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Honours Thesis

The Sensitivity of Australian Yields and the AUD/USD Exchange Rate to Macroeconomic News Surprises

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Declaration

I hereby declare that this submission is my own work and that, to the best of my knowledge, it contains no material which has been written by another person or persons, except where acknowledgement has been made. This thesis has not been submitted for the award of any degree or diploma at the University of New South Wales, or at any other institute of higher education.

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Sebastien PRINTANT
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Abstract

This thesis investigates the sensitivity of Australian bond yields and the AUD/USD exchange to various Australian and U.S. macroeconomics news releases. Using OLS, results for bond yields are consistent with the expectations hypothesis of the term structure. Results for the AUD/USD support the theory of uncovered interest rate parity. Modifying the model to account for uncertainty, I find that the sensitivity of the AUD/USD to news decreases in times of high global uncertainty. The sensitivity of bond yields is largely unaffected by uncertainty. Using a two-stage model that combines non-linear and rolling-window techniques I also estimate the time-varying sensitivity to news. In particular I identify how the sensitivity to news varied under different monetary policy regimes. Australian bond yields and the AUD/USD exchange rate were broadly unaffected by the presence of the Zero Lower Bound in the U.S. Empirical evidence suggests that the Reserve Bank of Australia experienced some success at managing interest rate and exchange rate market expectations.

Section 1

Introduction

In the hours following the Federal Reserve's decision to lower the Federal funds rate to historic lows of between zero and a quarter of a per cent, the Australian dollar (AUD) appreciated by approximately four per cent relative to the U.S. dollar (USD). This illustrates the susceptibility of Australian markets to be affected by global economic news. Given the exchange rate and market interest rates are key macroeconomic variables in Australia, the literature analysing the effect of news on them is relatively sparse. In particular, the effect of Australian news on the Australian exchange rate and interest rates has not been investigated directly in the literature. This thesis contributes to the discussion by examining the sensitivity of the Australian exchange rate and interest rates to various Australian and U.S. macroeconomic news between 2000 and 2015.

By capturing the unexpected component of news announcements, this paper is able to identify the Australian and U.S. macroeconomic news that are market-moving for the Australian exchange rate and interest rates. I also investigate whether the response of these rates to news varies over time. In particular, I test whether global uncertainty and monetary policy regimes affect the sensitivity of the Australian exchange rate and interest rates to macroeconomic news.

A review of the literature reveals extensive evidence that news affect interest rates and exchange rates. Since Fama, Fisher, Jensen, and Roll (1969), it has been commonly accepted that markets 'price in' their ex-ante expectations. As such, markets should only react to unexpected news or 'surprises'. Multiple papers have shown that the U.S. exchange rate and bond yields are highly sensitive to domestic macroeconomic news surpriseS. While research is not as widely available in Australia, there is evidence that U.S. macroeconomic news surprises affect the Australian exchange rate (Edwards and Plumb, 2009) and Australian bond yields (Craine and Martin, 2008). This paper adds to the literature by being the first to examine the sensitivity of the Australian exchange rate and bond yields to domestic macroeconomic news and Australian monetary surprises.

Using OLS I am able to determine how the Australian exchange rate and interest rates react to unexpected Australian and U.S. macroeconomic news. I find that Australian bond yields are highly sensitive to news that could proxy future domestic monetary policy. There is also evidence of monetary spillovers from the U.S. at the long end of

the Australian yield curve. Overall, findings for interest rates are largely consistent with the theory. The AUD/USD exchange rate appears primarily driven by interest rate differentials. It is also highly responsive to U.S. non-monetary news. However the AUD/USD appears relatively insensitive to Australian nonmonetary news. This provides some support to the theory that Australia is 'too small' to influence world markets. Overall results are largely consistent with the theory of uncovered interest rate parity.

The literature is divided as to whether markets respond to all news similarly. While the majority of the literature has largely ignored asymmetries, Andersen, Bollerslev, Diebold, and Vega (2003) and Edwards and Plumb (2009) have argued that the response of markets to news is state-contingent. Adapting my model to account for different uncertainty states provides little evidence that Australian bond yields behaved differently when global uncertainty was high. However I show that the AUD/USD tended to be less responsive to Australian cash rate surprises in periods of high uncertainty. The implications of this finding for the Reserve Bank of Australia (RBA) suggest that it should not attempt to target the level of the exchange rate in times of high global uncertainty as cash rate decisions are much less effective at moving the exchange rate during such times.

In the current context of low global rates and falling domestic rates, central banks have been heavily relying on non-conventional monetary policy tools such as quantitative easing and active expectation management (sometimes referred to as forward guidance). A key contribution of this paper is to analyse how Australian bond yields and the AUD/USD responded under two different monetary regimes: the Zero Lower Bound (ZLB) in the U.S. and active guidance of market expectations by the RBA. Using a two-stage model that combines non-linear least squares and rolling window estimation, I show that the sensitivity of Australian bond yields to news remained relatively unaffected by the presence of the ZLB in the U.S. The AUD/USD exchange rate remained highly responsive to Australian news but partially lost sensitivity to U.S. news while U.S. rates were at the ZLB. To my knowledge this paper is the first to find evidence suggesting that the exchange rate becomes less sensitive to foreign news when foreign interest rates are constrained by their lower bound and domestic rates remain unconstrained. This suggests that the uncovered interest rate parity condition holds. I also find evidence that the RBA experienced some success at managing interest rate and exchange rate market expectations. More research is required in this area but this preliminary finding suggests that expectation management should remain a credible monetary tool for the RBA in the future.

Section 2

Literature Review

This section provides a review of the surprise literature. First I present evidence that markets react to macroeconomic news. Second I introduce the surprise literature dealing specifically with interest rates and exchange rates. While this academic field is mainly U.S.-centric I also examine the literature in Australia.

2.1 News Surprises in the Financial Literature

The concept of market efficiency has been discussed at length since being introduced by Bachelier (1900). It was formalised by Fama in 1970 when he proposed the Efficient Market Hypothesis. Building on the earlier works of Samuelson (1965) and Mandelbrot (1966), Fama (1970) recognised three forms of market efficiency: weak, semi-strong and strong. Using theoretical and empirical frameworks he argued that market prices are determined by public and private information to various degrees. Importantly for this study, Fama (1970) claimed that an update in the information set available to investors would cause prices to adjust instantly. This implies that under some circumstances news announcements can affect prices.

In their event study Fama et al. (1969) found "that stock prices adjust rapidly" to new information. However, the study stressed that prices only adjusted when investors revised their expectations for future dividends as ex-ante expectations were incorporated in the market price prior to news announcements. Thus they concluded that only the unexpected surprise component of news was market-moving. This finding is key and has remained the foundation of the surprise literature.

The use of the event study methodology has since been widely replicated and extended to other financial markets. Studies on stock prices (Patell and Wolfson, 1984; Pearce and Roley, 1985) and bond prices (Urich and Wachtel, 1984; Hardouvelis, 1988) consistently identified quasi-instantaneous price adjustments following news releases. Patell and Wolfson (1984) found that the bulk of stock price adjustments following dividend and earnings announcements was completed within fifteen minutes and little effect of the news announcement could be observed after ninety minutes. It was also identified that, in the case of dividends, large price changes occurred primarily after unexpected dividend

announcements. While the focus in the information assimilation literature seems to have shifted to relatively new behavioural tools to explain market anomalies (for example over- and under-shooting), there is a broad consensus in the literature that markets react to unexpected news almost immediately.

More significantly for this study, there is strong evidence in the literature showing that interest and exchange rate markets are similarly affected by macroeconomic data news. Ederington and Lee (1993, 1995) demonstrate that prices in these markets adjust within a minute of the publication of macroeconomic news.

2.2 News Surprises for Interest Rate and Exchange Rate Markets

As will become apparent throughout this section, academics studying the effects of news surprises have often dealt with interest and exchange rate markets together. While there is clearly a theoretical foundation to study interest rate and exchange rate markets concurrently, I will argue that the treatment of interest rates and exchange rates together in the literature primarily reflects the ease with which the event study methodology can be adapted to the study of both markets. In this section I will cover the prominent surprise literature for interest and exchange rate markets.

Kuttner (2001) is the seminal paper in the monetary surprise literature and provides the foundation for this paper. Kuttner identified a "strong and robust relationship" between unexpected Federal Reserve decisions and a series of market interest rates. Kuttner's key contribution was to show that markets reacted similarly to unexpected Federal Reserve action and inaction. It reinforced the idea that only the surprise component of news (not the level) is necessary to capture the effect of surprises on markets.[1]

Andersen et al. (2003) used Kuttner's methodology to show that news surprises also affect exchange rates. Further they identified asymmetries in the response of the exchange rate to news. They claimed that negative news was treated by markets differently in 'good' times and in 'bad' times. Andersen et al. (2003) were also among the first to follow Balduzzi et al. (2001) and standardise surprises by their sample standard deviation. I describe this standardisation in Section 3 and adopt it to ensure my paper can be easily interpreted within the context of the broader literature.

Following these early seminal papers, focus in the literature increasingly shifted towards identifying the mechanisms through which news affects markets. Using Vector

[1]This result also holds for non-monetary generic macroeconomic news announcements, see Goodhart, Hall, Henry, and Pesaran (1993); Balduzzi, Elton, and Clifton Green (2001); Fleming and Remolona (1997, 1999).

Autoregression (VAR) models Gürkaynak, Sack, and Swanson (2005) showed that monetary policy shocks affected longer-term interest rates primarily through their effect on expectations of future monetary policy. Gürkaynak et al. (2005) predicted that monetary policy shocks should affect the entire yield curve. They also argued that credible expectation management by the Federal Reserve could be used to target the longer end of the yield curve. As a result of the new norm of low global rates, the importance of expectation management for monetary policy makers has increased as policy rates remain near zero. Given that low global rates are expected to persist for some time and that Australian rates are falling and approaching their own lower bound this thesis aims to improve our understanding of the factors influencing monetary management expectation in Australia.

Founding their research on Gürkaynak et al. (2005), Swanson and Williams (2014a,b) built on the existing literature to develop a two-country New Keynesian model, which they tested empirically. I present some of the key theoretical results from Swanson and Williams (2014b) which are relevant to this paper. While their model was extensive I will specifically focus on their modelling of interest rates and exchange rates. Swanson and Williams (2014b) defined the M-period yield to maturity i_t^M to be given by:

$$\mathrm{i}_t^M = \mathrm{E_t}\left[\sum_{j=0}^{M-1} \mathrm{i}_{t+j} + \phi^M\right] \tag{2.1}$$

where $\mathrm{E_t}$ denotes the mathematical expectation operator conditional on information at time t, i_{t+j} is the one-period Home nominal interest rate in period $t+j$ and ϕ^M is an exogenous term premium that may vary with maturity but is assumed constant over time. This model predicts that long-term rates are directly related to the sum of short-term rates over the period to maturity. I will use this interpretation throughout my paper.

They also proposed the following expression for the real exchange rate q_t between Home and Foreign:

$$q_t = \mathrm{E_t}\left[\sum_{j=0}^{\infty} -(\mathrm{i}_{t+j} - \mathrm{i}^*_{t+j}) + (\pi_{t+j+1} - \pi^*_{t+j+1}) + \Phi_{t+j} + \bar{q}\right] \tag{2.2}$$

where π_{t+j+1} denotes the Home inflation rate in period $t+j+1$, Foreign variables are denoted by an asterisk $(*)$, ϕ_{t+j} represents a risk premium adjustment that captures the riskiness of arbitrage and $\bar{q}$ is a long-run (or steady state) value of the exchange rate. Equation (2.2) shows that the exchange rate depends on the entire path of future expected real interest rate differentials between Home and Foreign. This is essentially a more complex forward iteration of the uncovered interest rate parity condition.

Using equations (2.1) and (2.2) Swanson and Williams (2014b) argued that, so long

as markets expect short-term rates to be unconstrained within a few quarters, exchange rates and long-term interest rates should remain sensitive to news even if Home or Foreign short-term rates are constrained by their Zero Lower Bound (ZLB). Indeed, if markets expect interest rates in the close future to be unconstrained by their Zero Lower bound then they should update their expectations of future interest rates when new information becomes available. This updated i_{t+j} should then affect the current level of the interest rates from (2.1) and the exchange rate from (2.2). Swanson and Williams (2014a,b) proposed a new method to test whether the sensitivity of interest rates and exchange rates to news announcements decreased at the ZLB. This allowed them to infer whether interest and exchange rates became constrained by the ZLB. They found that U.S. interest rates remained very responsive between 2008 and 2010. Their model implicitly captured the market expectation that interest rates would rise in the medium term. To their surprise, the sensitivity of medium-term rates to news only dropped after the Federal Open Market Committee (FOMC) committed in 2011 to keep the policy rate at zero until "mid-2013". Swanson and Williams (2014a) showed that markets stopped expecting the policy rate to increase in the medium term after the FOMC announcement. Thus they concluded that the FOMC had scope to affect medium- and longer-term yields up until 2011 when the sensitivity of interest rates of all maturities to news diminished.

Swanson and Williams (2014b) also applied the methodology to Germany and the UK. They also found that short- and medium-term rates lost their sensitivity to news after domestic interest rates reached their effective lower bound. However they showed that exchange rates with the U.S. dollar remained relatively unconstrained. This provides support for their theoretical framework. Considering that the Australian policy rate remained consistently unconstrained by its effective lower bound I expect Australian interest rates and the AUD/USD to remain unconstrained by the presence of the ZLB. In this paper I test this hypothesis.

2.2.1 Australia

Recent literature on surprises is relatively sparse in Australia. This mostly reflects the lack of high-frequency reliable data. Survey agencies such as Bloomberg only started collecting survey data on 'market-moving' series in Australia in the late 1990's or early 2000's. This has left researchers with very few data points to study until recently. Further, there have been concerns regarding liquidity in some bond markets which has somewhat narrowed the scope of analysis. I will address this issue in further detail in Section 3. Given the issues with Australian news data, it is unsurprising that the literature in Australia has primarily focused on the impact of U.S. news on Australian markets.

Craine and Martin (2008) were the first to examine international monetary surprise spillovers using unobserved component analysis and jointly estimate the effect of monetary

and non-monetary surprises on security prices. They argued that U.S. monetary surprises were "world surprises" which had a similar effect on Australian yields as Australian monetary surprises. Unsurprisingly they also argued that US-Australian monetary spillovers were unilateral as Australia was "too small to affect world markets". If these monetary spillovers from the U.S. to Australia persisted then it is possible that the constraint on short-term rates in the U.S. at the ZLB partially constrained Australian yields. However from equation (2.1) Australian yields should remain unconstrained unless markets expect future short-term rates to be constrained which has not been the case in Australia. In this paper I will test whether these spillovers from the U.S. constrained Australian yields or whether Australian rates remained unconstrained as theory predicts. Further, I will use survey data on monetary policy, as opposed to inferring surprises using market prices as Craine and Martin (2008) did. This will provide me with a more accurate measure of monetary surprises.

Following work done by Andersen et al. (2003), Edwards and Plumb (2009) tested for asymmetries in the responses of the AUD/USD exchange rate to news. To do so they constructed a global uncertainty index which I describe in Section 3. Using linear regression analysis they found that positive U.S. data releases appreciated the Australian dollar when global uncertainty was high and depreciated the AUD when global uncertainty was 'normal'. They attributed this difference to the different channels through which news spillovers occur from the U.S. to Australia. Edwards and Plumb (2009) argued that the exchange rate was primarily driven by interest rate differentials between the two countries when global uncertainty was 'normal'. They also argued that in times of high uncertainty positive U.S. news could be considered proxies for future global growth which tended to strengthen the Australian dollar. However their analysis did not capture directly monetary surprises. Instead they used growth surprises to implicitly proxy future monetary policy. Considering the prominence of monetary surprises both in the theory and in the broader literature, this omission is critical. I will test whether the asymmetries Edwards and Plumb (2009) identified remain robust to the inclusion of monetary surprises as well as to the addition of Australian variables. Further they also fail to differentiate between different uncertainty regimes. It is fair to assume that markets might have reacted differently during the GFC than they did after September 11. I will adapt the methodology introduced by Swanson and Williams (2014a) to allow sensitivity to change over time and seek further evidence of asymmetries.

Section 3

Presentation of the Data

This section introduces the data used in the analysis. All data is collected from Bloomberg for the period ranging from January 2000 to December 2015 unless otherwise specified. I account for the differences in time zones between Australia and the U.S. by standardising the release times of all data (bond yield and exchange rate movements, and surprises) to Eastern Time Zone (ETZ) time.

Below I provide details regarding the Australian interest rates that I consider. I do the same for the AUD/USD exchange rate. Then I describe the news announcements and subsequent standardisations necessary for this analysis. Finally I present a benchmark that explicitly identifies periods of high global uncertainty.

3.1 Australian Government Bond Yields

The first area of focus of this paper is to evaluate the sensitivity of Australian bond yields to news. To do this I use the widely traded and highly liquid one-year Australian Government bonds as a proxy for medium-term rates. Because of liquidity concerns surrounding thirty-year bonds, I use ten-year Australian Government bonds as my measure of long-term interest rates.

I collect daily data from Bloomberg to compute the daily change in the bond yield ΔBY_t over day t as follows:

$$\Delta \text{BY}_t = \ln\left(\frac{\text{BY}_{close}}{\text{BY}_{open}}\right) \times 100$$

where BY_{open} is the bond yield at 12.00am ETZ on day t and BY_{close} is the value of the bond yield at 11.59pm ETZ on day t.

3.2 AUD/USD Exchange Rate

I also evaluate the sensitivity of the AUD/USD exchange rate to news. Similar to the bond yields, I compute the daily change in the AUD/USD exchange rate $\Delta \text{AUD/USD}_t$

over day t as follows:

$$\Delta \text{AUD/USD}_t = \ln\left(\frac{\text{AUD/USD}_{close}}{\text{AUD/USD}_{open}}\right) \times 100$$

where AUD/USD_{open} is the value of the AUD/USD at 12.00am ETZ on day t and AUD/USD_{close} is the value of the AUD/USD at 11.59pm ETZ on day t. A positive value of $\Delta\text{AUD/USD}_t$ denotes an appreciation of the Australian dollar over day t.

3.3 Australian and U.S. Macroeconomic News

Previous research has shown that markets only react to the unexpected component of news announcements. It is therefore crucial that I identify an unbiased and accurate measure of these news surprises. To achieve this I heavily rely on past research. Because financial markets typically do not provide an explicit measure of expectations as they get 'priced in', I use Bloomberg survey data to measure ex-ante expectations of economic announcements. Thus I define the surprise component of each announcement as the difference between its realised value and the market expectation for that announcement as measured by Bloomberg surveys.

Bloomberg surveys professional forecasters and records their expectations relating to upcoming news announcements.[1] Several key papers identify the superiority of Bloomberg over other survey providers:

- Using 51 news releases, Noel (2000) found that Bloomberg forecasts were less volatile than MMS's.
- Andersen et al. (2003), Dungey, McKenzie, and Smith (2009) and Jiang, Lo, and Verdelhan (2011) verified that survey forecasts are informative. Further, they found that surprises as measured by survey data were correlated with market movements.
- Chen, Jiang, and Wang (2013) found that Bloomberg forecasts were more accurate and produced smaller forecast errors than Briefing.com. They emphasised that this result was particularly robust for important news announcements such as CPI, durable goods orders, GDP, personal spending and retail sales.

For each series of macroeconomics news in Table 3.1 I collect the realised and survey data from Bloomberg. The first part of the table refers exclusively to U.S. variables and the second portion describes Australian variables.

[1] I rely exclusively on Bloomberg survey data as surveys from the International Money Market Services (MMS) were discontinued in 2003.

Table 3.1: Description of the data

Variable	Units	Adjustments	Bloomberg ID
US			
Capacity Utilization	Pct. of Total Capacity	Seasonal	CPTICHNG
Consumer Price Index (Core)	Pct. change from previous year		CPIXYOY
Federal Funds Rate	Rate		FDTR
Gross Domestic Product (Chained 2009 Dollars)	Pct. change from previous quarter	Seasonal	GDPCQOQ
Industrial Production	Pct. change from previous month	Seasonal	IPCHNG
Non-Farm Payrolls	Pct. change from previous month	Seasonal	NFPTCH
ISM survey of professionals	Index	Seasonal	NAPMPMI
Producer Price Index	Pct. change from previous month	Seasonal	FDIDFDMO (PXFECHNG)
Initial Jobless Claims	Thousands of Workers	Seasonal	INJCJC
Unemployment rate	Percentage of labour force	Seasonal	USURTOT
Adjusted Retail Sales ex. Autos	Pct. change from previous month	Seasonal	RSTAXMOM
Australia			
Consumer Price Index (All Groups)	Pct. change from previous quarter		AUCPICHG
Gross Domestic Product (Real)	Pct. change from previous quarter	Seasonal	AUNAGDPC
Producer Price Index (Finished Goods)	Pct. change from previous year		AUPPFYOY
RBA Inflation Trimmed Mean	Pct. change from previous quarter		RBCPTRIQ
RBA Cash Rate	Rate		RBATCTR
Unemployment Rate	Percentage of labour force	Seasonal	AULFUNEM

For each of the series in Table 3.1 I use the median survey response as a measure of the markets' ex-ante expectations. This method is in line with the literature even though I show in Appendix A.2 that results remain robust when the average survey response is used. I obtain 3249 news surprises between January 2000 and December 2015, with a total of 493 macroeconomic news surprises from Australia and 2811 from the U.S.

While the literature primarily relies on survey data to record ex-ante expectations of news announcements, its usage also poses several problems. Most Bloomberg surveys are available for different (and often limited) sample ranges. This could significantly narrow the scope of this study if market-moving surprises are omitted due to lack of data. This is particularly problematic as surveys on the highly followed Australian trimmed mean inflation measure are only available from 2007 onwards. I adjust for this by creating a

'hybrid' inflation series. Before 2007, this hybrid series records the surprises associated with the ABS Consumer Price Index (All Groups). From 2007 onwards I use surveys on the Reserve Bank of Australia (RBA) trimmed mean inflation as my measure of inflation expectations instead. While merging these series is not ideal, I believe the benefits outweigh the limitations. Firstly, both series track each other fairly closely which renders the adjustment minimal. Secondly, results are essentially unaffected by the inclusion of the trimmed mean inflation expectations. Finally, the trimmed mean series is one of the most scrutinised measures of inflation in Australia and I feel that my analysis would have failed to properly capture inflation expectations without its inclusion.

3.4 Standardisation of Surprises

I match each news announcement with its corresponding Bloomberg survey and record the surprise component (realised minus expected). As the variables I am using have different units and variability, I follow the method used in Balduzzi et al. (2001) to standardise the news surprise relating to macroeconomic variable i at time t as follows:

$$S_{it} = \frac{R_{it} - E_{it}}{\hat{\sigma}_i}$$

where R_{it} is the realised announcement relating to macroeconomic variable i at time t, E_{it} is the ex-ante expectation of this announcement and $\hat{\sigma}_i$ is the sample standard deviation of $R_{it} - E_{it}$. This standardisation allows for an easier interpretation of results; regression coefficients are reported in units of basis points per standard deviation of the announcement.

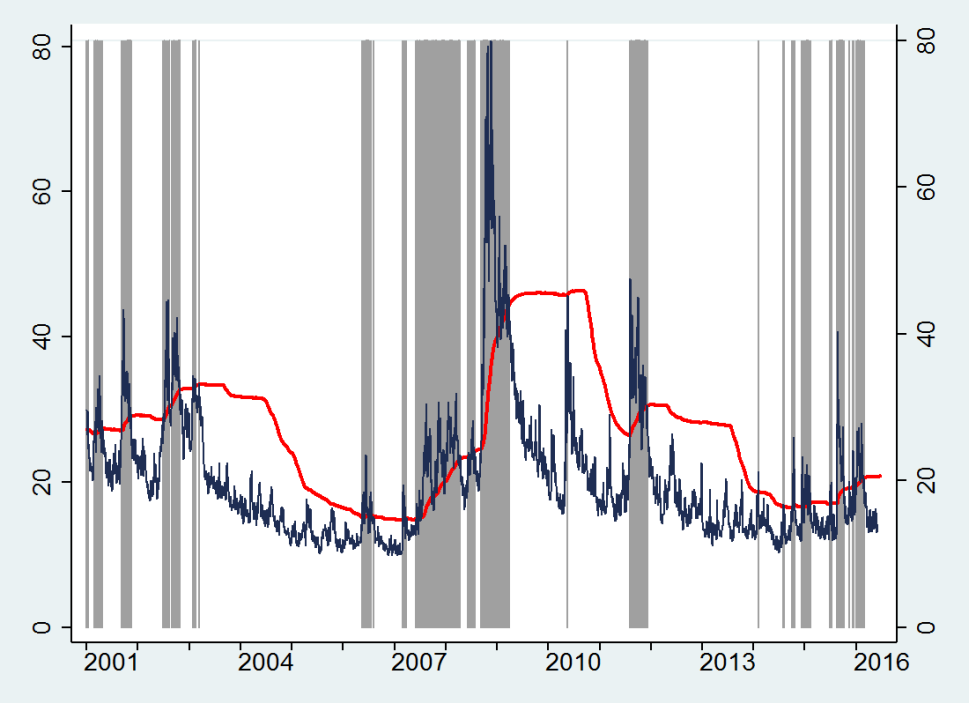
Most generated surprise series have a mean and median not significantly different from zero (refer to Appendix A.1 for more detailed summary statistics). As predicted by the efficient market theory, markets indeed seem to 'get it right' on average. This effect is particularly strong if the large surprises that occurred during the Global Financial Crisis (GFC) are ignored. The exception to this pattern is Australian unemployment rate surprises. The data seem to indicate that markets consistently and significantly overestimated the unemployment rate, particularly over the period ranging from 2000 to 2007. Because of its high frequency of release, the unemployment rate is one of the first indicators of unexpected downturns in the Australian economy. Accurately predicting the Australian unemployment rate might therefore prove more challenging than forecasting gross domestic product (GDP) which is released quarterly and is likely to be strongly correlated with intermediate unemployment figures. This might explain why markets seem to struggle to accurately predict Australian unemployment news. While this finding is an interesting result in itself, it is of little consequence for this analysis as the methodology does not require zero mean surprises. On the contrary, more variability in the recorded

surprises is preferable to ensure greater accuracy in the regression estimates.

3.5 VIX Index and Benchmark Construction

In this paper I test whether the response of market rates to news is state-contingent. As the Australian economy did not experience a recession over the sample, I consider different global uncertainty states instead. To create a representative proxy for global uncertainty, I use the Chicago Board Options Exchange (CBOE) Volatility Index more commonly referred to as VIX. The VIX is commonly regarded as a measure of global uncertainty because of the high correlation between volatility in the U.S. equity markets and uncertainty in global financial markets.

Figure 3.1: The VIX and constructed uncertainty benchmark



The navy line is the historical VIX. The smooth red line is the benchmark created using moving averages. Grey shaded areas indicate time periods of high global uncertainty when VIX is above the benchmark.

Using the raw VIX to determine whether global uncertainty is high at any given time might yield erroneous results. A VIX value of 25 would have been considered normal in 2001, relatively high in 2005 and extremely low in early 2009. To ascertain the relative level of uncertainty at a given time t, I compare the contemporaneous level of VIX to recent historical averages. Following Edwards and Plumb (2009) I construct a 'benchmark' uncertainty index $\overline{\text{VIX}}$. For each day in the sample, the benchmark is equal to the sum of the two-year moving historical average of the raw VIX and the two-year moving historical standard deviation of the raw VIX. Using the moving-average approach over two-year

windows allows for markets to slowly revise their expectations of what consists of a 'high' VIX. I will consider levels of VIX above the benchmark to indicate periods of significant global uncertainty. These periods of high global uncertainty are shaded in grey in Figure 3.1.

Section 4

Description of the Models

In this section I present the econometric models upon which my results are based. The first model uses OLS to identify the Australian and U.S. macroeconomic news that move Australian interest rates and the AUD/USD exchange rate. I extend this model to test for asymmetries caused by uncertainty. Finally, I introduce a two-stage model that enables me to identify how different monetary policy regimes affected the sensitivity to news of the Australian interest rates and the AUD/USD exchange rate.

4.1 Measuring the Sensitivity to Macroeconomic News

As mentioned previously, I apply the methodology to exchange rates and bond yields. For the sake of parsimony I define Δy_t as the change in variable y over day t, where y can be the AUD/USD exchange rate or one of the bond yields introduced in Section 3.[1]

As Gürkaynak et al. (2005) show, markets react differently to different news announcements. To estimate the sensitivity of each market rate to various surprises I run the following daily-frequency OLS regression:

$$\Delta y_t = \alpha + \boldsymbol{\beta}\mathbf{X_t} + \varepsilon_t \tag{4.1}$$

where $\mathbf{X_t}$ is a vector of macroeconomic news surprises and ε_t is the regression residual. While this linear model provides valuable results, its parametrisation assumes that the sensitivity of news remains constant over the sample.

However, Edwards and Plumb (2009) argue that global uncertainty impacts the responsiveness of the AUD/USD exchange rate to news. They suggest that the correlation between the exchange rate and surprises is reversed in 'uncertain' times compared to 'normal' times. I modify regression (4.1) to test for this asymmetry:

$$\Delta y_t = \alpha + \boldsymbol{\beta}_{\text{VIX}}\mathbf{X_t} + \boldsymbol{\delta}_{\text{VIX}}\left(\overline{\text{VIX}}_{\text{t}} \cdot \mathbf{X_t}\right) + \varepsilon_t \tag{4.2}$$

[1] To ensure consistency and transparency, I adopt the same notation as Swanson and Williams (2014a,b) throughout this section.

where $\overline{\text{VIX}}_t$ is a dummy variable that is equal to 1 when the VIX series is above the benchmark created in Section 3.5 and 0 otherwise. The interactions $\overline{\text{VIX}}_t \cdot \mathbf{X_t}$ measure how the sensitivity of Δy_t to $\mathbf{X_t}$ differs in times of high global uncertainty compared to times where global volatility is normal. To investigate whether the correlation between each surprise x and Δy_t changes when volatility is high, I check the sign of $\beta_{VIX} + \delta_{VIX}$ for each variable x and compare it to the sign of β in regression (4.1). It will be particularly interesting to see whether the findings from Edwards and Plumb (2009) also hold for the bond yields or if they are specific to the exchange rate.

I also test whether sensitivity to news changes during periods of high volatility. I test $|\beta_{VIX} + \delta_{VIX}| < \beta$ for each surprise to examine whether the sensitivity to news drops in times of uncertainty. This measure assumes that all periods of high volatility affect the relationship between news announcements and Δy_t similarly. Intuitively this might not prove to be accurate.

4.2 Measuring the Time-Varying Sensitivity to Macroeconomic News

To measure how sensitivity to news varies over time it is possible to run regression (4.1) on one-year rolling windows. However this approach is problematic. Most macroeconomic variables have new data available on a monthly or quarterly basis leaving between four and twelve data points to estimate the variable coefficient in the β vector. Consequently this approach is very likely to suffer from small sample problems.

To circumvent this problem, I use a two-stage specification that combines non-linear least squares and rolling-window estimate. The first stage of this method developed by Swanson and Williams (2014a,b) uses non-linear least squares to isolate and remove year-specific effects. This creates a 'generic surprise' regressor. In the second stage, bond yield and exchange rate movements are regressed against this generic surprise regressor using one-year rolling windows. This effectively captures the time-varying sensitivity of the bond yields and the exchange rate to news. The rest of this section details this methodology further.

The sensitivity of the exchange rate or bond yields to news is likely to be affected by external shocks over time. To capture the underlying sensitivity to news over time, I must remove these time-specific effects. For reasons that will soon become obvious I will focus on removing year-specific effects. To do this, I assume that sensitivity to all news is affected similarly each year. While this assumption is slightly restrictive, it makes sense to think that if bond yields or exchange rates are less sensitive to news in a given year, sensitivity to all news would be affected by a similar proportion. Swanson and

Williams (2014a,b) provide evidence that supports the validity of this assumption. In the following non-linear regression, I isolate the year-specific effects δ^{τ_i} and I identify the generic sensitivity vector β:

$$\Delta y_t = \gamma^{\tau_i} + \delta^{\tau_i} \boldsymbol{\beta} \mathbf{X_t} + \varepsilon_t \tag{4.3}$$

where I allow scalars γ^{τ_i} and δ^{τ_i} to take different values in each calendar year $i = 2000, ..., 2015$.[2] Implicitly this imposes that the relative sensitivities to each news remain constant over time. Instead, the absolute sensitivity to news is scaled up by δ^{τ_i} each year. For example if the AUD/USD is twice as sensitive to Australian monetary policy surprises as to Australian unemployment surprises, then the coefficient on 'Australian monetary policy' will be twice as large in the β vector than the coefficient on 'Australian unemployment'. This 2:1 ratio will hold for *all* years. Therefore while the sensitivity of the AUD/USD to Australian monetary policy and Australian unemployment surprises will be scaled by δ^{τ_i} in year i, the AUD/USD will remain twice as sensitive to Australian monetary policy surprises as to Australian unemployment surprises.

Scaling sensitivity coefficients has several advantages. Firstly, annual scaling factors δ^{τ_i} capture year-specific sensitivities in the data. Oil price shocks or natural disasters should be (at least partially) captured and removed by the δ^{τ_i}. Secondly, the average of 165 observations in each calendar year is sufficient to estimate γ^{τ_i} and δ^{τ_i}. Thirdly, this method allows me to use the full sample, almost tripling the number of observations that would have been available to me if I only used pre-GFC observations (2000-2006).

Ideally I would use this methodology to capture day-specific effects instead of year-specific effects as I do here. However this approach would greatly restrict the degrees of freedom to the point that the non-linear estimation might fail to converge. For computational purposes this analysis is limited to capturing year-specific effects.

Unless we impose a restriction we cannot identify β and δ^{τ_i} individually. As one of the aims of this method is to compare sensitivity to news under different monetary policy regimes (ZLB and RBA forward guidance), I normalise the δ^{τ_i} to take an average value of unity before 2007. Over that period, the U.S. and Australian central banks were using conventional monetary policy tools. Therefore, I am able to directly compare the sensitivity to news under new regimes to a period when conventional monetary policy was in place. From 2007 onwards, values of δ^{τ_i} close to unity indicate a year in which sensitivity to news was similar to the base period. Furthermore a value of zero indicates a complete loss of sensitivity to news.

Using the results from regression (4.3) I estimate daily-frequency one-year rolling-window regressions to get a more in-depth understanding of when sensitivity to news

[2]Refer to Appendix A.3 for a stylised application of this example.

changed:

$$\Delta y_t = \gamma^\tau + \delta^\tau \hat{\boldsymbol{X}}_{\mathbf{t}} + \varepsilon_t^\tau \tag{4.4}$$

where $\hat{\mathbf{X}}_{\mathbf{t}} \equiv \hat{\beta}\mathbf{X}_{\mathbf{t}}$ is the generic surprise regressor obtained using $\hat{\beta}$ from regression (4.3). I estimate this rolling-window regression over each business day between January 2000 and December 2015. The coefficient δ^τ measures the sensitivity to news in the year centred around τ when year-specific effects have been removed.[3] Plotting all δ^τ over the sample should therefore provide a clearer indication of when the overall sensitivity to news dropped. This allows me to compare the sensitivity to news under two different monetary policy regimes: when the U.S. rates were at their ZLB and when the RBA engaged in active market guidance.

[3]The standard errors around these τ need to be adjusted to account for the two-stage sampling uncertainty that arises from using $\hat{\beta}\mathbf{X}_{\mathbf{t}}$ from regression (4.3). Swanson and Williams (2014a,b) suggest "using the estimated standard errors of the δ^{τ_i}" from regression (4.3) and "interpolating between them using the standard errors estimated" in regression (4.4). For each full calendar year $i = 2000, ..., 2015$, I record the standard error on δ^{τ_i} in the non-linear estimation (4.3). I define this standard error as ς^{τ_i}. Further, I define σ^τ as the standard error on δ^τ in the OLS rolling window regression (4.3) centred around day τ. For τ in year i, I adjust the standard errors by scaling σ^τ by $\frac{\tau_{i+1}-\tau}{\tau_{i+1}-\tau_i} \cdot \frac{\varsigma^{\tau_i}}{\sigma^{\tau_i}} + \frac{\tau-\tau_i}{\tau_{i+1}-\tau_i} \cdot \frac{\varsigma^{\tau_{i+1}}}{\sigma^{\tau_{i+1}}}$.

Section 5

Results

This section is divided into two main parts. Section 5.1 presents the results of the estimation for Australian government bonds. Section 5.2 exclusively focuses on results for the AUD/USD exchange rate. All discussion of the results is undertaken in Section 6.

5.1 Australian Government Bonds

In this section I report the results of regressions (4.1), (4.2) and (4.4) for Australian government bonds. I conduct multiple hypothesis tests to determine which news releases Australian bond yields are significantly sensitive to. Further I test for asymmetries when global uncertainty is high. Finally the two-stage model provides an estimate of the time-varying sensitivity of Australian bond yields to news releases.

5.1.1 Sensitivity to News

I test whether Australian and U.S. macroeconomic news influence interest rate expectations in Australia. Columns 1 and 3 of Table 5.1 report the results of the OLS regression (4.1) where the daily percentage change in bond yields is regressed on a vector of Australian and U.S. macroeconomic news surprises.[1] Each coefficient is measured in standard deviation of a surprise. Following the literature I exclude days when no news are released for computational ease. Results are robust to the inclusion of all days.

I first test whether my measure of news surprises predicts Australian interest rate movements. In this case considering the R-squared values is not sufficient. The low R-squared scores in the one-year and ten-year regressions simply reflect that unobserved events are causing the majority of the interest rate movements. These low magnitudes are in line with previous studies in the literature.

Instead it is more appropriate to test whether the vector of coefficients $\boldsymbol{\beta}$ is jointly equal to zero versus the null that news announcements are jointly significant ($\boldsymbol{\beta} \neq 0$). I report the results for these tests and all subsequent tests relating to regression (4.1) at the bottom of Table 5.1. I find that the regression coefficients are jointly significant at the 1% significance level for both regressions. This provides strong evidence that Australian

[1] Note: This specification does not account for VIX.

Table 5.1: Regression of Australian Government bonds on news surprises

	1-year				10-year			
	Baseline Reg. (4.1) (1)		VIX Reg. (4.2) (2)		Baseline Reg. (4.1) (3)		VIX Reg. (4.2) (4)	
Australian CPI	0.024	(0.193)	−0.016	(0.213)	−0.050	(0.127)	0.063	(0.142)
VIX interaction			0.359	(0.455)			−0.459	(0.304)
RBA Cash Rate	1.028***	(0.154)	0.814***	(0.175)	0.503***	(0.101)	0.382***	(0.117)
VIX interaction			0.791**	(0.373)			0.540**	(0.249)
Australian GDP	−0.208	(0.199)	−0.185	(0.224)	0.010	(0.129)	0.017	(0.146)
VIX interaction			−0.470	(0.458)			0.080	(0.304)
Australian PPI	−0.300	(0.591)	0.431	(1.100)	0.132	(0.388)	0.466	(0.734)
VIX interaction			−1.050	(1.303)			−0.485	(0.869)
Aus. Unemployment Rate	−0.190*	(0.104)	−0.190*	(0.111)	0.065	(0.067)	0.040	(0.074)
VIX interaction			−0.011	(0.231)			−0.026	(0.146)
U.S. Capacity Utilization	0.183*	(0.105)	0.167	(0.115)	0.122*	(0.069)	0.092	(0.076)
VIX interaction			−0.117	(0.274)			0.033	(0.183)
U.S. CPI (Core)	0.016	(0.130)	0.036	(0.144)	−0.034	(0.085)	−0.011	(0.096)
VIX interaction			−0.158	(0.333)			−0.107	(0.222)
Federal Funds Rate	0.052	(0.133)	−0.111	(0.169)	0.199**	(0.087)	0.183	(0.113)
VIX interaction			0.437	(0.275)			0.047	(0.183)
U.S. GDP	−0.036	(0.198)	−0.098	(0.225)	−0.034	(0.130)	−0.115	(0.150)
VIX interaction			0.054	(0.392)			0.107	(0.261)
U.S. IP	0.177	(0.117)	0.023	(0.152)	0.075	(0.077)	0.035	(0.101)
VIX interaction			0.325	(0.245)			0.045	(0.164)
U.S. Nonfarm Payrolls	0.027	(0.110)	0.064	(0.129)	−0.036	(0.072)	−0.014	(0.086)
VIX interaction			0.097	(0.245)			−0.004	(0.164)
U.S. PMI	0.031	(0.110)	0.090	(0.126)	0.003	(0.072)	0.098	(0.084)
VIX interaction			−0.228	(0.249)			−0.354**	(0.166)
U.S. PPI	0.013	(0.109)	−0.007	(0.125)	−0.011	(0.071)	0.011	(0.083)
VIX interaction			0.059	(0.248)			−0.090	(0.165)
U.S. Retail Sales	0.155	(0.118)	0.167	(0.137)	0.040	(0.078)	0.105	(0.091)
VIX interaction			−0.058	(0.270)			−0.264	(0.180)
U.S. Unemployment Rate	0.253**	(0.108)	0.213*	(0.122)	0.107	(0.070)	0.108	(0.081)
VIX interaction			0.209	(0.267)			−0.026	(0.178)
U.S. Jobless Claims	−0.057	(0.053)	−0.036	(0.057)	0.022	(0.034)	0.029	(0.038)
VIX interaction			−0.154	(0.134)			−0.065	(0.090)
Constant	0.121***	(0.024)	0.106***	(0.023)	0.073***	(0.016)	0.055***	(0.016)
Observations	4.457		4.697		4.509		4.750	
R^2	0.045		0.056		0.025		0.038	
H_0: $\boldsymbol{\beta} = 0$, p-value	0.000		-		0.001		-	
H_0: $\boldsymbol{\beta}_{\text{AUS}} = 0$, p-value	0.000		-		0.000		-	
H_0: $\boldsymbol{\beta}_{\text{US}} = 0$, p-value	0.134		-		0.243		-	
H_0: $\boldsymbol{\beta}_{\text{NM}} = 0$, p-value	0.073		-		0.771		-	
H_0: $\boldsymbol{\beta}_{\text{AUS}_{\text{NM}}} = 0$, p-value	0.204		-		0.894		-	
H_0: $\boldsymbol{\beta}_{\text{US}_{\text{NM}}} = 0$, p-value	0.098		-		0.547		-	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
See text for details on significance tests

interest rates tend to react to the data releases captured in $\boldsymbol{\beta}$. This offers great credibility for the measure of news surprises used throughout this analysis. In the rest of this section I focus on identifying which news releases are particularly significant in predicting bond yield movements.

Firstly I test whether Australian yields respond to Australian news releases and U.S. news releases separately. Specifically, I perform two-tailed Wald tests of the nulls $\boldsymbol{\beta}_{\text{AUS}} = 0$ and $\boldsymbol{\beta}_{\text{US}} = 0$ where $\boldsymbol{\beta}_{\text{AUS}}$ is the vector of Australian coefficients and $\boldsymbol{\beta}_{\text{US}}$ is the vector of U.S. coefficients. Results for these tests are reported at the bottom of Table 5.1. I find that the responsiveness of one-year and ten-year bonds to Australian news is jointly significant at the 10% level but not for U.S. news. This suggests that Australian bond yields are significantly more responsive to domestic news than to U.S. news.

Unexpected Australian policy rate increases are associated with significant increases in Australian bond yields. A one standard deviation surprise in the RBA cash rate is expected to increase the one-year bond yield by 1.028%.[2] The response of ten-year yields to a similar surprise is approximately half that. Surprise hikes in the Federal funds rate also tend to raise Australian market interest rates. This effect is particularly significant at the ten-year horizon. Therefore unexpected policy rate changes seem to significantly affect Australian interest rates.

Further I test whether non-monetary surprises move markets. I define non-monetary news as any news release that is not the RBA cash rate or the U.S. Federal funds rate. Testing the null $\boldsymbol{\beta}_{\text{NM}} = 0$ against the alternative $\boldsymbol{\beta}_{\text{NM}} \neq 0$ I find that Australian yields are significantly less sensitive to my measure of non-monetary news. Again I consider Australian and U.S. news separately. Using a two-tailed Wald test of the null $\boldsymbol{\beta}_{\text{AUS}_{\text{NM}}} = 0$ I find that Australian yields are largely insensitive to non-monetary Australian news at the ten-year horizon. Non-monetary U.S. news surprises predict movements in the one-year bond yields but not at the longer horizon.

Section 5.1.1 establishes that the Australian and U.S. macroeconomic news releases used in this analysis significantly predict bond yield movements. In particular I identify that Australian yields are highly sensitive to the Australian news captured by the model. This effect is strongest for Australian cash rate news. Australian yields respond to the U.S. news surprises more moderately.

5.1.2 Time-varying Sensitivity to News

In this section I test whether the sensitivity of Australian yields to macroeconomic news releases remains constant over time. To do this I use OLS regression (4.2) to test for asymmetries when global uncertainty is high. Finally, I examine how the sensitivity of

[2]Note: The sample standard deviation of RBA cash rate surprises is 11.25 basis points.

bond yields to macroeconomic data releases varies over time using the two-stage model (4.4).

Under Regimes of Elevated Global Uncertainty

Edwards and Plumb (2009) found empirical evidence that the AUD/USD exchange rate reacted differently to U.S. news when global uncertainty was high. I test whether this is also the case for Australian bond yields. To allow for asymmetry between times of low and high uncertainty, I run the OLS specification (4.2). Columns 2 and 4 of Table 5.1 report results of this regression where the coefficient on the VIX interaction is the δ in regression (4.2). For instance when uncertainty is normal, a one standard deviation surprise in the RBA cash rate tends to raise one-year yields by 0.814%. In uncertain times, the same surprise tends to raise one-year yields by $0.814 + 0.791 = 1.605\%$. For this specification, I summarise the results of the tests run in Table 5.2.

Table 5.2: Effect of surprises on Australian bonds under uncertainty

	1-year maturity		10-year maturity	
	Correlation Reversal? (1)	p-value (2)	Correlation Reversal? (3)	p-value (4)
Australian CPI	-	0.655	-	0.959
RBA Cash Rate	-	0.989	-	0.986
Australian GDP	-	0.387	-	0.801
Australian PPI	-	0.323	yes	0.368
Australian Unemployment Rate	-	0.378	-	0.707
U.S. Capacity Utilization	-	0.504	-	0.772
U.S. CPI (Core)	yes	0.318	-	0.332
Federal Funds Rate	-	0.898	-	0.594
U.S. GDP	-	0.666	-	0.738
U.S. IP	-	0.833	-	0.519
U.S. Nonfarm Payrolls	-	0.559	-	0.370
U.S. PMI	yes	0.193	-	0.028
U.S. PPI	-	0.631	yes	0.419
U.S. Retail Sales	-	0.582	yes	0.095
U.S. Unemployment Rate	-	0.702	-	0.638
U.S. Jobless Claims	-	0.207	-	0.319

Notes: a 'yes' in the 'Correlation Reversal?' columns indicates that the correlation between the yields and the variable is reversed when global uncertainty is high.
The 'p-value' columns give the p-value of the one-tailed evaluation of the null $|\beta^x_{VIX} + \delta^x_{VIX}| \geq |\beta_{baseline}|$.

First, I test the hypothesis that the relationship between news and bonds yield is reversed between times of normal and high uncertainty. To do this, I compare the signs of $\beta^{\text{x}}_{\text{VIX}} + \delta^{\text{x}}_{\text{VIX}}$ and $\beta^{\text{x}}_{\text{baseline}}$, where $\beta^{\text{x}}_{\text{VIX}}$ and $\delta^{\text{x}}_{\text{VIX}}$ are the coefficients on variable x in regression (4.2) and $\beta^{\text{x}}_{\text{baseline}}$ is the coefficient on variable x in the baseline model (4.1). I report 'yes' in columns 1 and 3 of Table 5.2 if the signs on $\beta^{\text{x}}_{\text{VIX}} + \delta^{\text{x}}_{\text{VIX}}$ and $\beta^{\text{x}}_{\text{baseline}}$ are different. Overall, there is little evidence of a correlation reversal under uncertainty.

Second, I test the hypothesis that the sensitivity of bond yields to news decreases when

global uncertainty is high. Specifically, I test the null $|\beta^x_{VIX} + \delta^x_{VIX}| \geq |\beta_{baseline}|$ versus the one-tailed alternative $|\beta^x_{VIX} + \delta^x_{VIX}| < |\beta_{baseline}|$. I use absolute values here because I am interested in capturing changes in the overall sensitivity to news. I report the p-values for this test in the second and fourth columns of Table 5.2. There is insufficient evidence to suggest that the sensitivity of bond yields to news drops in times of high uncertainty. On the contrary the sensitivity to the RBA cash rate appears higher when global uncertainty is high.

Overall, I find little evidence to suggest that Australian bond yields respond differently to the selected macroeconomic data releases when global uncertainty is high.

Two-Stage Model: Time-Varying Coefficients

I further extend this analysis by allowing the overall sensitivity of bond yields to vary daily. Using the two-stage regression outlined in Section 4.2, I can identify periods during which the sensitivity of Australian yields to news is abnormal relative to the base period.

Figure 5.1 plots the time-varying coefficients δ^τ obtained using rolling window regressions (4.4). I normalise the average value of coefficients between 2000 and 2006 to unity. The navy blue lines in Figure 5.1 plot the estimated sensitivity coefficient δ^τ from regression (4.4) for each day τ. The top panel 5.1a plots δ^τ for the one-year maturity Australian Government bonds while the bottom panel 5.1b uses ten-year maturity Australian Government bonds. The red lines represent $\pm$ 2 standard-error bands adjusted for two-stage sampling uncertainty as outlined in Section 4.2. I also plot three black lines at -1, 0 and 1 to allow for comparison with the base period. Grey shaded areas indicate periods during which the absolute sensitivity of the bond yields to news dropped significantly below its absolute value over 2000-2006 and was not significantly different from zero. Using notation from regression (4.4), this occurs when $-1 < \delta^{\tau_i} < 1$. Grey shaded areas indicate periods during which bond yields became unresponsive to Australian and U.S. macroeconomic news.[3]

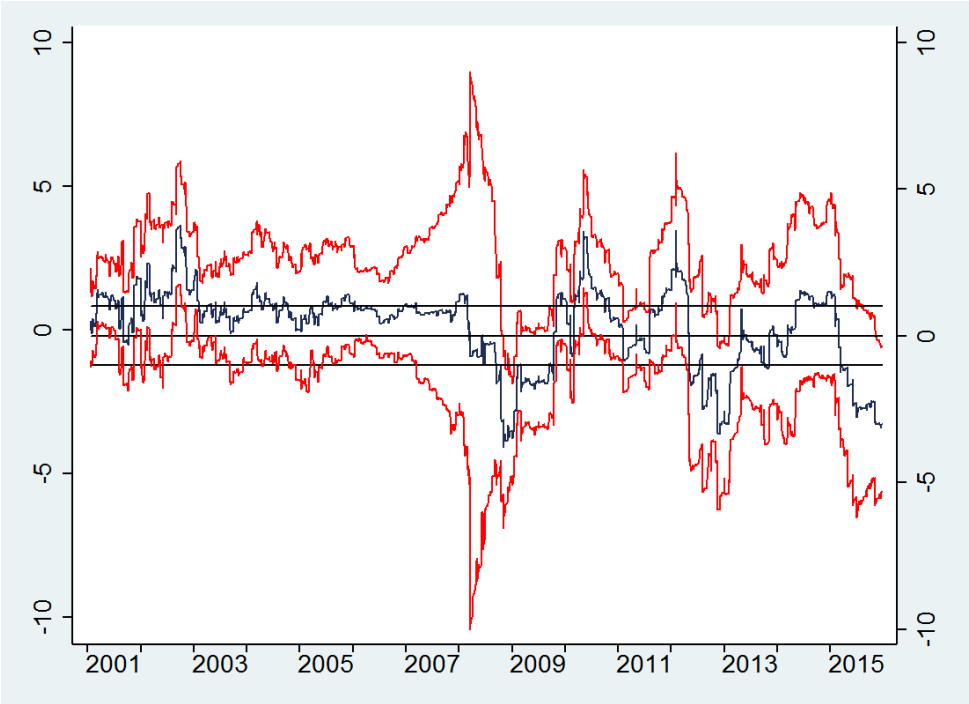
Figure 5.1a shows that the sensitivity of medium-term yields to data releases has varied greatly between 2000 and 2015. Following a period of relative stability, the sensitivity of one-year yields becomes extremely volatile after 2007 and fluctuates between -4 and 4. While the sensitivity fluctuates around zero in 2011 and 2013-2014 the evidence suggests that medium-term yields remain largely unconstrained over the sample.

From Figure 5.1b it appears that results are mostly similar for ten-year bonds. Longer-term yields also remain mostly sensitive to news between 2000 and 2015. The sensitivity of ten-year bonds is notably less volatile. Surprisingly I find that this sensitivity is somewhat

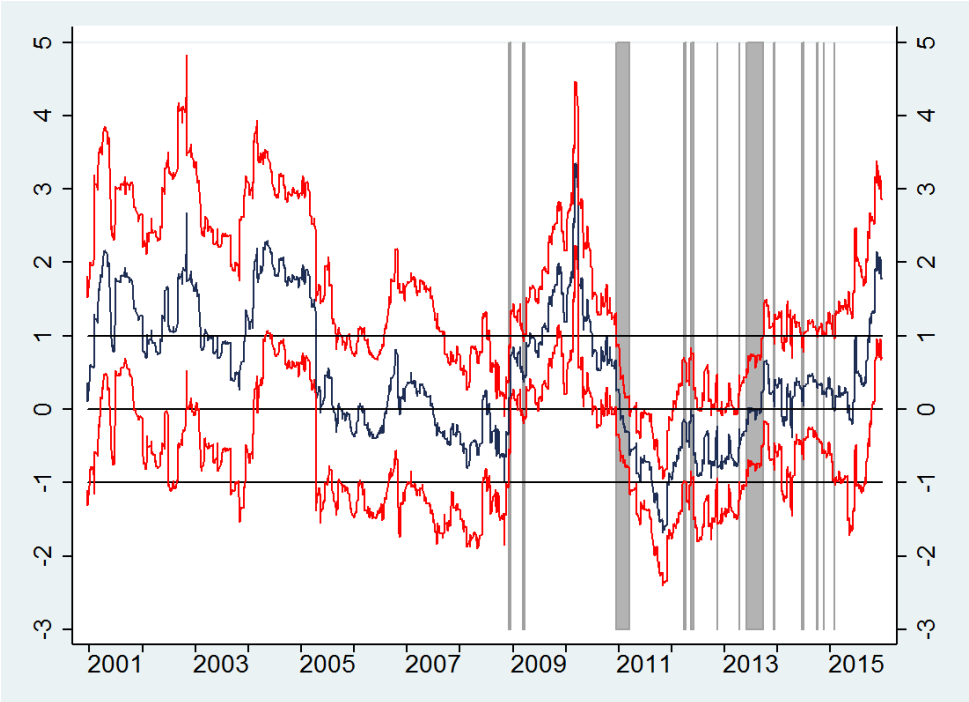
[3]Please refer to Appendix A.5 for details regarding the abnormally wide standard-error bands observed between 2006 and 2008 in Figure 5.1a.

Figure 5.1: Time-varying sensitivity of Australian bond yields to news

(a) One-year maturity



(b) Ten-year maturity



The red lines represent the ± 2 adjusted standard-error bands. Grey shaded areas indicate time periods when $-1 < \delta^{\tau_i} < 1$.

constrained between 2011 and 2015. Sensitivity increases significantly in 2015.

Section 5.1.2 provides evidence that the sensitivity of Australian yields to the macroeconomic news releases considered is not significantly affected when global uncertainty is high. Further medium- and long-term yields remained sensitive to news releases throughout the sample.

5.2 AUD/USD Exchange Rate

In this section I repeat the analysis for the AUD/USD exchange rate and report the results of regressions (4.1), (4.2) and (4.4). I conduct multiple hypothesis tests to determine which news releases the AUD/USD is significantly sensitive to. Further I test for asymmetries when global uncertainty is high. Finally the two-stage model provides an estimate of the time-varying sensitivity of the AUD/USD exchange rate to news releases. Results in this section are reported such that positive coefficients indicate an appreciation of the Australian dollar.

5.2.1 Sensitivity to News

I test whether various Australian and U.S. macroeconomic news releases predict movements in the AUD/USD exchange rate. The first column of Table 5.3 reports the results of the OLS regression (4.1) where the daily percentage change in the AUD/USD exchange is regressed on surprises. Following the literature I only consider days when news were released for computational ease. Results remain very robust to the inclusion of non-news days.

The R-squared value is not sufficient to determine whether the AUD/USD exchange rate responds to news releases. Instead I perform a two-tailed Wald test of $\boldsymbol{\beta} = 0$, where $\boldsymbol{\beta}$ is the full vector of regression coefficients. I report the results for this test and all subsequent tests relating to regression (4.1) at the bottom of Table 5.3. This Wald test yields a p-value of 0.002 so I conclude that the regression coefficients are jointly significant at the 10% significance level. This suggests that the AUD/USD is indeed responsive to the macroeconomic news captured in the $\boldsymbol{\beta}$ vector. The rest of this section focuses on identifying which news releases are particularly significant in predicting movements in the AUD/USD exchange rate.

Firstly I test whether the AUD/USD exchange rate responds to the Australian news releases captured in the analysis. I perform a two-tailed Wald test of the null $\boldsymbol{\beta}_{\text{AUS}} = 0$ where $\boldsymbol{\beta}_{\text{AUS}}$ is the vector of Australian coefficients. I also test whether the AUD/USD is sensitive to U.S. news releases by testing $\boldsymbol{\beta}_{\text{US}} = 0$ against the alternative $\boldsymbol{\beta}_{\text{US}} \neq 0$ where $\boldsymbol{\beta}_{\text{US}}$ is the vector of U.S. coefficients. It appears that the AUD/USD exchange is highly

Table 5.3: Regression of AUD/USD exchange rate on news surprises

	Baseline Reg. (4.1) (1)		VIX Reg. (4.2) (2)	
Australian CPI	−0.013	(0.101)	0.075	(0.110)
VIX interaction			−0.492*	(0.261)
RBA Cash Rate	0.169**	(0.079)	0.237***	(0.089)
VIX interaction			−0.301	(0.199)
Australian GDP	0.099	(0.101)	0.069	(0.115)
VIX interaction			0.017	(0.298)
Australian PPI	0.238	(0.307)	−0.008	(0.569)
VIX interaction			0.374	(0.674)
Australian Unemployment Rate	0.042	(0.053)	0.024	(0.060)
VIX interaction			0.062	(0.126)
U.S. Capacity Utilization	0.018	(0.055)	−0.005	(0.059)
VIX interaction			0.168	(0.148)
U.S. CPI (Core)	−0.057	(0.067)	−0.089	(0.074)
VIX interaction			0.261	(0.172)
Federal Funds Rate	−0.221***	(0.069)	−0.003	(0.088)
VIX interaction			−0.592***	(0.141)
U.S. GDP	−0.031	(0.101)	−0.089	(0.117)
VIX interaction			0.217	(0.228)
U.S. Industrial Production	−0.175***	(0.061)	−0.015	(0.079)
VIX interaction			−0.408***	(0.130)
U.S. Nonfarm Payrolls	−0.163***	(0.057)	−0.131*	(0.067)
VIX interaction			−0.077	(0.133)
U.S. PMI	−0.035	(0.055)	−0.029	(0.064)
VIX interaction			−0.018	(0.128)
U.S. PPI	0.018	(0.056)	0.034	(0.064)
VIX interaction			−0.048	(0.129)
U.S. Retail Sales	0.044	(0.061)	−0.014	(0.071)
VIX interaction			0.235	(0.140)
U.S. Unemployment Rate	0.042	(0.055)	0.061	(0.064)
VIX interaction			−0.050	(0.140)
U.S. Jobless Claims	0.009	(0.051)	−0.021	(0.151)
VIX interaction			0.021	(0.151)
Constant	0.025	(0.022)	0.028	(0.021)
Observations	1.557		1.538	
R^2	0.024		0.048	
H_0: $\boldsymbol{\beta} = 0$, p-value	0.002		-	
H_0: $\boldsymbol{\beta}_{\text{AUS}} = 0$, p-value	0.258		-	
H_0: $\boldsymbol{\beta}_{\text{US}} = 0$, p-value	0.001		-	
H_0: $\boldsymbol{\beta}_{\text{NM}} = 0$, p-value	0.071		-	
H_0: $\boldsymbol{\beta}_{\text{AUS}_{\text{NM}}} = 0$, p-value	0.698		-	
H_0: $\boldsymbol{\beta}_{\text{US}_{\text{NM}}} = 0$, p-value	0.028		-	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
See text for details on significance tests

responsive to U.S. news releases while being insensitive to Australian news releases.

Simlarly to the bond yields, coefficients on monetary policy news releases are highly significant. The model predicts that a one standard deviation surprise in the RBA cash rate should cause a 0.169% appreciation of the Australian dollar. Similarly an unexpected positive surprise in the Federal Funds Rate tends to depreciate the AUD. Therefore unexpected increases in the policy rate tend to appreciate the domestic currency.

I also test whether the exchange rate is moved by non-monetary news by testing the null that the vector of non-monetary surprises $\boldsymbol{\beta}_{\text{NM}} = 0$ against the alternative that $\boldsymbol{\beta}_{\text{NM}} \neq 0$. The effect is still significant. I again isolate non-monetary Australian and non-monetary U.S. news and perform two-tailed Wald tests of the nulls $\boldsymbol{\beta}_{\text{AUS}_{\text{NM}}} = 0$ and $\boldsymbol{\beta}_{\text{US}_{\text{NM}}} = 0$, where $\boldsymbol{\beta}_{\text{AUS}_{\text{NM}}}$ and $\boldsymbol{\beta}_{\text{US}_{\text{NM}}}$ are vectors of non-monetary Australian and U.S. coefficients respectively. Results are similar to the country-specific tests that included monetary policy. The exchange rate was highly sensitive to non-monetary U.S. news releases but particularly unresponsive to the non-monetary Australian news releases.

Overall, the evidence suggests that the exchange rate was particularly sensitive to most U.S. news but did not respond significantly to the non-monetary Australian news included in this analysis.

5.2.2 Time-varying Sensitivity to News

In this section I test whether the sensitivity of the AUD/USD exchange rate to macroeconomic news releases remains constant over time. To do this I use OLS regression (4.2) to test for asymmetries when global uncertainty is high. Finally, I examine how the sensitivity of the AUD/USD to macroeconomic data releases varies over time using the two-stage model.

Under Regimes of Elevated Global Uncertainty

Firstly, I investigate whether the AUD/USD responds to news releases differently when global volatility is high. This hypothesis was proposed by Edwards and Plumb (2009) who found that the correlation between U.S. news surprises and the AUD/USD exchange rate changed when global uncertainty was high. To allow for asymmetry between times of normal and high uncertainty, I use the OLS specification (4.2). Column 2 of Table 5.3 reports results for this regression where the coefficient on the VIX interaction term is the δ in (4.2). For instance, when global uncertainty is low, a one standard deviation surprise in the Federal Funds Rate will depreciate the AUD by 0.003%. When global uncertainty is high, the model predicts that the same surprise will depreciate the Australian currency by $0.003 + 0.592 = 0.595\%$. For this specification, I summarise the results of the tests run in Table 5.4.

Table 5.4: Effect of news surprises on AUD/USD under uncertainty

Variables	Correlation Reversal? (1)	p-value (2)
Australian CPI	-	0.962
RBA Cash Rate	yes	0.093
Australian GDP	-	0.530
Australian PPI	-	0.636
Australian Unemployment Rate	-	0.666
U.S. Capacity Utilization	-	0.842
U.S. CPI (Core)	yes	0.928
Federal Funds Rate	-	0.999
U.S. GDP	yes	0.811
U.S. IP	-	0.901
U.S. Nonfarm Payrolls	-	0.674
U.S. PMI	-	0.550
U.S. PPI	yes	0.398
U.S. Retail Sales	-	0.918
U.S. Unemployment Rate	-	0.593
U.S. Jobless Claims	-	0.391

Notes: a 'yes' in the 'Correlation Reversal?' column indicates that the correlation between the exchange rate and the variable is reversed when global uncertainty is high.
The 'p-value' column gives the p-value of the one-tailed evaluation of the null $|\beta^x_{VIX} + \delta^x_{VIX}| \geq |\beta_{baseline}|$.

First, I test the hypothesis that the relationship between news releases and the AUD/USD is reversed between times of normal and high uncertainty. To do this, I compare the signs of $\beta^{\text{x}}_{\text{VIX}} + \delta^{\text{x}}_{\text{VIX}}$ and $\beta^{\text{x}}_{\text{baseline}}$, where $\beta^{\text{x}}_{\text{VIX}}$ and $\delta^{\text{x}}_{\text{VIX}}$ are the coefficients on variable x in regression (4.2) and $\beta^{\text{x}}_{\text{baseline}}$ is the coefficient on variable x in the baseline model (4.1). I report 'yes' in column 1 of Table 5.4 if the signs on $\beta^{\text{x}}_{\text{VIX}} + \delta^{\text{x}}_{\text{VIX}}$ and $\beta^{\text{x}}_{\text{baseline}}$ are different. While there is some evidence of a sign reversal for some U.S. series as well as for the RBA cash rate, I do not find the systemic correlation reversal Edwards and Plumb (2009) observed. Overall there is little evidence of a correlation reversal under uncertainty.

Second, I test the hypothesis that the sensitivity of bond yields to news decreases when global uncertainty is high. Specifically, I test the null $|\beta^x_{VIX} + \delta^x_{VIX}| \geq |\beta_{baseline}|$ versus the one-tailed alternative $|\beta^x_{VIX} + \delta^x_{VIX}| < |\beta_{baseline}|$. I use absolute values here because I am interested in capturing changes in the overall sensitivity to news. I report the p-value for this test in the second column of Table 5.4. The sensitivity of the AUD/USD exchange rate to Australian monetary news is significantly lower when global uncertainty is high. There is insufficient evidence to suggest that the sensitivity to any other news was lower in times of high uncertainty.

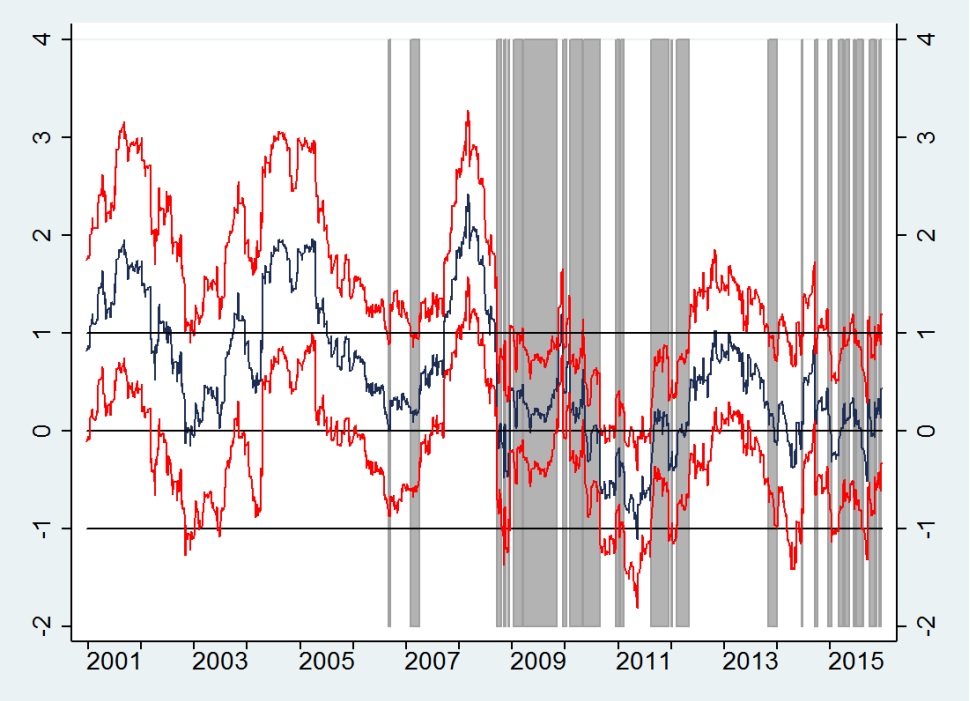
Overall, the evidence suggests that, similar to bond yields, the sensitivity of the Australian exchange rate to Australian and U.S. macroeconomic news remains relatively unchanged when global uncertainty is high. However it appears that the AUD/USD

becomes less responsive to RBA cash rate decisions in regimes of high uncertainty.

Two-Stage Model: Time-Varying Coefficients

I further extend this analysis by allowing the overall sensitivity of the AUD/USD exchange rate to vary daily. Using the two-stage regression outlined in Section 4.2 I can identify periods during which the sensitivity of the exchange rate to news is abnormal relative to the base period.

Figure 5.2: Time-varying sensitivity of AUD/USD exchange rate to news



The red lines represent the ± 2 adjusted standard-error bands. Grey shaded areas indicate time periods when $-1 < \delta^{\tau_i} < 1$.

Figure 5.2 plots the time-varying coefficients δ^{τ} obtained using rolling window regressions (4.4). I normalise the average value of coefficients between 2000 and 2006 to unity. The navy blue line in Figure 5.2 plots the estimated sensitivity coefficient δ^{τ} from the one-year rolling regression (4.4) centred around day τ. The red lines represent ± 2 standard-error bands adjusted for two-stage sampling uncertainty as outlined in Section 4.2. I also plot three black lines at -1, 0 and 1 to allow for comparison with the base period. Grey shaded areas indicate periods during which the absolute sensitivity of the exchange rate to news dropped significantly below its absolute value over 2000-2006 and was not significantly different from zero. Using notation from regression (4.4), this occurs when $-1 < \delta^{\tau_i} < 1$. Grey shaded areas indicate periods during which the exchange rate became essentially unresponsive to Australian and U.S. macroeconomic news.

Figure 5.2 shows that the sensitivity of the AUD/USD exchange rate to news releases dropped significantly after 2008. This sensitivity averaged zero over 2009-2011 and 2014-2015. Sensitivity in 2012-2013 was comparable to the base period.

In this Section I tested whether the sensitivity of the AUD/USD exchange rate to news remained constant over time. The evidence suggests that the sensitivity of the AUD/USD to news releases is largely unaffected under regimes of high global uncertainty. However the sensitivity of the AUD/USD to Australian monetary news drops when uncertainty is high. Furthermore the sensitivity of the AUD/USD exchange rate to Australian and U.S. macroeconomic news is mostly constrained after 2009. I discuss implications of these findings in Section 6.

Section 6

Discussion

In this Section I discuss the findings presented in Section 5. I also consider some extensions and robustness checks. I separate the discussion of bond yields and the exchange rate into two sections, Section 6.1 and Section 6.2.

6.1 Australian Government Bonds

6.1.1 News Surprises and Market Movements

Using linear and non-linear estimation, I showed that Australian bond markets reacted to news. I identify two channels through which news affects yields. First, unexpected increases in the Australian policy rate immediately raise expected returns on government securities, causing yields to rise. I call this the direct channel. Second, some news move bond yields by affecting expectations of future policy rates in Australia. This is the indirect channel. I also examine whether the sensitivity of bond yields varies significantly when global uncertainty is high.

Direct Channel: Australian Policy Rate Surprises

As expected the data identifies a strong positive relationship between surprises in the Australian cash rate and Australian bond yields. This is consistent with the no-arbitrage condition which predicts that unexpected increases in the policy rate should increase returns on Government securities. This should immediately be reflected by higher market yields.

The response of one-year yields to Australian monetary surprises is twice as large as that of ten-year yields. This difference likely reflects the relative importance of the current policy rate for the one-year yields. Indeed the current policy rate is more likely to be correlated with short-term rates within the year than short-term rates ten years from now. This is consistent with research that has shown there is strong correlation in short-term rates a few quarters apart but that this effect is not observed at longer horizons (see Rudebusch (2002); Coibion and Gorodnichenko (2012)). This finding suggests that the RBA should primarily use the cash rate to target short- and medium-term rates as

it has been relatively less successful at moving long-term rates. To target the long-term rate, alternative methods should used. One such method involves actively managing expectations and is examined further later in this paper.

Indirect Channel: Expectations of Future Policy Rate Changes

News other than the Australian cash rate also appear to affect Australian bond yields. From the expectations hypothesis of the term structure, Australian yields should only move if current or expected future short-term rates change. If Australian yields move following a news release other than the RBA cash rate, this reflects that market participants are updating their expectations of future Australian short-term rates. This is the indirect channel.

It appears that there are monetary spillovers from the U.S. to Australia as Australian yields tend to increase when the Federal funds rate rises unexpectedly. Markets tend to revise their expectation of future Australian rates upwards when U.S. interest rates unexpectedly rise. This is consistent with the idea that U.S. monetary policy surprises are "world surprises" that affect global interest rates (Craine and Martin, 2008). In particular Australian interest rates are more sensitive to U.S. monetary news at the long-end of the yield curve. This was also identified by Craine and Martin (2008). This has several implications. First, markets expect most of the effects of Federal funds rate changes on Australian interest rates to occur with a lag greater than one year. Second, markets expect short-term rates in the long-run to be more significantly influenced by current U.S. monetary policy than by current Australian monetary policy.

Australian bond yields are also less sensitive to Australia non-monetary news releases. Non-monetary releases provide an indication of the state of the economy in Australia. The release of better-than-expected Australian news should ceteris paribus increase the likelihood of future policy rate increases. This would be reflected in market interest rates being highly sensitive to non-monetary domestic news. While I find some evidence of this sensitivity for medium-term bonds, it appears that long-term bonds are insensitive to non-monetary domestic news. This is consistent with the theory that news today is unlikely to affect interest rates in ten years. Overall, it appears that the Australian yield curve is not significantly influenced by current domestic economic conditions, particularly at the long end.

Interestingly, Australian yields tend to be significantly more responsive to U.S. non-monetary news. This effect is particularly significant for one-year bonds. To my knowledge this finding is new. It suggests that markets expect the path of future Australian economic growth (and thus the path of future Australian policy rates) to be highly influenced by the current state of the U.S. economy. This is particularly reasonable as Australia is a

small open economy that has historically been highly sensitive to external factors such as commodity prices and global growth. The new finding here is that markets expect the majority of the spillovers from the real U.S. economy into the real Australian economy to occur within the year. This suggests that markets expect the bulk of the RBA's response to changes in U.S. economic conditions to occur within a year. Combining this result with the low sensitivity of yields to Australian non-monetary news implies that markets expect the RBA's cash rate decisions within the next year to be driven by current U.S. economic conditions. This implies that markets perceive future Australian monetary policy to be primarily determined by U.S. factors rather than current Australian economic conditions.

This result could be driven by the identification strategy employed. I explore two possible reasons. First, the low sensitivity to Australian non-monetary news could stem from markets having more time to respond to U.S. news than Australian news because of the time zone differences.[1] However this should have little impact on the analysis. Ederington and Lee (1993, 1995) showed that the majority of the interest rate adjustments to news is done within 40 seconds of the announcement. Thus, I expect my methodology to capture the majority of market movements attributable to news releases. Second, it is possible that the low sensitivity to Australian non-monetary news can be explained by the low frequency of Australian news releases used in this analysis. As most non-monetary Australian news are released quarterly, it is conceivable that markets focus primarily on intermediary data releases to update their expectations more frequently. Therefore there is scope for this research to be revisited once survey data on higher frequency series are available. An alternative would be to construct an index of news surprises using market-based measures of surprises. From derivatives such as futures a measure of the unexpected component of news can be derived. This method is commonly used when dealing with unobserved expectations. Using this methodology, future research could also incorporate measures of exchange shocks and foreign news surprises. However adding all this information to my linear specification might lead to over-parametrisation. To avoid this I suggest employing Bayesian or model-averaging approaches. In particular, the model-averaging is suggested by Elliott, Gargano, and Timmermann (2015) to identify significant predictors and find accurate estimates of the effects of these news shocks on the variable of interest in the large constructed dataset.

High Global Uncertainty

There has been debate in the literature regarding asymmetries. Andersen et al. (2003) and Edwards and Plumb (2009) argue that the market response to news is state-contingent, while other authors such as Gürkaynak et al. (2005) and Swanson and Williams (2014a)

[1] All times are ETZ so for some Australian news there is only 2 hours between the announcement and the end of trading day.

largely ignore the presence of asymmetries in their papers. I seek to add to the discussion by testing for possible asymmetries in the response of bond yields to news in Australia. Ideally I would compare the response of yields to news in expansionary and recessionary states. However the Australian economy remained in an expansionary state over the sample, leaving 0 observations in recessions. Instead, I use a measure of global uncertainty to test whether the market response changes significantly under different global uncertainty states. Future research should revisit this matter and test for asymmetries during contractionary years.

Empirically there is little evidence to suggest that Australian bond markets respond differently to news when global uncertainty is high.[2] This yields some support to the view put forward by Gürkaynak et al. (2005) that asymmetries can be largely ignored. The implications of this finding for monetary policy makers are significant. It suggests that monetary policy will have similar effects on the yield curve independently of the state of uncertainty. It also implies that forecasters can ignore asymmetries in their modelling of bond yields without much loss of generality. I must stress however that the asymmetries I refer to are linked to global uncertainty derived from VIX. Further research should test for asymmetries under different states of the domestic economies.

6.1.2 Different Monetary Policy Regimes

This section explores the sensitivity of Australian bond yields to news under different monetary policy regimes. In particular, I consider the period of zero interest rates in the U.S., and instances of forward guidance by the RBA.

Zero Lower Bound

Between 2008 and 2015 the U.S. resorted to non-conventional monetary policy tools and kept the policy rate at the ZLB. Theory suggests that the sensitivity of Australian bond yields should be largely unaffected by U.S. rates reaching their ZLB. I examine whether this holds empirically.

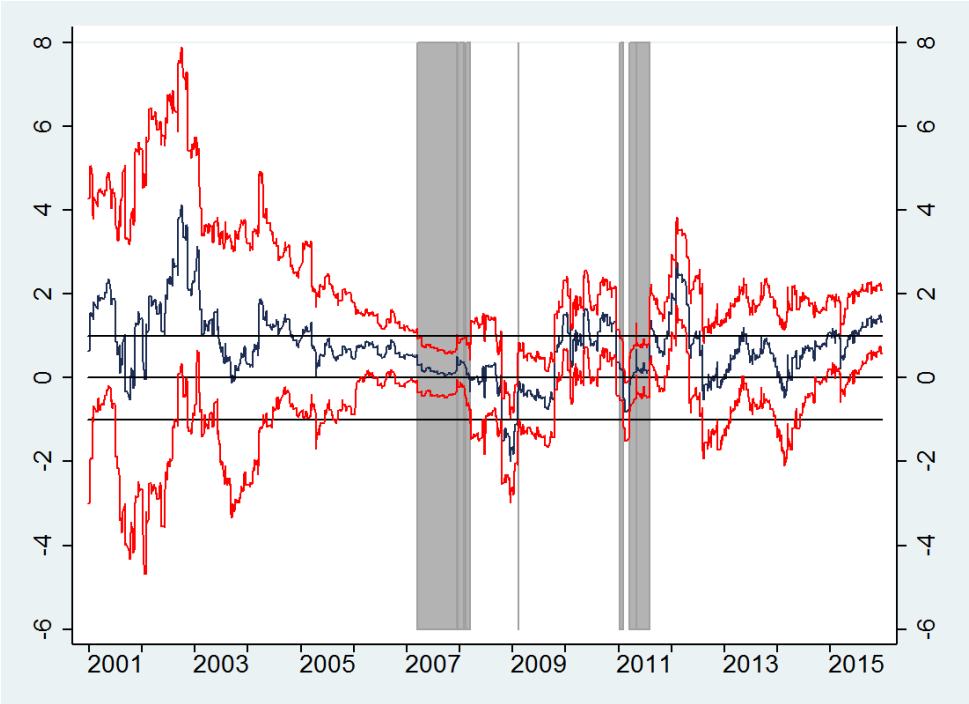
Swanson and Williams (2014a) found that short- and medium-term U.S. Treasury bond yields become significantly unresponsive to U.S. news under the ZLB as markets stop updating their medium-term interest rate expectations. If this effect is also observed in Australian bond markets, Australian yields should lose sensitivity to non-monetary U.S. news when U.S. rates are at zero. I test this in Figure 6.1 by restricting the analysis to only consider the sensitivity of Australian yields to U.S. news.

From Figures 6.1a and 6.1b it can be seen that medium- and long-term yields remain

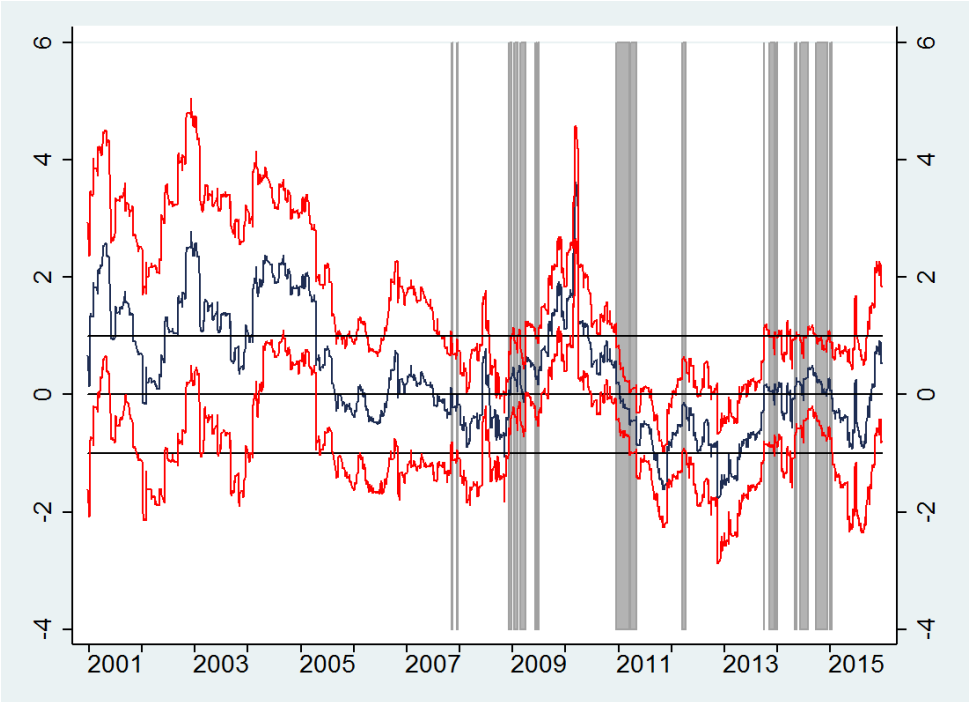
[2]This finding remains robust when I change the definition of $\overline{\text{VIX}}_t$ to impose that markets update their uncertainty expectations faster using a one-year moving average. Refer to Appendix A.4 for details.

Figure 6.1: Time-varying sensitivity of Australian bond yields to U.S. news

(a) One-year maturity



(b) Ten-year maturity



The red lines represent the ± 2 adjusted standard-error bands. Grey shaded areas indicate time periods when $-1 < \delta^{\tau_i} < 1$.

relatively sensitive to U.S. news while U.S. rates are at zero. This finding has significant implications. It indicates that U.S. news affect Australian yields through channels other than the interest differentials channel. If this relationship persists then the RBA might experience limited success at moving the medium- and long-ends of the yield curve in the future as they seem highly sensitive to U.S. news.

I also test whether the overall sensitivity of Australian yields to macroeconomic news is affected by the presence of the ZLB.[3] The evidence suggests that medium- and long-term yields do not experience significant constraints after 2009. On the contrary one-year yields, which had previously been higly stable, appear particularly volatile and highly sensitive to macroeconomic news from 2008 onwards.[4] The fact that one-year bond yields markets are particularly responsive to news could reflect the uncertainty caused by quickly falling interest rates worldwide, low growth in most developed economies and high global volatility. This might indicate that over the period markets were actively looking for signals regarding future RBA cash rate decisions. Therefore there might be scope for central banks in small open economies to use active expectation management to reduce uncertainty in domestic bond markets. I further explore this avenue in the following section.

RBA 'Forward Guidance'

In this section I focus on the apparent constraint that ten-year yields experience in 2014.[5] I hypothesise that forward guidance from the RBA partially contributed to the constraint on yields in 2014.

Over the majority of the sample the RBA carefully guided market expectations of future monetary policy. This forward guidance was principally communicated in the monetary decision statements released after each Board meeting.[6] Throughout the period of interest, the RBA actively managed interest rate expectations. While they suggested several times that policy rates were on a downward path, the RBA never committed to a level in the policy rate until 2014. The RBA stated in every monetary decision in 2014 that "the most prudent course of action is likely to be a period of stability in interest rates", suggesting it would not move rates in the short run. If markets regarded the RBA's suggestion of stable interest rates as credible, Australian yields should lose sensitivity to

[3] This paragraph refers to Figures 5.1a and 5.1b.

[4] Sensitivity of one-year yields also remains stable across 2007 despite the restriction on sensitivity applying between 2000 and 2006. This suggests that the increased sensitivity is not caused by the lack of restriction on coefficients from 2009 onwards.

[5] I ignore one-year yields in this Section because while the sensitivity of one-year yields hovered around zero several times in Figure 5.1a the standard errors were too large to detect any constraining on one-year yields.

[6] I outline instances of forward guidance in Appendix A.10.

news as interest rate expectations should remain relatively unaffected by new information. Indeed there is evidence that Australian yields became partially constrained after 2013. Sensitivity to news increased significantly after the RBA's rate decrease in February 2015 marked the end of the RBA's commitment to rate stability. While the RBA committed to a period of stability, it is unlikely that markets expected stable rates for the next ten years. This would account for the partial sensitivity of bond yields to news in 2014 as short-term rate expectations remain unaffected by news but long-term rates expectations are moved by news. Therefore the evidence suggests that the RBA might have experienced some success in managing interest rate expectations throughout 2014 by indicating it would pursue a "period of stability in interest rates". While further research is required to establish causation, this preliminary finding yields significant implications for policy makers. It suggests that expectation management should remain a credible monetary tool for the RBA in the future. However I have only identified the case when the RBA commits to a certain level of the cash rate. Future research should look to establish whether the RBA must commit to a level of the policy rate for forward guidance to be fully effective.

6.2 The AUD/USD Exchange Rate

6.2.1 News Surprises and Market Movements

Using linear and non-linear estimation, I showed that the AUD/USD exchange rate reacted to news releases. In this section I first highlight the prominent role of interest rate differentials in predicting exchange rate movements. I also discuss how news variables regarding current economic conditions affect the AUD/USD. Further, I examine whether the sensitivity of the AUD/USD varies significantly when global uncertainty is high.

Interest Rate Differential

For Australia and the U.S., the domestic currency tended to significantly appreciate following unexpected raises in their respective policy rates. This is consistent with the uncovered interest rate parity holding. This condition suggests that an unanticipated tightening of the domestic policy rate should increase demand for the domestic currency as investments in the currency are now relatively more attractive. This in turn should appreciate the domestic currency. Therefore the data seems to confirm that this condition holds for the AUD/USD exchange rate. This finding should be of particular significance to the RBA. It suggests that the RBA is able to significantly affect the value of the AUD by influencing investment decisions in the AUD. This finding is especially relevant in the context of the recent economic history in Australia. Between 2012 and 2014 the RBA repeatedly cut the cash rate, partly to try and depreciate what it thought was

an overvalued AUD.[7] This finding strongly suggests that the RBA was employing the appropriate policy tools to depreciate the exchange rate over that period. Given the norm of low global rates and falling domestic rates it is likely that the RBA will not be able to rely on the cash rate to bring the exchange rate back to its fundamental value. In Section 6.2.2 I evaluate how successful the RBA has been in its expectations management of the exchange rate and consider it as an alternative policy tool going forward.

However it appears that the uncovered interest rate parity might only hold generally but not at every point in time. In particular, I note that the sensitivity of the AUD/USD to Australian monetary news is much weaker when global uncertainty is high. This will be discussed in further detail later in the 'High Global Uncertainty' part of this Section.

Current Economic Conditions

A priori stronger-than-expected domestic news should increase the value of the domestic currency. This effect has been recorded for a multitude of exchange rates.[8] While stronger-than-predicted U.S. non-monetary news indeed tend to significantly depreciate the Australian currency, the AUD/USD is relatively insensitive to Australian non-monetary news. These findings again suggest that U.S. news is a primary driver of the AUD/USD exchange rate but that Australian macroeconomic news is not. This would be consistent with the theory that a small open economy such as Australia should have a significantly smaller influence on world markets than the U.S. However it is plausible that the low frequency of release of the Australian data considered in this analysis is driving down the sensitivity of the AUD/USD to Australian non-monetary news. This casts doubts that the AUD/USD is insensitive to Australian macroeconomic data releases.

Further, I note interesting trends in the sensitivity of the exchange rate to particular news. The exchange rate appears significantly more sensitive to U.S. news that are released monthly than to U.S. news released quarterly. This might indicate that markets update their expectations of growth using intermediate U.S. industrial production and U.S. nonfarm payrolls data thus minimising the 'surprise' element of GDP releases. However markets tend to not react to highly frequent and potentially less accurate news releases such as the U.S. jobless claims. This suggests that while markets actively seek signals to update their expectations, they value slightly less frequent but less noisy indicators of the state of the economy. These findings suggest that policy agencies should release monthly data if they are concerned with smoothing the expectation updating process.

[7] See Appendix A.11 for details

[8] Hardouvelis (1988) found this result was generally strong for the USD/DM, the USD/JPY, the USD/CHF, the USD/GBP, the USD/FRF, the USD/CAD and the USD/ITL. Swanson and Williams (2014b) obtained similar results for the USD/EUR and the USD/GBP.

High Global Uncertainty

I seek to add to the recent debate in the literature surrounding state-contingent asymmetries in the response of exchange rates to news. I use a measure of global uncertainty to test whether the sensitivity of the exchange rate to news varies significantly under different global uncertainty regimes.

I do not identify a significant reversal in the correlation between news surprises and the AUD/USD exchange rate when global uncertainty was high. This contrasts findings from Edwards and Plumb (2009). This difference can most likely be attributed to two main factors. First, this analysis includes Australian and monetary surprises. Second, I examine the sensitivity of the exchange rate to individual news whereas Edwards and Plumb (2009) are interested in the sensitivity of the AUD/USD to four group of U.S. news: growth/employment, production, consumption and housing. Thus their methodology is likely to be capturing different effects to the ones discussed here. However my findings do not entirely contradict Edwards and Plumb (2009) as I identify asymmetry in the response of the AUD/USD to Australian cash rate decisions in regimes of high uncertainty. In particular, the AUD/USD tends to be relatively insensitive to Australian monetary policy decisions when uncertainty is high. This suggests that the uncovered interest rate parity might not hold in times of high uncertainty. This result has significant implications for policy makers. It suggests that efforts by the RBA to move the exchange rate through cash rate changes will be unsuccessful when global uncertainty is high. While further sensitivity analysis is required to determine precisely the threshold of uncertainty above which the AUD/USD stops responding to cash rate changes, the RBA should consider using non-conventional tools such as expectation management in times of high uncertainty if it is concerned that the AUD is away from its fundamental value.

Nevertheless I note that the AUD/USD remains highly sensitive to surprises in the Federal funds rate and U.S. industrial production when uncertainty is high. Therefore it seems that sensitivity to some U.S. news remains high. This suggests that U.S. news are particularly scrutinised by Australian markets in times of high uncertainty. This phenomenon could indicate that Australian markets primarily look to U.S. news for an outlook for future global growth (Edwards and Plumb, 2009). Policy makers and forecasters interested in AUD/USD movements should therefore closely monitor developments in the U.S. economy when global uncertainty is high. This finding might be slightly mitigated by the endogeneity caused by using a U.S.-based measure of uncertainty. Further research might consider the robustness of this finding using different proxies for global uncertainty.

6.2.2 Different Monetary Policy Regimes

This section explores the sensitivity of the AUD/USD exchange rate to news under different monetary policy regimes. In particular, I consider the period of zero interest rates in the U.S. and instances of active guidance by the RBA.

Zero Lower Bound

Swanson and Williams (2014b) show that exchange rates depend on the entire path of expected future interest rate differentials between the two countries.[9] This implies that the exchange rate should remain relatively unconstrained if markets expect future short-term rates to be unconstrained by their lower bound. Given that the Australian policy rate remained unconstrained over the sample and that forecasters consistently expected the Federal Reserve to 'liftoff' within 4 quarters until 2011 (Aspen Publishers, 2014), theory predicts that the ZLB should not significantly constrain the AUD/USD exchange rate. However I expect the AUD/USD to be much less sensitive to U.S. news typically affecting the Federal funds rate, particularly after 2011 as markets stopped updating their interest rate expectations in the U.S.

In Figure 6.2a I measure the time-varying sensitivity of the AUD/USD to non-monetary U.S. news. As expected this sensitivity dropped significantly from 2009 onwards and hovered around zero between mid-2011 and mid-2014. Meanwhile the sensitivity to non-monetary Australian news remained high. This suggests that the exchange rate becomes less sensitive to foreign news when foreign interest rates are constrained by their lower bound and domestic rates remain unconstrained. This is consistent with the theory and provides further empirical support that the uncovered interest rate parity condition holds. This contrasts the finding that the sensitivity of bond yields to U.S. news was largely unaffected by the presence of the ZLB. This provides evidence that the AUD/USD is significantly more sensitive to U.S. monetary policy than Australian bond yields are.

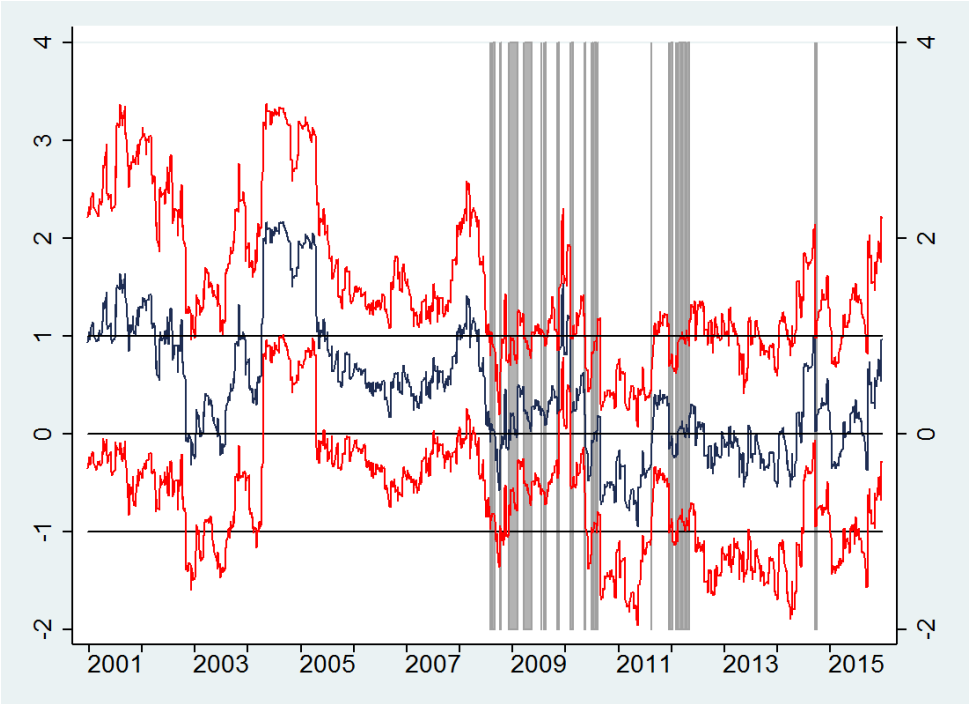
The overall responsiveness of the exchange rate to Australian and U.S. macroeconomic news also dropped rapidly to zero in late 2008. This constraint on the exchange rate coincided with the series of policy rate cuts from the FOMC that lowered the Federal funds rate from 1.5% in October 2008 to its ZLB in December 2008. While this behaviour could appear consistent with the hypothesis that the presence of the ZLB constrained the exchange rate, there are nonetheless some issues with fully attributing the lack of sensitivity from 2008 onwards to the presence of the ZLB.

As shown in the bond yield section, Australian medium- and longer-term interest rates remained relatively responsive to news between 2008 and 2015 which suggests

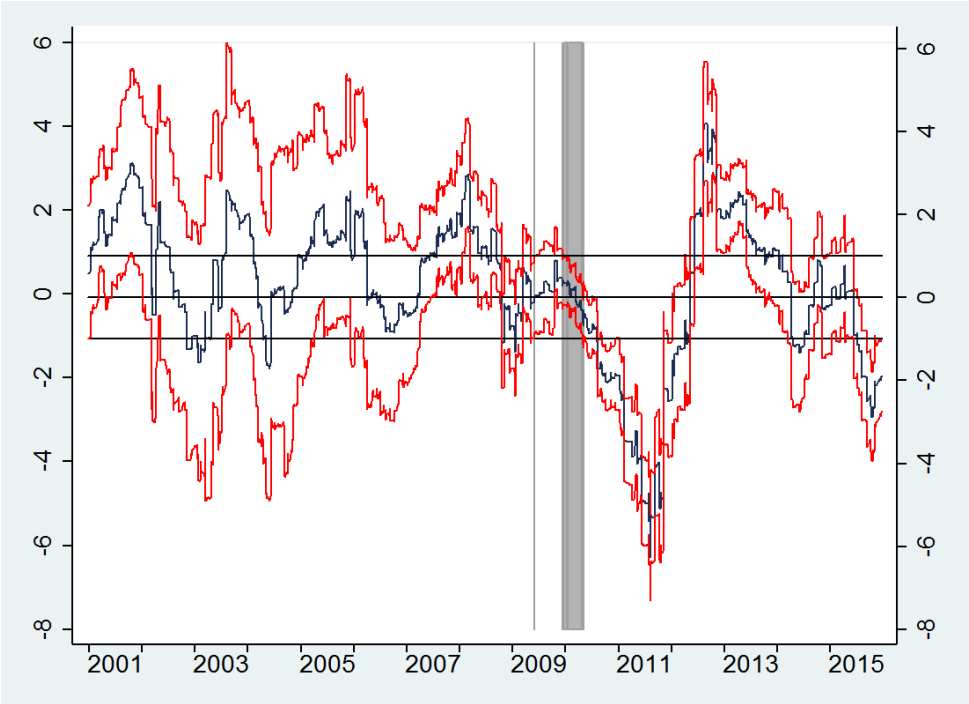
[9] Refer to Swanson and Williams (2014b); Clarida, Gali, and Gertler (2002) for details.

Figure 6.2: Sensitivity of AUD/USD exchange rate to non-monetary U.S. and Australian news

(a) Sensitivity to U.S. news only



(b) Sensitivity to Australian news only



The red lines represent the ± 2 adjusted standard-error bands. Grey shaded areas indicate time periods when $-1 < \delta^{\tau_i} < 1$.

that markets continued updating their interest rate expectations following news releases. According to the uncovered interest rate parity condition the exchange rate should remain unconstrained when domestic interest rate expectations are not constrained by their ZLB. Therefore a theoretical argument cannot attribute the constraint on the exchange rate to the presence of the ZLB.

Empirical evidence also supports the theory. There is a clear mismatch in the timing post-2011. If the constraint on the AUD/USD was primarily driven by the presence of the ZLB then the AUD/USD should be fully constrained until 2015, and the constraint should begin easing in 2015 when the FOMC started suggesting that it would lift rates. This is not the case. The sensitivity to news increased significantly between mid-2012 and late 2013, and the predicted easing in 2015 is not observed. Moreover studies in other economies have found that exchange rates remained largely unconstrained even when both countries were at their effective lower bound.[10] Overall, there seems to be little theoretical or empirical evidence suggesting that the constraint of the AUD/USD to all news was caused by the presence of the ZLB.

I also consider the possibility that the constraint was driven by the Federal Reserve's running of its Quantitative Easing (QE) programs between 2008 and 2014. However I reject this possibility. In 2012 the sensitivity to news increased significantly, over a year before the tapering of QE was announced in June 2013. Furthermore, if QE had solely constrained the exchange rate the sensitivity to news should increase throughout 2014 and return to 2000-2006 levels after the QE program was ended in October 2014. This clearly does not happen.[11] Thus, I conclude that there is little evidence suggesting that the AUD/USD was constrained by the QE programs run by the Federal Reserve.

In this section I found evidence that the AUD/USD lost its sensitivity to U.S. non-monetary news when the Federal funds rate was at its ZLB. This is in line with expectations. Nevertheless I conclude that the overall lack of sensitivity of the AUD/USD to the Australian and U.S. macroeconomic news considered cannot be solely explained by the presence of the ZLB in the U.S. In Section 6.2.3 I attempt to identify the news that were driving the AUD/USD over the period.

RBA Active Guidance

As early as March 2012, the RBA Board expressed concerns that the mining boom might be coming to an end, noting "structural changes occurring in the economy" (Reserve Bank of Australia, 2012). They noted stalling mining investment growth in Australia amid concerns regarding the carbon pricing scheme that was due to take effect on 1

[10] Refer to Swanson and Williams (2014b) for details regarding the USD/GBP and USD/EUR.
[11] Refer to Figure 5.2.

July 2012. The RBA was particularly concerned that the exchange rate had failed to adjust to the slowing of the economy. Throughout 2012 and 2013, the RBA repeatedly suggested that the value of the AUD needed to depreciate to reflect the deterioration in fundamentals as mining-related growth slowed.[12] Throughout this period of extensive exchange rate 'guidance' by the RBA, the AUD was relatively sensitive to news as seen in Figure 5.2. Separating the effect of Australian and U.S. news in Figure 6.2 I find that this period of sensitivity was driven by increased responsiveness to Australian news. Therefore it appears that sensitivity to news increased during periods of RBA guidance. This suggests that markets were somewhat responsive to suggestions by the RBA that the AUD was above its fundamental value. This apparent tendency of markets to respond to signals by the RBA highlights the credibility of the RBA.

While further analysis is required in this area, this finding could have significant implications for policy makers. As shown in Section 5.2 the exchange rate tends to be insensitive to conventional monetary policy in times of high uncertainty. Therefore the RBA might be able to resort to expectation management to guide markets towards what it perceives to be the fundamental value of the AUD. This finding is particularly timely as Australian policy rates have been falling, leaving little scope for active monetary policy action.

6.2.3 The Exchange Rate Constraint Puzzle

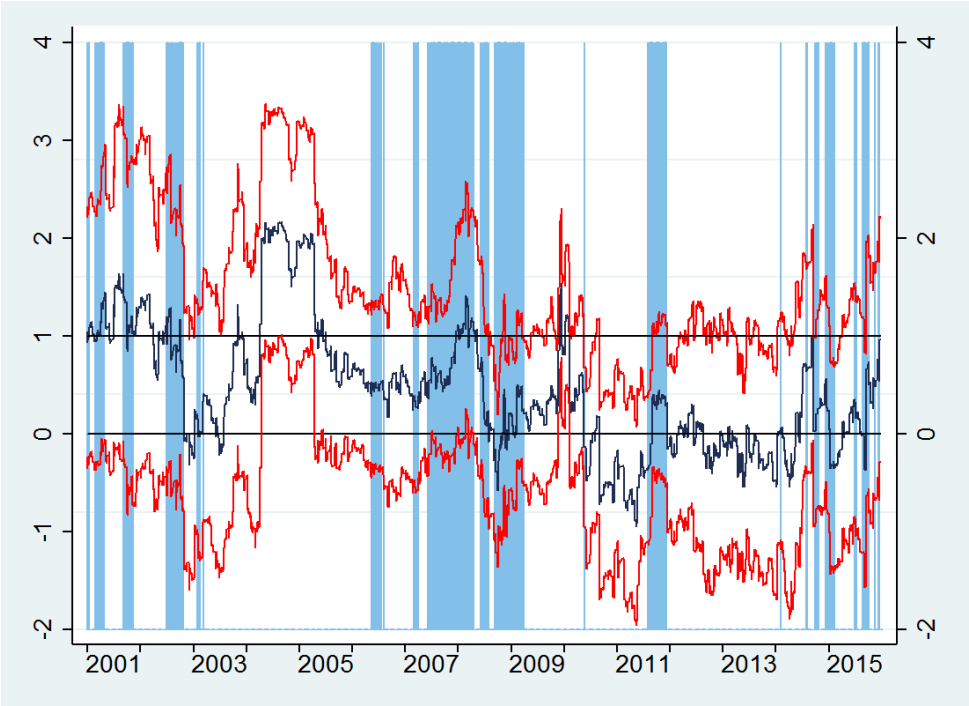
The presence of the constraint on the exchange rate between 2009 and 2015 is puzzling. In this Section, I seek to identify the possible sources of the constraint through various extensions. I use the results from the baseline OLS estimation (4.1) as a starting point. In Table 5.3, I found that in general U.S. news significantly influenced the value of the exchange rate. I test whether the AUD/USD exchange rate remained sensitive to non-monetary U.S. news in Figure 6.2a. I find that the AUD/USD exchange rate became virtually unresponsive to non-monetary U.S. news after 2009. Hence the AUD/USD stopped responding to U.S. news between 2009 and 2015. Within the scope of this paper, I can identify two potential reasons for this lack of responsiveness.

Firstly, effects from the 'growth differentials' and 'global growth' channels outlined by Edwards and Plumb (2009) could be cancelling each other out. They argue that stronger than expected U.S. data should depreciate the AUD via the 'growth differentials' channel. They also suggest that the same positive U.S. news are considered positive for global growth. In times of high global uncertainty they find that this second effect is likely to support the AUD and dominate the 'growth differentials' effect. This model implies that the magnitude of each effect is determined by the level of global uncertainty. I would therefore expect the sensitivity of news, and possibly the correlation between exchange

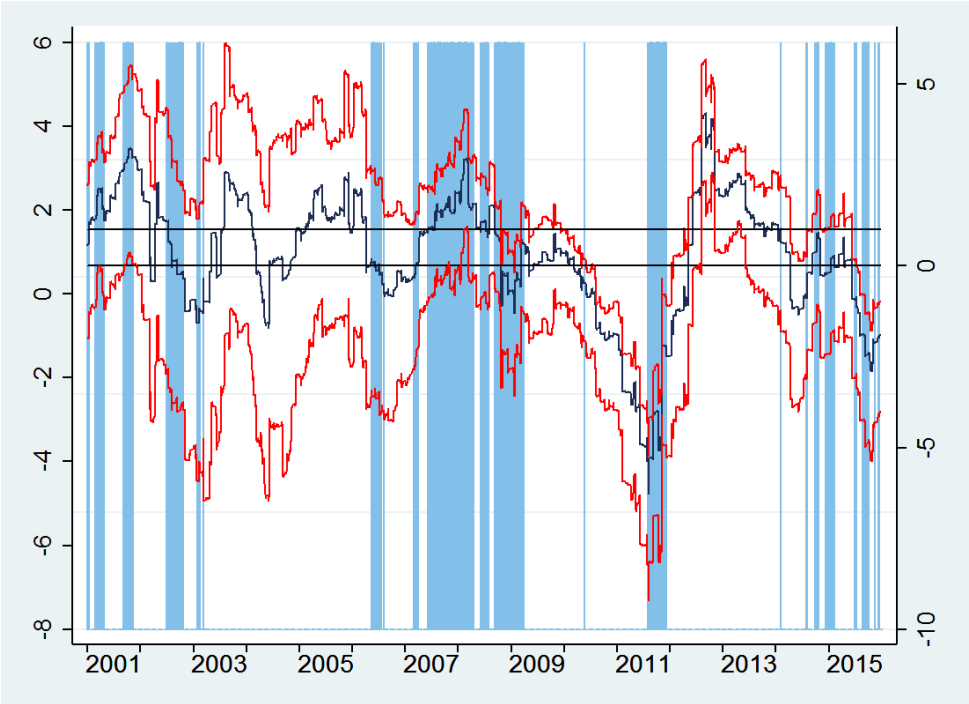
[12] Refer to Appendix A.11 for further details.

Figure 6.3: Sensitivity of AUD/USD exchange rate to non-monetary U.S. and Australian news and VIX

(a) Sensitivity to U.S. news only



(b) Sensitivity to Australian news only

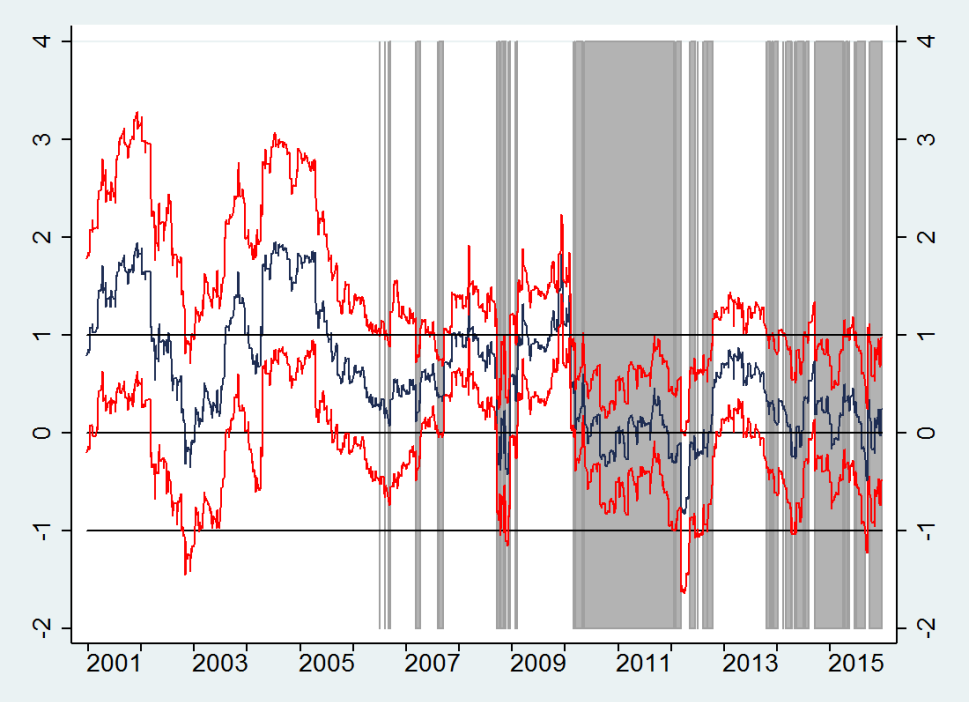


The red lines represent the ± 2 adjusted standard-error bands. Blue shaded areas indicate time periods when the VIX series was above the benchmark constructed in Section 3.5.

rate movements and news surprises to change when the VIX is high. In Figure 6.3a I add blue shaded areas to indicate periods of high global uncertainty. While sensitivity to U.S. news tends to increase slightly in uncertain times, it also drops in 2008 and in 2014-2015 when VIX is high. In addition VIX is not particularly stable between 2009 and 2015 while sensitivity to news remains relatively stable near zero. I do not observe the robust relationship between VIX and U.S. news as Edwards and Plumb (2009) suggested. Therefore there is little evidence suggesting that a combination of the 'growth differentials' and 'global growth' channels constrained the AUD/USD exchange rate.

A second possibility is that the AUD/USD exchange rate was primarily driven by factors my model is not accounting for. I consider this the more likely explanation. I attempt to address this limitation in my analysis by including other news that are likely to move the AUD/USD.

Figure 6.4: Time-varying sensitivity of AUD/USD exchange rate to Australian, U.S. and Chinese news



The red lines represent the ± 2 adjusted standard-error bands. Grey shaded areas indicate time periods when $-1 < \delta^{\tau_i} < 1$.

In the decade leading up to 2013, Australia experienced a mining boom driven by global commodity prices. Figure A.2 in Appendix A.7 shows that the AUD/USD exchange rate appears strongly correlated with the RBA Index of Commodity Prices and the quarter-on-quarter mining investment growth rate after 2009. It is possible that the significant post-2009 drop in sensitivity of the AUD/USD exchange rate to U.S. and Australian news was partially caused by Australia's mining boom. This period of

sustained growth was driven by strong Chinese demand for Australia's mineral exports. Between 2007 and 2013, the value of the exports of Australian goods to China quadrupled to around 6% of Australia's GDP (Department of Foreign Affairs and Trade, 2016). Therefore it is possible that the value of the AUD was particularly sensitive to Chinese news, and that this effect dominated the sensitivity to Australian and U.S. news over the period. To account for Chinese news, I add Chinese news to the model and first re-estimate the OLS regressions (4.1) and (4.2). Previous results for Australian and U.S. news are virtually unaffected the inclusion of Chinese news. Even though a joint significance test indicates that Chinese news are not significant linear predictors of the AUD/USD exchange rate over the entire sample, I add the selected Chinese news to the two-stage model. I report results of the rolling-window estimation (4.4) in Figure 6.4. If Chinese news is the main driver of the exchange rate between 2009 and 2015 I would expect the constraint on the exchange rate to diminish. However this is not the case. While the exchange rate remains responsive to news in 2009 when Chinese news is added, overall findings remain fairly robust to the inclusion of Chinese news. I also measure the sensitivity of the exchange rate to Chinese news separately in Appendix A.12. Once again I find that sensitivity to news is low after 2010. This suggests that Chinese news cannot explain the constraint on the exchange rate.

To try and identify the driver of the exchange rate post-2009, I also considered including global commodity prices in this analysis. However, Chen, Rogoff, and Rossi (2008) show that while commodity currency exchange rates tend have significant predicting power in forecasting global commodity prices the reverse relationship is less robust. Because commodity prices are not significant predictors of commodity currency movements, I do not include global commodity prices.

It is also possible that mining-specific news in Australia predominantly drove the exchange rate during the mining boom. If markets considered the value of the AUD to be primarily determined by mining activity in Australia this might have caused the sensitivity of the AUD/USD exchange rate to other Australian and U.S. macroeconomic news to decrease over the period. However, my model cannot detect such news 'substitution' as I do not have access to mining-specific surprises in Australia. Future research could focus on building a 'mining surprise' series using market-traded derivatives. Using derivatives such as futures, swaps or options, it is possible to derive ex-ante market expectations. Comparing this to ex-post data, the unexpected component of a news release can be derived. For the purpose of this analysis a series highly correlated with mining activity in Australia is required. Future research could consider BHP Billiton, Rio Tinto or Fortescue Metals Group exchange traded option contracts. As these companies operate globally, further analysis should be undertaken to identify the movements in derivative prices directly attributable to Australian mining news. Alternatively, further research

could consider series that reflect global demand for Australian mining exports. Such series might include Australian coking coal futures contracts or Australian iron ore swap contracts. A combination of these series might be necessary to better capture dynamics in the Australian mining industry.

Finally I test whether the responsiveness to news of the exchange rate varied with the level. In particular, it is possible that agents are more sensitive to news when the AUD/USD is higher than its historical mean. If this hypothesis holds then the low sensitivity from 2009 to 2015 might solely be driven by the rapid appreciation and subsequent fall in the exchange rate over the period. To test this I add the level of the exchange rate to the vector of regressors. This does not affect results which suggests that the sensitivity of the AUD/USD to news is not dependent on the level of the exchange rate.[13]

In this section I have shown that between 2009 and 2015 the AUD/USD was relatively insensitive to the Australian and US macroeconomic variables I consider in this paper. I suspect that this reflects the fact that the AUD/USD was primarily driven by other factors over the period. Moreover there is little evidence that Chinese news became drivers of the AUD or that the changing sensitivity was caused by the exchange rate being significantly above its historical mean. It is possible that the value of the AUD was highly sensitive to domestic mining-related news. To test this hypothesis, I suggest that future research constructs measures of mining surprises using derivatives.

[13]I also add the deviation of the level from the historical mean in a separate test and find that results are unchanged.

Section 7

Concluding Remarks

To my knowledge this paper is the first to examine the sensitivity of Australian bond yields and the AUD/USD exchange to various Australian and U.S. macroeconomics news releases. The inclusion of Australian data releases, in particular news concerning the Australian cash rate, delivers key results. Australian bond yields are highly sensitive to news affecting the current and future expected domestic policy rate. This effect is weaker at the long-end of the yield curve. The AUD/USD exchange rate appears primarily driven by interest rate differentials and is also highly responsive to U.S. non-monetary news. Overall, findings for the AUD/USD suggest that the uncovered interest rate parity condition holds.

Using a two-stage model that combines non-linear estimation and rolling-windows I estimate the time-varying sensitivity of Australian bond yields and the AUD/USD exchange to news. Australian bond yields are broadly unaffected by the presence of the Zero Lower Bound in the U.S. However the AUD/USD becomes less sensitive to foreign news releases when foreign interest rates are at the Zero Lower Bound. After 2009 the AUD/USD appear driven by factors other than the U.S., Australian or Chinese news considered in this analysis. Future analysis could consider measures of mining surprises to further this research. Further, empirical evidence suggests that the Reserve Bank of Australia has experienced some success at managing interest rate and exchange rate market expectations. In the current context of low global interest rates and falling domestic rates this finding reinforces the appeal of expectation management as a credible monetary policy tool.

However there are clear limitations to this thesis that should be addressed in further research. Macroeconomic news that are not captured in this analysis are likely to affect markets. This is particularly a concern for Australia as data is only available on quarterly news releases whereas U.S. findings suggest that the market-moving effect is most significant for monthly releases. Thus future research would benefit from incorporating more frequently released news. This could be achieved by deriving market-based measures of surprises using derivatives. To mitigate the risk of over-parametrisation as more news releases are added to the model, model-averaging or Bayesian methods could also be employed.

Section A

Appendices

A.1 Summary Statistics

In this appendix I present basic summary statistics for the Australian and U.S. standardised surprises that I use in my analysis. In Table A.1 I report the number of observations, the mean, the median, the minimum and the maximum for each standardised surprise over the period I consider in my paper (2000-2015).

I also report the same summary statistics for two sub-periods. I report in Table A.2 the summary statistics for the base period defined in Section 4.2 (2000-2006). Table A.3 reports summary statistics for the non-base period (2007-2015).

Table A.1: Summary statistics of standardised surprises (2000-2015)

Variable	Obs	Mean	Median	Min	Max
Australian CPI	71	-0.03	0.00	-2.81	3.28
RBA Cash Rate	106	-0.11	0.00	-2.25	2.25
Australian GDP	71	0.25	0.20	-1.81	2.61
Australian PPI	36	-0.07	-0.11	-1.94	2.16
Australian Unemployment Rate	209	-0.57	-0.49	-3.91	1.47
U.S. Capacity Utilization	215	-0.53	-0.72	-3.25	1.77
U.S. CPI (Core)	151	-0.03	0.00	-2.22	3.33
Federal Funds Rate	141	-0.09	0.00	-5.20	5.20
U.S. GDP	72	-0.27	-0.21	-2.93	1.74
U.S. IP	217	-0.17	-0.12	-7.17	2.56
U.S. Non Farm Payrolls	219	-0.07	-0.03	-4.04	2.20
U.S. PMI	217	-0.20	-0.28	-2.70	2.92
U.S. PPI	217	-0.01	0.00	-3.84	3.84
U.S. Retail Sales	181	0.02	0.00	-3.61	2.71
U.S. Unemployment Rate	218	-0.22	0.00	-2.65	2.65
U.S. Unemployment Claims	936	0.15	0.12	-4.39	6.04

Table A.2: Summary statistics of standardised surprises (2000-2006)

Variable	Obs	Mean	Median	Min	Max
Australian CPI	35	-0.11	-0.47	-2.81	3.28
RBA Cash Rate	25	-0.18	0.00	-2.25	2.25
Australian GDP	34	0.27	0.30	-1.81	2.61
Australian PPI	12	-0.07	0.11	-1.30	0.86
Australian Unemployment Rate	102	-0.94	-0.98	-3.91	1.47
U.S. Capacity Utilization	108	0.06	0.22	-2.03	1.77
U.S. CPI (Core)	42	-0.08	0.00	-2.22	3.33
Federal Funds Rate	68	-0.08	0.00	-5.20	5.20
U.S. GDP	35	-0.25	-0.21	-2.93	1.74
U.S. IP	108	-0.02	-0.05	-3.07	2.56
U.S. Non Farm Payrolls	111	-0.03	-0.03	-2.77	2.20
U.S. PMI	109	-0.45	-0.51	-2.70	2.70
U.S. PPI	108	-0.08	0.00	-3.84	3.36
U.S. Retail Sales	72	0.15	-0.18	-1.99	2.71
U.S. Unemployment Rate	110	-0.25	0.00	-1.99	1.99
U.S. Unemployment Claims	464	0.10	0.08	-4.39	6.04

Table A.3: Summary statistics of standardised surprises (2007-2015)

Variable	Obs	Mean	Median	Min	Max
Australian CPI	44	0.00	0.23	-1.87	1.40
RBA Cash Rate	82	-0.11	0.00	-2.22	2.22
Australian GDP	43	0.36	0.20	-1.81	2.61
Australian PPI	26	-0.11	-0.22	-1.94	2.16
Australian Unemployment Rate	128	-0.49	-0.49	-3.91	1.47
U.S. Capacity Utilization	131	-0.81	-0.97	-3.25	1.77
U.S. CPI (Core)	114	-0.02	0.00	-2.22	2.22
Federal Funds Rate	85	-0.09	0.00	-5.20	2.49
U.S. GDP	44	-0.21	-0.17	-2.58	1.60
U.S. IP	133	-0.16	-0.12	-7.17	2.56
U.S. Non Farm Payrolls	135	0.02	0.07	-4.04	2.20
U.S. PMI	133	0.05	-0.06	-2.64	2.92
U.S. PPI	133	0.04	0.00	-3.84	3.84
U.S. Retail Sales	114	-0.07	0.00	-3.61	2.71
U.S. Unemployment Rate	134	-0.18	0.00	-2.65	2.65
U.S. Unemployment Claims	572	0.14	0.06	-3.72	4.15

A.2 Average and Median Surprises

Table A.4: Regression on surprises using median and average survey responses

	1-year bonds		10-year bonds		AUS/USD	
	Median	Average	Median	Average	Median	Average
Australian CPI	0.026	-0.221	-0.050	-0.076	-0.013	0.059
	(0.182)	(0.182)	(0.128)	(0.128)	(0.100)	(0.101)
RBA Cash Rate	0.981***	1.161***	0.488***	0.397***	0.169**	0.114
	(0.143)	(0.155)	(0.100)	(0.109)	(0.079)	(0.086)
Australian GDP	-0.205	0.093	0.010	0.059	0.099	0.105
	(0.188)	(0.190)	(0.129)	(0.130)	(0.102)	(0.102)
Australian PPI	-0.299	-0.245	0.138	0.176	0.238	0.202
	(0.557)	(0.582)	(0.390)	(0.409)	(0.307)	(0.321)
Australian Unemployment Rate	-0.209**	-0.212**	0.061	0.060	0.042	0.042
	(0.099)	(0.099)	(0.068)	(0.068)	(0.053)	(0.053)
U.S. Capacity Utilization	0.166*	0.169*	0.118*	0.113	0.018	0.021
	(0.100)	(0.100)	(0.070)	(0.070)	(0.055)	(0.055)
U.S. CPI (Core)	0.022	0.057	-0.035	0.013	-0.057	-0.096
	(0.122)	(0.121)	(0.086)	(0.085)	(0.067)	(0.067)
Federal Funds Rate	0.048	0.019	0.198**	0.193**	-0.221***	-0.258***
	(0.125)	(0.127)	(0.088)	(0.090)	(0.069)	(0.070)
U.S. GDP	-0.037	-0.054	-0.038	-0.044	-0.031	-0.026
	(0.187)	(0.199)	(0.131)	(0.140)	(0.101)	(0.105)
U.S. IP	0.174	0.177	0.075	0.089	-0.175***	-0.172***
	(0.110)	(0.110)	(0.077)	(0.077)	(0.061)	(0.061)
U.S. Non Farm Payrolls	0.022	0.020	-0.037	-0.041	-0.163***	-0.169***
	(0.104)	(0.103)	(0.072)	(0.072)	(0.057)	(0.057)
U.S. PMI	0.022	0.012	0.001	-0.006	-0.035	-0.036
	(0.104)	(0.104)	(0.072)	(0.073)	(0.055)	(0.055)
U.S. PPI	0.014	0.006	-0.016	-0.017	0.019	0.021
	(0.102)	(0.102)	(0.071)	(0.072)	(0.056)	(0.056)
U.S. Retail Sales	0.151	0.148	0.0415	0.0429	0.044	0.037
	(0.111)	(0.111)	(0.077)	(0.078)	(0.061)	(0.061)
U.S. Unemployment Rate	0.243**	0.242**	0.105	0.101	0.046	0.045
	(0.102)	(0.102)	(0.071)	(0.071)	(0.055)	(0.055)
U.S. Jobless Claims	0.056	0.067	0.001	-0.001	0.009	0.020
	(0.096)	(0.099)	(0.067)	(0.070)	(0.051)	(0.052)
Constant	0.080**	0.077*	0.065**	0.063**	0.025	0.024
	(0.040)	(0.040)	(0.028)	(0.028)	(0.022)	(0.022)
Observations	1,526	1,526	1,542	1,542	1,557	1,557
R^2	0.045	0.050	0.025	0.018	0.024	0.025

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

As mentioned in Section 3 I define surprises as the difference between the realised value and its ex-ante expectation. The standard way to measure expectations in the literature is to use the median survey response from forecasters such as Bloomberg. In this section I briefly show that results are robust when the average survey response is used instead.

Table A.4 presents results of the OLS regression (4.1) using 1-year bonds, 10-year bonds and the AUD/USD exchange rate as the dependent variable. For each specification I report regression coefficients when surprises are measuring using the median survey response and when the average survey response is used. None of the coefficients calculated using average responses are statistically different from their corresponding coefficients when median responses are used. As both surprise measures seem to yield similar results I will follow the literature and only consider median surprises when constructing my surprise series.

A.3 A working example of the two-stage non-linear and rolling-window methodology

Let's consider a working example of the two-stage linear and rolling-window estimation outlined in Section 4.2. The first stage consists of running regression (4.3). In this simplified example I assume that I run the model over all 16 years in the sample (2000-2015) but I only consider two news surprises: Australian CPI and Australian GDP. I can rewrite (4.3) as follows:

$$\begin{aligned}\Delta y_t =& \gamma^{\tau}_{2000} + \gamma^{\tau}_{2001} + \cdots + \gamma^{\tau}_{2015} \\ &+ \delta^{\tau}_{2000} \left(\beta_1 \cdot \mathrm{CPI}_{\mathrm{AUS}} + \beta_2 \cdot \mathrm{GDP}_{\mathrm{AUS}}\right) \\ &+ \delta^{\tau}_{2001} \left(\beta_1 \cdot \mathrm{CPI}_{\mathrm{AUS}} + \beta_2 \cdot \mathrm{GDP}_{\mathrm{AUS}}\right) \\ &+ \ldots \\ &+ \delta^{\tau}_{2015} \left(\beta_1 \cdot \mathrm{CPI}_{\mathrm{AUS}} + \beta_2 \cdot \mathrm{GDP}_{\mathrm{AUS}}\right) \\ &+ \varepsilon_t\end{aligned}$$

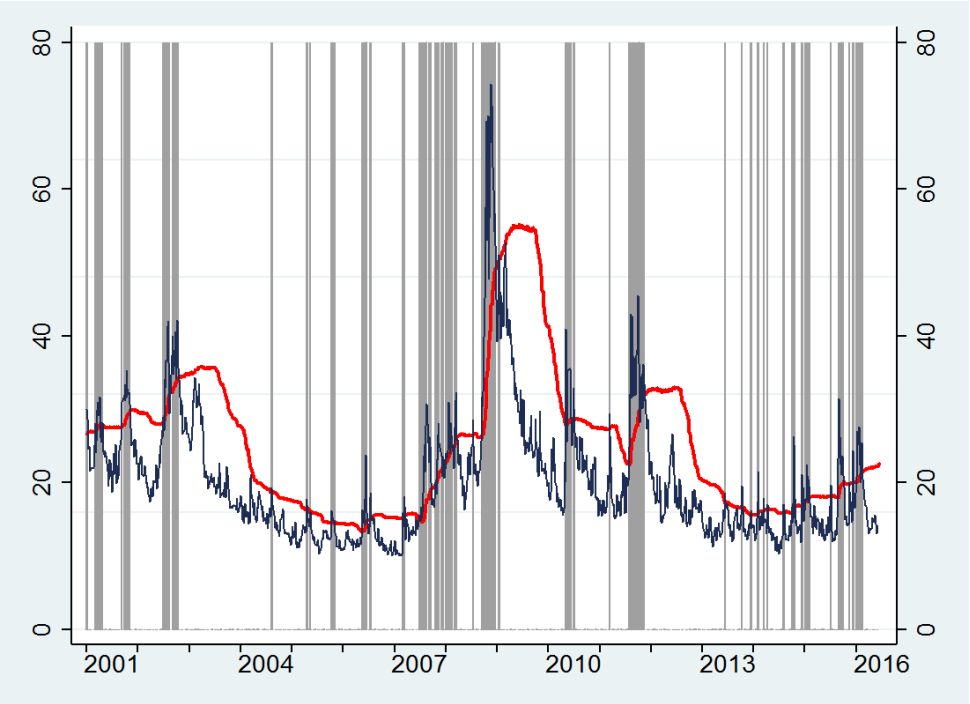
The model allows the mean response in each year to be different. This is represented in different intercepts γ^{τ}_i being computed for each year $i = 2000, \ldots, 2015$. Further year-specific effects are isolated and captured by the δ^{τ}_i for each year $i = 2000, \ldots, 2015$. The generic regressors β_1 and β_2 are captured in the vector β. Each coefficient in vector β thus estimates the generic sensitivity of variable y to each particular news.

Technical note: to successfully identify δ^{τ_i} and β separately I impose that δ^{τ_i} take an average value of unity between 2000-2006.

A.4 Changing adaptive learning period under uncertainty to 1 year

In this Appendix I investigate whether results obtained using equation (4.2) are robust to the definition of $\overline{\text{VIX}}$. Here I allow markets to adapt their expectations of what constitutes a 'high' VIX reading by changing the moving average window to one year instead of the two years used in the paper. This means that periods of lesser uncertainty not picked up in the body of the analysis are now treated as periods of high uncertainty. Figure A.1 graphs the VIX and the benchmark overtime.

Figure A.1: The VIX and constructed uncertainty benchmark



The navy line is the historical VIX. The smooth red line is the benchmark created using moving averages. Grey shaded areas indicate time periods of high global uncertainty when VIX is above the benchmark.

Tables A.5 and A.6 provide a summary of results using regression (4.2) with this faster adaptive measure of uncertainty.

Table A.5: Effect of surprises on Australian bonds under uncertainty

	1-year maturity		10-year maturity	
	Correlation Reversal?	p-value	Correlation Reversal?	p-value
	(1)	(2)	(3)	(4)
Australian CPI	-	0.039	-	0.471
RBA Cash Rate	-	0.295	-	0.314
Australian GDP	yes	0.170	-	0.080
Australian PPI	yes	0.317	-	0.455
Australian Unemployment Rate	-	0.425	-	0.384
U.S. Capacity Utilization	-	0.113	-	0.199
U.S. CPI (Core)	-	0.019	yes	0.406
Federal Funds Rate	-	0.000	-	0.113
U.S. GDP	yes	0.443	yes	0.133
U.S. IP	-	0.017	-	0.142
U.S. Nonfarm Payrolls	-	0.494	-	0.172
U.S. PMI	yes	0.387	yes	0.314
U.S. PPI	-	0.394	-	0.382
U.S. Retail Sales	-	0.070	-	0.464
U.S. Unemployment Rate	-	0.405	-	0.334
U.S. Jobless Claims	-	0.455	yes	0.449

Notes: a 'yes' in the 'Correlation Reversal?' columns indicates that the correlation between the yields and the variable is reversed when global uncertainty is high.
The 'p-value' columns give the probability that the absolute values of coefficients when uncertainty is 'high' are smaller than the absolute values of coefficients when uncertainty is 'normal'

Table A.6: Effect of news surprises on AUD/USD under uncertainty (1-year rolling window)

Variables	Correlation Reversal? (1)	p-value (2)
Australian CPI	-	0.038
RBA Cash Rate	yes	0.294
Australian GDP	-	0.170
Australian PPI	-	0.316
Australian Unemployment Rate	-	0.425
U.S. Capacity Utilization	yes	0.113
U.S. CPI (Core)	yes	0.019
Federal Funds Rate	-	0.000
U.S. GDP	yes	0.442
U.S. IP	-	0.017
U.S. Nonfarm Payrolls	-	0.495
U.S. PMI	-	0.387
U.S. PPI	yes	0.395
U.S. Retail Sales	-	0.069
U.S. Unemployment Rate	yes	0.405
U.S. Jobless Claims	yes	0.455

Notes: a 'yes' in the 'Correlation Reversal?' column indicates that the correlation between the yields and the variable is reversed when global uncertainty is high. The 'p-value' column gives the probability that the absolute values of coefficients when uncertainty is 'high' are smaller than the absolute values of coefficients when uncertainty is 'normal'

Overall, results remain little changed.

A.5 Understanding the large standard-error bands in Figure 5.1a

This appendix address the abnormally wide standard-error bands observed in 2007 and early 2008 in Figure 5.1a. In Section 4.2 I defined the adjusted standard-error bands as the standard errors of regression (4.4) scaled by $\pm \left[\frac{\tau_{i+1}-\tau}{\tau_{i+1}-\tau_i} \cdot \frac{\varsigma^{\tau_i}}{\sigma^{\tau_i}} + \frac{\tau-\tau_i}{\tau_{i+1}-\tau_i} \cdot \frac{\varsigma^{\tau_i+1}}{\sigma^{\tau_i+1}} \right]$. The abnormal width of the standard-error bands before the GFC is partially caused by larger than average standard errors in regression (4.4) in 2007. This effect is compounded by nonlinear standard errors ς_i^τ and ς_{i+1}^τ twice as large as average in 2007.

A.6 Chinese Data

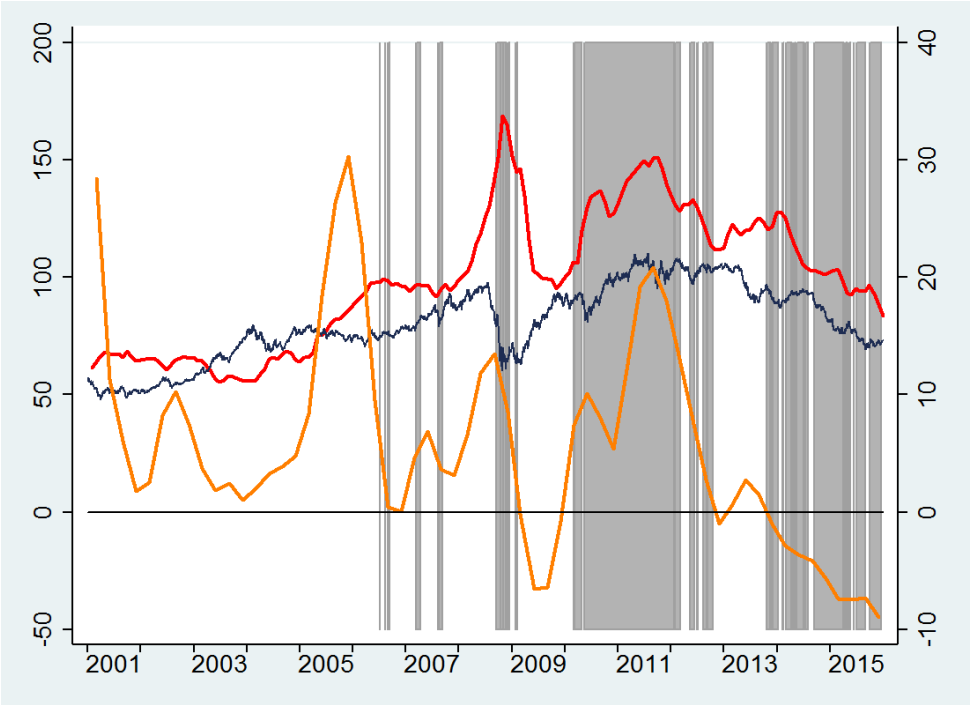
Table A.7: Description of the Chinese data

Variable	Units	Bloomberg ID
Consumer Price Index	Pct. change from previous year	CNCPIYOY
Gross Domestic Product (constant prices)	Pct. change from previous quarter	CNGDPYOY
Industrial Production	Pct. change from previous year	CHVAIOY
Producer Price Index	Pct. change from previous year	CHEFTYOY
Retail Sales Value	Pct. change from previous year	CNRSCYOY
Volume of Exports	Pct. change from previous year	CNFREXPY
Volume of Imports	Pct. change from previous year	CNFRIMPY

A.7 The AUD/USD exchange rate and mining activity in Australia

Figure A.2 shows the relationship between the AUD/USD exchange rate and some Australian mining indicators. The navy blue and red lines represent the AUD/USD exchange rate and the RBA Index of Commodity Prices respectively and are indexed on the left axis. The orange line is the quarter-on-quarter mining investment percentage growth rate and is indexed on the right axis. The grey shaded areas correspond to the grey shaded areas in Figure 5.2.

Figure A.2: Plot of AUD/USD exchange rate, RBA index of commodity prices and Australian mining investment (rescaled)



A.8 OLS Baseline Regression 4.1 with Chinese news

Table A.8: Regression 4.1 with AUD/USD exchange rate (extension with Chinese news)

	Baseline Reg. (4.1)	
AUS/US Exchange Rate		
Australian CPI	−0.015	(0.105)
RBA Cash Rate	0.169**	(0.082)
Australian GDP	0.101	(0.108)
Australian PPI	0.232	(0.319)
Australian Unemployment Rate	0.062	(0.066)
US Capacity Utilization	0.022	(0.059)
US CPI (Core)	−0.058	(0.070)
Federal Funds Rate	−0.222***	(0.072)
US GDP	−0.029	(0.105)
US IP	−0.176***	(0.064)
US Non Farm Payrolls	−0.173***	(0.061)
US PMI	−0.040	(0.059)
US PPI	0.018	(0.059)
US Retail Sales	0.038	(0.064)
US Unemployment Rate	0.044	(0.058)
US Jobless Claims	0.059	(0.048)
China CPI	−0.072	(0.075)
China Exports Volume	−0.114	(0.092)
China GDP	−0.048	(0.088)
China Imports Volume	0.155	(0.096)
China Industrial Production	0.108	(0.081)
China PPI	−0.013	(0.083)
China Retail Sales	0.131*	(0.076)
Constant	0.024	(0.022)
Observations	1.706	
R^2	0.025	
H_0: $\beta = 0$, p-value	0.006	
H_0: $\beta_{\text{AUS}} = 0$, p-value	0.277	
H_0: $\beta_{\text{US}} = 0$, p-value	0.002	
H_0: $\beta_{\text{NM}} = 0$, p-value	0.066	
H_0: $\beta_{\text{AUS}_{\text{NM}}} = 0$, p-value	0.675	
H_0: $\beta_{\text{US}_{\text{NM}}} = 0$, p-value	0.028	
H_0: $\beta_{\text{CHINA}_{\text{NM}}} = 0$, p-value	0.399	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

A.9 OLS VIX Regression 4.2 with Chinese news

Table A.9: Regression 4.2 with AUD/USD exchange rate (extension with Chinese news)

	VIX Reg. (4.2)			
	Coefficients on level		Coefficients on VIX interaction	
AUS/US Exchange Rate				
Australian CPI	0.072	(0.116)	−0.490*	(0.274)
RBA Cash Rate	0.238**	(0.093)	−0.301	(0.208)
Australian GDP	0.069	(0.124)	0.017	(0.313)
Australian PPI	−0.021	(0.595)	0.386	(0.705)
Australian Unemployment Rate	0.057	(0.072)	0.048	(0.173)
US Capacity Utilization	0.000	(0.064)	0.171	(0.157)
US CPI (Core)	−0.087	(0.077)	0.254	(0.181)
Federal Funds Rate	−0.004	(0.091)	−0.591***	(0.148)
US GDP	−0.090	(0.122)	0.266	(0.237)
US IP	−0.004	(0.085)	−0.438***	(0.138)
US Non Farm Payrolls	−0.142*	(0.073)	−0.066	(0.140)
US PMI	−0.035	(0.069)	−0.011	(0.133)
US PPI	0.027	(0.068)	−0.026	(0.138)
US Retail Sales	−0.020	(0.074)	0.235	(0.146)
US Unemployment Rate	0.066	(0.067)	−0.056	(0.147)
US Jobless Claims	0.055	(0.052)	0.106	(0.139)
China CPI	−0.115	(0.089)	0.072	(0.192)
China Exports Volume	−0.034	(0.103)	−0.397*	(0.241)
China GDP	−0.071	(0.108)	0.107	(0.200)
China Imports Volume	0.074	(0.119)	0.252	(0.221)
China IP	0.107	(0.089)	−0.009	(0.226)
China PPI	−0.019	(0.116)	0.047	(0.170)
China Retail Sales	0.149*	(0.081)	−0.272	(0.239)
Constant	0.028	(0.022)		
Observations	1.677			
R^2	0.049			

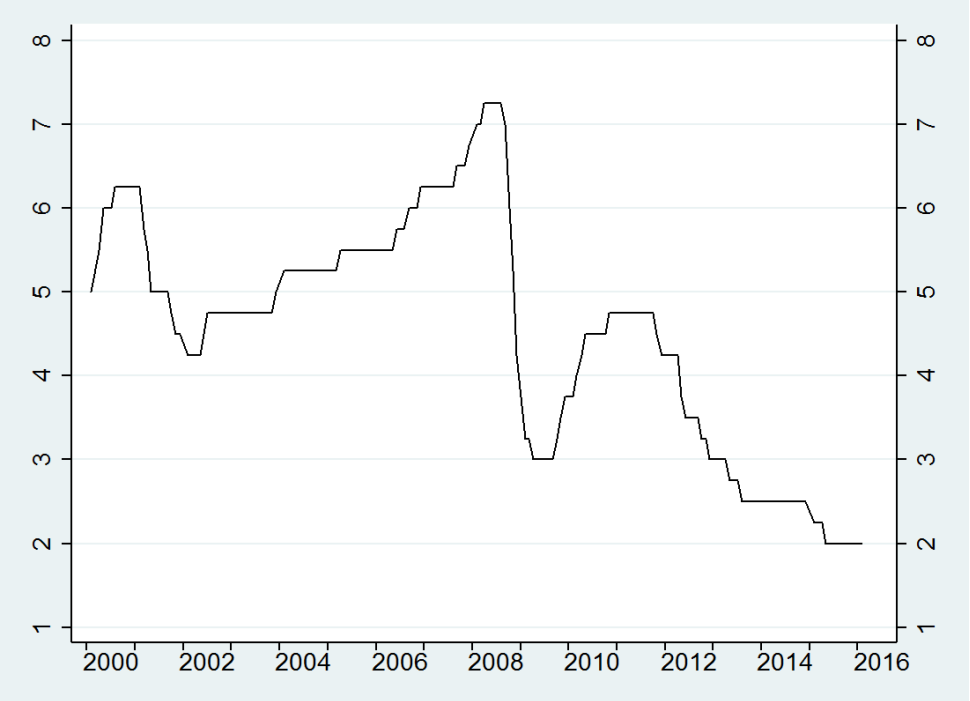
Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

A.10 RBA interest rate forward guidance

In this section I report instances of interest rate forward guidance between 2010 and 2015. I must stress that I only consider monetary policy statements and I recognise that the Bank has a multitude of other tools at their disposal to manage expectations. I also acknowledge that this lexicon might not be comprehensive. Figure

Figure A.3: Plot of Australian policy rate (2000-2016)



I list below instances of forward guidance by the Reserve Bank of Australia between 2010 and 2015:

- Feb-April 2010: "Interest rates to most borrowers nonetheless remain lower than average. If economic conditions evolve broadly as expected, the Board considers it likely that monetary policy will, over time, need to be adjusted further in order to ensure that inflation remains consistent with the target over the medium term". Indicates possible future rate hikes.
- August-September 2011: "At today's meeting, the Board considered whether the recent information warranted further policy tightening. On balance, the Board judged that it was prudent to maintain the current setting of monetary policy, particularly in view of the acute sense of uncertainty in global financial markets over recent weeks. In future meetings, the Board will continue to assess carefully the evolving outlook for growth and inflation". Indicates possible future rate cuts.

– Dec 2011: "Overall, the Board concluded, on the basis of all the available information, that the inflation outlook afforded scope for a modest reduction in the cash rate. The Board will continue to set policy as needed to foster sustainable growth and low inflation over time" Commitment by the Bank to actively stimulate the economy with monetary policy if required.

– Feb-April 2012: "Should demand conditions weaken materially, the inflation outlook would provide scope for easier monetary policy". Commitment to markets that the Bank is ready to intervene to stimulate the economy if necessary.

– May 2012: "The inflation outlook would provide scope for easier monetary policy, if needed, to support demand". Reiteration that the Bank is ready to use monetary policy if required.

– Nov 2012: "Further effects of actions already taken to ease monetary policy can be expected over time. The Board will continue to monitor those effects, together with information about the various other factors affecting the outlook for growth and inflation. At today's meeting, with prices data slightly higher than expected and recent information on the world economy slightly more positive, the Board judged that the stance of monetary policy was appropriate for the time being". Potentially signals that the Board would consider cutting rates if inflation or global conditions deteriorate.

– March-April 2013: "The inflation outlook, as assessed at present, would afford scope to ease policy further, should that be necessary to support demand". Indication of possible rate cuts followed by a rate cut in May 2013.

– June-July 2013 "The Board also judged that the inflation outlook, as currently assessed, may provide some scope for further easing, should that be required to support demand". Indication of possible rate cuts followed by a rate cut in August 2013.

– February-December 2014: "On present indications, the most prudent course is likely to be a period of stability in interest rates". Actively guiding markets to expect stable interest rates.

– March-April 2015: "Further easing of policy may be appropriate over the period ahead". Indication of possible future rate cuts. Followed by a rate cut in May 2015.

– November-December 2015: "Members also observed that the outlook for inflation may afford scope for further easing of policy, should that be appropriate to lend support to demand". Indication of possible future rate cuts.

A.11 RBA guidance and the exchange rate

In this section I report instances of active guidance of exchange rate expectations by the RBA between 2010 and 2015. The caveats outlined in Appendix A.10 also apply here.

- February-April 2011: "the high level of the exchange rate"
- May-July 2011: "The exchange rate has risen further and, in real effective terms, is at its highest level in several decades."
- August-September 2011: "The exchange rate is high."
- February 2012: "The exchange rate has risen further, even though the terms of trade have started to decline. This is largely a reflection of a decline in the euro against all currencies. Nonetheless, the Australian dollar in trade-weighted terms is somewhat higher than the Bank had previously assumed."
- As early as March 2012, the RBA Board expressed concerns that the mining boom might be coming to end, noting 'structural changes occurring in the economy'.
- April 2012: "The exchange rate has remained high over recent months, even though the terms of trade have declined somewhat."
- May 2012: "Output growth was affected in part by temporary factors, but also by the persistently high exchange rate."
- July 2012: "The exchange rate has been volatile recently, but overall remains high."
- August 2012: "The exchange rate, however, has remained high, despite the observed decline in the terms of trade and the weaker global outlook."
- September 2012-April 2013: "The exchange rate has declined over the past month or two, though it has remained higher than might have been expected, given the observed decline in export prices and the weaker global outlook."
- May 2013: "The exchange rate, on the other hand, has been little changed at a historically high level over the past 18 months, which is unusual given the decline in export prices and interest rates during that time. "
- June 2013: "The exchange rate has depreciated since the previous Board meeting, although, as the Board has noted for some time, it remains high considering the decline in export prices that has taken place over the past year and a half."

– November-December 2013: “The Australian dollar, while below its level earlier in the year, is still uncomfortably high. A lower level of the exchange rate is likely to be needed to achieve balanced growth in the economy.”

– February 2014: “The exchange rate has declined further, which, if sustained, will assist in achieving balanced growth in the economy.”

– March 2014: “The decline in the exchange rate seen to date will assist in achieving balanced growth in the economy, though the exchange rate remains high by historical standards.”

– April- August 2014: “The decline in the exchange rate from its highs a year ago will assist in achieving balanced growth in the economy, but less so than previously as a result of the rise over the past few months. The exchange rate remains high by historical standards.”

– September 2014: “The exchange rate, on the other hand, remains above most estimates of its fundamental value, particularly given the declines in key commodity prices.”

– October 2014: “The exchange rate has declined recently, in large part reflecting the strengthening US dollar, but remains high by historical standards, particularly given the further declines in key commodity prices in recent months.”

– November 2014- March 2015: “The Australian dollar remains above most estimates of its fundamental value, particularly given the further declines in key commodity prices in recent months.”

– April-July 2015: “The Australian dollar has declined noticeably against a rising US dollar over the past year, though less so against a basket of currencies. Further depreciation seems likely, particularly given the significant declines in key commodity prices. A lower exchange rate is likely to be needed to achieve balanced growth in the economy.”

– Late 2014: The exchange rate has declined recently, in large part reflecting the strengthening U.S. dollar, but remains high by historical standards, particularly given the further declines in key commodity prices in recent months. It is offering less assistance than would normally be expected in achieving balanced growth in the economy.

– November, December 2013: The Australian dollar, while below its level earlier in the year, is still uncomfortably high

– May 2015: Further depreciation seems both likely and necessary, particularly given the significant declines in key commodity prices.

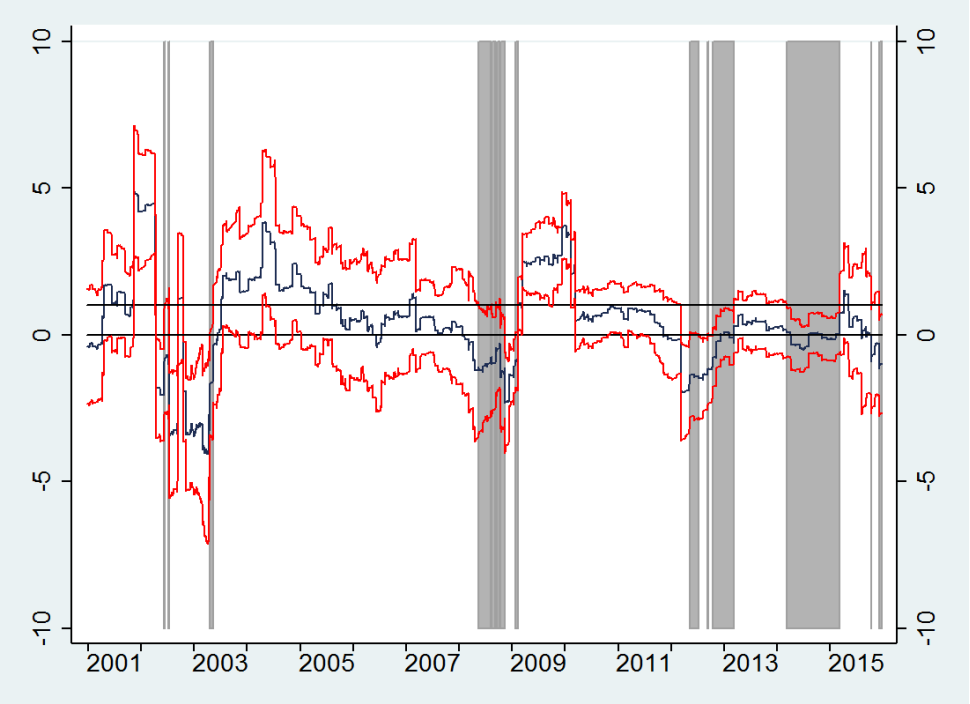
Other notable examples often reported include:

– November 2012: the Australian Broadcasting Corporation (2012) reported comments from Glenn Stevens declaring the Australian dollar 'too high'.

– December 2012 in an Australian Financial Review (2012) interview: "Its still the case that most of the former models we have for the exchange rate, for what theyre worth, it looks a bit high compared to those."

A.12 The AUD/USD exchange rate and Chinese news

Figure A.4: Time-varying sensitivity of AUD/USD exchange rate to Chinese news



The red lines represent the ± 2 adjusted standard-error bands. Grey shaded areas indicate time periods when the sensitivity to news was significantly less than 1, significantly more than 1 but not different from 0.

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