividing data into target and path surprise factors. The target factor measures the degree to which the market is able to anticipate the monetary policy decision, while the path surprise factor expresses the extent that market participants revise their expectations of future monetary policy. Evidence suggests that the path factor is driven largely by monetary policy statements.

Brenner, Pasquariello and Subrahmanyam (2009) utilise futures data for US Federal Reserve (Fed) Funds Rate decisions, but also expectation data from the International Money Market Services (MMS) survey for macroeconomic variables. According to the authors, this survey data is typically assumed to represent unbiased estimates of the anticipated component of these announcements.

It is debatable that survey data is unbiased and not stale information. Overall, based on the literature reviewed, the method introduced by Kuttner (2001) to calculate the surprise component, is preferable for this study.

2.3 Equity markets

2.3.1 Macroeconomic variables and the effect on *returns*

Monetary policy is an important determinant of equity returns either by altering the discount rate used by market participants or by influencing expectations of future economic activity (Ioannidis & Kontonikas, 2008). Bernanke and Kuttner (2005) define this as a change in the 'expected equity premium'. Restrictive monetary policy, for example, lowers stock prices by raising the

expected equity premium due to an increase in risk. This increase in risk may be caused by an increase in interest expense or a weakening of the balance sheet or a fall in the expected level of consumption. Thus, Bernanke and Kuttner (2005) and Ioannidis and Kontonikas (2008) postulate that changes in monetary policy are transmitted through the stock market via their influence on consumption spending ('wealth effect') and investment spending (effect on the balance sheet through changes in the cost of capital).

This is echoed by Bjørnland and Leitemo (2009) who state that monetary policy is likely to influence stock prices via the interest rate (discount) channel as well as indirectly through factors determining dividends and stock return premiums. Moreover, as stock prices are determined based on future expectation, monetary policy and particularly surprise policy actions are likely to influence prices based on the degree of uncertainty met by market participants.

Extending from US equity returns, Ioannidis and Kontonikas (2008) analyse the impact on stock returns on 13 OECD countries. Results suggest that 80% of the countries under investigation suffer declines in stock value associated with periods of tightening, despite different monetary policy frameworks. However, all these regimes focus on price stability as the primary monetary policy objective.

Kim, S and In (2002) discuss Australian financial markets and the impact of macroeconomic news announcements from major stock markets (US, UK and Japan), while Kim, S-J and Nguyen (2008) also examine Australian equities with a broader scope; including the stock prices of the biggest four banks in Australia. Their aim is to disaggregate the influence of the target rate surprises on the segment of the stock market that is most directly and immediately affected by the RBA's announcements. They find that the stock prices of NAB and WBC significantly rise in

response to an increase in interest rates and suggest that this might be due to a higher amount of interest rate sensitive assets rather than liabilities.

The literature offers a variety of macroeconomic variables used to discuss the reaction of stock markets to news announcements. The majority use the Fed Funds rate (Bernanke & Kuttner, 2005; Brenner, Pasquariello & Subrahmanyam, 2009; Kurov, 2012; Rigobon & Sack, 2004), but some include other variables such as CPI, unemployment or GDP (Brenner, Pasquariello & Subrahmanyam, 2009; Nikkinen et al., 2006). A study conducted on the Australian market by Kim, S and In (2002) does not consider Fed Funds Rate announcements, only CPI, GDP and employment. This study seems particularly simplified and their choice of variables appears in contrast to all other literature that considers the Fed Funds Rate highly important. Brenner, Pasquariello and Subrahmanyam (2009) provide references to support their use of macroeconomic variables; total CPI, unemployment rate, nonfarm payroll employment and the target Fed Funds Rate. They argue that when setting interest rate policy the main concerns are employment and inflation, and markets are most sensitive to this news.

2.3.2 Macroeconomic variables and the effect on *volatility*

Various works (Bomfim, 2003; Harju & Hussain, 2011; Kim, S-J & Nguyen, 2008; Kim, S & In, 2002) have considered the effect of macroeconomic announcements on asset price volatility. The majority of research finds that the release of monetary policy news results in a rapid increase in return volatility. Those who tested high-frequency data found the majority of the effects to peak at the time of announcement and subside within the first hour (Harju & Hussain, 2011; Rosa, 2011; Smales, 2012a).

Rosa (2011) focuses on the US market while Harju and Hussain (2011) examine the impact of US announcements on European markets. Despite their use of different markets, the results are the same; stock prices react immediately to monetary policy surprises and settle into a new equilibrium after approximately one hour.

Bomfim (2003) offered a unique perspective by studying longer periods either side of the regularly scheduled meetings, to enable a comparison of event and non-event days. This research uncovered an important consideration, described as the 'calming effect'; stock markets can tend to be relatively quiet - conditional volatility is abnormally low – on days preceding regularly scheduled policy announcements. Bomfim (2003) used a variety of models in his research, and while not all models provided empirical support for this notion, supporting evidence was stronger for pre-determined news releases.

This phenomenon has been discussed in more recent literature by Brenner, Pasquariello and Subrahmanyam (2009) who look at the reaction of stock and bond markets to unanticipated macroeconomic news releases. It was found that after initially falling, conditional stock return volatility increases on the day of announcement, and subsequently decreases. This was in contrast to conditional bond return volatility that instead first rises and then declines.

This research highlights an important consideration; in examining the volatility of equity returns only on the day of announcement, a volatility increase may be relatively larger due to this pre-announcement effect.

Varying degrees of volatility may imply that an unexpected target rate change creates further uncertainty surrounding future rate changes (Kim, S-J & Nguyen, 2008) or that an increase in the volume of trades occurs as market participants rebalance their portfolios (Smales, 2012b).

The majority of literature so far has not considered the influence of trade volumes in their volatility calculations and this is a limitation of their research. Kim, S and In (2002) find that higher price volatility in response to news announcements may arise from an increased volume of trade following the announcement.

2.4 Other financial markets and spillover

The literature on the impact of monetary policy announcements has included the reaction of foreign exchange (Kim, S-J & Nguyen, 2008; Rigobon & Sack, 2004), Government debt (Brenner, Pasquariello & Subrahmanyam, 2009; Kim, S-J & Nguyen, 2008) and even the corporate bond market (Brenner, Pasquariello & Subrahmanyam, 2009). Many studies have not only considered domestic markets, but also the spillover effect on international markets (Craine & Martin, 2008; Harju & Hussain, 2011) with the majority concluding that US policy decisions affect global markets. Kim, S and In (2002) have examined the spillover from other international markets on the Australian stock market and found that in addition to the US decisions, UK and Japanese monetary announcements influence Australian equities (and futures) significantly. This implies that information spillover exists from large financial markets to smaller financial markets. They conclude that this is a result of increased uncertainty and investors requiring further compensation for their investments. This is an important limitation of this research as the models used do not include the spillover effect of macroeconomic announcements from other countries.

One of the most recent articles reviewed is from Laeven and Tong (2012) which looks at the reaction of global stocks to US policy announcements. Unlike earlier works, this paper contains data during the GFC. The financial crisis refreshed debate surrounding the link between monetary policy and asset price and Laeven and Tong (2012) discuss the argument that US

monetary policy fueled an asset price boom. The sample is large and considers 20,121 companies spanning 44 countries, including Australia, from 1990 to 2008. They find that global stock prices respond strongly to changes in US interest rates, with stock prices increasing (decreasing) following unexpected interest rate decreases (increases) (Laeven & Tong, 2012).

Kim, S-J and Nguyen (2008) find that when the US Fed's target interest rate news reduces the degree of uncertainty in US markets, the lower volatility environment is transmitted to the Australian markets (Kim, S-J & Nguyen, 2008).

For debt markets, results indicate that an increase (decrease) in short-term interest rates results in an upward (downward) shift in the yield curve with a stronger effect in short-term yields that becomes weaker at longer maturities (Kim, S-J & Nguyen, 2008; Rigobon & Sack, 2004). Shorter maturity yields have also been found to be more volatile than longer maturity yields (Craine & Martin, 2008; Kim, S-J & Nguyen, 2008).

Multiple studies have considered the effect of monetary policy on the Australian interest rate futures market (Kim, S & In, 2002; McCredie et al., 2013; Smales, 2012a, 2012b). They provide evidence that monetary policy releases have a significant impact on the returns and volatility of contracts across the maturity spectrum, with the impact observed to be stronger in the shorter maturity futures.

2.5 Asymmetric news effect

When considering conditional volatility, a number of studies (Bernanke & Kuttner, 2005; Bomfim, 2003; Brenner, Pasquariello & Subrahmanyam, 2009; Kim, S-J & Nguyen, 2008; Smales, 2012a) have analysed the directional impact of monetary policy announcements and uncover evidence of an asymmetric news effect. In a study on the US market, Bomfim (2003)

finds that positive surprises – higher-than-expected values of the target rate – tend to have a larger effect on the volatility of equities than negative surprises. Bernanke and Kuttner (2005) also show extreme market reactions sometimes occur for reversals in the direction of rate changes. However, these results are not strong with only five observations in the sample.

More recently, similar evidence for the asymmetric news effect has been shown in a study by Kim, S-J and Nguyen (2008), providing weak evidence that Australian markets generally respond more strongly to unexpected rate rises than rate falls. Regarding conditional means, interest rates rose in debt markets in response to unexpected rises, but only short-term debt responded to rate falls. Regarding the exchange rate, no asymmetric response was found in the spot rate, the 1-month forward responded only to unexpected falls whereas the 3-month forward responded only to unexpected rises. This study found no asymmetric response in stock market returns. Moreover, the evidence for an asymmetric effect on conditional volatility is less uniform. Overall, only unexpected target rate falls raised the interest rate volatilities, with the opposite being true for exchange rates. For the stock market, unexpected rises generally resulted in higher volatility, although unexpected falls also increased the volatility for one of four bank stocks investigated (Commonwealth Bank of Australia) and the stock index returns.

The study on US equities, Government and corporate bonds by Brenner, Pasquariello and Subrahmanyam (2009) finds that they react asymmetrically to surprise announcements, particularly, but not exclusively, to the release of 'bad' news. The reason for this asymmetry may be due to various market frictions and financial constraints that are more pronounced after negative announcements (Brenner, Pasquariello & Subrahmanyam, 2009). Restrictions on investment behaviour include borrowing, short-selling and wealth constraints, all of which can affect asset returns and volatility. Higher frequency data may be necessary to uncover

asymmetries, as this research also shows that monthly data contains very little confirmation for the sorts of asymmetries revealed in the daily data (Brenner, Pasquariello & Subrahmanyam, 2009).

This is in contrast to Smales (2012a) who finds that when considering conditional volatility in the Australian futures market, there is evidence that markets tend to have a stronger reaction to bad news (falling yields) than to good news (rising yields). However, Smales (2012a) does not consider the equity market in his research and being the most recent study, includes data after the GFC. Therefore, the difference in results may be due to the state of the economy at the time of analysis; contractionary rather than expansionary.

Due to the varied results for asymmetry found in this literature review, an asymmetric news effect in this thesis may not be robust.

2.6 State dependence and the GFC

Multiple studies have demonstrated that monetary policy transmission is affected due to the state of the economy (Kurov, 2012; McCredie et al., 2013) The literature has found that information communicated through monetary policy has important state dependent implications for stock prices; for future monetary tightening during periods of economic expansion, stocks tend to respond negatively, but in recessions, there is a strong positive reaction of stocks to seemingly similar signals (Kurov, 2012).

2.7 Frequency of data

The literature presents findings for varying frequencies of data and the consequences for these choices. Bernanke and Kuttner (2005) and Brenner, Pasquariello and Subrahmanyam (2009) argue that using daily data in an event-study approach is appropriate; any bias tends to

underestimate the true response to monetary policy, and results may simply produce conservative estimates of the stock market's reaction to policy decisions. This concept is echoed by Rigobon and Sack (2004) whose findings also suggest that the event-study estimates contain biases that minimise the estimated effects on stock prices and inflate those on Treasury yields, although not statistically significant for equities.

Rosa (2011) argues that high-frequency data is more appropriate in that it allows better assessment of market adjustment to new information on a micro level. Harju and Hussain (2011) agree that high frequency data is critical for the identification of news that impacts the markets. Unlike daily data, intra-day data allows for the investigation of the speed of response in equity prices to policy decisions. Contrary to studies mentioned above that find daily results to be merely conservative estimates, Rosa (2011) believes that daily studies can produce weaker results and some data may even be absent. One particular advantage of high-frequency data outlined in Rosa's study is the reduction in variable bias; that is, the likelihood that other macroeconomic announcements will impact results.

When analysing the effect of RBA monetary policy communication on Australian futures, Smales (2012a) compares three different frequencies; 5-minute, 15-minute and daily data. Results are similar for intraday and daily measures on most days, with an absolute difference of only 1.4 bp. However, there are a few days when the difference is quite large; eleven events exceeding 5 bp and three events greater than 10 bp. These three occasions do not correspond with other important Australian news, but do coincide with speeches by members of the US Fed and the European Central Bank (ECB). Smales (2012a) suggests that to focus solely on the effect of the RBA monetary policy announcement, analysis should centre on intraday data.

Based on the literature reviewed, this research follows the methodology employed by Bernanke and Kuttner (2005). Daily data is used in testing the impact of monetary policy on the equity market, while recognising the possible bias and underestimation of results.

2.8 Gap in the literature

Reviewing relevant literature surrounding the impact of monetary policy announcements on equities markets has revealed a gap in Australian research. Despite extensive international literature, a focus on Australian equities and particularly the decomposition of surprise and expected reaction is limited. Thus, research contained in this thesis offers a unique and valuable perspective.

Section 3 Methodology

This section outlines the methodology used to establish the effect of monetary policy announcements on Australian stock returns.

3.1 Research Design

This research was designed based on the assumption that changes in interest rates have an effect on asset prices (Bernanke & Kuttner, 2005; Bjørnland & Leitemo, 2009; Ioannidis & Kontonikas, 2008). Figure 1 depicts the conceptual model used for this research. Bridging the effect of monetary policy announcements on equities is the idea that market reaction is based on a surprise change in interest rates. Short-term interest rate futures data is used to determine market expectation and compute the surprise component. Other concepts that may influence results include the direction of the change in interest rates, the state of the economy at the time of decision, study design elements such as frequency and the impact of other variables omitted from the model.

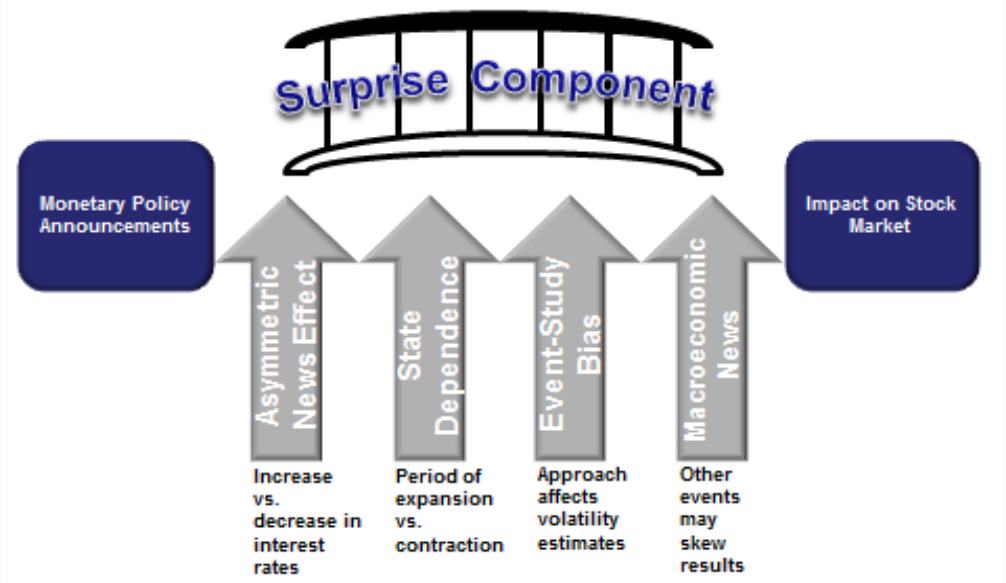


Figure 1. Conceptual Model

This research takes on a quantitative approach; testing hypotheses through statistical inference.

3.2 R Project

Statistics and graphics are constructed using the free software environment R; an integrated suite of software facilities for data manipulation, testing and graphical display. R is a collaborative project with contributors from all over the world and requires code to function.[1]

Depending on the statistical techniques or graphics required, R can be extended via packages. There are about eight packages supplied with the R distribution and substantially more are freely supplied by contributors. The production and analysis of results in this research has required the use of R packages such as 'tseries' for Jarque-Bera testing, 'sandwich' for heteroskedastic-consistent errors, 'stats' for normality testing and 'stargazer' for producing regression outputs in table form. For a complete list of packages used within this report, including citations, refer to the table in the Appendix.

3.3 Hypotheses

This research aims to test the following hypotheses using regression modelling and the impact of particular variables on the All Ords index. The hypotheses have been formed based on findings from the literature reviewed in Section 2.

H1: There is a significant impact on All Ordinaries returns at the RBA announcement

This hypothesis is tested using All Ords 1-day returns calculated using the difference in daily returns on the day of announcement and day prior. The announcement of the policy decision may reveal new information not previously incorporated into asset prices and volatility is likely to rise

[1] More information about R is available at: http://www.r-project.org/

(Bomfim, 2003; Harju & Hussain, 2011; Kim, S-J & Nguyen, 2008; Kim, S & In, 2002). Thus, returns may be impacted as market participants process the newly received information.

H2: There is a significant impact on All Ordinaries returns with *unexpected* RBA decisions

All Ords returns will also be tested for a significant impact from unanticipated policy actions. The unexpected portion of market reaction is calculated using the surprise component calculations outlined in this report (see Ch. 3.4.5). Regressions are performed using expected change and surprise change variables. The impact of unexpected RBA decisions is then investigated further (see H5) with the addition of independent variables that include actual change and announcement dummy, as well as interaction terms to gain a complete picture of this relationship (if any).

H3: The impact on stock returns is expected to be greater when there is a *surprise increase* in the cash rate

Directional analysis will look at the impact on stock returns whether the cash rate is increased, decreased or kept on hold by the RBA. This hypothesis stems from a study by Kim, S-J and Nguyen (2008) who provide weak evidence that Australian markets generally respond more strongly to unexpected rate rises than rate falls. However, the literature displays opposing results on the asymmetric news effect of policy surprises and this may be due to a difference in business cycles for each study (Bomfim, 2003; Brenner, Pasquariello & Subrahmanyam, 2009; Kim, S-J & Nguyen, 2008; Smales, 2012a). Thus, directional influence models will include interaction variables to test if the surprise component is significant in periods of contraction or expansion within the Australian economy (see H5).

H4: There is a significant impact on All Ordinaries returns at the release of explanatory meeting minutes

In December 2007, the RBA changed its communication policy and began releasing explanatory meeting minutes two weeks after each announcement. As the market processes this new information, variance in returns is likely to increase. Studies on the impact of minutes releases on Australian interest rate futures have shown a significant impact (McCredie et al., 2013; Smales, 2012a). Tests to confirm these results will use similar regression models as H1 and H2 with the addition of minutes release data.

H5: There is a significant impact on returns after the introduction of a more transparent monetary policy communication regime in December 2007

The impact (if any) of a change in monetary policy communication practices will take place by using an interaction term to differentiate any effect post-2008. Since December 2007 the RBA has announced cash rate decisions on the day of the meeting rather than the day after, and further increased transparency by making explanatory minutes public two weeks after this (RBA, 2007). All Ords returns will be regressed with this dummy variable as well as independent variables including an announcement day dummy, the raw cash rate change and directional rate change. In addition, this hypothesis will be examined through multiple tests involving the surprise and expected response of market participants.

The testing of this hypothesis may also be impacted by an alternate effect, and that is state dependence. The state of the economy was contracting prior to 2008 due to global economic collapse surrounding the GFC. In 2009, markets were recovering and economies were expanding in comparison. Therefore, any significant results of tests with the post-2008 interaction variable will be interpreted with caution.

H6: The impact on stock returns is greater when the RBA announces a *large change* to the cash rate target

Between October 2008 and March 2009, the RBA lowered the cash rate by a total of 375 basis points. Cash rate changes greater than 25 basis points in magnitude will be tested, using a dummy variable for large changes. The aim is to determine if they cause a greater impact on the stock market than typical changes of 25 basis points and lower.

3.4 Data Collection

This section discusses the sample selection used in the research including sample size and independent variable data. Sample and variable selection is based on appropriateness of information, validity of data and availability.

3.4.1 All Ordinaries

ASX market indices offer a broad indication of performance of the Australian stock market and the All Ords, S&P/ASX 200 and S&P/ASX 300 were considered prior to conducting this research. After a comparison of the three market indices, the All Ords was selected as being more representative of the Australian stock market as its constituents include the largest 500 companies based on market capitalisation. The S&P/ASX 200 and S&P/ASX 300 indices were considered less representative of the entire market, only encompassing 80% and 81% of Australian equity market capitalisation, respectively (S&P Dow Jones Indices, 2014a, 2014b).

The All Ords daily adjusted closing price is used and obtained from Yahoo! Finance for the sample period 1 September 2003 to 31 August 2013.

3.4.2 RBA target cash rate announcements

Since around 1993, the RBA has been conducting monetary policy following an inflation target regime and has been releasing interest rate changes since January 1990. The RBA conducts eleven scheduled board meetings per year, on the first Tuesday of every month except January. Since December 2007, the RBA has issued a media release of the decision at 2.30 PM Australian EST on the day of each meeting. Prior to this, announcements were only made regarding a change in the cash rate, and released the day after the relevant meeting at 9:30 AM Australian EST (RBA, 2013).

For this reason, the reaction of the stock market has been tested over the entire sample period as well as separating pre-2008 and post-2008 to determine if results are impacted by this change in communication. Table I provides an outline of RBA policy decisions spanning the sample period.

Table I Reserve Bank of Australia Announcement Data

The table outlines RBA meeting decisions for the sample period September 2003 to August 2013. The sample has also been separated based on the RBA media release 5 Dec 2007 detailing a change in communication. Prior to this date, cash rate changes were only announced if a change occurred, and at 9:30am on the day after a scheduled meeting. After this, announcements were at 2:30pm on the day of the meeting, regardless of a change being made. Data is readily available on the RBA website.

	Full Sample	Announcements on the Day After Meeting	Announcements on the Day of Meeting
	Sep 2003-Aug 2013	Sep 2003-Dec 2007	Feb 2008-Aug 2013
Number of events: RBA monetary policy decisions	110	48	62
Rate increase	17	8	9
Rate decrease	14	0	14
Rates on hold	79	40	39
Proportion of rate changes taking place out of total RBA meetings	0.28	0.07	0.21

Source: Interest Rate Decisions (RBA, 2014a)

3.4.3 RBA explanatory minutes

On 5 December 2007, the RBA released a media statement outlining a change in communication (RBA, 2007). From this point, minutes pertaining to each month's policy meeting would be made public two weeks after each meeting, improving transparency around policy decisions.

Although three explanatory minutes were released in December 2007, the sample being tested is from January 2008. The reason for this is to allow for the transition period, where minutes were not released exactly two weeks after the meeting. Table II shows the period in question.

Table II Explanatory minutes transition period

Meeting Month	Meeting Date	Minutes Release Date	Used in data testing
October	10/2/2007	12/18/2007	No
November	11/6/2007	12/5/2007	No
December	12/4/2007	12/18/2007	No
February	2/5/2008	2/19/2008	Yes
March	3/4/2008	3/18/2008	Yes

Source: RBA Board Minutes (RBA, 2014b)

Statistical testing for minutes spans all trading days from 1 January 2008 to 30 August 2013, inclusive, for a total of 1435 observations. This period covers 62 meetings and therefore 62 minute releases by the RBA.

3.4.4 30-day interbank cash rate futures

This study adopts a similar use of 30-day interbank futures contracts as Smales (2012a); using front-contract interbank futures due to their explicit reading of market expectations on RBA monetary policy. Strengthening the decision to use futures, studies indicate an inefficiency in information processing in that the futures market may respond more quickly than the stock market (Kim, S & In, 2002). Figure 2 depicts how a change in the futures price on the day of announcement should encapsulate any change in market opinion based on the RBA's decision.

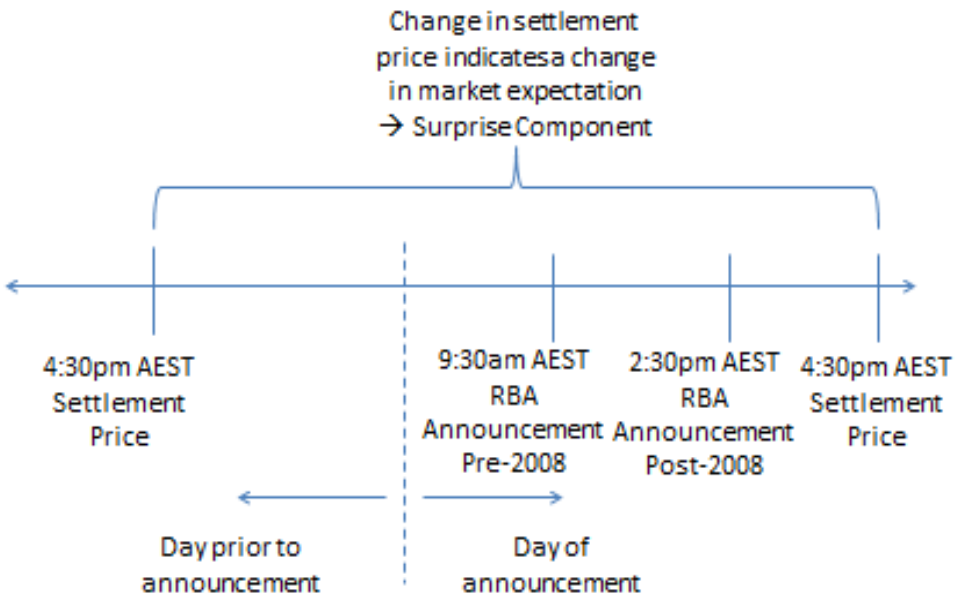


Figure 2. Change in market expectation captured in futures data

Moreover, futures prices are readily available from the Thomson Reuters Tick History database. The sample period has been restricted due to the availability of futures data. The lower bound is based on the launch of 30-day interbank cash rate futures by the Sydney Futures Exchange (SFE); the first contract month to be listed for trade was September 2003 (SFE Corporation Limited, 2003). The upper bound of the sample is due to tick history from Thomson Reuters only being available up to August 2013 (as at July 2014).

3.4.5 Calculating Surprise Component

Consistent with international literature (Bernanke & Kuttner, 2005), the method to calculate the surprise component of monetary policy decisions utilises that outlined by Kuttner (2001); 30-day interbank cash rate futures are used as a proxy for market expectation of short-term interest rates. By using the 1-day change in the price of the contract (see Eq. (1)), on the day that the RBA meeting announces its cash rate target, the surprise can then be calculated (see Eq. (2)).

For an RBA meeting on day *d* of month *m*, the monetary policy surprise is the change in price of the interbank futures contracts relative to the day prior to the policy action. 30-day interbank futures are settled against the monthly average of the cash rate as published by the RBA for that contract month. Therefore, the change in the implied futures rate should be scaled up by a factor related to the number of days in the month affected by the change, or:

$$\Delta i^{u} = \frac{D}{D-d}\left(f_{m,d} - f_{m,d-1}\right) \quad (1)$$

Where Δi^{u} is the unexpected target rate change, $f_{m,d}$ is the current month futures rate at day *d*, and *D* is the number of days in the month.

The expected rate change is therefore the actual change minus the unexpected change, or:

$$\Delta i^{e} = \Delta i_{t} - \Delta i^{u} \quad (2)$$

Similar to Bernanke and Kuttner (2005), for an announcement on the first day of the month, the prior month's contract price is used to calculate the day prior future's price.

3.5 Regression Analysis

This research uses regression analysis to test the hypotheses and determine if a relation exists between monetary policy decisions and the Australian stock market. Using a simple linear model does not account for the heteroskedastic nature of stock returns.

3.5.1 Heteroskedasticity

The volatility of stock returns is not equal over time due to the change in investor behaviour over different periods. Changes in investor confidence, risk appetite, state of the economy or macroeconomic policy are some issues that will change the variance levels of stock returns. Thus, it can be reasonably expected that in a regression model, the error terms may be larger for

some points or ranges than others. Data in which the variances of the error terms are not equal are said to suffer from heteroskedasticity (Engle, 2001). In the presence of heteroskedasticity for an ordinary least squares (OLS) regression, the regression coefficients are still unbiased, but the standard errors and confidence intervals estimated will be too narrow, giving a false sense of precision.

3.5.2 Generalized autoregressive conditional heteroskedasticity (GARCH)

Periods of relative calm and periods of high volatility are recognized as phenomena of market data. GARCH (Generalized AutoRegressive Conditional Heteroskedasticity) seeks to model this volatility 'clustering'.

The literature demonstrates that GARCH models are well suited to modelling daily stock returns series, which are often characterised as skewed, leptokurtic and having non-normal distributions (Kim, S-J & Nguyen, 2008; Kurov, 2012; McCredie et al., 2013). The benefits of this methodology include the allowance of negative coefficients in the conditional variance equation and the ability to measure the asymmetric news effects on both the conditional mean and variance of daily returns.

Rather than using GARCH modelling to account for heteroskedasticity, the data analysis in this report employs the use of heteroskedasticity-robust standard errors (MacKinnon & White, 1985).

3.5.3 Robust standard errors

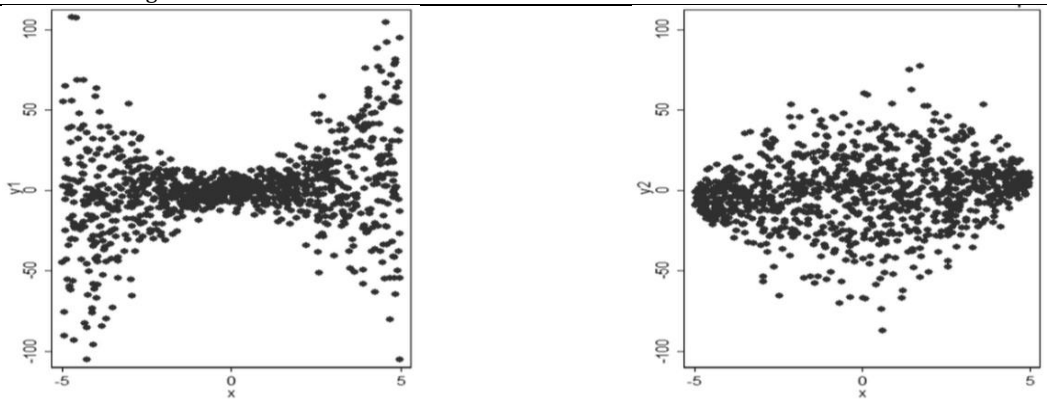
Further development in the estimation of standard errors, that reduces issues of heteroskedasticity, is known as robust standard errors. With a large sample size, robust standard errors are able to provide a good estimate of standard errors even with the presence of

heteroskedasticity (Engle, 2001). This report uses the White method to produce standard errors consistent under heteroskedasticity, but thought to be biased in small samples (MacKinnon & White, 1985).

Following the White method, 'vcovHC' is a function in R for estimating a robust variance-covariance (vcov) matrix of parameters that is heteroskedasticity-consistent (HC) (MacKinnon & White, 1985). This method makes a negligible change to OLS coefficients, but minimises the sums of squared residuals by calculating the variance for each individual observation. The sum of the squared residuals no longer has an F-distribution, so this report uses the Wald test to calculate the maximum likelihood of the parameters. Additionally, when testing using robust standard errors, the adjusted R^2 is no longer valid as each observation is contributing different information to the model.

(a) **OLS standard errors will tend to be biased down** Plot of error terms for independent variable x and dependent variable y^1. As x moves further from the mean, the variance of error terms tends to be higher. RSE will tend to be larger than OLS standard errors.

(b) **OLS standard errors will tend to be biased up** Plot of error terms for independent variable x and dependent variable y^2. As x moves further from the mean, the variance of error terms tends to be lower. RSE will tend to be smaller than OLS standard errors.



Source: The Intuition of Robust Standard Errors (Auld, 2012)[2]

Figure 3. Variance of error terms and its effect on standard errors

[2] Chris Auld is an Associate Professor in the Department of Economics at the University of Victoria, Canada. His research focus is micro-econometrics, and with over 30 publications has been cited 1,338 times (Google Scholar).

The models in this report display a comparison between OLS regression and heteroskedasticity-consistent (HC) errors to see if there are any significant differences between conventional standard errors and robust standard errors. If they are similar, results are based more on homoskedasticity. If naive OLS standard errors (SE) are greater than HC robust standard errors (RSE), this indicates that the variance of the error terms reduces as the dependent variable gets further from the mean (see Figure 3(b)). The opposite is true if variance increases as the independent variable moves from its mean, and naive SE tend to be greater than RSE (see Figure 3(a)). Typically, variance of the error increases the further away the independent variable is from the mean, thus it is more likely that robust standard errors are larger than OLS. This will be compared in the regression results.

3.6 Anomalies and unusual events

Seen often in the literature, those who have tested the US markets have removed outliers in results. As an example, Harju and Hussain (2011) did not include the September 2001 announcement due to the 9/11 attack skewing results. For this research, outliers will be investigated and excluded based on the Cook's distance test (see Ch. 4.2). As shown by Bernanke and Kuttner (2005), statistical testing excluding outlier values may significantly influence results. For this reason, results in this report will offer a comparison of regressions, both including and excluding influential observations.

Section 4 Analysis of Results

This section outlines the results of the data analysis. First, the data is assessed for normality to ensure valid results for statistical inference. Second, the data is tested for outliers and heteroskedasticity. The third part of this section reports descriptive statistics of the data. Finally, this section takes an in depth look at each model comparing the results of OLS linear regression, robust standard errors and regressions excluding an outlier.

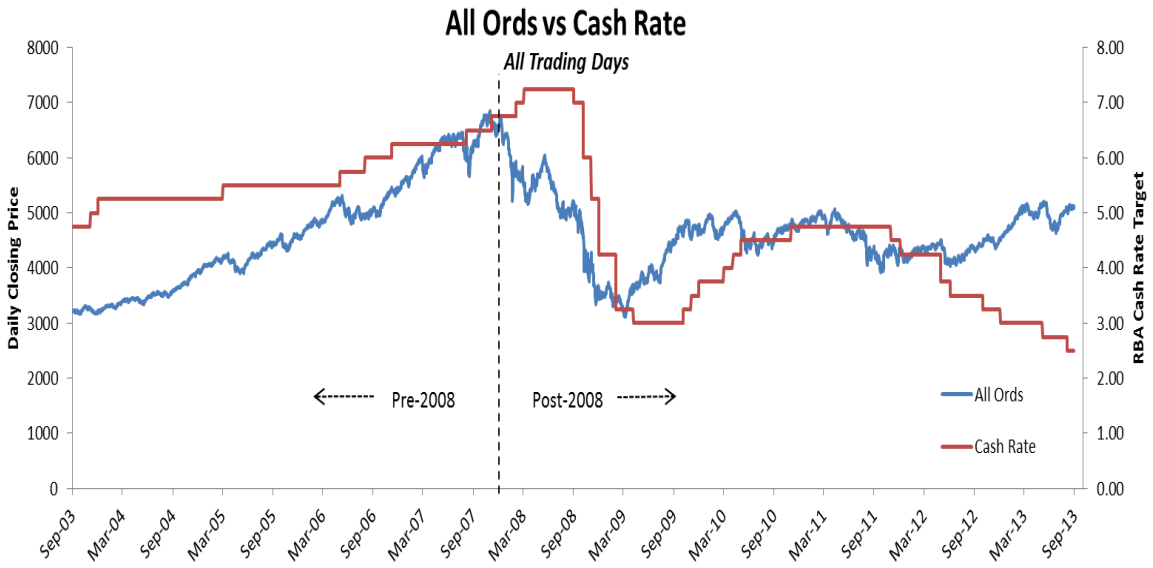
Two datasets are used for the regression analysis within this report. The first consists of all trading days for the All Ords index within the sample period (see Figure 4(a)) while the second dataset consists of only those days where the RBA has announced a decision regarding monetary policy (see Figure 4(b)). The sample spans ten years, from September 2003 to August 2013.

Data testing also uses interaction variables to separate and distinguish results (pre-2008 and post-2008), based on the RBA media release December 2007 detailing a change in communication (RBA, 2007). Prior to this date, cash rate changes were only announced if a change occurred, and at 9:30am on the day after a scheduled meeting. After this, announcements were at 2:30pm on the day of the meeting, regardless of a change being made.

The two datasets are shown graphically in Figure 3. As these price charts show, the All Ords has lead the cash rate for the most part, indicating a more reactive approach to monetary policy by the RBA (decisions based on economic data). However, they have diverged since 2012 while the RBA maintains exceptionally low interest rates to boost economic recovery after the GFC. This could be seen as a more proactive approach (steering the economy) (Ioannidis & Kontonikas, 2008). To calculate the degree in which the All Ords and cash rate are associated, the correlation

coefficient for these variables is calculated, indicating that they are positively correlated (0.434 for both Figure 4 (a) and (b)).

(a)



(b)

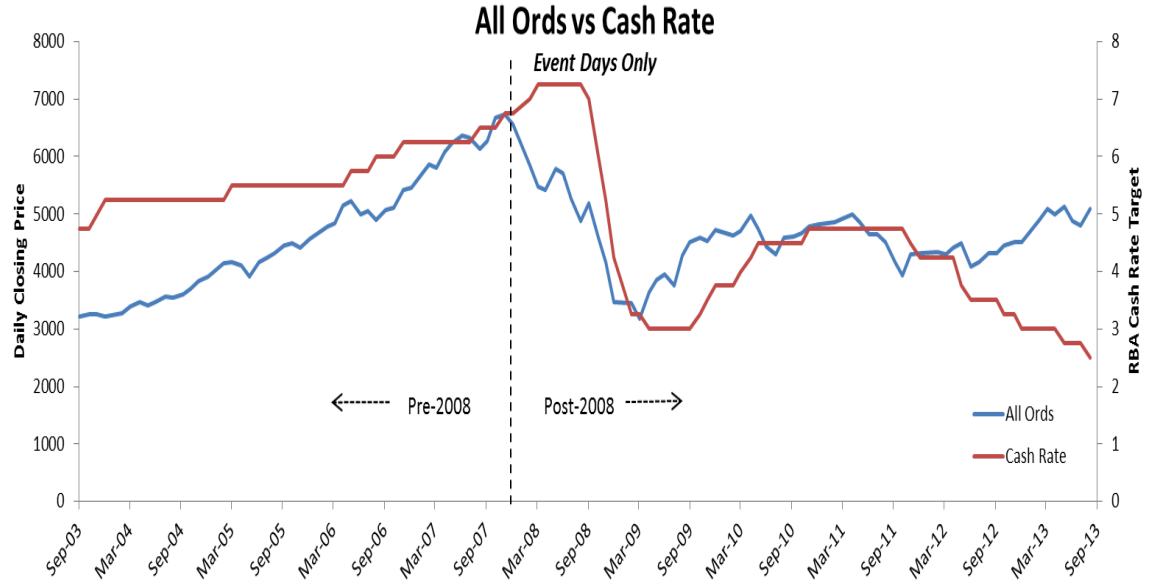


Figure 4. All Ords Price and policy decisions for all trading days (a) and event days only (b)

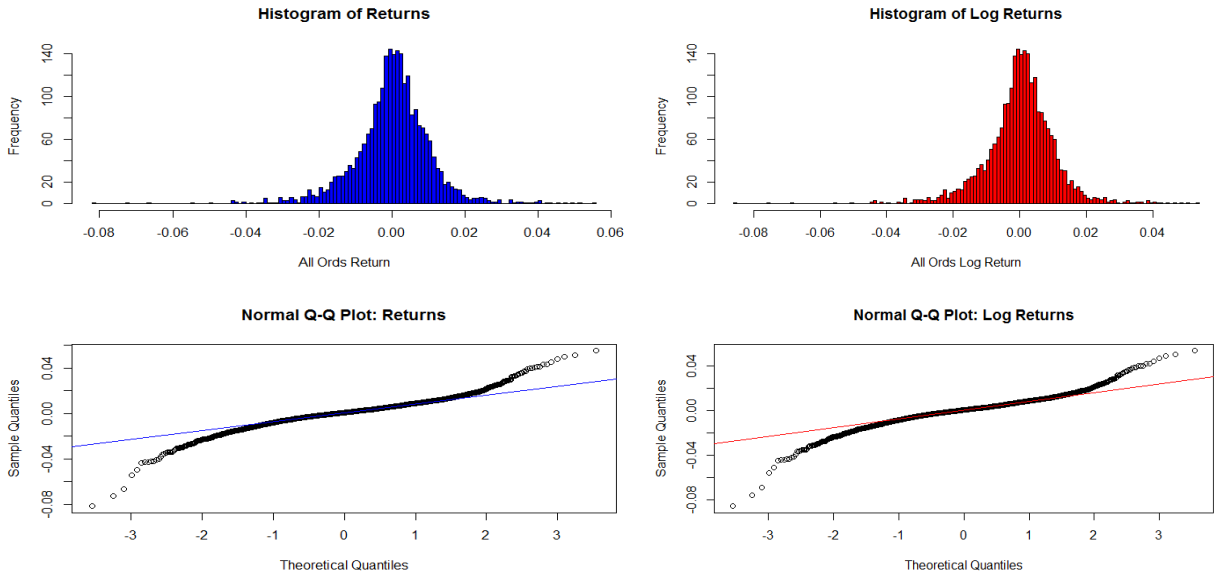
Before performing regression analysis on these datasets, a series of checks are performed to ensure robust statistical inference. These include normality and heteroskedasticity testing as well as checking for influential observations.

4.1 Normality Checks for Returns

Many statistical tests require that data is normally distributed. The following tests check if this assumption is violated. Returns data is widely recognised as being non-normally distributed. Using the log of returns is often used to improve normality and thus ensure the validity of statistical testing.

4.1.1 Normality checks for all trading days

The following is a comparison of daily All Ords returns and log returns for all trading days within the sample period.



Created using R package 'stats'

Figure 5. Normality: Comparison of Daily Returns and Log Returns – All Trading Days

The histograms and Q-Q plots in Figure 5 show that All Ords returns are reasonably normally distributed. Using the log of these returns does not make a substantial difference to the shape of the histogram or Q-Q plot. The line in the Q-Q plots passes through the first and third quartiles. The majority of points falling along this line indicate normality.

Shapiro-Wilk normality Test

To further test for normality, the Shapiro-Wilk (W) test is conducted. The null-hypothesis of this test is that the population is normally distributed. Therefore, if the p-value is less than alpha (0.05), the null hypothesis is rejected based on evidence that the data tested is not normally distributed. Contrary to this, if the p-value is greater than the 5%, then the null hypothesis that the data came from a normally distributed population cannot be rejected.

Both the All Ords returns and log returns were tested with the following results:

Returns: W = 0.9383, p-value < 2.2e-16

Log Returns: W = 0.9357, p-value < 2.2e-16

The p-values of returns and log returns (< 2.2e-16) indicate that the null hypothesis is rejected. Thus the results of the Shapiro-Wilk normality test for the All Ords data indicate a non-normally distributed sample.

Jarque-Bera Test

The Jarque–Bera tests whether the sample data has the skewness and kurtosis matching a normal distribution. For a true normal distribution, the sample skewness should be near 0 and the sample kurtosis should be near 3. The null hypothesis is that the data is normally distributed and the

alternative hypothesis is that it does not come from such a distribution. We reject the hypothesis if the test is significant at the 5% level.

Both the All Ords returns and log returns were tested with the following results:

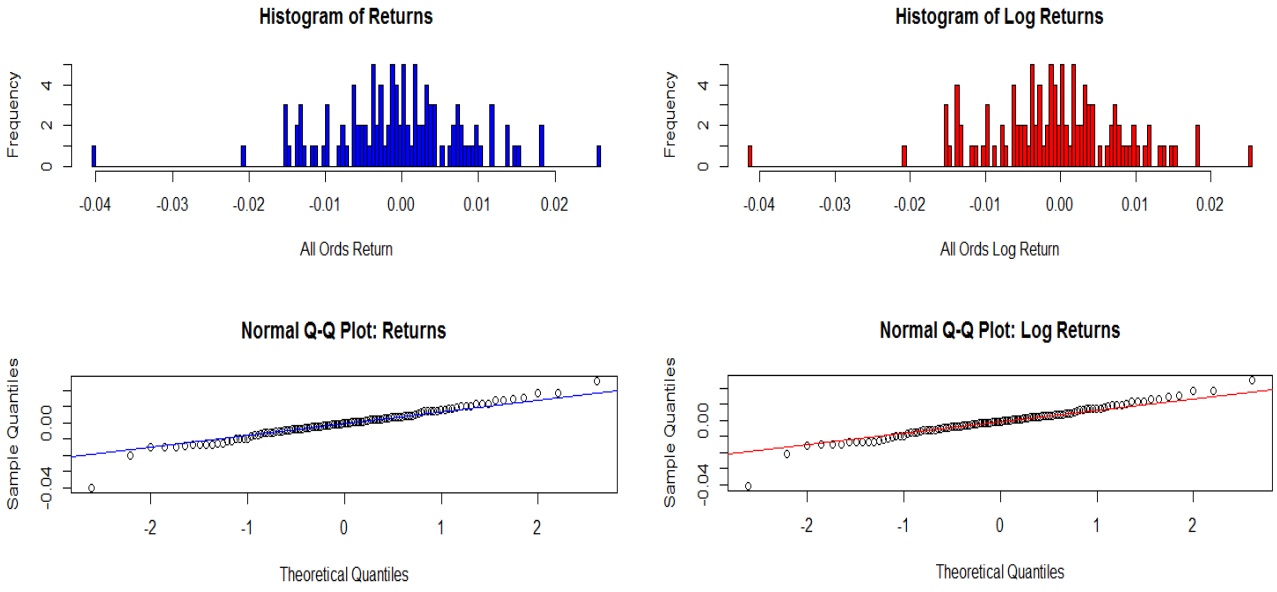
Returns: X-squared = 3136.745, df = 2, p-value < 2.2e-16

Log Returns: X-squared = 3607.389, df = 2, p-value < 2.2e-16

The results of the Jarque-Bera test for the All Ords returns and log returns (p-value < 2.2e-16) indicate that we reject the null hypothesis. Both p-values are well below the 5% significance level indicating that it is highly unlikely that this data is normally distributed.

4.1.2 Normality checks for event days only

The following is a comparison of daily All Ords returns and log returns for event days only.



Created using R package 'stats'

Figure 6. Normality: Comparison of Daily Returns and Log Returns – Event Days Only

Similar to tests involving all trading days (see Figure 5), the histograms and Q-Q plots in Figure 6 show that All Ords returns are reasonably normally distributed for trading days only. Using the log of these returns does not make a substantial difference to the shape of the histogram or Q-Q plot. The line in the Q-Q plots passes through the first and third quartiles. The majority of points falling along this line indicate normality.

Shapiro-Wilk normality Test

Again, we apply more stringent normality tests with the Shapiro-Wilk (W) method. Results for the sample containing event days only are as follows:

Returns: W = 0.9671, p-value = 0.008026

Log Returns: W = 0.9647, p-value = 0.005225

The p-values of returns (0.008) and log returns (0.005) indicate that the null hypothesis is rejected. Thus the results of the Shapiro-Wilk normality test for the All Ords data indicate a non-normally distributed sample.

Jarque-Bera Test

Similarly, the Jarque-Bera test is used to test for normality with results as follows:

Returns: X-squared = 33.6194, df = 2, p-value = 5.008e-08

Log Returns: X-squared = 38.9036, df = 2, p-value = 3.566e-09

The results of the Jarque-Bera test for the All Ords returns (p-value of 5.008e-08) and log returns (p-value of 3.566e-09) indicate that we reject the null hypothesis. Both p-values are well below the 5% significance level indicating that the distribution is not normal.

4.1.3 Results of normality testing

Based on these tests, the normal distribution is a poor fit for the daily percentage returns of the All Ords. The lognormal distribution is also a poor fit. However, with large sample sizes, statistical inference from linear regression should remain valid. Because the histograms and Q-Q plots appear fairly normal, it may be that outliers are causing the non-normal results for the Shapiro-Wilk and Jarque-Bera tests. Thus, testing for outliers is conducted in the following section.

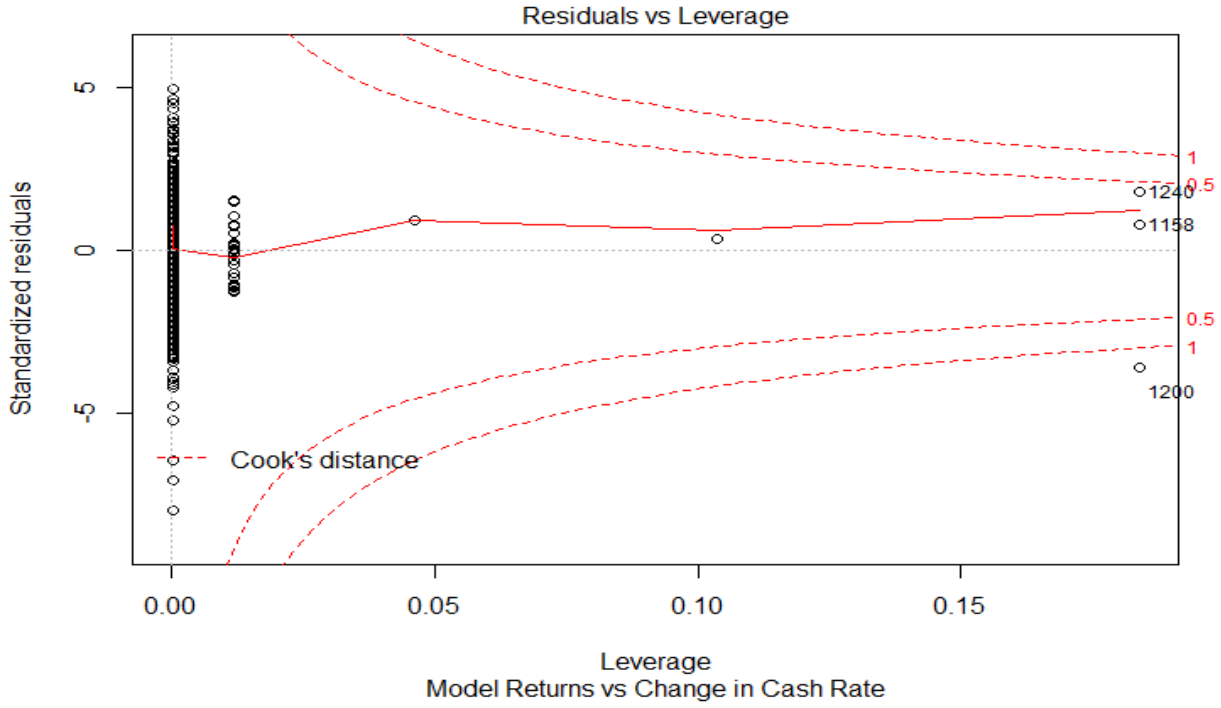
4.2 Testing for Outliers and Influential Observations

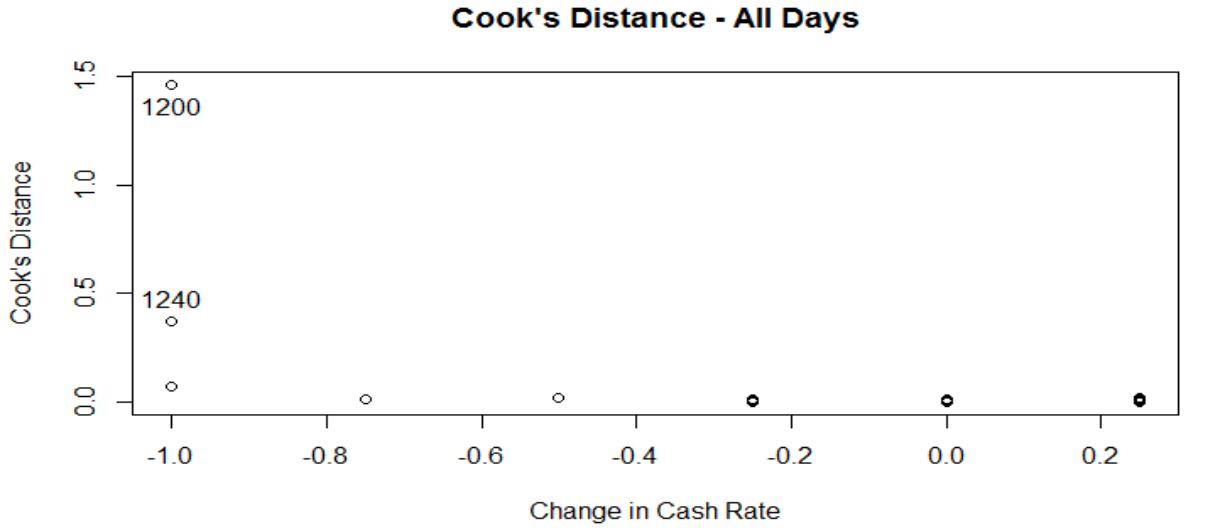
To assess if the results are sensitive to potential outliers, the Cook's Distance method is used. Using this test for All Ords returns and the actual cash rate change, points that are above 1.0 are considered influential. A more stringent test would include points that are above 0.5.

Results of the test for all trading days indicate that there is one observation with a Cook's distance above 1.0 (obs. #1200), and it should be considered as influential (see Figure 7(a)). Occurring on 2 Dec 2008, this observation is the result of the RBA lowering the cash rate by 100 basis points. The observation for 7 Oct 2008 (obs. #1240), also corresponds to a 100 basis point lowering by the RBA. However, falling just below the more stringent test of 0.5, this observation is not quite as influential (see Figure 7(a)).

Results of the Cook's distance test for event days only find the same influential observations (see Figure 7(b)). Again, these are due to the drastic monetary policy decisions by the RBA to reduce rates by 100 basis points on 7 Oct 2008 (obs. #57) and 2 Dec 2008 (obs. #59). However, in Figure 7(b) displaying event days only, the decrease on 7 Oct 2008(obs. #57) is slightly more influential (above 0.5 rather than below).

(a) All Trading Days

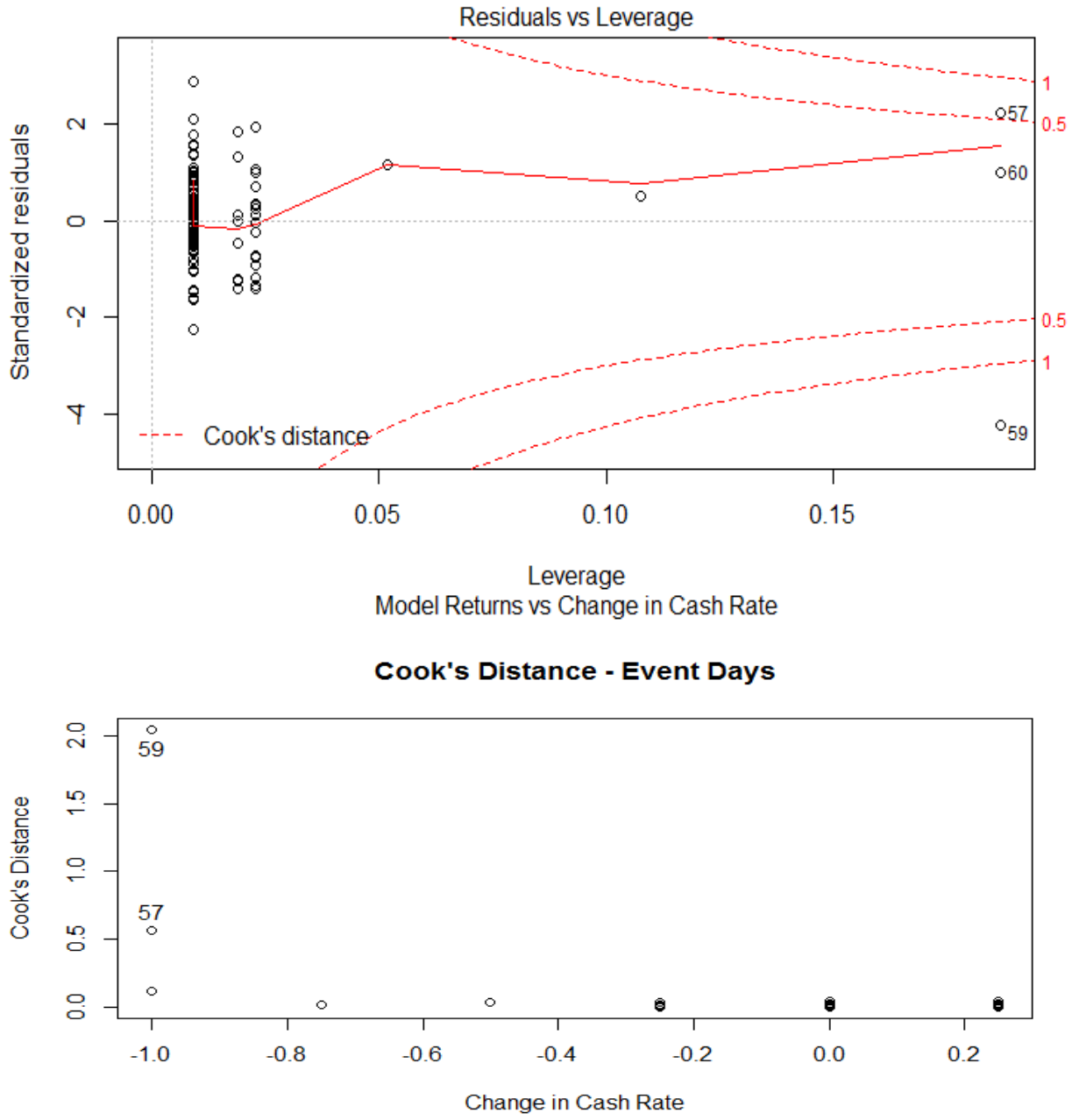




Calculated using R packages 'lmtest' and 'car'

Figure 7. (a) Influential Observations All Trading Days

(b) Event Days Only



Calculated using R packages 'lmtest' and 'car'

Figure 7. (b) Influential Observations Event Days Only

4.2.1 Results of Cook's distance

Cook's distance testing for influential observations has recommended that the models using All Ords returns data may be better fitted with the exclusion of one point. This observation relates to the 100 basis point decrease on 2 December 2008. From this date to 3 Feb 2009, the RBA held 4 meetings and lowered the cash rate by a total 375 basis points. This was a drastic response to the global financial crisis (GFC).

The investment banking industry of the U.S. was failing, culminating on 15 Sep 2008 when the investment bank Lehman Bros collapsed (CNBC, 2008). The observation on 7 Oct (Figure 7 (b), obs. #57) occurred three weeks after this during a time of great market uncertainty. It is not surprising that this point also falls outside of the normal range of All Ords returns.

According to the RBA minutes, the reduction on 2 Dec 2008 was a result of a slowing world economy, with conditions predicted to worsen in the near future. In addition, with no meetings held in January, the RBA wanted to display a firm expansionary stance to boost confidence (RBA, 2008).

Before exclusion from data analysis it is beneficial to see if removing this point alters the previous normality results for Shapiro-Wilk and Jarques-Bera testing.

4.2.2 Testing for normality excluding an influential observation

Table III displays a comparison of previous normality testing (see Ch. 4.1.1 and Ch. 4.1.2), as well as tests excluding the influential observation on 2 Dec 2008.

Results indicate that excluding the observation 2 Dec 2008 may improve statistical inference for regression tests using the dataset for event days only; p-values for both tests exceed 5% when

this point is excluded. No change occurs when the point is excluded for all trading days. For this reason, a comparison of regression models excluding this observation is conducted for event day only calculations.

Table III Normality testing excluding influential observation

The table reports the resulting p-values of normality tests using Shapiro-Wilk and Jarques-Bera methods. Tested using the sample containing all trading days, columns (a) and (c) include all observations while (b) and (d) exclude the influential observation from 2 Dec 2008. Tested using the sample containing event days only, columns (e) and (g) include all observations while (f) and (h) exclude the influential observation from 2 Dec 2008.

	All Trading Days				**Event Days Only**			
	Returns		Log Returns		Returns		Log Returns	
Normality Test	All Data (a)	Exclude 2 Dec 2008 (b)	All Data (c)	Exclude 2 Dec 2008 (d)	All Data (e)	Exclude 2 Dec 2008 (f)	All Data (g)	Exclude 2 Dec 2008 (h)
Shapiro-Wilk	<2.2e-16	<2.2e-16	<2.2e-16	<2.2e-16	0.008	0.634	0.005	0.682
Jarques-Bera	<2.2e-16	<2.2e-16	<2.2e-16	<2.2e-16	5.01e-08	0.564	3.57e-09	0.642

Calculated using R packages 'tseries' and 'stats'

4.3 Testing for Heteroskedasticity

Both datasets are tested for violation of non-constant variance using the 'ncvTest' command from the 'car' package in R (see Table IV). This Breusch-Pagan test, computes a score test for the hypothesis of constant error variance, i.e. homoskedasticity. The alternative hypothesis is that the error variance changes with the level of the response fitted values, i.e. heteroskedasticity.

Table IV Non-constant variance

	All Trading Days	Event Days Only
Chi-Square	11.97196	27.68849
p-value	0.00054	1.42508e-07

Calculated using R package 'car'

As expected, with p-values less than 5%, this test reports that heteroskedasticity is present with returns data. For this reason, data will be tested using heteroskedasticity-consistent estimation and include a comparison of OLS regression.

4.4 Descriptive Statistics

This section gives a brief look at descriptive statistics including the surprise versus expected reaction of the stock market to RBA rate announcements. The focus of this research on the surprise component of rate changes provides a unique insight into market reaction. The summary statistics in the table below are based on the reaction of the All Ords to RBA monetary policy announcements for the period spanning September 2003 to August 2013.

Table V Descriptive Statistics

The table outlines descriptive statistics for the Reserve Bank of Australia (RBA) surprise rate changes and the All Ordinaries market index returns for the sample period September 2003 to August 2013. The table reports results for event days (announcements) and nonevent days (all other trading days where no announcement occurs). Data has also been separated (pre-2008 and post-2008) based on the RBA media release 5 Dec 2007 detailing a change in communication .

	Sep 2003 – Aug 2013	Sep 2003 – Dec 2007	Feb 2008 – Aug 2013
Number of events: RBA monetary policy announcement	110	48	62
Number of observations: RBA change in cash rate	31	8	23
Number of observations: RBA minutes released	65	3*	62
Average equity return on event days, %	-0.069	0.031	-0.147
Average equity return on nonevent days, %	0.022	0.065	-0.010
Standard deviation of RBA cash rate surprise, basis points	14.43	4.952	18.78
Standard deviation of equity return on event days, %	0.915	0.740	1.030
Standard deviation of equity return on nonevent days, %	1.084	0.727	1.292
Proportion of rate changes taking place at RBA announcements, %	28.2	7.3	20.9

*Note: *3 x minutes releases prior to 2008 are not included in data analysis*

The regression analysis performed in this report is based on RBA policy announcements and also the release of RBA minutes. This data is also divided into pre-2008 and post-2008 samples to understand if the market responds differently to a change in communication after December 2007. As can be seen from Table V, although the number of events is not significantly different between these two time periods, the proportion of rate changes is much higher post-2008. The post-2008 period includes policy decisions announced throughout the GFC where the RBA was frequently reducing the cash rate to stimulate the contracting economy.

Looking at equity returns for the All Ords index, it can be seen that a small negative return exists on event days (-0.069%) in comparison to a positive return for nonevent days (0.022%). However, pre-2008 returns were positive and post-2008 returns were negative. This asymmetry is likely due to economic expansion pre-2008 before global markets collapsed and followed by a contractionary period post-2008. The large negative return of -0.147% during this time indicates that markets react strongly to RBA announcements. Regression models in the following section aim to distinguish if this is based on surprise or expected reactions.

As measured by the standard deviation, the cash rate surprise varies significantly between periods. The large variance of 18.78 basis points post-2008 is due to the RBA surprising the market by lowering interest rates 100 basis points; three times between September 2008 and February 2009 in response to economic conditions due to the GFC. Looking at returns, volatility on event days is higher after the implementation of regular communication, with the standard deviation of returns increasing from 0.74% to 1.03%. However, volatility has also increased on nonevent days (0.73% to 1.29%) suggesting that the market was overall more volatile post-2008. The increase in volatility for non-events may indicate that the market expected change when

interest rates were kept on hold. However, with only 7% of rate changes taking place pre-2008, inference may be weak.

4.5 Hypothesis testing of RBA cash rate targets with regression analysis

The statistical analysis in this report considers fourteen different models all looking at the response of Australian equities using the All Ords index. The first five models consider the impact of monetary policy announcements and actual cash rate decisions. The reaction of the stock market is explored further by considering whether announcements are expected, a surprise or asymmetric (positive vs. negative changes). Next, three models are used to investigate market reaction to RBA minutes release dates. This section concludes by analysing six models with the addition of interaction variables. Five of these look at the impact of monetary policy announcements and actual cash rate decisions while the final model considers the impact of drastic changes to the cash rate.

All tables offer a comparison of OLS regression and that using robust standard errors (RSE). RSE are created by taking the covariance matrix for OLS estimated coefficients and using White's heteroskedasticity-consistent (HC) estimator (see Ch. 3.5.3). Models using the 'event day only' dataset (110 observations) also include a comparison of RSE excluding the outlier from 2 Dec 2008 (see Tables VI, X, XVI, XVIII and XIX).

4.5.1 Hypothesis 1

There is a significant impact on All Ords returns at the RBA announcement

To test H1, three models are developed that examine the impact (if any) of RBA announcements on All Ords returns. The first reports results for any impact on the day of announcement (see

Table VI), the second considers the magnitude of the change in cash rate (see Table VII) and the third tests for a significant impact depending on the direction of the announced policy action (see Table VIII).

Model 1: The Response of equity prices at RBA announcements

To test if there is a significant impact on All Ords returns on the day of the RBA announcement, the following equation is used:

$$R_t = \alpha + \beta(d_{ANN}) + \varepsilon_t \quad , \qquad (3)$$

where R_t represents the daily returns, the model's intercept is denoted by α, the independent variable coefficient by β, d_{ANN} is a dummy variable = $\begin{cases} 1, & if\ announcement \\ 0, & if\ otherwise \end{cases}$, and ε_t is a residual which embodies all other variables not included in the model.

This model looks at whether there is an effect on returns for announcement days compared with every other trading day. As some of the models only consider event days, it is necessary to provide a basis for comparison.

Table VI indicates that over the entire period, September 2003 to August 2013, the cash rate announcement by the RBA has no significant impact on Australian equities. All p-values are above 10% and R^2 is close to zero (0.03%) suggesting that the model has very little explanatory power. As expected, with p-values less than 5%, the Breusch-Pagan test (3.1%) indicates that heteroskedasticity is present. However, using RSE has made no significant difference to results.

Table VI The Response of equity prices at RBA announcements

The table reports the regression results of the All Ords return on the day of the RBA monetary policy announcement. Column (a) shows the result of OLS regression and (b) is calculated using heteroskedasticity-consistent estimates of the standard errors. The full sample consists of 2538 trading days spanning 110 RBA meetings (31 involving a change to the cash rate), over the period September 2003 to August 2013. Standard errors are presented in parentheses.

Regression Results Equation 3		
	All Ords Returns	
	Naive SE	Robust SE
	(a)	(b)
RBA Announcement (d_{ANN})	-0.0009	-0.0009
	(0.0011)	(0.0009)
Intercept	0.0002	0.0002
	(0.0002)	(0.0002)
Observations	2538	2538
R^2	0.0003	0.0003
Adjusted R^2	-0.0001	-
Residual Std. Error	0.0108	-
F Statistic	0.7653	-
Wald Test	-	0.3053
Breusch-Pagan	0.03101	-
Note:	*p<0.1; **p<0.05; ***p<0.01	

Reporting no significant results, model 1 does not support H1, that there is an impact on All Ords returns at the RBA announcement.

Model 2: The Response of equity prices to RBA rate changes

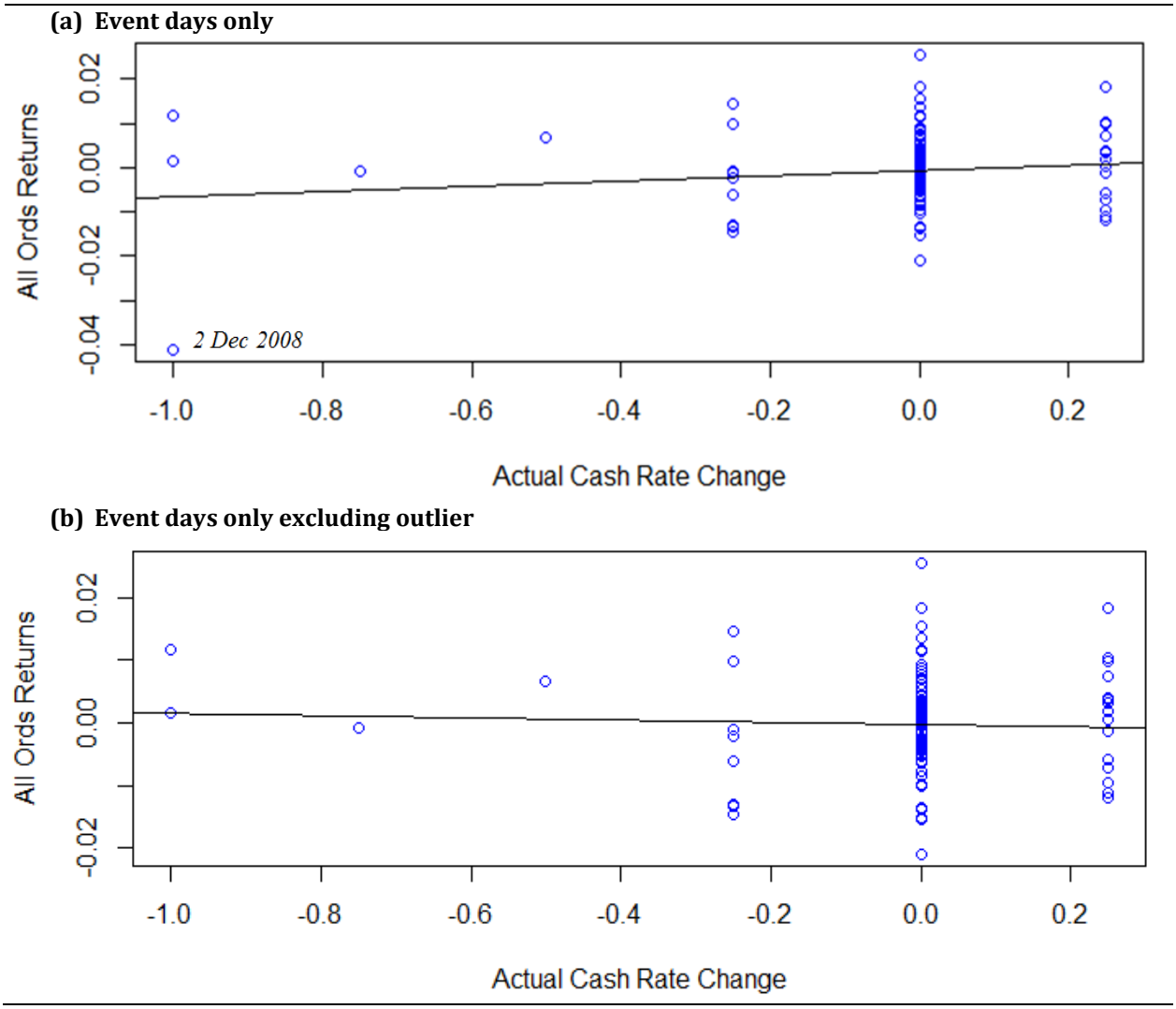
The second model (see Table VII) compares All Ords returns to the actual cash rate change announced by the RBA. Both datasets are tested: all trading days and event days only. Additionally, the event day only model is regressed excluding the influential observation 2 December 2008. The aim of this model is to determine if rate changes by the RBA impact the Australian stock market.

Impact of change in cash rate on All Ords returns is conducted using the following equation:

$$R_t = \alpha + \beta(\Delta i_t) + \varepsilon_t \quad , \qquad (4)$$

where R_t represents the daily returns, the model's intercept is denoted by α, the independent variable coefficient by β, Δi_t is the actual change in cash rate, and ε_t is a residual which embodies all other variables not included in the model.

To graphically show the impact of excluding the outlier, Figure 8 displays scatterplots of All Ords returns on announcement day against the actual change in cash rate.



Created using R

Figure 8. Equity response to change in cash rate target with and without outlier

In Figure 8(a), the outlier is included and the line is the result of the OLS regression reported in Table VII (column (c)). From this plot it can be seen that as the change increases and becomes more positive, the impact on equity returns also rises. The observation with a date label is associated with a 100 basis point reduction in the cash rate. This event is likely to be manipulating the regression line downward due to its extreme position. Using Cook's distance this observation has already been identified as influential (see Figure 7) .

To demonstrate the influence of this observation, Figure 8(b) displays the scatterplot excluding the outlier. The line is now the result of OLS regression without this observation (see Table VII, column (e)). Without the influencial observation (obs. #59), the regression line alters its slope and shows that as the cash rate change becomes larger and more negative, equity returns rise.This confirms the findings by Bernanke and Kuttner (2005) that outliers may produce significant variation in results. Thus, it is important to offer a comparison within regression tables.

Considering the results of model 2 (see Table VII), OLS results provide a positive but insignificant rate change coefficient (p-values of 17.8% in column (a) and 13.5% excluding the outlier in column (b)). Although weak, this would indicate, against expectation, that All Ords returns have a positive relationship with changes to the cash rate. Interestingly, and demonstrated in Figure 8(b), when 2 Dec 2008 is discarded, the estimated market response to a rate change becomes negative, as would be expected, but is small and insignificant (p-value of 35.2%). Excluding this observation, model (e), marginally improves the R^2 (0.196%) but with a Wald F-test probability of 65% and insignificant coefficients, this model does not explain market reaction.

Table VII The Response of equity prices to RBA rate changes

The table details the results from regressions of the All Ords returns, calculated from the closing prices on the day of announcement and day prior, and the change in cash rate. The regressions in columns (a) and (b) corresponds to the impact on returns due to the actual cash rate change for all trading days. Testing for event days only is displayed in columns (c), (d) and (e). Columns (a) and (c) use OLS, while (b), (d) and (e) are calculated with heteroskedasticity-consistent estimators. Column (e) excludes observation from 2 Dec 2008 due to its high influence within the model. The full sample consists of 2538 trading days spanning 110 RBA announcements over the period September 2003 to August 2013. Standard errors are presented in parentheses.

	Regression Results Eq. 4 - All Days		**Regression Results Eq. 4 - Event Days**		
	All Ords Returns				
	Naive SE	Robust SE	Naive SE	Robust SE	RSE Ex. Outlier
	(a)	(b)	(c)	(d)	(e)
Actual Rate Change	0.0062	0.0062	0.0059	0.0059	-0.002
	(0.005)	(0.008)	(0.0039)	(0.0076)	(0.004)
Intercept	0.0002	0.0002	-0.0006	-0.0006	0.000
	(0.0002)	(0.0002)	(0.0009)	(0.0008)	(0.079)
Observations	2538	2538	110	110	109
R^2	0.0007	0.0007	0.021	0.021	0.002
Adjusted R^2	0.0003	-	0.012	-	-
Residual Std. Error	0.0108	-	0.009	-	-
F Statistic	1.8149	-	2.2734	-	-
Wald Test		0.4189	-	0.4397	0.6062
Breusch-Pagan	0.0005	-	1.43e-07	-	-
Note:			*p<0.1; **p<0.05; ***p<0.01		

Thus, model 2 does not support H1, that there is a significant impact on All Ords returns at the RBA announcement.

Model 3: Response of equity prices when considering direction of RBA rate changes

Continuing the exploration of H1, it may be possible that the response of equity prices to monetary policy depends on the direction of the cash rate decision.

To determine if the market responds differently to expansionary or contractionary monetary policy, a multiple regression is performed with dummy variables. A dummy variable is set for 1 for the 17 observations with a positive change and a second dummy variable is set for 1 for the

14 observations where a negative change takes place. For 79 of the 110 RBA meetings, no change occurs, and this becomes the reference category in the regression model.

Test for asymmetry on All Ords returns is conducted using the following equation:

$$R_t = \alpha + \beta_1(d_{INC}) + \beta_2(d_{DEC}) + \varepsilon_t \quad , \qquad (5)$$

where R_t represents the daily returns, the model's intercept is denoted by α, the coefficient for a cash rate increase by β_1, d_{INC} is the positive change dummy variable = $\begin{cases} 1, & if\ rate\ increased \\ 0, & if\ otherwise \end{cases}$, the coefficient for a cash rate decrease is denoted by β_2, d_{DEC} is the negative change dummy variable = $\begin{cases} 1, & if\ rate\ decreased \\ 0, & if\ otherwise \end{cases}$ and ε_t is a residual which embodies all other variables not included in the model.

A number of studies (Bernanke & Kuttner, 2005; Bomfim, 2003; Brenner, Pasquariello & Subrahmanyam, 2009; Kim, S-J & Nguyen, 2008; Smales, 2012a) have analysed the directional impact of monetary policy announcements and uncover evidence of an asymmetric news effect.

Results for model 3 (see Table VIII), show that neither dummy variable is significant. Overall, this model provides little evidence to support H1, that there is a significant impact on All Ords returns at the RBA announcement, even when a directional influence is considered.

Table VIII Response of equity prices considering direction of rate change

This table reports the results from regressions of the All Ords returns on the positive and negative changes to the RBA cash rate. Column (a) shows the result of OLS regression and (b) is calculated using heteroskedasticity-consistent estimates of the standard errors. The full sample consists of 2538 trading days spanning 110 RBA meetings (17 involving a positive change and 14 relating to a negative change to the cash rate), over the period September 2003 to August 2013. Standard errors are presented in parentheses.

	Regression Results Equation 5	
	All Ords Returns	
	Naive SE	Robust SE
	(a)	(b)
Increase (d_{INC})	0.0002	0.0002
	(0.0026)	(0.0020)
Decrease (d_{DEC})	-0.0037	-0.0037
	(0.0029)	(0.0037)
Intercept	0.0002	0.0002
	(0.0002)	(0.0002)
Observations	2538	2538
R^2	0.0007	0.0007
Adjusted R^2	-0.0001	-
Residual Std. Error	0.0108	-
F Statistic	0.8242	-
Wald Test	-	0.5966
Breusch-Pagan	0.0925	-
Note:	*p<0.1; **p<0.05; ***p<0.01	

The weak results of this model lead to further questions regarding state dependence and also asymmetry. Equity markets tend to act differently during contractions and expansions and the results in Table VIII may be insignificant due to the impact of directional rate changes being averaged over the entire sample period. This hypothesis (H4) will be tested in models at the end of this section using interaction terms that divide the sample into pre-2008 and post-2008 periods (see Table XVIII). Asymmetrical results with cash rate changes will be investigated further by decomposing surprise and expected components into positive and negative announcement reactions (see Table X and XIX).

4.5.2 Hypothesis 2

There is a significant impact on All Ords returns with unexpected RBA decisions

Hypothesis 2 seeks to determine if unanticipated monetary policy announcements have a more significant impact on equities than those expected by market participants. Providing uniqueness to this thesis, it involves modelling the impact of announcements on equity prices while distinguishing between the surprise and expected components of market reaction. One of the issues with estimating the response of equity prices to monetary policy decisions is that markets are unlikely to react to announcements that they have already anticipated. It has been found that the surprise component in monetary policy announcements boost stock market volatility significantly in the short run (Bomfim, 2003). Research in this area is therefore important in gaining more understanding on the impact that monetary policy actions will have on the stock market. A complex methodology has been employed using 30-day interbank cash rate futures as a proxy for market expectation (see Ch. 3.4.5).

Model 4: Distinguishing between surprise and expected changes

Model 4 consists of four variations of regressions aimed at determining the impact of surprise on the Australian stock market (see Table IX).

Impact of surprise and expectation on equity returns is conducted using the following equation:

$$R_t = \alpha + \beta_1(X_{SUR}) + \beta_2(X_{EXP}) + \varepsilon_t \quad , \qquad (6)$$

where R_t represents the daily returns, the model's intercept is denoted by α, the coefficient for a cash rate surprise by β_1, X_{SUR} is the surprise change in cash rate, the coefficient for expected cash

rate change is denoted by β_2, X_{EXP} is market expectation of change at announcement and ε_t is a residual which embodies all other variables not included in the model.

As the regressions in this model use the sample containing event days only (110 observations), the influential observation (2 Dec 2008) is removed in some models for comparison (see Table IV, columns (c) and (d)). Interestingly, based on futures data the market was reasonably accurate in their expectation of rate change on this day. The actual change by the RBA was a reduction of 100 basis points, market expectation was -1.01% and thus the surprise component was a mere 0.01%. However, the All Ords fell 4.02% on this day, skewing the equity return results.

Under normal circumstances, tests excluding the outlier would only be conducted using HC estimators. However, with the significant results in model (a) under OLS methodology, it is interesting to see if removing 2 Dec 2008 from (a) would make a difference to results. Indeed it has, with model (c) resulting in zero significant coefficients.

Model 4 has produced some interesting and significant results. Considering column (a) of Table IX, when the target rate change is broken down into its surprise and expected components, the estimated expected market response is positive and highly significant (p-value of 1.06%). These results imply a 1.17% 1-day return in response to a 100 bp expected rate increase. According to adjusted R^2, 5.6% of the variance in equity prices on announcement days is associated with news about the cash rate. While monetary policy decisions by the RBA account for a small portion of the variance in stock returns, events other than RBA announcements obviously impact the Australian stock market.

Further, this model is significant with an F-statistic p-value of 1.69%. However, the Breusch-Pagan test (p-value of 2.25e-05) implies that this model is highly heteroskedastic. Thus, despite

being significant, OLS methodology may be producing still unbiased coefficients but too narrow SE, giving a false sense of precision (see Ch. 3.5.1). Heteroskedasticity is confirmed with the difference in standard errors of the expected change coefficient (see Figure 3 for explanation). The SE produced by OLS (0.45%, see Table IX, column (a)) is less than RSE (0.89%, column (b)).

Table IX Distinguishing between surprise and expected changes

The table reports the results from regressions of the All Ords returns and the change in cash rate, separating this raw change into surprise and expected components. The expected component is calculated using the weighted change in 30-day interbank futures on announcement day from the day prior. The sample consists of 110 events, with 31 changes to the cash rate by the RBA and 79 days where no change occurred. This is over the period September 2003 to August 2013. Columns (a) and (c) show the result of OLS regression while (b) and (d) are calculated using heteroskedasticity-consistent estimates of the standard errors. Colums (c) and (d) exclude the influential observation from 2 Dec 2008. Standard errors are presented in parentheses.

Regression Results Equation 6

	All Ords Returns			
	Inc. Outlier		Ex. Outlier	
	Naive SE	Robust SE	Naive SE	Robust SE
	(a)	(b)	(c)	(d)
Surprise Rate Change	-0.0054	-0.0054	-0.0070	-0.0070**
	(0.0060)	(0.0040)	(0.0056)	(0.0037)
Expected Rate Change	0.0117***	0.0117	0.0019	0.0019
	(0.0045)	(0.0089)	(0.0049)	(0.0042)
Intercept	-0.0006	-0.0006	-0.0004	-0.0004
	(0.0009)	(0.0008)	(0.0008)	(0.0008)
Observations	110	110	109	109
R^2	0.0734	0.0734	0.0177	0.0177
Adjusted R^2	0.0561	-	-0.0008	-
Residual Std. Error	0.0089	-	0.0083	-
F Statistic	4.2399**	-	0.9564	-
Wald Test	-	0.0933*	-	0.1479
Breusch-Pagan	2.25e-05	-	0.8421	-
Note:		*p<0.1; **p<0.05; ***p<0.01		

Overall, the statistically significant effect on All Ords returns in column (a) should be interpreted with care due to the heteroskedastic nature of the OLS regression. A more accurate model is found in column (b) with the use of HC estimators. Here, a Wald test for the joint hypothesis that the coefficients for surprise and expected change are zero cannot be rejected at the 10%

significance level. Therefore, despite being individually insignificant, surprise and expected change may have some explanatory power for the reaction in All Ords returns.

In Table IX, columns (c) and (d), simply removing the influential observation (2 Dec 2008), has produced significant results contrary to those just described. Based on the Breusch-Pagan test for the model excluding the outlier (column (c)), it is more likely that the results are homoskedastic. Similarly, when considering the standard errors of the surprise coefficient (column (d)), RSE are less than naive SE, indicating homoskedasticity (see Figure 3 for further explanation). Moreover, the significant variable has changed from expected change to surprise change with the exclusion of the outlier.

Results from model (d) imply that the estimated surprise market response is negative and significant (p-value of 5.98%). Thus, a 100 bp increase in the cash rate would produce an estimated -0.70% fall in 1-day equity returns. According to adjusted R^2, 1.8% of the variance in equity prices on announcement days is associated with news about monetary policy. The Wald test statistic is insignificant (p-value of 14.8%), offering weak support that RBA monetary policy decisions impact the Australian stock market.

Based on the Breusch-Pagan result for OLS regression in column (c) indicating homoskedasticity (84.2%), the results in column (d) should be relied upon with caution. Thus, while model 4 has reported some significant results, column (c) is likely the most reliable. This implies that there is weak support of hypothesis 2 and unexpected RBA decisions do not, in fact, have a significant impact on equities in Australia.

Based on these insignificant results, it is possible that the impact of changes to the cash rate is offset by the impact of other macroeconomic news announcements. This has been demonstrated

within both international (Bernanke & Kuttner, 2005; Brenner, Pasquariello & Subrahmanyam, 2009; Nikkinen et al., 2006) and Australian literature (Kim, S-J & Nguyen, 2008; Smales, 2012a). For example, Brenner, Pasquariello and Subrahmanyam (2009) argue that when setting interest rate policy the main concerns are employment and inflation, and markets are most sensitive to this news.

Results may be more significant if the model considers an asymmetric news effect of surprise and expected announcements. This will be tested using the following hypothesis.

4.5.3 Hypothesis 3

The impact on stock returns is expected to be greater when there is a surprise increase in the cash rate

Considering that market expectation has yielded some significant results in OLS regression and a significant surprise component using RSE excluding the outlier (see Table IX), it is then important, as the next step, to test H3 and explore if a directional influence exists. Within international literature, Bomfim (2003) finds that positive surprises – higher-than-expected values of the target rate – tend to have a larger effect on the volatility of US equities than negative surprises. Similarly, a study by Kim, S-J and Nguyen (2008) provides weak evidence that Australian markets generally respond more strongly to unexpected rate rises than rate falls. Therefore, it is expected that results of model 5 will yield similar results and support this hypothesis.

Model 5: Asymmetrical response with surprise and expected changes

Testing for an asymmetrical response is accomplished by regressing All Ords returns with dummy variables for positive and negative surprise and expected changes.

Directional impact of surprise and expected change on equity returns is conducted using the following equation:

$$R_t = \alpha + \beta_1(d+_{SUR}) + \beta_2(d-_{SUR}) + \beta_3(d+_{EXP}) + \beta_4(d-_{EXP}) + \varepsilon_t \quad , \quad (8)$$

where R_t represents the daily returns, the model's intercept is denoted by α, the coefficient for a positive cash rate surprise by β_1, $d+_{SUR}$ is the positive surprise dummy, the coefficient for a negative cash rate surprise by β_2 and $d-_{SUR}$ is the negative surprise dummy. The coefficient for positive expected cash rate change is denoted by β_3, $d+_{EXP}$ is the positive expected dummy, the coefficient for a negative expected change by β_4 and $d-_{EXP}$ is the negative expected dummy. All other variables not explained in the model are embodied by the residual term, ε_t and dummy variables $= \begin{cases} 1, & if\ condition\ exists \\ 0, & if\ otherwise \end{cases}$.

The results of model 5 reported in Table X do not support the findings in the literature, showing no significant impact on returns when the direction of rate changes is applied. The results are consistent with those in Table IX and do not support H3.

Table X **Asymmetrical response with surprise and expected changes**

The table reports the results from regressions of the All Ords returns and the change in cash rate, separating this raw change into positive and negative dummy variables for both surprise and expected change. The sample consists of 110 events, with 31 changes to the cash rate by the RBA and 79 days where no change occurred. This is over the period September 2003 to August 2013. Column (a) shows the result of OLS regression while (b) and (c) are calculated using heteroskedasticity-consistent estimates of the standard errors. Column (c) excludes the influential observation from 2 Dec 2008. Standard errors are presented in parentheses.

	Regression Results Equation 8		
	All Ords Returns		
	Naive SE	Robust SE	RSE Ex. Outlier
	(a)	(b)	(c)
+ve Surprise Change $(d+_{SUR})$	-0.0003	-0.0003	0.0010
	(0.009)	(0.002)	(0.0017)
-ve Surprise Change $(d-_{SUR})$	-0.0016	-0.0016	-0.0007
	(0.0096)	(0.0024)	(0.0023)
+ve Expected Change $(d+_{EXP})$	-0.0002	-0.0002	-0.0011
	(0.0099)	(0.0029)	(0.0028)
-ve Expected Change $(d-_{EXP})$	-0.002	-0.002	-0.0020
	(0.0096)	(0.0017)	(0.0017)
Intercept	0.0009	0.0009	0.0009
	(0.0024)	(0.0017)	(0.0017)
Observations	110	110	109
R^2	0.0104	0.0104	0.0104
Adjusted R^2	-0.0273	-	-
Residual Std. Error	0.0093	-	-
F Statistic	0.2759	-	-
Wald Test	-	0.6992	0.6451
Breusch-Pagan	0.0853	-	-
Note:		*p<0.1; **p<0.05; ***p<0.01	

Considering more closely what characterises the directional change of the cash rate, Table XI breaks down these components:

Table XI Direction of surprise and expected components

	Positive	Negative	Zero	Total
Surprise Change	45	49	16	110
Expected Change	60	35	15	110

Recall that, where Δi^e is the expected target rate change, Δi^u is the unexpected rate change (surprise component), the actual rate change Δi_t is therefore the sum of expected and surprise, or:

$$\Delta i_t = \Delta i^e + \Delta i^u \qquad (7)$$

This shows that over the entire ten year sample period, September 2003 to August 2013, the market is more likely to expect a positive change in the cash rate. However, there may be a difference if the economy is experiencing a contraction or expansion. This will be explored using a post-2008 interaction dummy variable (see Ch. 4.7.5) to see if significant results exist when the timing of announcements is considered (see H5).

4.6 Hypothesis testing of RBA minutes with regression analysis

This section examines the effect of RBA meeting minutes on Australian equities. The aim is to test H4 and determine if the release of the explanatory minutes has an impact on the stock market.

4.6.1 Hypothesis 4

There is a significant impact on All Ordinaries returns at the release of explanatory meeting minutes

The inclusion of minutes data has been discussed in the literature and highlights the importance of central bank communication. When investigating the impact on Australian interest rate futures (Jan 2004 to Dec 2010), Smales (2012a) finds that implementation of the new policy communication regime in Dec 2007 improves the ability of the RBA to influence market expectation. McCredie et al. (2013) also examine the differential impact of monetary policy announcements and minutes on the Australian interest rate futures market. They find that both have a significant impact on the returns and volatility of the futures contracts, while the release of minutes elicits a larger response.

In an international study, Rosa (2011) makes an interesting point; not only is central bank communication an essential tool for managing expectations and reducing uncertainty about the economic outlook, but that 'when the policy rate is near its zero lower bound, the Fed can still ease financial conditions, and thus provide additional stimulus, through its communication' (p.928). Economies are still trying to recover from the GFC and European debt crisis, and central banks have been reducing interest rates close to zero to stimulate growth. This study has important implications in that even if there is limited room to move with interest rates, communication in itself is a powerful tool.

The three models used to test H4 are explored in this section. RBA minutes releases span the period from 1 January 2008 to 30 August 2013, inclusive, for a total of 1435 trading days. This period covers 62 meetings and therefore 62 minute releases by the RBA.

The first model seeks to explain if there is any impact on the equity market on the day of release while the second explores the possibility that the magnitude of the policy action is related to returns. The final model considers a differential impact between the days where the cash rate is announced and when the explanatory minutes are released.

Model 6: Response of equity prices at RBA minutes release

This model tests if there is an impact in the market when minutes become public as opposed to any other trading day. Table XII offers a comparison of results for the full sample period (Sep 2003 to Aug 2013) and only the time period that meeting minutes have been available (since 2008).

Impact of minutes release on All Ords daily returns is conducted using the following equation:

$$R_t = \alpha + \beta(d_{MIN}) + \varepsilon_t \quad , \qquad (9)$$

where R_t represents the daily returns, the model's intercept is denoted by α, the independent variable coefficient by β, d_{MIN} is a dummy variable = $\begin{cases} 1, & if\ released \\ 0, & if\ otherwise \end{cases}$, and ε_t is a residual which embodies all other variables not included in the model.

Table XII Response of equity prices at RBA minutes release

The table reports the regression results of the All Ords return on the day of the RBA minutes release. Columns (a) and (c) show the result of OLS regression while columns (b) and (d) are calculated using heroscedasticity-consistent estimates of the standard errors. The sample for columns (a) and (b) consists of 2538 trading days, while columns (c) and (d) have been calculated using trading days since meeting minutes started becoming public.[3] This sample consists of 1435 trading days spanning 62 RBA meetings (23 involving a change to the cash rate), over the period January 2008 to August 2013. Standard errors are presented in parentheses.

	Regression Results Eq. 9: Sep 2003 - Aug 2013		**Regression Results Eq. 9: post-2008**	
	All Ords Returns			
	Naive SE	Robust SE	Naive SE	Robust SE
	(a)	(b)	(c)	(d)
RBA Minutes Release (d_{MIN})	-0.0014	-0.0014	-0.0011	-0.0011
	(0.0014)	(0.0015)	(0.0017)	(0.0016)
Intercept	0.0002	0.0002	-0.0001	-0.0001
	(0.0002)	(0.0002)	(0.0004)	(0.0004)
Observations	2538	2538	1435	1435
R^2	0.0004	0.0004	0.0003	0.0003
Adjusted R^2	0.0000	-	-0.0004	-
Residual Std. Error	0.0108	-	0.0128	-
F Statistic	1.0445	-	0.4252	-
Wald Test	-	0.3535	-	0.4836
Breusch-Pagan	0.2163	-	0.4288	-
Note:		*p<0.1; **p<0.05; ***p<0.01		

Results of Table XII imply that the introduction and release of RBA meeting minutes has no significant impact on the Australian stock market, providing no support for H4.

[3] Minutes actually became public in December 2007. Refer to Ch. 3.4.3 for explanation on their exclusion.

Model 7: Response of equities to cash rate change associated with minutes

RBA meeting minutes contain factual information that the Board use to assess the magnitude of policy actions. When the RBA releases the minutes they are informing the market of the reasons behind their policy decisions. This model is used to determine if, based on All Ords returns, the magnitude of the cash rate change has some relation with the day the market receives this information.

Impact of rate change associated RBA with minutes release, on Australian equities, is conducted using the following equation:

$$R_t = \alpha + \beta(\Delta i_{MIN}) + \varepsilon_t \quad , \qquad (10)$$

where R_t represents the daily returns at time t, the model's intercept is denoted by α, the independent variable coefficient by β, Δi_{MIN} is the raw change in cash rate regressed at the date of minutes release (two weeks after meeting), and ε_t is a residual which embodies all other variables not included in the model.

The results reported in Table XIII are calculated using the change in cash rate, but regressed on the day of minutes release rather than on the day of announcement (Δi_{MIN}). Using the entire sample period (Sep 2003 to Aug 2013) rather than just the period that minutes have been released (since 2008), has produced a significant result for the raw cash rate (see column (a)).

Regressions using Equation 10 and displayed in Table XIII calculated only one significant result (see column (a)). This implies that a 100 bp increase by the RBA will yield an estimated 0.79% 1-day return in the All Ords. Although significant, this result is very weak and the model only accounts for 0.07% of the variance in equity prices on the day the minutes are released (see

Adjusted R^2 in column (a)). Obviously, information other than that contained in the minutes is influencing market reaction. Overall, the model is significant at the 10% level with an F-statistic p-value of 8.88%. Yet the Breusch-Pagan test (p-value of 2.99e-10) implies that this model is highly heteroskedastic. Consequently, significant results should be interpreted with caution.

Table XIII Response of equities to cash rate change associated with minutes

The table reports the regression results of the All Ords return on the day of the RBA minutes release and the change associated with these minutes, announced two weeks prior at each meeting. Columns (a) and (c) show the result of OLS regression while columns (b) and (d) are calculated using heroscedasticity-consistent estimates of the standard errors. The sample for columns (a) and (b) consists of 2538 trading days, while columns (c) and (d) have been calculated using trading days since meeting minutes started becoming public.[4] This sample consists of 1435 trading days spanning 62 RBA meetings (23 involving a change to the cash rate), over the period January 2008 to August 2013. Standard errors are presented in parentheses.

	Regression Results Eq. 10: Sep 2003 - Aug 2013		**Regression Results Eq. 10: post-2008**	
	All Ords Returns			
	Naive SE	Robust SE	Naive SE	Robust SE
	(a)	(b)	(c)	(d)
Change Associated with Minutes (Δi_{MIN})	0.0079*	0.0079	0.0077	0.0077
	(0.0046)	(0.0094)	(0.0058)	(0.0103)
Intercept	0.0002	0.0002	-0.0001	-0.0001
	(0.0002)	(0.0002)	(0.0003)	(0.0003)
Observations	2538	2538	1435	1435
R^2	0.0011	0.0011	0.0012	0.0012
Adjusted R^2	0.0007	-	0.0005	-
Residual Std. Error	0.0108	-	0.0128	-
F Statistic	2.8980*	-	1.7608	-
Wald Test	-	0.4027	-	0.4557
Breusch-Pagan	2.99e-10	-	3.66e-05	-
Note:		*p<0.1; **p<0.05; ***p<0.01		

Further, all other tests within this model imply that the cash rate change, calculated on the day that the minutes are released, has no significant impact on equity returns. This model is performed in a similar way to model 2 which looks at the impact of RBA rate changes on the day of announcement (see table VII). Results are consistent with Model 2 which reported no significant results.

[4] Minutes actually became public in December 2007. Refer to Ch. 3.4.3 for explanation on their exclusion.

Model 8: Differential response of equities to RBA announcements and minutes release

This model seeks to further explore H4 and determine whether monetary policy announcements and explanatory minutes releases have a differential impact on Australian equities. It compares tests of both events spanning January 2008 to August 2013 as well as the full sample period from September 2003.

This model is tested by the inclusion of RBA announcement and minute release dummy variables. Dummy variables are set at 1 if they occur and zero if not. This is to determine if the market reacts differently to announcements or minutes. Both offer information as to the RBA's position on economic outlook for Australia.

Differential impact of announcement and minutes on All Ords returns is conducted using the following equation:

$$R_t = \alpha + \beta_1(d_{ANN}) + \beta_2(d_{MIN}) + \varepsilon_t \quad , \qquad (11)$$

where R_t represents the daily returns, the model's intercept is denoted by α, the announcement variable coefficient by β_1, d_{ANN} is a dummy variable = $\begin{cases} 1, & if\ announcement \\ 0, & if\ otherwise \end{cases}$, the minutes variable coefficient by β_2, d_{MIN} is a dummy variable = $\begin{cases} 1, & if\ minutes\ release \\ 0, & if\ otherwise \end{cases}$, and ε_t is a residual which embodies all other variables not included in the model.

The results presented in Table XIV indicate that regardless of the sample period and the treatment of standard errors, neither the cash rate announcement by the RBA nor the release of explanatory minutes has a significant impact on Australian equities. The Breusch-Pagan result above 5% (column (a)) implies homoskedasticity and as expected, using RSE has made no

significant difference to results (column (b)). Testing using only the period covering the release of minutes (1435 trading days spanning 62 RBA meetings from Jan 2008), also provided no support for H4. Column (c) reports heteroskedasticity, thus the regression in column (d) using HC estimators should be more reliable, but also reports insignificance.

Table XIV Differential response of equities to RBA announcements and minutes

The table reports the regression results of the All Ords return on the days of the RBA minutes release and announcement. Columns (a) and (c) show the result of OLS regression while columns (b) and (d) are calculated using heroscedasticity-consistent estimates of the standard errors. The sample for columns (a) and (b) consists of 2538 trading days, while columns (c) and (d) have been calculated using trading days since meeting minutes started becoming public.[5] This sample consists of 1435 trading days spanning 62 RBA meetings (23 involving a change to the cash rate), over the period January 2008 to August 2013. Standard errors are presented in parentheses.

	Regression Results Eq. 11: Sep 2003 - Aug 2013		**Regression Results Eq. 11: post-2008**	
	All Ords Returns			
	Naive SE	Robust SE	Naive SE	Robust SE
	(a)	(b)	(c)	(d)
Minutes Release *(d_{MIN})*	-0.0015	-0.0015	-0.0012	-0.0012
	(0.0014)	(0.0015)	(0.0017)	(0.0016)
RBA Announcement *(d_{ANN})*	-0.0010	-0.0010	-0.0014	-0.0014
	(0.0011)	(0.0009)	(0.0017)	(0.0014)
Intercept	0.0003	0.0003	-0.0001	-0.0001
	(0.0002)	(0.0002)	(0.0004)	(0.0004)
Observations	2538	2538	1435	1435
R^2	0.0007	0.0007	0.0008	0.0008
Adjusted R^2	-0.0001	-	-0.0006	-
Residual Std. Error	0.0108	-	0.0128	-
F Statistic	0.9361	-	0.5763	-
Wald Test	-	0.3720	-	0.4551
Breusch-Pagan	0.6308	-	0.0310	-
Note:		$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$		

All models considered in this section have provided no significant results to support H4. Thus, contrary to the literature (McCredie et al., 2013; Smales, 2012a), the cash rate change does not elicit a market response on announcement day or when minutes are released.

[5] Minutes actually became public in December 2007. Refer to Ch. 3.4.3 for explanation on their exclusion.

4.7 Hypothesis testing with regression using interaction variables

The change in policy regime from 2008 may have had a significant impact on how equity markets respond to monetary policy actions. This section seeks to explore hypothesis 5 by examining models 1 through to 5 with the addition of an interaction term; a dummy variable for post-2008.

4.7.1 Hypothesis 5

There is a significant impact on returns after the introduction of a more transparent monetary policy communication regime in December 2007

This dummy is set to 1 for observations from January 2008 to August 2013 and zero for the period spanning September 2003 to December 2007. Because the release of explanatory minutes was also part of this new communication regime by the RBA, some models within this section include a minutes dummy variable. Significant interaction terms could indicate that the change in communication has affected how equity markets respond to RBA cash rate announcements.

It is important to note however, that the state of the economy was also contracting prior to 2008 due to global economic collapse surrounding the GFC. In 2009, markets were recovering and economies were expanding in comparison. Therefore, the results in this section may be due to state dependence rather than the change in communication. Regardless, it is worthwhile determining if there is in fact a difference between these two periods.

Model 9: Equity response with RBA announcement post-2008 dummy

This model tests H5 to determine if the introduction of RBA announcements on the day of each scheduled meeting, as well as the introduction of explanatory minutes, has any impact on the Australian stock market.

Impact of announcement on All Ords daily returns with post-2008 interaction term is conducted using the following equation:

$$R_t = \alpha + \beta_1(d_{ANN}) + \beta_2(d_{ANN}\, x\, d_{2008}) + \beta_3(d_{MIN}) + \varepsilon_t \quad , \qquad (12)$$

where R_t represents the daily returns, the model's intercept is denoted by α, the announcement variable coefficient by β, d_{ANN} is a dummy variable = $\begin{cases} 1, & if\ announcement \\ 0, & if\ otherwise \end{cases}$, the interaction coefficient by β_2, d_{2008} is a dummy variable = $\begin{cases} 1, & if\ occurs\ post-2008 \\ 0, & if\ occurs\ pre-2008 \end{cases}$, the minutes variable coefficient by β_3, d_{MIN} is a dummy variable = $\begin{cases} 1, & if\ minutes\ release \\ 0, & if\ otherwise \end{cases}$, and ε_t is a residual which embodies all other variables not included in the model.

Table XV Equity response with RBA announcement post-2008 dummy

The table reports the regression results of the All Ords return on the day of the RBA monetary policy announcement as well as an interaction term and minutes dummy variable to capture the effect of the change in communication post-2008. Column (a) shows the result of OLS regression and (b) is calculated using heteroskedasticity-consistent estimates of the standard errors. Standard errors are presented in parentheses.

Regression Results Equation 12		
	All Ords Returns	
	Naive SE	Robust SE
	(a)	(b)
Announcement Dummy *(d_{ANN})*	0.00004	0.00004
	(0.0016)	(0.0011)
Ann X Post-2008 Dummy *(d_{ANN} x d_{2008})*	-0.0018	-0.0018
	(0.0021)	(0.0017)
Minutes Dummy *(d_{MIN})*	-0.0015	-0.0015
	(0.0014)	(0.0015)
Intercept	0.0003	0.0003
	(0.0002)	(0.0002)
Observations	2538	2538
R^2	0.001	0.001
Adjusted R^2	-0.0002	-
Residual Std. Error	0.0108	-
F Statistic	0.8684	-
Wald Test	-	0.4588
Breusch-Pagan	0.6756	-
Note:	*p<0.1; **p<0.05; ***p<0.01	

Insignificant results in Table XV do not support H5 in that the new communication regime by the RBA has no significant impact on the Australian stock market.

Model 10: Equity response with cash rate change post-2008 dummy

This model seeks to determine if announcing the change in cash rate on the day of each meeting, rather than the day after a meeting (and only when a change occurs), has a significant impact on Australian equities. Recall that in model 2 without interaction variables (see Table VII), no significant effect was reported.

Impact of change in cash rate on All Ords returns with post-2008 interaction term is conducted using the following equation:

$$R_t = \alpha + \beta_1(\Delta i_t) + \beta_2(\Delta i_t \, x \, d_{2008}) + \varepsilon_t \quad , \qquad (13)$$

where R_t represents the daily returns, the model's intercept is denoted by α, the rate change coefficient by β_1, Δi_t is the actual change in cash rate, the interaction coefficient by β_2, d_{2008} is a dummy variable = $\begin{cases} 1, & if\ occurs\ post-2008 \\ 0, & if\ occurs\ pre-2008 \end{cases}$ and ε_t is a residual which embodies all other variables not included in the model.

Referring to Table XVI, this model is tested with the two datasets spanning the entire sample period; all trading days (2538 observations, see columns (a) and (b)), and announcement days only (110 observations, see columns (c) and (d)). In addition to this, a fifth column (e) is calculated in the same way as (d), with RSE but excluding the influential observation from 2 Dec 2008.

Results of this testing show that there is no significant difference on returns as a consequence of cash rate announcements under the new communication regime (see Table XVI).

Table XVI Equity response with cash rate change post-2008 dummy

The table details the results from regressions of the All Ords returns, the change in cash rate as well as an interaction term to capture the effect of the change in communication post-2008. The regressions in columns (a) and (b) corresponds to the impact on returns due to the actual cash rate change for all trading days. Testing for event days only is displayed in columns (c), (d) and (e). Columns (a) and (c) use OLS, while (b), (d) and (e) are calculated with heteroskedasticity-consistent estimators. Column (e) excludes observation from 2 Dec 2008 due to its high influence within the model. Standard errors are presented in parentheses.

	Regression Results Eq. 13 – All trading days		**Regression Results Eq. 13 – Event days only**		
	All Ords Returns				
	Naive SE	Robust SE	Naive SE	Robust SE	Ex. Outlier
	(a)	(b)	(c)	(d)	(e)
Actual Rate Change (Δi_t)	0.0071	0.0071	0.0105	0.0105	0.0103
	(0.0153)	(0.0127)	(0.0134)	(0.0131)	(0.0131)
Change X Post-2008 Dummy	-0.0009	-0.0009	-0.0051	-0.0051	-0.0137
(Δi_t x d_{2008})	(0.0160)	(0.0153)	(0.0143)	(0.0156)	(0.0137)
Intercept	0.0002	0.0002	-0.0007	-0.0007	-0.0006
	(0.0002)	(0.0002)	(0.0009)	(0.0008)	(0.0008)
Observations	2538	2538	110	110	109
R^2	0.0007	0.0007	0.0218	0.0218	0.0121
Adjusted R^2	-0.0001	-	0.0035	-	-
Residual Std. Error	0.0108	-	0.0091	-	-
F Statistic	0.9087	-	1.1922	-	-
Wald Test	-	0.6559	-	0.5901	0.4524
Breusch-Pagan	0.0006	-	0.0000	-	-
Note:			*p<0.1; **p<0.05; ***p<0.01		

So far, the models with interaction terms have not supported H5, reporting no significant results. The following three models will delve deeper into the impact on equities from improved communicatioin practices by the RBA. First, the sample is tested for a differential impact regarding positive and negative changes. Second, the raw change is separated into its surprise and expected components and finally, these components are explored for any asymmetrical response. All models include post-2008 dummy variables to ascertain the effect of the new regime, while model 11 (see Eq. 14) is calculated with the addition of a minutes dummy (see Table XVII). A minutes dummy is only possible when the sample being tested includes all trading days as opposed to announcement days only.

Model 11: Asymmetrical rate change and response of equities with post-2008 dummy

This model seeks to determine the impact (if any) on the Australian stock market if either an increase or decrease in the cash rate is announced by the RBA. A post-2008 interaction and minutes dummy variable test the effect of a more transparent communication policy.

Test for asymmetry on All Ords returns with post-2008 interaction term is conducted using the following equation:

$$R_t = \alpha + \beta_1(d_{INC}) + \beta_2(d_{INC}\ x\ d_{2008}) + \beta_3(d_{DEC}) + \beta_4(d_{MIN}) + \varepsilon_t \quad , \qquad (14)$$

where R_t represents the daily returns, the model's intercept is denoted by α, the coefficient for a cash rate increase by β_1, d_{INC} is the positive change dummy variable = $\begin{cases} 1, & if\ rate\ increased \\ 0, & if\ otherwise \end{cases}$, and the increase interaction coefficient by β_3. The coefficient for a cash rate decrease is denoted by β_3, d_{DEC} is the negative change dummy variable = $\begin{cases} 1, & if\ rate\ decreased \\ 0, & if\ otherwise \end{cases}$, the minutes variable coefficient by β_4, d_{MIN} is a dummy variable = $\begin{cases} 1, & if\ minutes\ release \\ 0, & if\ otherwise \end{cases}$, and ε_t is a residual which embodies all other variables not included in the model.

There is no cash rate decrease interaction variable because prior to 2008, from the beginning of the sample period (Sep 2003), the RBA did not decrease the cash rate. Thus, both the negative change dummy and decrease interaction dummy provide the same information and only one should be included in the model.

Results of this model reported in Table XVII show that the direction of the cash rate change along with the change in communication, have no significant impact on equity prices.

Table XVII Asymmetrical rate change with post-2008 dummy

This table reports the results from regressions of the All Ords returns on the positive and negative changes to the RBA cash rate, as well as an interaction term and minutes dummy to capture the effect of the change in communication post-2008. Column (a) shows the result of OLS regression and (b) is calculated using heteroskedasticity-consistent estimates of the standard errors. Standard errors are presented in parentheses.

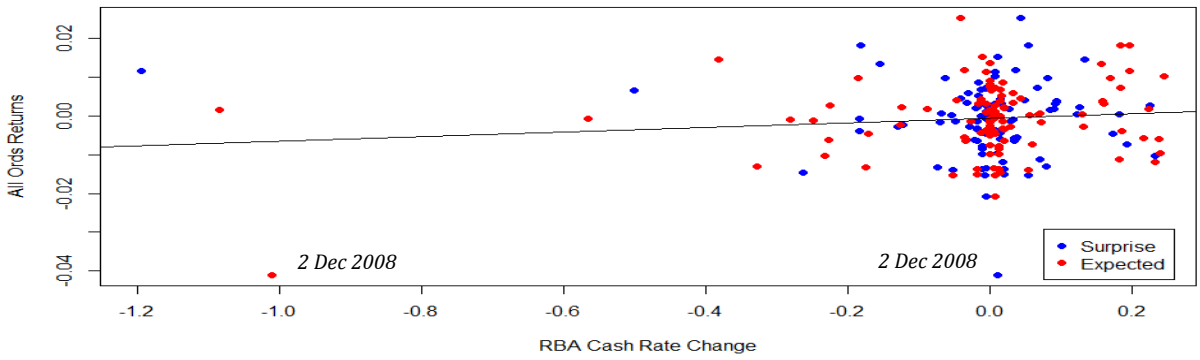
Regression Results Equation 14		
	All Ords Returns	
	Naive SE	Robust SE
	(a)	(b)
Increase (d_{INC})	0.0017	0.0017
	(0.0038)	(0.0032)
Increase X Post-2008 Dummy $(d_{INC} \times d_{2008})$	-0.003	-0.003
	(0.0052)	(0.0039)
Decrease (d_{DEC})	-0.0037	-0.0037
	(0.0029)	(0.0037)
Minutes Dummy (d_{MIN})	-0.0014	-0.0014
	(0.0014)	(0.0015)
Intercept	0.0002	0.0002
	-0.0002	-0.0002
Observations	2538	2538
R^2	0.0012	0.0012
Adjusted R^2	-0.0004	-
Residual Std. Error	0.0108	-
F Statistic	0.7609	-
Wald Test	-	0.6448
Breusch-Pagan	0.0652	-
Note:	*p<0.1; **p<0.05; ***p<0.01	

Model 12: Surprise and expected response with post-2008 dummy variable

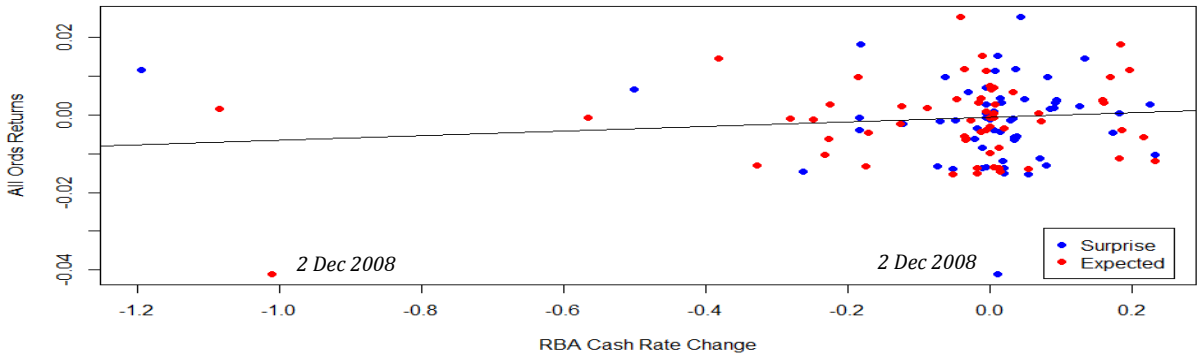
Already in this research, the investigation of H4 has produced some significant results regarding the surprise and expected components of a cash rate change (see Table IX). This model tests H5 and seeks to determine if the addition of a post-2008 dummy variable also produces significant results.

Looking at this graphically, Figure 9 displays scatterplots of announcement day returns against the surprise and expected components of the change in cash rate.

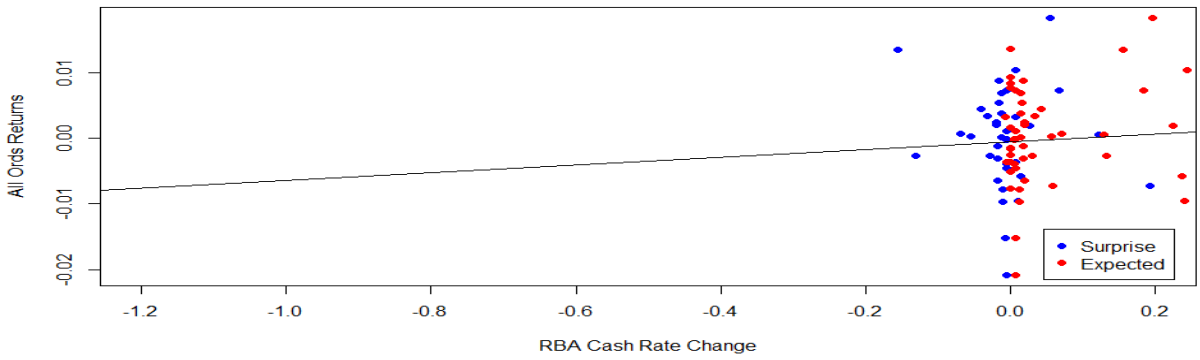
(a) All announcement days, September 2003 – August 2013 (110 observations)



(b) Announcement days post-2008, January 2008 – August 2013 (62 observations)



(c) Announcement days pre-2008, September 2003 – December 2007 (48 observations)



Created using R

Figure 9. Equity response to surprise and expected change in cash rate

The first looks at all announcement days in the sample period (see Figure 9(a)) while the remaining two plots separate the sample into post-2008 (b) and pre-2008 (c). The line is the OLS regression of equity returns against the raw cash rate changes (see Table VII, column (c)), and includes the influential observation 2 December 2008 (see date labels in Figure 9(a) and (b)).

While surprise and expected change in Figure 9(a) appear randomly distributed around the regression-line, we know from Table XI that for all announcements, expected change is more often positive. Dividing the sample from January 2008, Figure 9(b) is characterised by negative expectation, with red plot points heavier to the left of zero. Even more distinct is the negative surprise bias in Figure 9(c), with blue surprise points clearly to the left of zero (note the change in y-axis labels for this scatterplot). This is interesting, as it appears that in the earlier period (pre-2008), the model shows the market underestimating the expected change in cash rate. This is consistent with research from Smales (2012a), finding that the December 2007 modification in policy communication has improved the ability of the RBA to influence market expectations. This has important implications as future expectations of interest rates influence investment decisions and consequently economic output (Smales, 2012a).

The following model may determine this is the case by testing the impact of surprise and expected change on the All Ords, with post-2008 interaction dummy variables for each component.

Impact of surprise and expectation on equity returns with post-2008 interaction term is conducted using the following equation:

$$R_t = \alpha + \beta_1(X_{SUR}) + \beta_2(X_{SUR} \, x \, d_{2008}) + \beta_3(X_{EXP}) + \beta_4(X_{EXP} \, x \, d_{2008}) + \varepsilon_t \quad , \qquad (15)$$

where R_t represents the daily returns, the model's intercept is denoted by α, the coefficient for a cash rate surprise by β_1, X_{SUR} is the surprise change in cash rate, the surprise interaction coefficient by β_2, the coefficient for expected cash rate change is denoted by β_3, X_{EXP} is market expectation of change at announcement, the expected interaction coefficient is denoted by β_4, d_{2008} is a dummy variable = $\begin{cases} 1, & if\ occurs\ post-2008 \\ 0, & if\ occurs\ pre-2008 \end{cases}$ and ε_t is a residual which embodies all other variables not included in the model.

Table XVIII Surprise and expected response with post-2008 dummy variable

The table reports the results from regressions of the All Ords returns and the change in cash rate, separating this raw change into surprise and expected components. The sample consists of 110 events, with 31 changes to the cash rate by the RBA and 79 days where no change occurred. This is over the period September 2003 to August 2013. Column (a) shows the result of OLS regression while (b) and (c) are calculated using heteroskedasticity-consistent estimates of the standard errors. Column (c) excludes the influential observation from 2 Dec 2008. Standard errors are presented in parentheses.

Regression Results Equation 15

	All Ords Returns		
	Naive SE	Robust SE	RSE Ex. Outlier
	(a)	(b)	(c)
Surprise Change (X_{SUR})	-0.01823	-0.01823	-0.0182
	(0.0263)	(0.0176)	(0.0176)
Surprise X Post-2008 Dummy $(X_{SUR} \times d_{2008})$	0.01318	0.01318	0.011
	(0.0270)	(0.0181)	(0.0180)
Expected Change (X_{EXP})	0.02089	0.02089	0.0209
	(0.0158)	(0.0164)	(0.0164)
Expected X Post-2008 Dummy $(X_{EXP} \times d_{2008})$	-0.01017	-0.01017	-0.0218
	(0.0168)	(0.0194)	(0.0171)
Intercept	-0.00086	-0.00086	-0.0009
	(0.0009)	(0.0009)	(0.0009)
Observations	110	110	109
R^2	0.0785	0.0785	0.0365
Adjusted R^2	0.0434	-	-
Residual Std. Error	0.0090	-	-
F Statistic	2.2370*	-	-
Wald Test	-	0.1756	0.2029
Breusch-Pagan	8.118e-05	-	-
Note:		*p<0.1; **p<0.05; ***p<0.01	

The results reported in Table XVIII are calculated using the announcement day only sample (110 observations). Column (a) is produced using OLS regression while (b) and (c) use the RSE

method. Column (c) tests if removing the outlier has a significant impact on the model's explanatory power.

This model has produced some interesting and significant results. Considering column (a) of Table XVIII, when the target rate change is broken down into its surprise and expected components, the explanatory power of the model improves. A significant F-statistic (p-value of 7.0%) indicates that taken together all independent variables are not zeroes and the model has some explanatory power. However, according to adjusted R^2 (4.3%), the explanatory power of the variance in equity prices is weak. Moreover, considering the Breusch-Pagan test (p-value of 8.118e-05) this model is highly heteroskedastic. Thus, despite being significant, OLS methodology should not be relied upon for significant results.

To improve reliability, models (b) and (c) are calculated with the use of HC estimators. Here, a Wald test for the joint hypothesis that the coefficients for surprise and expected change, as well as interaction variables, are zero is rejected at the 10% significance level. Therefore, model 12 does not offer strong support for H5, and it is unlikely that there is a significant impact on returns after the introduction of the new policy communication regime in December 2007.

Model 13: Asymmetry of surprise and expected components with post-2008 dummy

The final model used to investigate H5 considers asymmetrical tests and whether the direction of surprise and expected changes has a significant impact on Australian equities post-2008.

Directional impact of surprise and expected change on equity returns with post-2008 interaction term is conducted using the following equation:

$$R_t = \alpha + \beta_1(d+_{SUR}) + \beta_2(d+_{SUR} \; x \; d_{2008}) \; + \beta_3(d-_{SUR}) + \beta_4(d-_{SUR} \; x \; d_{2008}) \; +$$

$$\beta_5(d+_{EXP}) + \beta_6(d+_{EXP} \; x \; d_{2008}) \; + \beta_7(d-_{EXP}) + \varepsilon_t \quad , \qquad (16)$$

where R_t represents the daily returns, the model's intercept is denoted by α, the coefficient for a positive surprise by β_1, $d+_{SUR}$ is the positive surprise dummy, the positive surprise interaction coefficient by β_2, the coefficient for a negative surprise by β_3, $d-_{SUR}$ is the negative surprise dummy and the negative surprise interaction coefficient by β_4. The coefficient for positive expected change is denoted by β_5, $d+_{EXP}$ is the positive expected dummy, the positive expected interaction coefficient by β_6, the coefficient for a negative expected change by β_7 and $d-_{EXP}$ is the negative expected dummy. d_{2008} is a dummy variable = $\begin{cases} 1, & if\ occurs\ post-2008 \\ 0, & if\ occurs\ pre-2008 \end{cases}$ and all other variables not explained in the model are embodied by the residual term ε_t For all other dummy variables = $\begin{cases} 1, & if\ condition\ exists \\ 0, & if\ otherwise \end{cases}$.

Because there are only two observations involving a negative expected change pre-2008 (8 June 2005 and 5 Sept 2007), this model does not include a negative expected change interaction variable.

Results reported in Table XIX include OLS regression (column (a)), RSE (column (b)) and RSE excluding the outlier (column (c)). All testing is calculated with the announcement only sample of 110 observations.

Table XIX Asymmetry of surprise and expected with post-2008 dummy

The table reports the results from regressions of the All Ords returns and the change in cash rate, separating this raw change into positive and negative dummy variables for both surprise and expected change. This model also includes an interaction term to capture the effect of the change in communication post-2008. Column (a) shows the result of OLS regression while (b) and (c) are calculated using heteroskedasticity-consistent estimates of the standard errors. Column (c) excludes the influential observation from 2 Dec 2008. Standard errors are presented in parentheses.

Regression Results Equation 16			
	All Ords Returns		
	Naive SE	Robust SE	Ex. Outlier
	(a)	(b)	(c)
+ve Surprise Change $(d+_{SUR})$	0.0009	0.0009	0.0009
	(0.0115)	(0.0024)	(0.0024)
+ve Surprise X Post-2008 Dummy $(d+_{SUR} \times d_{2008})$	-0.0014	-0.0014	5.00e-06
	(0.0069)	(0.0033)	(0.0030)
-ve Surprise Change $(d-_{SUR})$	-0.0017	-0.0017	-0.0017
	(0.0121)	(0.0042)	(0.0042)
-ve Surprise X Post-2008 Dummy $(d-_{SUR} \times d_{2008})$	0.0007	0.0007	0.0014
	(0.0082)	(0.0050)	(0.0049)
+ve Expected Change $(d+_{EXP})$	0.0002	0.0002	0.0002
	(0.0122)	(0.0043)	(0.0043)
+ve Expected X Post-2008 Dummy $(d+_{EXP} \times d_{2008})$	-0.0014	-0.0014	-0.0023
	(0.0080)	(0.0048)	(0.0047)
-ve Expected Change $(d-_{EXP})$	-0.002	-0.002	-0.002
	(0.0097)	(0.0017)	(0.0017)
Intercept	0.0009	0.0009	0.0009
	(0.0024)	(0.0017)	(0.0017)
Observations	110	110	109
R^2	0.0148	0.0148	0.0137
Adjusted R^2	-0.0528	-	-
Residual Std. Error	0.0094	-	-
F Statistic	0.2196	-	-
Wald Test	-	0.9065	0.8883
Breusch-Pagan	0.0612	-	-
Note:		*p<0.1; **p<0.05; ***p<0.01	

The model in Table XIX reports no significant results. Therefore, consistent with model 5 (see Table X), there is no strong evidence to support the existence of asymmetry in the effect of RBA announcements on the All Ords. Moreover, these results do not offer strong support for H5.

Overall, despite a thorough investigation of the impact on equities as a result of a change in communication practices by the RBA, these models do not support H5.

4.8 Hypothesis testing of large rate changes using regression analysis

The final model in this study seeks to test H6 and considers the impact of large changes to the cash rate, greater than 25 bp, and whether this has a significant impact on Australian equities.

4.8.1 Hypothesis 6

The impact on stock returns is greater when the RBA announces a large change to the cash rate target

Previous models have shown that raw changes have no real impact on the stock market and significant results are only produced when the change is divided into surprise and expected components (see Ch. 4.5.2). Model 4 demonstrates that excluding one outlier can drastically change results (see Table IX), and this leads to further possible considerations regarding the impact of monetary policy announcements: If one extreme cash rate change can have such an impact, perhaps it is only large policy actions that impact stock returns. This will be tested using an interaction variable for raw changes greater than 25 bp.

Model 14: Equity response with drastic changes to the cash rate

To test this hypothesis (H6), model 14 contains a large change dummy variable set at 1 for raw changes above 25 basis points in magnitude. This dummy consists of 5 observations (see Table XX).

Table XX Observations with cash rate change greater than 25 basis points

Date of Announcement	Cash Rate Target %	Raw Change b.p.	1-day Returns %
10/7/2008	6.00	-100	1.16
11/4/2008	5.25	-75	-0.08
12/2/2008	4.25	-100	-4.11
2/3/2009	3.25	-100	0.16
5/1/2012	3.75	-50	0.67

Impact of large change in cash rate on All Ords returns is conducted using the following equation:

$$R_t = \alpha + \beta_1(\Delta i_t) + \beta_2(d_{LGE}) + \varepsilon_t \quad , \quad (17)$$

where R_t represents the daily returns, the model's intercept is denoted by α, the raw change coefficient by β_1 and Δi_t is the actual change in cash rate, the large change dummy coefficient is denoted by β_2 and d_{LGE} is the large change dummy variable. ε_t is a residual which embodies all other variables not included in the model.

The model is tested for both sample sizes; all trading days and announcement days only.

Table XXI Equity response with drastic changes to the cash rate

The table details the results from regressions of the All Ords returnsand the large change in cash rate dummy variable. The regressions in columns (a) and (b) corresponds to results for all trading days while testing for event days only is displayed in columns (c) and (d). Columns (a) and (c) use OLS, while (b) and (d) are calculated with heteroskedasticity-consistent estimators. The full sample consists of 2538 trading days spanning 110 RBA announcements over the period September 2003 to August 2013. Standard errors are presented in parentheses.

	Regression Results Eq. 17 - All Trading Days		**Regression Results Eq. 17 - Announcement Days Only**	
	All Ords Returns			
	Naive SE	Robust SE	Naive SE	Robust SE
	(a)	(b)	(c)	(d)
Actual Rate Change (Δi_t)	0.0079	0.0079	0.0089	0.0089
	(0.0080)	(0.0072)	(0.0068)	(0.0072)
Large Change Dummy (d_{LGE})	0.0022	0.0022	0.0039	0.0039
	(0.0083)	(0.0080)	(0.0073)	(0.0081)
Intercept	0.0002	0.0002	-0.0007	-0.0007
	(0.0002)	(0.0002)	(0.0009)	(0.0008)
Observations	2538	2538	110	110
R^2	0.0007	0.0007	0.0232	0.0232
Adjusted R^2	-0.0001	-	0.0050	-
Residual Std. Error	0.0108	-	0.0091	-
F Statistic	0.9411	-	1.2709	-
Wald Test	-	0.5382	-	0.4716
Breusch-Pagan	0.0010	-	9.54e-06	-
Note:		*p<0.1; **p<0.05; ***p<0.01		

Results reported in Table XXI infer that the market does not react to extraordinarily large changes to the cash rate on the day of announcement. This may be because the market has already factored the expected future change prior to this day, thus there is no significant change to the variance of 1-day returns. Alternatively, this could imply that the market is not particularly concerned with the announced change in cash rate.

Section 5 Conclusion

5.1 Summary of results

A variety of tests were conducted involving the impact of policy announcements on stock returns including the raw rate change and the response to expansionary or contractionary policy actions. Results have shown that there is no significant impact on All Ords returns at the RBA announcement (H1).

The main uniqueness of this thesis involves exploring the impact of announcements on Australian equity prices while distinguishing between the surprise and expected components (H2). Consistent with other literature (Bernanke & Kuttner, 2005; Bomfim, 2003), this study finds that decomposing the raw cash rate change into these components improves the significance of results. Using OLS methodology has found that there is a small but significant impact on All Ords returns with unexpected RBA decisions and excluding the outlier finds the estimated surprise response to be negative. However, it should be noted that these results offer only a small fraction of explanation for the overall variability of stock returns. Considering the effect of heteroskedasticity, the most accurate model testing H2 implies that surprise and expected change are individually insignificant, but together may have some explanatory power for the reaction in All Ords returns.

Additionally, and in contrast to other studies (Bernanke & Kuttner, 2005; Bomfim, 2003; Brenner, Pasquariello & Subrahmanyam, 2009; Kim, S-J & Nguyen, 2008; Smales, 2012a), results have not supported that an asymmetric news effect exists when considering the direction of a rate change (H3), even when the unanticipated component is isolated. It was expected to find that the Australian market responds more strongly to unexpected rate rises than rate falls, based

on evidence of a similar study by Kim, S-J and Nguyen (2008), but insignificant results have not shown that the response of Australian equity prices to monetary policy depends on the direction of the cash rate decision.

The inclusion of minutes data has been discussed in the literature and highlights the importance of central bank communication (McCredie et al., 2013; Smales, 2012a). In determining if the release of explanatory meeting minutes by the RBA has an effect on the level of returns, five models are tested. The first three consider the impact on the day of release, magnitude of the policy action and whether a difference exists between the target rate announcement and release of the minutes. Minutes release dummy variables were then included in two tests with interaction terms to ascertain if the policy communication regime installed December 2007 had an effect on returns.

Analysis on the impact of the release of explanatory minutes (H4) reveals one significant result: there is a small but positive response to the change in cash rate on the day of minutes release. However, the model is heteroskedastic and calculated using OLS methodology, therefore unable to be relied upon. Further testing fails to provide support for H4, and results find that the cash rate change does not elicit a significant market response on announcement day or when minutes are released.

To determine if the market responds differently to improved communication practices from December 2007, returns data is tested for a differential impact pre-2008 and post-2008 (H5). Only one of five models produced a significant result: when the surprise and expected components are tested with post-2008 dummy variables, the model has some explanatory power. However, these results are calculated with OLS and shown to be heteroskedastic so should not be

relied upon. Overall, it is unlikely that there is a significant impact on returns after the introduction of the new policy communication regime in December 2007.

The tests for hypothesis 5 were also inadvertently testing for an impact on returns considering state dependence, whereby the economy was contracting pre-2008 and expanding approximately post-2008. But with no significant results and contrary to expectation, the impact on stock returns is not found to be greater when the state of the economy is in a contraction.

After considering the substantial variation in results after excluding one influential observation of 100 basis points (2 Dec 2008), particularly model 4, a final hypothesis was tested for a significant impact based on RBA cash rate changes greater than 25 basis points (H6). Despite a large reaction on this particular day with the All Ords falling 4.1%, the other four observations tested in this hypothesis only saw the market move between -0.08% and 1.16%. Consequently, findings show that no significant impact on stock returns occurs when the RBA announces a large change to the cash rate target.

5.2 Implications of research

This research shows that monetary policy announcements by the RBA have very little effect on the Australian stock market. This could be interpreted in several ways.

Firstly, Australian equity market participants do not actually consider monetary policy actions in their decision making and therefore no significant reaction is recorded, even when the RBA drastically changes the cash rate. This would imply that the RBA need not worry about the equity market when making their decisions. It may be that the market is more concerned with other macroeconomic news such as employment or inflation, and there would be a greater market reaction to these types of announcements.

An alternative interpretation is that the RBA could be making announcements in such a way, so as not to introduce a negative impact on the stock market. This would mean that the introduction of the new communication regime provides no additional effectiveness.

In contrast to this, no strong relation is observed between the stock market and decisions, thus it could be inferred that the market does not need interference from the RBA in the first place. This would imply that the All Ords exists as a free market, already fairly stable and policy decisions are actually not required.

The fact that Australian banks make up a large portion of the All Ords and yet no significant impact is recorded in results could imply that these banks also do not care much about the announcements. It is possible that Australian interest rates are not paramount, especially with the availability of finance from overseas.

Findings within this study show that one of the issues with estimating the response of equity prices to monetary policy decisions is that markets are unlikely to react to announcements that they have already anticipated. Therefore, results could be indicating that the market is well-informed, RBA communication does not provide substantially new information, and announcements are already expected. With some significant results when isolating the surprise component, it is recommended that market participants consider the unanticipated rate change for decision making.

5.3 Limitations

The scope of this research is limited to the equities market and monetary policy decisions of Australia. In contrast, similar studies have compared other financial markets such as the bond market (Andersen et al., 2007; Brenner, Pasquariello & Subrahmanyam, 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 monetary policy influencing equity prices. Thus, the absence of other macroeconomic variables such as employment or GDP is a limitation.

Regarding data used in this study, the sample period is restricted due to 30-day interbank futures (used to calculate market expectation), only being listed since August 2003. Australian monetary policy has only witnessed 31 interest rate changes out of 110 meetings (Sep 2003 – Aug 2013) and this may have reduced the robustness of results.

Using daily data may limit the accuracy of regression modelling and has most likely biased estimates of stock market reactions downward (Brenner, Pasquariello & Subrahmanyam, 2009). Further, this study has not dealt with the issue of simultaneity whereby independent variables may simultaneously influence asset prices and short-term interest rates, such as meeting minutes that provide information about the macroeconomic outlook (Rigobon & Sack, 2004).

In all models, the error term (ε_t) is a residual which embodies variables other than monetary policy that effect equities on announcement days. Using the OLS method, it is assumed that these factors are orthogonal to cash rate changes and confined to All Ords returns (Bernanke & Kuttner, 2005). A further limitation of the models is the exclusion of control variables for announcements close to a holiday (alters information availability), or for the effect of trade volumes.

Much of the literature reviewed for this study contained GARCH modelling due to its ability to measure both the conditional mean and variance of daily returns (Kim, S-J & Nguyen, 2008;

Kurov, 2012; McCredie et al., 2013). Although beneficial, GARCH modelling is not included in this thesis and presents a limitation in reporting volatility results.

Overall, much of the literature has been produced prior to the GFC offering limited comparability due to study samples covering different states of the economy. Additionally, the amount of literature available with an Australian focus is quite limited in comparison to larger economies.

Moreover, the inclusion of the spillover effects of the US Fed's interest rate announcement news on the Australian equities markets is absent. This is an important limitation to the study as the information leadership role of the US in Australia is well documented (Kim, S-J & Nguyen, 2008; Kim, S & In, 2002; Laeven & Tong, 2012).

5.4 Areas for further research

This study investigates the relationship between monetary policy and 1-day stock market returns on the day of the announcement. Similar studies have examined longer periods either side of the regularly scheduled meetings to enable a comparison (Bomfim, 2003), and this could improve the strength of results.

An important consideration would be to consider specific sectors of the equities market such as the financial sector. The big four banks of Australia comprise four out of the five largest stocks that make up the All Ords index, thus it may be expected that the All Ords moves in part due to commercial banks. Similar to Kim, S-J and Nguyen (2008), the stock prices of the biggest four banks in Australia could be considered and the influence of target rate surprises on this important sector could be investigated. This segment is directly and immediately affected by the RBA's

monetary policy decisions and commercial banks are an important transmission channel (Kim, S-J & Nguyen, 2008).

Alternatively, a sector index, such as the S&P/ASX 200 Financial-x-A-REIT, could be utilised to test a hypothesis that RBA announcements have a significant impact on the financial sector. This would add value to the study considering this sector is also an integral part of the monetary transmission mechanism.

As the financial markets are becoming more globalized, 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, S & In, 2002). Thus, testing could include comparisons across countries or regions.

This study only focuses on equity markets, but further research could include the interaction, co-movement or relationship between other financial markets such as futures, and Government or corporate debt markets. These markets do not exist independently and investors often hold and trade many of these securities at the same time (Brenner, Pasquariello & Subrahmanyam, 2009).

Again, it is likely that the impact of small changes to the cash rate is offset by the impact of other news announced on this day. This has been demonstrated within both international (Bernanke & Kuttner, 2005; Brenner, Pasquariello & Subrahmanyam, 2009; Nikkinen et al., 2006) and Australian literature (Kim, S-J & Nguyen, 2008; Smales, 2012a). For example, Brenner, Pasquariello and Subrahmanyam (2009) argue that when setting interest rate policy the main concerns are employment and inflation, and markets are most sensitive to this news. In a study by Smales (2012a) of the Australian futures market, the Australian Bureau of Statistics (ABS)

released at least one scheduled macroeconomic announcement on the same day as the RBA's target rate decision on 49 occasions during the sample period (2004-2010). ABS statements also impacted the study by Kim, S-J and Nguyen (2008). The inclusion of domestic news announcements may improve results and offered as a suggestion for further research.

Although this study has found that the unexpected change in the cash rate has a negative impact on stock returns, a more difficult question would be to consider *why* equity prices respond in a particular way to monetary policy. Perhaps, an investigation into the effect on stock values through a change in real interest rates or expected future dividends could provide an answer to this question (Bernanke & Kuttner, 2005).

APPENDIX

This table outlines the R packages used in this thesis for both statistical calculations and the graphical presentation of data. Citations are provided to acknowledge the effort of contributors who improve the depth and scope of the statistical analysis achievable using R.

Table XXII R-Project Packages used in this report:

Name of Package	Citation	Description
stargazer	Hlavac, Marek (2014). stargazer: LaTeX/HTML code and ASCII text for well-formatted regression and summary statistics tables. R package version 5.1. http://CRAN.R-project.org/package=stargazer	Produces LaTeX code, HTML/CSS code and ASCII text for well-formatted tables that hold regression analysis results from several models side-by-side, as well as summary statistics.
sandwich	Achim Zeileis (2004). Econometric Computing with HC and HAC Covariance Matrix Estimators. Journal of Statistical Software 11(10), 1-17. URL http://www.jstatsoft.org/v11/i10/.	Model-robust standard error estimators for cross-sectional, time series, and longitudinal data.
lmtest	Achim Zeileis, Torsten Hothorn (2002). Diagnostic Checking in Regression Relationships. R News 2(3), 7-10. URL http://CRAN.R-project.org/doc/Rnews/	A collection of tests, data sets, and examples for diagnostic checking in linear regression models. Furthermore,some generic tools for inference in parametric models are provided.
MASS	Venables, W. N. & Ripley, B. D. (2002) Modern Applied Statistics with S. Fourth Edition. Springer, New York. ISBN 0-387-95457-0	Functions and datasets to support Venables and Ripley,'Modern Applied Statistics with S' (4th edition, 2002).
car	John Fox and Sanford Weisberg (2011). An R Companion to Applied Regression, Second Edition. Thousand Oaks CA: Sage. URL: http://socserv.socsci.mcmaster.ca/jfox/Books/Companion	Provides many functions that are applied to fitted regression models such as performing additional calculations on the model or returning values and graphs. Examples include test for non-constant variance and create arguments for bootstrap.
stats	R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.	This package contains functions for statistical calculations and random number generation such as influence statistics and normality.

REFERENCES

Andersen, TG, Bollerslev, T, Diebold, FX & Vega, C, 2007, 'Real-time price discovery in global stock, bond and foreign exchange markets', *Journal of International Economics*, vol. 73, no. 2, pp. 251-277.

Auld, C, 2012, *The intuition of robust standard errors*, <http://chrisauld.com/2012/10/31/the-intuition-of-robust-standard-errors/ >.

Bernanke, BS & Kuttner, KN, 2005, 'What explains the stock market's reaction to Federal Reserve policy?', *The Journal of Finance*, vol. 60, no. 3, pp. 1221-1257.

Bjørnland, HC & Leitemo, K, 2009, 'Identifying the interdependence between US monetary policy and the stock market', *Journal of Monetary Economics*, vol. 56, no. 2, pp. 275-282.

Bomfim, AN, 2003, 'Pre-announcement effects, news effects, and volatility: Monetary policy and the stock market'.

Brenner, M, Pasquariello, P & Subrahmanyam, M, 2009, 'On the Volatility and Comovement of U.S. Financial Markets around Macroeconomic News Announcements', *Journal of Financial and Quantitative Analysis*, vol. 44, no. 06, p. 1265.

CNBC, 2008, 'Lehman Brothers Files For Bankruptcy, Scrambles to Sell Key Business'.

Craine, R & Martin, VL, 2008, 'International monetary policy surprise spillovers', *Journal of International Economics*, vol. 75, no. 1, pp. 180-196.

Engle, R, 2001, 'GARCH 101: The use of ARCH/GARCH models in applied econometrics', *Journal of economic perspectives*, pp. 157-168.

Harju, K & Hussain, SM, 2011, 'Intraday Seasonalities and Macroeconomic News Announcements', *European Financial Management*, vol. 17, no. 2, pp. 367-390.

Ioannidis, C & Kontonikas, A, 2008, 'The impact of monetary policy on stock prices', *Journal of Policy Modeling*, vol. 30, no. 1, pp. 33-53.

Kim, S-J & Nguyen, DQT, 2008, 'The reaction of the Australian financial markets to the interest rate news from the Reserve Bank of Australia and the U.S. Fed', *Research in International Business and Finance*, vol. 22, no. 3, pp. 378-395.

Kim, S & In, F, 2002, 'The influence of foreign stock markets and macroeconomic news announcements on Australian financial markets'.

Kurov, A, 2012, 'What determines the stock market's reaction to monetary policy statements?', *Review of Financial Economics*, vol. 21, no. 4, pp. 175-187.

Kuttner, KN, 2001, 'Monetary policy surprises and interest rates: Evidence from the Fed funds futures market'.

Laeven, L & Tong, H, 2012, 'US monetary shocks and global stock prices', *Journal of Financial Intermediation*, vol. 21, no. 3, pp. 530-547.

MacKinnon, JG & White, H, 1985, 'Some heteroskedasticity-consistent covariance matrix estimators with improved finite sample properties', *Journal of Econometrics*, vol. 29, no. 3, pp. 305-325.

McCredie, B, Docherty, P, Easton, S & Uylangco, K, 2013, 'An examination of the differential impact of monetary policy announcements and explanatory minutes releases on the Australian interest rate futures market.'.

Nikkinen, J, Omran, M, Sahlström, P & Äijö, J, 2006, 'Global stock market reactions to scheduled U.S. macroeconomic news announcements', *Global Finance Journal*, vol. 17, no. 1, pp. 92-104.

RBA, 2007, *Reserve Bank Board - New Arrangements for Communication*, viewed 25 May 2014, <http://www.rba.gov.au/media-releases/2007/mr-07-22.html>.

RBA, 2008, *Minutes of the Monetary Policy Meeting of the Reserve Bank Board*, <http://www.rba.gov.au/monetary-policy/rba-board-minutes/2008/02122008.html>.

RBA, 2013, *About monetary policy*, Reserve Bank of Australia, viewed 25 May 2014, <http://www.rba.gov.au/monetary-policy/about.html>.

RBA, 2014a, *Interest Rate Decisions*, viewed 25 August 2014, <http://www.rba.gov.au/monetary-policy/int-rate-decisions/index.html>.

RBA, 2014b, *Minutes*, viewed 25 May 2014, <http://www.rba.gov.au/monetary-policy/rba-board-minutes/index.html>.

Rigobon, R & Sack, B, 2004, 'The impact of monetary policy on asset prices', *Journal of Monetary Economics*, vol. 51, no. 8, pp. 1553-1575.

Rosa, C, 2011, 'Words that shake traders. The stock market's reaction to central bank communication in real time', *Journal of Empirical Finance*, vol. 18, no. 5, pp. 915-934.

S&P Dow Jones Indices, 2014a, *S&P/ASX 200*, McGraw Hill Financial, viewed 25 May 2014, <http://au.spindices.com/indices/equity/sp-asx-200>.

S&P Dow Jones Indices, 2014b, *S&P/ASX 300*, McGraw Hill Financial, viewed 25 May 2014, <http://www.spindices.com/indices/equity/sp-asx-300>.

SFE Corporation Limited, 2003, *SFE To Launch 30 Day Interbank Cash Rate Futures*, <http://www.sfe.com.au/content/bulletins/sfe/2003/sfe2003_042.pdf>.

Smales, LA, 2012a, 'RBA monetary policy communication: The response of Australian interest rate futures to changes in RBA monetary policy', *Pacific-Basin Finance Journal*, vol. 20, no. 5, pp. 793-808.

Smales, LA, 2012b, '30-Day Interbank futures: Investigating the process of price discovery following RBA cash target rate announcements', *Journal of International Financial Markets, Institutions and Money*, vol. 22, no. 4, pp. 1006-1023.

Taylor, JB, 1995, 'The monetary transmission mechanism: an empirical framework', *The Journal of Economic Perspectives*, pp. 11-26.