# “The role of information arrival for the Australian dollar trading volume and volatility”


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# The role of information arrival for the Australian dollar trading volume and volatility

## Abstract

This study investigates the impact of scheduled and unscheduled information arrival on realized volatility and volume in the USD/AUD exchange rate. The authors find that trading outside of Australian business hours dominates and this is mostly due to the higher frequency of information arrivals during the offshore trading period. Where the different sources of information are considered, our findings reveal that it is offshore money market news that is the most important determinant of AUD volatility. Fixed income and, to a lesser extent, foreign exchange related news however, were found to be the most important determinants of AUD volume. Finally, while Australian macroeconomic announcements were found to have a more consistent impact on AUD volatility, US macroeconomic news had a considerably larger impact.

**Keywords:** news, Australian dollar, foreign exchange, market microstructure.
**JEL Classification:** F31, G15.

## Introduction

The Australian dollar is unique amongst the major currencies[1] in that the majority of trading activity (and hence price discovery), occurs outside of Australian business hours (Reserve Bank Bulletin, 2007). Hogan and Batten (2005) suggest that this phenomenon is a direct result of the intensity of information arrival (consisting of both scheduled macroeconomic announcements and unscheduled newswire flashes), which are higher when the European and North American markets are trading[2].

A variety of literature exists that focuses on the relationship between scheduled announcements (such as macroeconomic and interest rate policy announcements) and high frequency exchange rate return volatilities (see *inter alia* Goodhart et al., 1993; Degennaro and Shrieves, 1997; Andersen and Bollerslev, 1998; Cai et al., 2001; Anderson et al., 2003). More recent studies have delved deeper into this relationship and have found that scheduled macroeconomic information releases are reflected in price and volatility via order flow (Evans and Lyons, 2008; and Love and Payne, 2008). Further, order flow was found to have greater explanatory power during periods of information releases compared to other times (see Love and Payne, 2008).

In addition to scheduled news, unscheduled information arrivals have also been considered in this context. A number of studies report a significant positive relationship between exchange rate volatility, order flows and the flow of information, measured as the amount of news headlines in addition to scheduled news (see Bauwens, Omrane and Giot, 2005; and Dominguez and Panthaki, 2006). Another branch of this literature has ignored the information content of the news altogether and focused solely on some measure of the intensity of information flows (see Melvin and Yin, 2000; and Chang and Taylor, 2003).

The purpose of this paper is to provide insights into the response of the foreign exchange market to *both* forms of information arrivals. To the best of the authors' knowledge, this is the first such paper to do so. Specifically, we investigate the relationship between realized volatility and trade volume on the one hand and scheduled and unscheduled information arrivals on the other. The advantage of our research framework is that it allows us to consider whether the market responses to information arrivals are different, distinguishing between different types of news and trading during and outside of Australian market hours. Further, our focus on the Australian dollar provides an important alternative perspective on the U.S. dollar focused prior literature.

The major findings of this paper can be summarized as follows. First, we find significant volatility and volume responses to unscheduled Reuters news headlines about 20-30 minutes before the release. Even after factoring in the possibility of a 5 to 20 minute delay for some of the news headlines, this finding suggests heightened market activity prior to the arrival of unscheduled news. In addition, we find that the responses are predominantly driven by offshore news components.

Second, we find that there are significant and immediate volatility and volume responses to macroeconomic announcements. The market responses were largely driven by the Australian and the U.S. announcements, whereas the scheduled

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[1] The 2010 BIS Triennial Central Bank Survey ranks the Australian dollar as the fifth most heavily traded currency in the world and the USD/AUD exchange rate is also ranked fifth most heavily traded currency pair by market turnover with a daily average of US$249b.

[2] Note that the intensity of information arrival in the overnight session is compounded for the AUD as it is influenced by commodity price movements, whose trading is also predominantly after-hours. The CAD is another major commodity-based currency, however, its trading overlaps with that of the US market.

news from the Eurozone and Japan were not found to be important. In addition, we find evidence of elevated volume prior to any scheduled news release, however volatility was found to respond only during the post-announcement period.

Third, we find that volatility and volume are generally more sensitive to macroeconomic announcements than the unscheduled news. This is consistent with previous findings in information-related foreign exchange literature (Dominguez and Panthaki, 2005; Bauwens et al., 2005).

Fourth, upon disaggregating the unscheduled news into three Reuters news sub-headings of foreign exchange, money and fixed income market reports, we find that money market news is most active in determining the volatility response to unscheduled news due no doubt to their macro-related headlines, while fixed income news is the driver of the volume response to the aggregate unscheduled news.

Thus, by jointly simultaneously considering both types of news, this paper is able to provide new insights into the relative important of un/scheduled information to the market. The results of our investigations have important implications for all levels of participants in the AUD market. By detailing the volume and volatility responses surrounding both types of information arrivals, market participants can factor these into their trading strategies. Also, our findings are of relevance for policy makers in relation to the timing and the method of delivery of policy announcements (e.g. target interest rate announcements and foreign exchange intervention announcements) and intervention activities.

The rest of the paper is organized as follows. Section 1 explains the types of data used in this research and section 2 discusses the empirical methodology. Empirical results are then presented and discussed in section 3, which is followed by conclusion in the final section.

## 1. Data description

**1.1. Tick by tick AUD exchange rate data.** We use tick by tick indicative quotes from all quoting banks in the USD/AUD market on a 24-hour basis. The data is sourced from the Reuters Tick Data History (RTDH) via SIRCA. The sample period for the intra-day quote data is from 1 April 2008 to 30 September 2008. The database contains dates and time-of-day stamped to the second in Greenwich Mean Time (GMT), the dealer bid and ask quotes, and a bank identifier. As the focus of this paper is on trading during and outside of Australian business hours, each quote was then adjusted to Australian Eastern Standard Time (AEST, GMT+10 and +11 during daylight saving period). We use the mid rate between bid and ask quotes for each tick. From the raw tick-by-tick data, the entire length of the sample was then divided into equal length holding periods of five minutes each, beginning at 11:00:00 am AEST on 1 April 2008 and ending at 9:59:99 am AEST on 1 October 2008. The initial and final mid rates that fall within the bounds of each holding period are recorded respectively as the opening and closing mid rates for that period, thereby treating them as though they fell exactly on the boundaries of the period.

The variables of interest in this study are volume and volatility measured over the fixed intervals of five minutes[1]. Volume is defined as the number of quotes made in a five minute interval[2]. Volatility is the realized volatility estimator which is the sum of all squared tick-by-tick returns within a five minute interval, where returns are defined as the log difference between successive mid quotes[3]. For our sample, there are 184 days and 288 five minute intervals for each day. Excluding weekends and non-trading intervals as in the literature (e.g. Melvin and Yin, 2000) we end up with a total of 34,104 five minute holding periods.

The final transformation of data consists of adjusting the volume and volatility time series for seasonal patterns. Literature has shown that high frequency time series are often subject to seasonal patterns (Andersen and Bollersev, 1994; Dacorogna et al., 1993). To account for seasonal effects for any given time series, 288 cross-sectional standard deviations for each of the five minute intervals in the day are calculated. After estimating these 'seasonal multipliers' for a given time series, each observation is divided by the seasonal multiplier to obtain the de-seasonalized time-series. This seasonal adjustment process follows the methodology outlined in Melvin and Yin (2000) and is similar to the approach taken by Taylor and Xu (1997)[4].

[1] Five minute intervals have been chosen as the length of each holding period in order to best capture short-term changes within the variables as well as to allow for the possibility of pre-emptive and delayed response from the market. The choice of five minutes as the holding period length is consistent with the literature (Berger et al., 2008; Faust et al., 2007; Andersen et al., 2007)

[2] Berger et al. (2008) argue that the tick-frequency is an effective proxy for the actual volume. By employing actual volume measured in terms of order flow, they find that their measure was not significantly different from volume as measured on a tick-by-tick basis as each trade is more or less standardized in size.

[3] In preliminary estimations, volatility was also estimated using the method provided by Garman and Klass (1980). While Garman and Klass (1980) argued that GK volatility is more efficient than either the PARK (Parkinson, 1980) estimator or the realized volatility estimator, subsequent studies such as Andersen and Bollerslev (1998) and Cai et al. (2001) have provided more compelling evidence for the superiority of the realized volatility estimator for high frequency analyses.

[4] In preliminary estimations, various other seasonal adjustment methods, such as using the cross-sectional average as the seasonal multiplier, and adding an additional seasonal adjustment factor as a regressor (Andersen and Bollerslev, 1998) were also considered. However, these methods proved to be weak as seasonal patterns persisted in the de-seasonalized series.

To aid in understanding the data, Figure 1 presents a comparison between the cross-sectional average of overall news intensity and the cross-sectional averages of the volume and volatility for the AUD data across the 288 five minute intervals in the day. The two vertical lines in each graph delineate three broad trading zones for Sydney, London and New York and it is evident that the overwhelming majority of news arrival and market activity occurs during offshore trading periods. Volume is at its lowest at around 8:00 am AEST, increasing to the first peak at around 11:30 am AEST, which coincides with the scheduled release of all Australian macroeconomic announcements by the Australian Bureau of Statistics. The second peak occurs around 5:00 pm AEST, which is approximately the time of the commencement of London trading. The third peak appears at around 10:30 pm – 12:00 am AEST, which corresponds to the period of scheduled economic data announcements in the United States. These pronounced peaks in trading volume clearly highlight the importance of scheduled macroeconomic news variables to be foreign exchange market.

The cross-sectional averages of the intraday volatility display a similar multi-peak pattern to the cross-sectional averages of volume. The peaks in the volatility appear to occur at around the same time as the peaks in volume: 11:30 am, 5:00 pm, and around 10:30 pm AEST. This is not surprising given the well documented positive correlation between volume and volatility. Moreover, a seasonal effect in volatility that is induced by the regularly scheduled news announcements is also evident. The timing of the volatility peaks observed within the data differs slightly from those found by Hogan and Batten (2005). However, as with volume, the same fundamental multi-peak pattern exists. One potential source for this difference may be the longer sample period of this study, rendering it more representative of the market for the AUD. In addition, a different method for estimating realized volatility is utilized, which could be an additional cause of these discrepancies.

**1.2. Scheduled and unscheduled information arrivals.** The primary source of unscheduled news is the Reuters Headline News database obtained from the SIRCA RTDH database. The database contains all news headlines that were released on the Reuters alert screens, which are standard equipment on foreign exchange trading desks and are also used by non-dealer market participants. Reuters collects news reports from approximately 150 bureaus and the presence of an editorial process means that most news items in the data set are viewed as containing newsworthy information. At the same time, competition between Reuters, Bloomberg and Dow Jones ensures publication delays are minimized (Evans and Lyons, 2008).

The database contains news headlines which are date and (GMT) time stamped to the second. Each news headline also includes a news category code which classifies every headline into foreign exchange-related (FX), fixed income-related (FI) or money market-related (MM) news. In general, the Reuters news headlines are a collection of real time reporting of breaking news and the general reporting of market events as they occur (e.g. "The Australian FX market rose 2.5% in the opening"). It is worth noting that there are potentially two minor limitations to the Reuters News Headlines database: first, there are occurrences of overlaps in the headlines classified as FX, FI or MM news; and second, some headlines reports may be delayed by 5 to 20 minutes[1].

News intensity is measured as the number of news headlines within a five minute interval. A news intensity variable is computed for the aggregate news and also for each of the three disaggregated forms of news: FX News, FI News and MM News[2]. After adjusting the timestamps from GMT to AEST and excluding weekends from the sample, we end up with a total of 11,421 news headlines, of which approximately 80% are classified as FX News, 15% as FI News and 5% as MM News. Table 2 presents some examples of each the three type of news headlines.

To test the differential impact of onshore and offshore news on market activity, onshore and offshore dummies were constructed. The onshore dummy is 1 from 7:00 am to 4:00 pm AEST, which corresponds to the Australian trading period, and 0 otherwise. The offshore dummy is 1 from 4:00 pm to 7:00 am AEST the next calendar day (approximately the offshore trading hours), and 0 otherwise. We then construct news intensity variables for offshore and onshore news by multiplying the news intensity variables by appropriate dummies. The on/offshore measures of FX, FI and MM News are also constructed in the same manner. Table 2 summarizes the relative frequency of each of the different news groups. We note that while the Australian trading period accounts for one-third of the trading day, it only provides 21.40% of the total news headlines, of which the majority (around 80%) are FX news.

[1] In general, Reuters news items are initially released in real time as a news alert, which is just a short headline of the event (e.g. "BOJ announces it intervention intentions"). Within about 5 to 20 minutes a more detailed commentary (usually a few lines of report) is added and then the news reported again. This is known as a news headline or the first take. Another 20-25 minutes may elapse when a second take is released with additional information that is either clarification or corrections of the first take.
The Reuters news database during our sample period does not contain distinct alerts and headlines. Instead, both types of releases are classified as headlines. There are however, second takes which we removed from the sample. Therefore, some of the headlines are contemporaneous (alerts) and the others are with 5-20 minutes of delay (first takes). We acknowledge this as a potential weakness of our database.

[2] It should be noted that there are news headlines which overlap amongst the three news categories. However, this is not widespread.

A macroeconomic announcement database for Australia, the U.S., the European Union and Japan is also constructed. These announcements are sourced from the Bloomberg database of Economic Releases and contains the date, time-of-day stamped to the minute (AEST), and the name of the macroeconomic announcement. The macroeconomic announcements we consider include major macroeconomic headlines such as GDP, CPI and unemployment, but the data also includes monetary policy announcements from the central banks in Australia, the U.S., European Union and Japan. Table 3 presents a description of the macroeconomic headlines captured in this database.

## 2. Methodology

**2.1. Model 1: The aggregate model.** The aim of this paper is to explore the impact of scheduled and unscheduled information arrivals on the trading of the Australian dollar. To ensure that the time series characteristics of the data, as well as the economic effects of the news variables are adequately captured, autoregressive moving average models with independent variables (ARMAX) are utilized. Model 1 is designed to capture the differential impact of aggregate scheduled and unscheduled news. The aggregate form of an ARMAX model to be estimated for volume and volatility is[1]:

$$RV_{t,i} \text{ or } Vlm_{t,i} = \alpha_0 + \sum_j b_j UNews_{t,i-j} + \\ + \sum_j c_j SNews_{t,i-j} + \sum_g d_g Vlm_{t,i-g} + \\ + \sum_p e_p RV_{t,i-p}\varepsilon_{t,i} + \sum_q f_q \varepsilon_{t,i-q}, \quad (1)$$

where, $RV_{t,i}$ = Realized Volatility in the $i$th 5 minute holding period on day $t$; $Vlm_{t,i}$ = Volume, or the number of ticks within an $i$th 5 minute holding period on day $t$; $UNews_{t,i-j}$ = the intensity of unscheduled Reuters news within an $i$th 5 minute holding period on day $t$ at the $j$th lead/lag; $SNews_{t,i-j}$ = the intensity of scheduled macroeconomic announcements within an $i$th 5 minute holding period on day $t$ at the $j$th lead/lag; $\varepsilon_{t,i}$ = the white noise error term.

As noted, $t$ spans from 1 April 2008 through to 1 October 2008, with $i$ encompassing the 288 five-minute holding periods in a trading day. In (1) the independent variables to be modelled are realized volatilities, $RV_{t,i}$ and trading volumes, $Vlm_{t,i}$, using the intensity of all unscheduled news within a five-minute holding period as represented by the term $UNews_{t,i-j}$ and the intensity of all scheduled news for one five-minute holding period as represented by the term, $SNews_{t,i-j}$ where $j$ is the number of leads and lags for both news variables. As stated earlier, news intensity is calculated as the number of news headlines or announcements that fall within the holding period.

To account for the established positive relationship between volume and volatility[2], volatility ($RV_{t,i}$) and volume ($Vlm_{t,i}$) are 'controlled' against $g$ lags of each other. We set the number of lags for the 'control' variable, $g$, to be three[3]. In addition, we use $p$ and $q$ lags of autoregressive and moving average in each equation. The optimal combination of $p$ and $q$ for each estimation is determined according to the Schwartz Information Criterion[4]. The number of leads and lags for unscheduled news intensity and scheduled news intensity, $j$, is six, i.e. $j$ = -6 to 6. This represents 30 minutes of analysis prior to the release of a news announcement and 30 minutes of analysis subsequent to the release of a news announcement – a total of 65 minutes of analysis on the response of market activities surrounding the release of news to the market[5].

The primary focus of the baseline model presented in Equation 1 is, $b_j$, the impact of the aggregate unscheduled news on market activity, and, $c_j$, the impact of the aggregate scheduled news on market activity. The sign and significance of the coefficients will provide insights on the nature of the impact of each types of news on volume and volatility, the time taken to process new information and also whether the Australian dollar market exhibits evidence of participants pre-empting news.

A positive (negative) and statistically significant contemporaneous unscheduled (or scheduled) news coefficient indicates that market activity in the AUD/USD is greater (lower) within the first five minute interval during which the information is released onto the market[6]. This suggests that volume or volatility is almost immediately higher (lower) as result of greater (lower) news intensity. Statistically significant lagged unscheduled news coefficients

[1] The research methodologies and the methods of presenting summary results in graphs developed in this paper were also used in a follow up paper, Daniel, Kim and McKenzie (2014).

[2] e.g. Melvin and Yin (2000), Chang and Taylor (2005).

[3] The number of lags for the 'control' variable was determined during preliminary estimations and up to 12 lags were considered. In all specifications of the baseline model, it was found that volatility (volume) was significant to volume (volatility) for no more than 3 lags, i.e. 15 minutes.

[4] An alternative to estimating the volatility is via a GARCH methodology. This is consistent with the approach of Hsieh (1988), Gallant et al. (1991), Bollerslev et al (1992), Degennaro and Shrieves (1997), and Melvin and Yin (2000). GARCH volatilities utilize significantly fewer price observation points in a given holding period, usually opening and closing prices, and so they are in essence smoothed approximation of the holding period volatility and can be less accurate than the realized volatilities that use all available price observation points.

[5] The number of leads and lags for the news variables was determined during preliminary estimations, where up to 12 leads and lags of unscheduled and macroeconomic announcements variables were considered. In all specifications, news was found to have an impact on market activity for no more than 30 minutes before and after the news release.

[6] For the scheduled announcements, there is no problem of delayed reporting. Thus, lead/lag zero represents contemporaneous holding period.

would indicate that market activity is higher (lower) after the actual arrival of the news in the contemporaneous five minute interval. This suggests 1) a delayed market reaction to news arrival, 2) an increase in market uncertainty stimulates higher levels of trading as a result or 3) market heterogeneity in the interpretation of the news content (Bauwens et al., 2005; Degennaro and Shrieves, 1997).

Statistically significant leads of unscheduled news would indicate that market activity is higher (lower) before the actual arrival of news in the contemporaneous five minute interval. This suggests four possible explanatory factors: 1) systematic delays in the reporting of Reuters news headlines[1], 2) the presence of informed traders trading on private information, 3) evidence of traders closing out their positions to avoid surprises when news is actually released, or 4) the retrospective characteristic of a proportion of reported news headlines classified as unscheduled news (Bauwens et al., 2005).

**2.2. Model 2: Onshore vs. offshore news model.** In order to capture the differential impacts of unscheduled onshore and offshore news we apply on and offshore dummies to the unscheduled news variables in (1A) and (1B). This will allow us to determine which of the two trading zones is the principal driver of the aggregate unscheduled news. The modified ARMAX models are:

$$RV_{t,i} \text{ or } Vlm_{t,i} = \alpha_0 + \sum_k \sum_j (b_{1,j}^{k,Onshore} \cdot Dum_{t,i}^{k,Onshore} + b_{2,j}^{k,Offhore} \cdot Dum_{t,i}^{k,Offshore}) \cdot UNews_{t,i-j}^{k} + \\ + \sum_j c_j SNews_{t,i-j} + \sum_g d_g Vlm_{t,i-g} + \sum_p e_p RV_{t,i-p} + \varepsilon_{t,i} + \sum_q f_q \varepsilon_{t,i-q}, \quad (2)$$

where, $Dum_{t,i}^{k,onshore}$ = the onshore news dummy which takes the value 1 between 7:00 am and 4:00 pm AEST, and 0 otherwise; $Dum_{t,i}^{k,offshore}$ = The offshore news dummy which takes the value 1 from 4:00 pm to 7:00 am AEST, and 0 if otherwise.

The intensity of onshore unscheduled news within a five-minute holding period is represented by the term, $Dum_{t,i}^{k,onshore} \cdot UNews_{t,i-j}^{k}$, and the intensity of offshore unscheduled news for one five-minute holding period is represented by the term, $Dum_{t,i}^{k,offshore} \cdot UNews_{t,i-j}^{k}$, where *j* is the number of leads and lags for the news variable in both time zones.

The coefficients of interest in this model are $b_{1,j}^{k,onshore}$, which measures the impact of onshore news on volatility and volume, and $b_{2,j}^{k,offshore}$, which captures the impact of offshore news on volatility and volume. An analysis of these variables will provide insight into the differential impact of onshore and offshore news on volume and volatility. Recall from Figure 1, the cross-sectional average of volatility and volume were found to increase during offshore trading periods, which coincides with heightened news intensity. Thus, Equation 2 provides a more formal test of this relationship and, a *priori*, offshore news is expected to be the driver of market activity. This hypothesis is also consistent with empirical findings from the current literature which, 1) establishes that news intensity during offshore trading hours for the AUD are comparatively greater than the news intensity during domestic Australian trading hours (Clifton and Plumb, 2007) and, 2) finds statistically significant positive relationships between news intensity and market activity variables in other global currency pairs (Dominguez and Panthaki, 2006).

**2.3. Model 3: The disaggregated news model.** Where unscheduled news is disaggregated into the 3 Reuters news categories (FX, FI, and MM News) and scheduled news is disaggregated into 4 countries of origin (Australia, the U.S., the Eurozone and Japan), the ARMAX model becomes:

$$RV_{t,i} \text{ or } Vlm_{t,i} = \alpha_0 + \sum_k \sum_j (b_{1,j}^{k,FX} \cdot Dum_{t,i}^{k,FX} + b_{2,j}^{k,FI} \cdot Dum_{t,j}^{k,FI} + b_{3,j}^{k,MM} \cdot Dum_{t,i}^{k,MM}) \cdot UNews_{t,i-j}^{k} + \\ + \sum_l \sum_j (c_{1,j}^{l,AUS} \cdot Dum_{t,i}^{l,AUS} + c_{2,j}^{l,US} \cdot Dum_{t,i}^{l,US} + c_{3,j}^{l,EU} \cdot Dum_{t,i}^{l,EU} + c_{4,j}^{l,JP} \cdot Dum_{t,i}^{l,JP}) \cdot SNews_{t,i-j}^{l} \quad (3) \\ + \sum_g d_g Vlm_{t,i-g} + \sum_p e_p RV_{t,i-p} + \varepsilon_{t,i} + \sum_q f_q \varepsilon_{t,i-q},$$

where, $Dum_{t,i}^{k,FX}, Dum_{t,i}^{k,FI}, Dum_{t,i}^{k,MM}$ = FX, FI and MM news dummy which takes the value 1 if news is classified as FX, FI and MM and 0 if otherwise, respectively. $Dum_{t,i}^{l,AUS}, Dum_{t,i}^{l,US}, Dum_{t,i}^{l,EU}, Dum_{t,i}^{l,JP}$ = Australian, US, Eurozone and Japanese macro-economic news dummy which takes the value 1 if news originates from Australia, US, Eurozone and Japan and 0 if otherwise, respectively.

In Equation 3, the disaggregated unscheduled news variables are FX news – $Dum_{t,i}^{k,MM} \cdot UNews_{t,i-j}^{k}$, FI

[1] As discussed in the data section, some of the headlines may be reporting market events of 5 to 20 minutes earlier and as such, significant leads up to 20 minutes (4th lead) may be regarded as potentially contemporaneous.

News – $Dum_{t,i}^{k,FI} \cdot UNews_{t,i-j}^{k}$, and MM news – $Dum_{t,i}^{k,MM} \cdot UNews_{t,i-j}^{k}$, whereas the disaggregated scheduled news variables are Australian macroeconomic announcements $Dum_{t,i}^{l,AUS} \cdot SNews_{t,i-j}^{l}$, U.S. macroeconomic announcements – $Dum_{t,i}^{l,US} \cdot SNews_{t,i-j}^{l}$, Eurozone macroeconomic announcements – $Dum_{t,i}^{l,EU} \cdot SNews_{t,i-j}^{l}$, and Japanese macroeconomic announcements – $Dum_{t,i}^{l,JP} \cdot SNews_{t,i-j}^{l}$ where $j$ is the number of leads and lags for both types of news variables.

We focus on 1) the coefficients of the disaggregated unscheduled news variables: $b_{1,j}^{k,FX}$, $b_{2,j}^{k,FI}$ and $b_{3,j}^{k,MM}$, and 2) the coefficients of the disaggregated macroeconomic news variables: $c_{1,j}^{l,AUS}$, $c_{2,j}^{l,US}$, $c_{3,j}^{l,EU}$ and $c_{4,j}^{l,JP}$. The analysis of the first group will provide insight into the differential impact of the Reuters news classification on market activity and the analysis of the second will shed light on the differential impact of macroeconomic news by country of origin. This will enable us to identify the main drivers of aggregate unscheduled and macroeconomic announcements respectively. *A priori*, FX news are expected to drive the volume and volatility response to aggregate unscheduled news as it accounts for the greatest portion of the total Reuters news headlines and relates directly to the foreign exchange market. In addition, *a priori*, the Australian and the U.S. macroeconomic news are likely to have more significant impacts on the market activities as they are directly linked to the currency pair.

## 3. Empirical results

**3.1. Aggregate news impacts.** The estimation results for the aggregate model given in equations (1A) and (1B) are presented in Table 4. The coefficients for the lead and lag of both types of news variables are reported in panels A and B, while a summary of the optimal combinations of AR and MA components that produce white noise residuals are reported in Panels C and D along with some estimation diagnostics[1].

To aid the reader in interpreting these results, Figure 2 provides a graphical representation of the information contained in Table 3[2]. For example, Panel A of Figure 2 presents a plot of the estimated unscheduled news coefficients where the vertical axis captures the size of the estimated coefficients and each lead and lag is represented along the horizontal axis. Leads 2-6 represent 25 minutes of the pre-announcement period prior to the actual release of the news announcement. Lead 1 to Lag 0 represents the 10 minutes surrounding the news release. Lags 1-6 represent up to 35 minutes of the post-announcement period. The significance of the coefficients is represented by the color of each bar: black columns represent statistical significance at 1%; columns in grey represent statistical significance at 5%; and the white columns represents insignificant coefficients ($p$-value of 5% or larger).

The positive and statistically significant coefficients for the two contemporaneous periods, Lead 1 and Lag 0, indicate that the aggregate unscheduled Reuters news has a positive impact on the volatility of the exchange rate. This is consistent with the findings of Chang and Taylor (2003) and Dominguez and Panthaki (2006). Moreover, the concentration of positive and significant lead news variables in the pre-announcement periods suggest that volatility is greater for up to 30 minutes prior to the news headline release[3]. Considering the potential of some of the news being delayed anywhere between 5 to 20 minutes, the pre-announcement responses can be as short as 10 minutes.

The significance of the news variables in the pre-announcement periods is potentially driven by the following three factors – volatility in the AUD rises before the news hits the market as a result of: 1) systematic delays in the reporting of Reuters news headlines, 2) the presence of informed traders trading on private information, and 3) the retrospective characteristics of a proportion of reported news headlines classified as unscheduled news.

The first explanation is unlikely as intense competition among data providers means that the extent of delay by Reuters is likely to be trivial. The second and third explanations for the volatility response appear to be more plausible. As suggested by Degennaro and Shrieves (1997) and Bauwens et al. (2005), an increase in volatility during pre-announcement is linked to the presence of informed traders who exploit their private information. Therefore, under the second hypothesis, the positive and statistically significant lead news coefficients suggest that some market participants possess private information regarding the content of the

[1] While all of the ARMAX models required different ARMA lag combinations, we can report that around 8 to 9 lags of both AR and MA components were required and the estimated coefficients are mostly positive. This is as expected given the positive relationship between volume and volatility reported in the literature.

[2] To conserve space, only the graphical representation of the estimated coefficients is presented for all other models estimated. The unreported full results are available from the authors on request.

[3] In preliminary estimations, up to 12 leads and lags of the news variable were estimated for both market activity variables (i.e. 60 minutes of analysis pre-announcement and post-announcement). While there were significant lead or lag variables with an order that was higher than Lead/Lag 6, these were isolated incidences where e.g. only one of the leads in the 60 minute period was significant. In contrast, most news variables were significant for up to 30 minutes prior to and subsequent to the news release.

unscheduled Reuters news headlines obtained from their customer order flow and hence, the ability to react to these headlines before the actual time of release. The third hypothesis suggests that the heightened volatility is evidence of a response to a real time event which is later reported in a retrospective Reuters news headline up to 20-30 minutes after the occurrence of the event. The Reuters News Headlines database is a collection of different types of headlines which includes both 1) real time reporting of macroeconomic events, policy announcements, etc. which are generally not predictable, and 2) general reporting of market observations and events that have already occurred. As a result, it is likely that both types of news could account for the significant leads. The volatility response graph supports this hypothesis as volatility diminishes around 5 minutes subsequent to the news release, indicating that the impact of news on volatility tapers off shortly after the release as more market participants become aware of the event and adjust their views accordingly.

The second column of Panel A shows that the impact of unscheduled Reuters news on volumes in the AUD is markedly different to that of the impact on the volatility. All of the estimated coefficients are significant at the 1% level and they indicate that volumes in the USD/AUD generally rise prior to the news announcement, peak in the contemporaneous period and fall in the post-announcement period. The significance of the pre-announcement news variables suggest the presence of anticipatory trades and the possible access to private information by a segment of the market. This is consistent with the implications suggested by the volatility response to unscheduled news as discussed above. The significance of the post-announcement news variables indicates evidence for market heterogeneity in the interpretation of news content for up to 30 minutes.

Table 4 and Panel B of Figure 2 report the estimated coefficients for the impact of aggregate scheduled news events. For volatility, positive and statistically significant coefficients at the 1% level are found for lead 2, 1 and 0, indicating that aggregate macro-economic announcements have a positive impact on volatility. Unlike the volatility response to unscheduled Reuters news however, the volatility response to macroeconomic announcements is not concentrated in the pre-announcement period, rather it is also pronounced in the post-announcement period. The significant volatility responses shown during the pre-announcement periods might suggest potential information leakages surrounding macroeconomic announcements (e.g. private information based trading). However, this lacks empirical support as discussed in the disaggregated news impact analyses in section 3.3 below. With positive and statistically significant coefficients to Lag 4, the results suggest that volatility remains at an elevated level even after around 20-25 minutes after the news release.

There are two potential explanations for the volatility response to macroeconomic announcements in the post-announcement period. The first suggests that the significance of news variables in the post-announcement period indicates the presence of heterogeneity in the market's interpretation of the content of the news. This is consistent with the findings of Evans and Lyons (2008) who found that dealers in the DM/$ spot market observe macroeconomic announcements, but have little idea of how to interpret it, or how the rest of the market will interpret it. In the second, the volatility response is seen as a reflection of surprised reactions by market participants and the closing of positions based on prior anticipations (Bauwens et al., 2005). Interestingly, Lag 5 is statistically significant at 1% with a negatively signed coefficient. This suggests that volatility generally diminishes around 25-30 minutes after macroeconomic announcements which can be interpreted as a market correction to an overreaction in the variation of USD/AUD quotation which follows an announcement.

The impact of the scheduled news on volume are shown in the second column of Panel B. The volume effect generally increases in magnitude up to the time of the announcement, however unlike unscheduled news where all of the coefficients were significant, here the significant news variables are concentrated in the pre-announcement periods. This can be driven by two factors: 1) a greater number of anticipatory or speculative trades initiated on the 'private' information, or 2) by traders who rebalance their positions in order to avoid announcement 'surprises'. We conjecture that while the market is able to make anticipatory trades prior to the release of macroeconomic announcements (as seen in the statistical significance of Lead 2 and Lead 1 at 1%), it does so immediately prior to the release of the news on a less extensive scale in comparison to the volatility response to unscheduled Reuters news. Moreover, only 2 out of the 6 news lags in the post-announcement period are positive and statistically significant at least at 5%. This suggests that while there is still some evidence of market heterogeneity in the interpretation of the news content there is less heterogeneity regarding the scheduled news releases. This finding is consistent with Bauwens et al.'s (2005) argument that there should be a greater divergence in price post-announcement with regards to unscheduled news announcements.

**3.2. The differential impacts of impact of on- and offshore unscheduled Reuters news.** Equation 2 captures the volatility and volume responses to unscheduled Reuters news released during on and offshore trading hours. The estimation results are graphically summarized in Figure 3 and reveals that the volatility response to offshore news shown in Panel A is very similar to the aggregate volatility response discussed in Section 3.1. In contrast, the volatility response to onshore news shown in Panel B of Figure 3 is markedly different as all onshore news variables, except for Lead 6, are insignificant. Thus, the volatility response to the aggregate unscheduled Reuters news is principally driven by the impact of offshore news on volatility. This result addresses our first research question and provides a confirmation that a major determinant of heightened volatility is the intensity of news arrival.

The volume graph in Panel A shows the pyramid-shaped pattern that was observed for the aggregate model originates from the offshore period. In contrast, the periods with significant news variables on volume are negative for the onshore news. This suggests that volumes in the AUD diminish during the release of unscheduled news headlines onto the market during Australian trading hours. A plausible interpretation is that in comparison to their counterparts in the offshore markets, Australian traders in the AUD refrain from trading around information events.

**3.3. The impact of unscheduled Reuters news by category type.** To further investigate the results of the previous section, we estimate equation (3), which disaggregates news into its various types. The estimated coefficients are summarized in Figure 4 and the volatility responses to FX and FI news lack any distinct pattern. For FX news, only Lead 6 and Lead 3 are statistically significant indicating that the volatility response to FX news is concentrated in the pre-announcement period where volatility rises around 15-30 minutes before the release of the news. As discussed previously, the significant lead coefficients might represent either mostly contemporaneous volatility responses or information leakage on some of the news by about 10 minutes. The contemporaneous periods (Lead 1 and Lag 0) for FI news are statistically significant at 5%, suggesting a lack of information leakage for FI news. MM news have the greatest number of statistically significant news variables, most of which are concentrated in the post-announcement period. This pattern suggests some heterogeneity in the interpretation of MM news content by the market and resembles the volatility responses to macroeconomic announcements rather than the volatility response to unscheduled Reuters news. An investigation into the content of MM news explains this pattern whereby macroeconomic related headlines were found to account for a sizeable portion of MM news. Furthermore, MM news have the highest number of statistically significant variables of the three news type and an examination of the magnitudes of the coefficients shows that it also has the greatest impact on the volatility response to aggregate unscheduled Reuters news. Therefore, the volatility response to the aggregate unscheduled Reuters news appear to be predominantly driven by MM news.

The volume responses to FX and FI news display a pyramid-shaped pattern of increasing and then decreasing coefficients, that is similar to the pattern previously observed in the volume response to aggregate unscheduled Reuters news. An examination of the magnitudes of the coefficients for FX and FI news shows that the volume response is almost twice as sensitive to FI news compared to FX news. Further, while FX news is significant across the board, the effect of FI news is predominantly concentrated in the pre-announcement and contemporaneous periods, suggesting the presence of anticipatory trades leading up to the release of the news. Volume drops off considerably during post-announcement periods suggesting low levels of market heterogeneity with regards to FI news. The volume response to MM news is significant only in the post-announcement period suggesting market heterogeneity. In general, we find that FI and FX are the main drivers of the volume response to the aggregate unscheduled Reuters news.

*3.3.1. The impact of scheduled macroeconomic news by region of origin.* Equation 3 also assesses the impact of Australian macroeconomic announcements on volatility and volume and the estimation results are summarized in Panel A of Figure 5. The volatility responses to Australian macroeconomic announcements appear to take a similar pattern to the volatility response to aggregate macroeconomic announcements. However, there is no strong evidence of information leakage as only Lead 1 is significant at 1% in the pre-announcement periods. This reflects the difficulty of speculative trading on macroeconomic announcements given its public nature and suggests that anticipatory trades before unscheduled Reuters news are more prevalent than anticipatory trades before macroeconomic news as private information related to unscheduled news might be more accessible to market participants.

Where U.S. announcements are considered however, the volatility responses show a different pattern (Panel B of Figure 5). U.S. announcements have a positive and statistically significant impact at 1% at Lead 1 and at Lag 4 (around 20-25 minutes after the release of the news). This provides some evidence for market heterogeneity in the interpretation of the news

content in U.S. macroeconomic announcements, but this evidence is relatively weak in light of the negative Lag 3 which is statistically significant at 5%. The lack of significance and relatively smaller estimated coefficients of the volatility response to US macroeconomic announcements compared to Australian macroeconomic announcements suggest that the latter are a more significant driver of the aggregate volatility response.

The volatility and volume responses to Eurozone and Japanese macroeconomic announcements were also modelled and we found that while there were some significant news variables, the impact they had on volatility and volume were relatively minor compared to the impact of Australian and U.S. macroeconomic announcements[1]. This suggests that the AUD market is mostly determined by the bilateral information flows between the U.S. and Australia.

Where we turn our attention to consider the volume response of the market to Australian macroeconomic announcements, we find that the impact is primarily concentrated in the post-announcement period. Specifically, the response is greatest during the contemporaneous periods (Lead 1 and Lag 0), with the volume response gradually decreasing for higher lags. This is in contrast to the volume response to the aggregate macroeconomic announcements, in which volume impact is concentrated in the pre-announcement periods. This disparity suggests that Australian traders are less inclined to close out their positions prior to the news release in order to avoid surprises in the pre-announcement periods, and 1) experience greater levels of market uncertainty and 2) they might be comparatively less efficient in its absorption of the news content in the post-announcement periods.

In contrast, the volume response to U.S. macroeconomic announcements are more consistent with volume response to the aggregate macroeconomic announcements. Almost all news coefficient in the pre-announcement period are positive and statistically significant at 1% which suggests that U.S. traders are more inclined to close out their positions prior to the news release in order to avoid surprises. The statistical significance of Lag 3 and Lag 4 also provides some evidence of market heterogeneity in interpreting the U.S. macro news.

Despite some differences in the pattern of volume responses between the aggregate macroeconomic announcements and U.S. and Australian macro-economic announcements, there is still sufficient evidence to surmise that the aggregate macroeconomic announcements are driven by the Australian and the U.S. macroeconomic announcements. This suggests that the AUD market is mostly determined by the bilateral information flows between the U.S. and Australia. Closer examination of the source of the announcements however, does reveal some interesting differences between the markets response to U.S. and Australian macroeconomic news.

## Conclusion

This paper investigates the impact of information arrival events on the realized volatility and volume in the USD/AUD foreign exchange market. For the sample period from 1 April to 30 September, we examined the impact of news for up to 30 minutes in the pre-announcement period, and 35 minutes in the post-announcement period. This study offers an economic explanation for the relationship between market activities and news announcements in the Australian dollar market. We provide insights into the nature of price discovery in the market during the post-announcement period, as well as evidence for the market to be able to pre-empt various types of news and undertake anticipatory trades in the pre-announcement period.

Specifically, we find evidence to support the hypothesis that heightened news intensity is a key driver for the dominance of offshore market activity in the Australian dollar. The impact of unscheduled news on volatility and volume is largely driven by offshore news. Most interestingly, this study shows that it is offshore money market news that is the most important determinant of AUD volatility. Fixed income and, to a lesser extent, foreign exchange related news however, were found to be the most important determinants of AUD volume. Finally, while Australian macroeconomic announcements were found to have a more consistent impact on AUD volatility, US macroeconomic news had a considerably larger impact (while Euro and Japanese news were found to have a relatively insignificant role to play).

The observed pattern of volatility and volume responses to news may suggest that traders are inclined to close outpositions in the pre-announcement period to avoid surprises and provides evidence for market heterogeneity in the interpretation of the news content. Moreover, while there is evidence of heightened volatility in the pre-announcement period for unscheduled news (due to private information and retrospective headlines) the volatility response to macroeconomic announcements suggests that there are few information leakages and less anticipatory trading as a result.

[1] These results are not reported to save space. Interested readers may obtain them from the corresponding author.

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## Appendix

Table 1. Summary statistics for USD/AUD volatility and volume

| | Indicative quotes | |
|---|---|---|
| | Volatility | Volume |
| a. Raw series | | |
| Mean | 0.19 | 156.8 |
| Variance | 0.11 | 5880.62 |
| Skewness | 11.32 | 0.27 |
| Kurtosis | 229.51 | -0.11 |
| b. De-seasonalized series | | |
| Mean | 0.75 | 2.46 |
| Variance | 1.05 | 2.54 |
| Skewness | 3.76 | 0.23 |
| Kurtosis | 20.33 | -0.64 |

Table 2. Reuters news headline categories

| | All news | FX News | FI News | MM News |
|---|---|---|---|---|
| Frequency | 11421 | 9085 | 1741 | 595 |
| % of all news | - | 79.50% | 15.20% | 5.20% |
| Onshore | 2446 | 1928 | 287 | 231 |
| % of all news | 21,40% | 16.90% | 2.50% | 2.00% |
| Offshore | 8975 | 7157 | 1454 | 364 |
| % of all news | 78,60% | 62.70% | 12.70% | 3.20% |
| Headline examples | n/a | Dollar to rebound versus, euro, pound – BNP | European credit spreads tighter | RBA head says 4% inflation likely |
| | | Lehman shorts euro/dollar | US 2Y swap spread narrows with Libor broadly lower | Money mkt rates remain high, spreads wide |
| | | Dollar seen gaining ground ahead of G7 meeting | Treasury yield curve flattest since February | BOJ gov nominee: Japan economy faces risks |
| | | Won lead Asian FX down vs firmer dollar | Lower volatility and buying buoying mortgage bonds | 3-month Euribor slips to 4964 pct |
| | | Watch resistance at 10576 in USD/CAD – RBC | Treasuries dip in Asia, eye bailout approval | Nomura sees TED spreads shrinking in mid-Q4 |

Table 3. Summary statistics of macroeconomic news announcements

| Announcement | Frequency | Local time | AEST time |
|---|---|---|---|
| Australian announcements (total = 31) | | | |
| CPI | 2 | 11:30 am | 11:30 am |
| GDP | 2 | 11:30 am | 11:30 am |
| International trade on goods and services | 6 | 11:30 am | 11:30 am |
| Retail sales | 7 | 11:30 am | 11:30 am |
| Unemployment rate | 6 | 11:30 am | 11:30 am |
| Current account | 2 | 11:30 am | 11:30 am |
| RBA cash rate target announcements | 6 | 2:30 pm | 2:30 pm |
| US announcements (total = 36) | | | |
| CPI | 6 | 8:30 am | 10:30 pm |
| GDP | 6 | 8:30 am | 10:30 pm |
| Trade balance | 6 | 8:30 am | 10:30 pm |
| Advance retail sales | 6 | 8:30 am | 10:30 pm |
| Unemployment rate | 6 | 8:30 am | 10:30 pm |
| Current account | 2 | 8:30 am | 10:30 pm |
| FOMC announcements | 4 | 2:15pm (D-1) | 4:15 am |
| Eurozone announcements (total = 51) | | | |
| CPI | 12 | 11:00 am | 7:00 pm |
| GDP | 6 | 11:00 am | 7:00 pm |
| Trade balance | 8 | 11:00 am | 7:00 pm |
| Retail trade | 6 | 11:00 am | 7:00 pm |
| Unemployment rate | 6 | 11:00 am | 7:00 pm |
| Current account | 4 | 11:00 am | 7:00 pm |
| Employment | 3 | 11:00 am | 7:00 pm |
| ECB announcements | 6 | 1:45 pm | 9:45 pm |
| Japanese announcements (total = 38) | | | |
| CPI | 6 | 8:30 am | 9:30 am |
| GDP | 4 | 8:50 am | 9:50 am |
| Trade balance | 6 | 8:50 am | 9:50 am |
| Retail trade | 6 | 8:50 am | 9:50 am |
| Unemployment | 6 | 8:30 am | 9:30 am |
| Tankan survey | 1 | 8:50 am | 9:50 am |
| BOJ announcements | 9 | 11:00 am – 1:00 pm | 12:00 am – 2:00 pm |

Notes: The frequency of news reported correlates to the data samples containing 37716 observations before the exclusion of non-trading intervals. The exclusion of non-trading intervals leads to the omission of 5 macro announcements in the indicative and inside quote data sample and 6 macro announcements in the trade data sample. BOJ's announcements do not have a set time but usually fall between 11am – 1pm local time.

Table 4. The aggregate news model

The table below presents the results from estimation of the ARMAX($p$,$q$) for Model 1: The aggregate model.

$$RV_{t,i} or Vlm_{t,i} = \alpha_0 + \sum_j b_j UNews_{t,i-j} + \sum_j c_j SNews_{t,i-j} + \sum_g d_g Vlm_{t,i-g} + \sum_p e_p RV_{t,i-p} + \varepsilon_{t,i} + \sum_q f_q \varepsilon_{t,i-q} \quad (1)$$

| Panel A: Volatility | | | Panel B: Volume | | |
|---|---|---|---|---|---|
| | Coeff[a)] | p-value | | Coeff[a)] | p-value |
| Constant[b)] | 0.664*** | {0.0000} | Constant[b)] | 2.4707*** | {0.0000} |
| Unscheduled | | | Unscheduled | | |
| Lead 6 | 0.0208*** | {0.0015} | Lead 6 | 0.0403*** | {0.0000} |
| Lead 5 | 0.0056 | {0.4159} | Lead 5 | 0.0351*** | {0.0000} |
| Lead 4 | 0.0200*** | {0.0038} | Lead 4 | 0.0509*** | {0.0000} |
| Lead 3 | 0.0215*** | {0.0019} | Lead 3 | 0.0753*** | {0.0000} |
| Lead 2 | 0.0095 | {0.1719} | Lead 2 | 0.0681*** | {0.0000} |
| Lead 1 | 0.0216*** | {0.0020} | Lead 1 | 0.0738*** | {0.0000} |
| Lag 0 | 0.0187*** | {0.0074} | Lag 0 | 0.0856*** | {0.0000} |
| Lag 1 | 0.0157** | {0.0243} | Lag 1 | 0.0756*** | {0.0000} |
| Lag 2 | 0.0030 | {0.6689} | Lag 2 | 0.0585*** | {0.0000} |
| Lag 3 | 0.0169** | {0.0157} | Lag 3 | 0.0641*** | {0.0000} |
| Lag 4 | -0.0031 | {0.6504} | Lag 4 | 0.0384*** | {0.0000} |
| Lag 5 | 0.0071 | {0.2992} | Lag 5 | 0.0385*** | {0.0000} |
| Lag 6 | 0.0024 | {0.7182} | Lag 6 | 0.0316*** | {0.0000} |
| Macro news | | | Macro news | | |
| Lead 6 | 0.0252 | {0.6503} | Lead 6 | 0.0580 | {0.2998} |
| Lead 5 | 0.1354** | {0.0203} | Lead 5 | 0.1913*** | {0.0014} |
| Lead 4 | 0.0186 | {0.7538} | Lead 4 | 0.2391*** | {0.0001} |
| Lead 3 | 0.1340** | {0.0254} | Lead 3 | 0.1618*** | {0.0099} |
| Lead 2 | 0.2771*** | {0.0000} | Lead 2 | 0.2189*** | {0.0005} |
| Lead 1 | 0.4030*** | {0.0000} | Lead 1 | 0.4105*** | {0.0000} |
| Lag 0 | 0.3482*** | {0.0000} | Lag 0 | 0.2356*** | {0.0002} |
| Lag 1 | 0.2081*** | {0.0006} | Lag 1 | 0.1211* | {0.0578} |
| Lag 2 | 0.1854*** | {0.0020} | Lag 2 | 0.1602** | {0.0115} |
| Lag 3 | 0.1409** | {0.0187} | Lag 3 | 0.0495 | {0.4303} |
| Lag 4 | 0.1769*** | {0.0029} | Lag 4 | 0.2018*** | {0.0011} |
| Lag 5 | -0.1671*** | {0.0042} | Lag 5 | 0.0520 | {0.3856} |
| Lag 6 | -0.0689 | {0.2148} | Lag 6 | 0.0188 | {0.7372} |
| Panel C: Volatility diagnostics | | | Panel D: Volume diagnostics | | |
| BIC Selected ARMAX | | ARMAX (8,10) | BIC Selected ARMAX | | ARMAX (10,9) |
| BIC | | 431 346.98 | BIC | | 432 808.42 |
| Log likelihood | | -38 089.43 | Log likelihood | | -38826.55 |
| Adjusted $R^2$ | | 0.4995 | Adjusted $R^2$ | | 0.7283 |
| Q(10) | | 1.3170 (0.9994) | Q(10) | | 3.7313 (0.9587) |
| Observations | | 33 827 | Observations | | 33 827 |

Notes: a) Significance at the 1%, 5% and 10% significance levels is signified by ***, ** and * respectively. b) For presentation purposes, the autoregressive component, the white noise component and volume (volatility) for the volatility (volume) model are not presented.

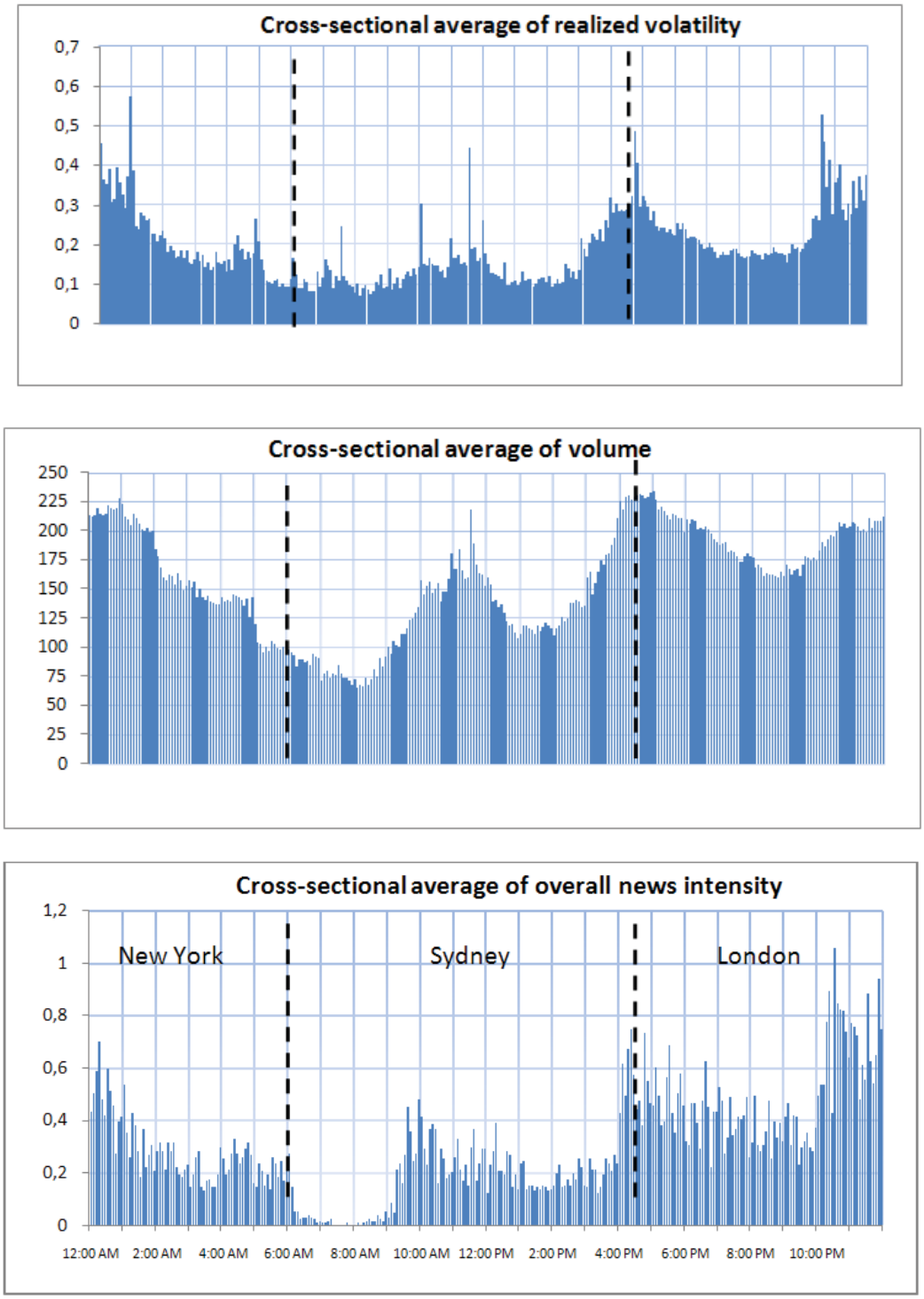
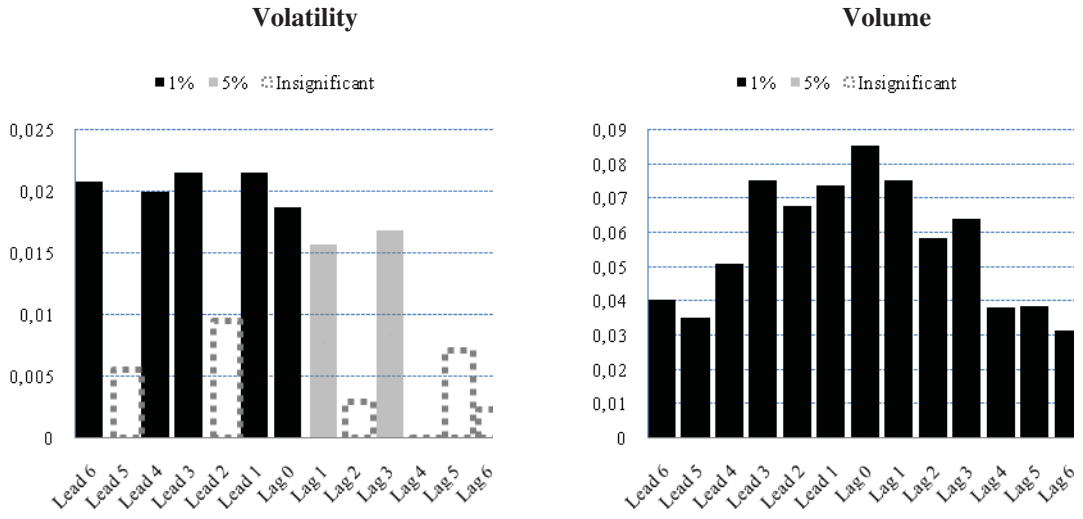



**Fig. 1. Cross-sectional average of FX data sets**

**Panel A: Aggregate unscheduled news**




**Panel B: Aggregate scheduled news**

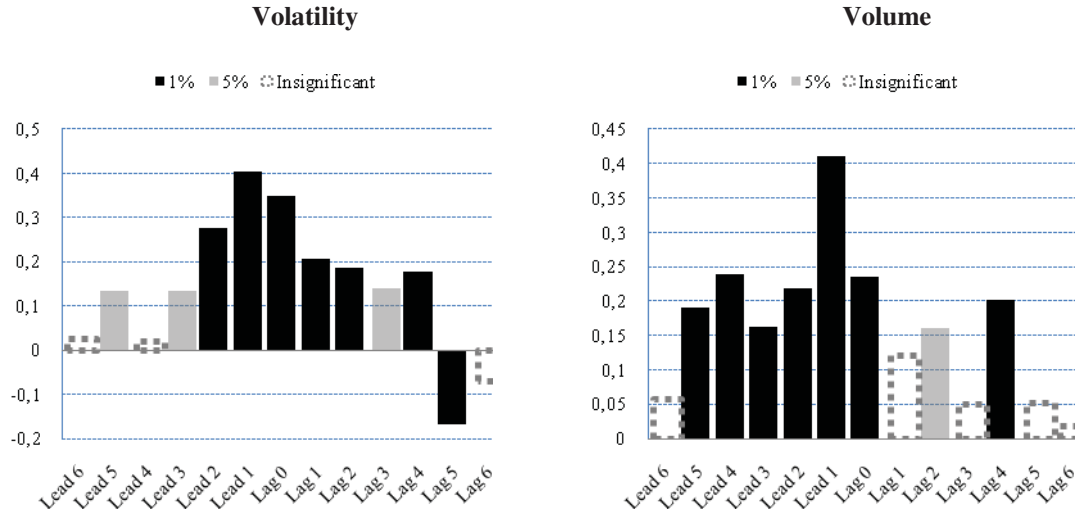
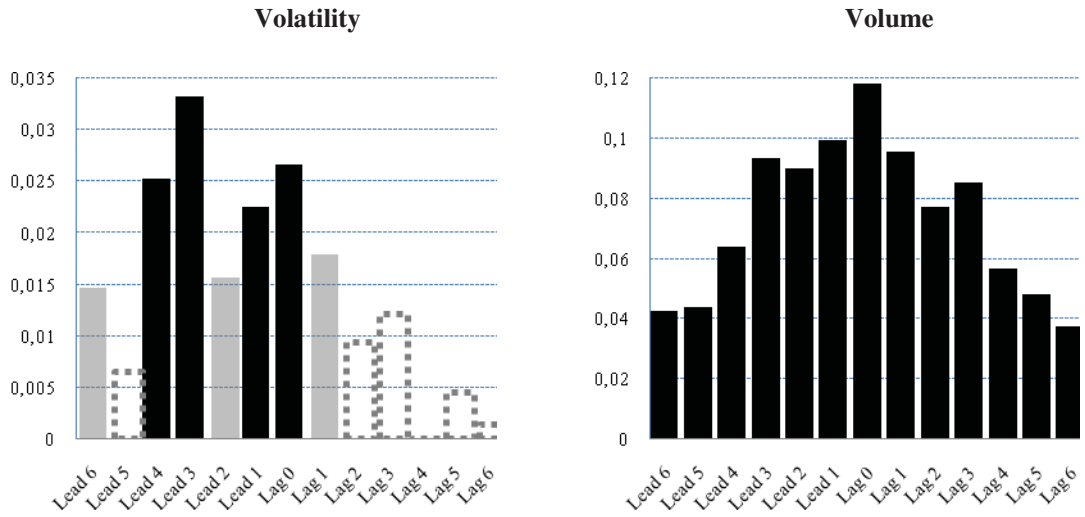



**Fig. 2. Aggregate news effects on volatility and volume**

**Panel A: Disaggregate unscheduled news - offshore news**




**Panel B: Disaggregate unscheduled news - onshore news**

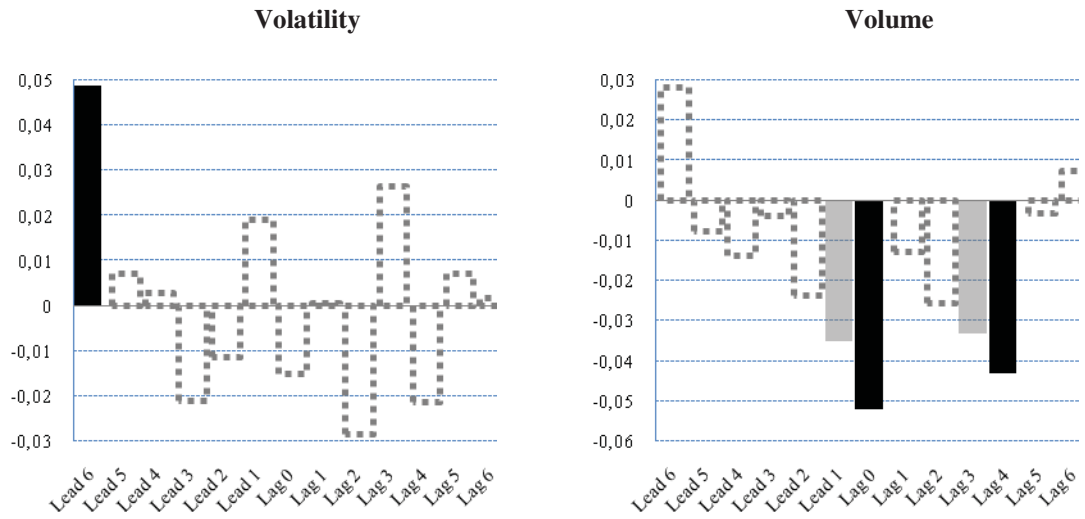



**Fig. 3. Disaggregate unscheduled news effects on volatility and volume**

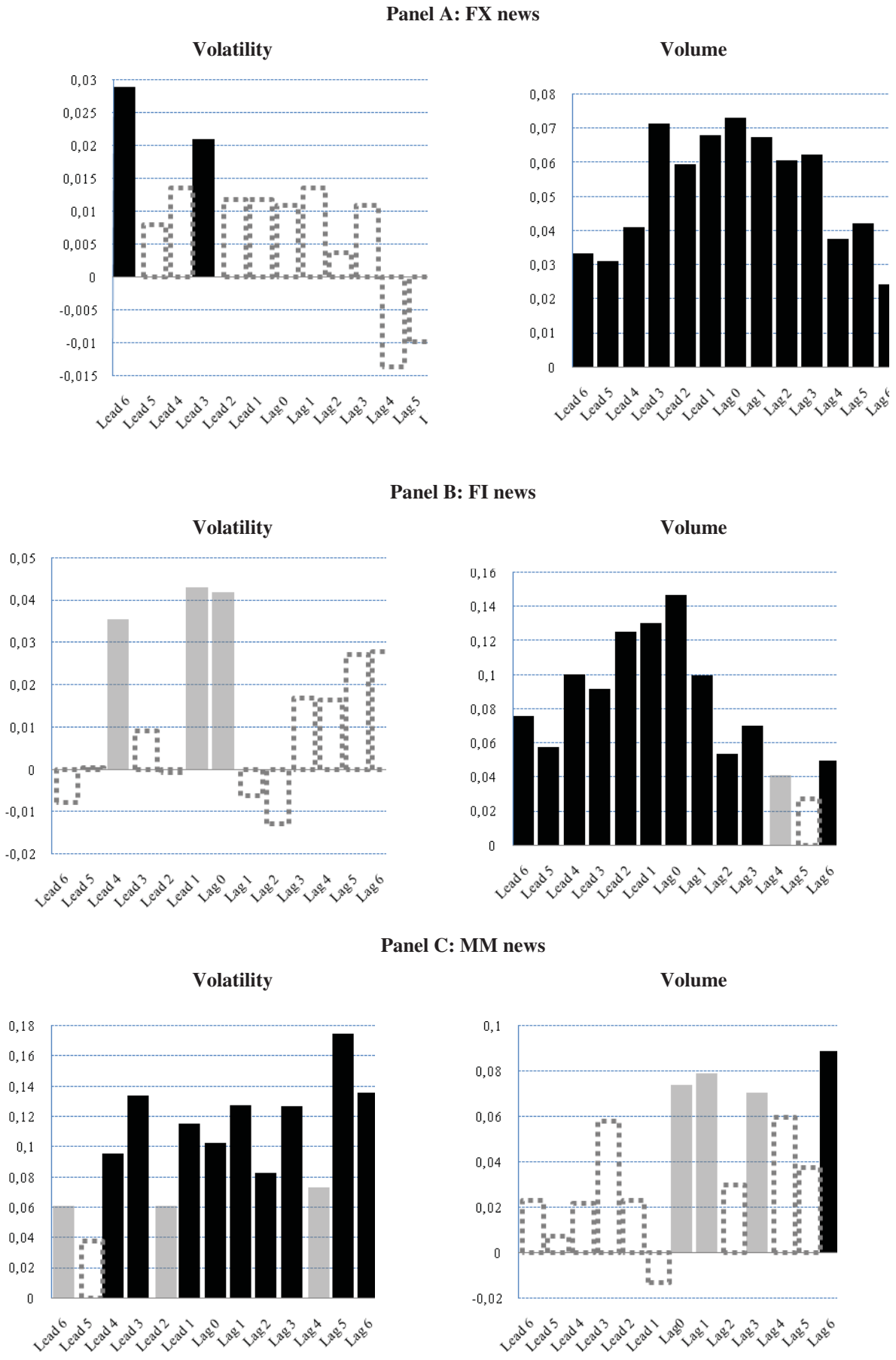



**Fig. 4. Decomposition unscheduled Reuters news (by news category)**

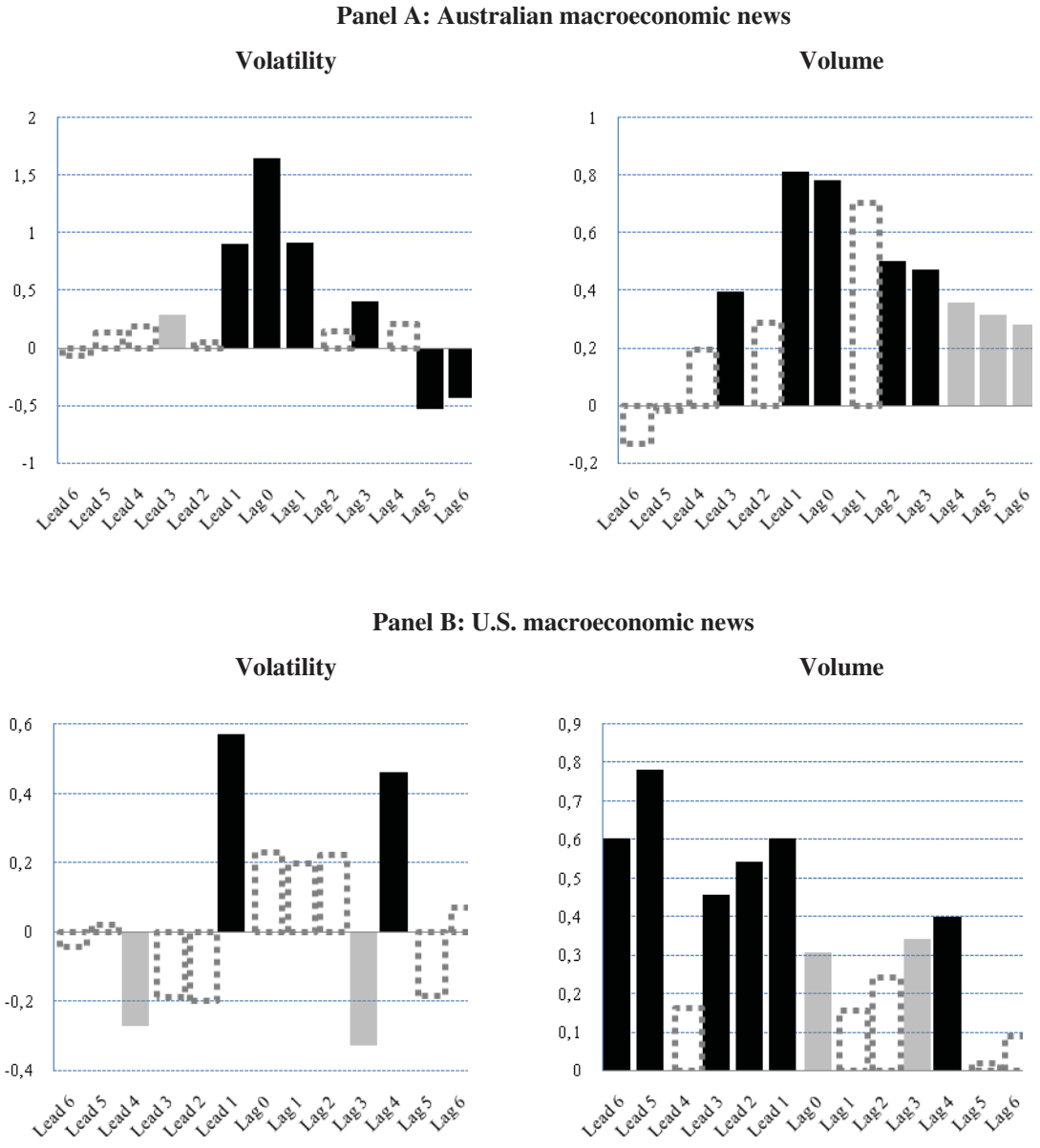



**Fig. 5. Decomposition of macroeconomic announcements**