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Abstract

This paper provides comprehensive evidence on the spillover effects of the U.S. Fed's and the European Central Bank (ECB)'s target interest rate news on the market returns and return volatilities of twelve stock markets in the Asia-Pacific over the period 1999-2006. The news spillover effects on the returns are generally consistent with the literature where a majority of stock markets shows significant negative returns in response to unexpected rate rises. Whilst the results of the speed of adjustment for the Fed's news are mixed across the markets, the ECB news was absorbed slowly, in general. The return volatilities were higher in response to the interest rate news from both sources. In addition, both the Fed and the ECB news elicited tardy or persisting volatility responses. These findings have important implications for all levels of market participants in the Asia Pacific stock markets.

JEL classification: E44; G14; G15

Keywords: Target interest rate news; Spillover effects; U.S. Fed; ECB

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1. Introduction

Since the abandonment of monetary aggregate targeting in the mid-1980s, central banks of advanced countries have moved to directly targeting policy interest rates. These policy rates are formally announced and any change thereof constitutes an adjustment in the monetary policy stance. Financial market participants must take positions based upon their expectations on the impending announcements of a central bank's target interest rate stance. This expectation is already factored into the market prices observed immediately prior to the announcement. If the actual target rate announcement is different from that already priced, markets would react to this surprise component accordingly (for the U.S. Fed's news impacts on the U.S. markets, among others, see Bernanke and Blinder, 1992; Kuttner, 2001; Bonfim, 2003; and Bernanke and Kuttner, 2005).

In addition, interest rate announcements of major central banks may have spillover impacts on other countries' financial markets. Considering the leadership role played by the U.S. markets, any new information on the Fed's interest rate policies would have both direct and indirect influences on other stock markets around the world. The indirect influence is via the influence of the U.S. stock market movements resulting from the news announcement on the stock returns in other countries. The literature has provided ample evidence for the information leadership of the U.S. markets, and its influence in the Asia-Pacific in particular (*inter alia* Arshanapalli et al., 1995; Liu et al., 1998; Liu and Pan, 1997; Ghosh et al, 1999; Ng, 2000; Miyakoshi, 2003; Kim, 2003, 2005; Phylaktis and Ravazzolo, 2005). Thus, to the extent that the U.S. stock market responds significantly to the Fed's news and that the stock markets in other countries look to the U.S. for market momentum, there is potential for the Fed's news to be significantly priced in other markets.

The direct influence of the Fed's interest rate news can be examined by investigating the extent to which markets in other countries respond directly to the news over and above the documented overall influence of the U.S. stock index movements. The spillover effects of the Fed's news have been a topic of interest not only to policy makers but also to market participants alike. Thus far, there are only a handful of studies that examine the direct influence of the Fed's news on the financial markets of other countries. Wongswan (2006, 2008) provide a mixed evidence on the Fed's interest news spillover effects on the stock market returns in a number of countries. Ehrmann and Fratzscher (2006) report that the U.S. monetary policy shocks have a negative impact on the returns of fifty equity markets including the twelve Asia-Pacific markets examined in this paper. However, none of these papers examines the Fed's target interest rate news spillover effects on the volatility of market returns in a number of other countries.[1] This is a significant oversight because the news does not only affect the direction of market movements in these countries (first moment influence) but also influences the trading environment, and hence the level of volatility (second moment effect). Another oversight in the literature is the lack of investigation of the spillover effects of the European Central Bank's (ECB) interest rate news. Given the increasing prominence of the euro area's equity markets, there is a strong potential for spillover impacts of the ECB's news in the stock markets of other regions. In particular, considering the growing bilateral flows of trade and financial investments between the euro area and the Asia-Pacific[2], the

[1] However, there is limited evidence of the Fed's target rate surprises increasing the Irish equity market volatility (Bredin et. Al., (2005).

[2] The EU is the largest trading partner for Australia and China; second largest trading partner for Hong Kong, New Zealand, Taiwan, and Thailand; the third for Indonesia, Japan, Malaysia, and Singapore; and the fourth for Korea and the Philippines (see http://ec.europa.eu/trade/issues/bilateral/data.htm).

ECB's monetary policy decisions are keenly monitored by the market participants in the latter. In addition, the literature is silent on how quickly the news from these two central banks are absorbed in foreign stock markets.

Our motivation in this paper is to address these important shortfalls in the literature and provide comprehensive evidence on the existence and the nature of the transmission of the Fed's and the ECB's policy interest rate news in the Asia Pacific. We investigate the direct news effects on the first two moments of the stock market returns in twelve Asia-Pacific countries for the period January 1999 to December 2006.

Our contributions to the literature are in many dimensions. First, we report extensive evidence of the direct effects of the U.S. Fed's and the ECB's target rate news in the Asia Pacific. We establish not only the presence of the news effects but also document additional contributions of the news that are significant over and above the documented overall index return information spillovers from the two markets. We also investigate the potential of heterogeneity of the directions of the news impacts and the varying degrees of strengths of responses across the twelve countries. Second, we provide comprehensive evidence of the news effects on the second moments of stock returns to see if the news significantly increase or decrease volatility in the Asia Pacific. Third, we investigate the news effects across both overnight and intradaily holding periods of the Asia Pacific markets and this allows us to investigate the potential differences of the speeds of the news absorption across the region.

To the best of our knowledge, this paper is the first research that reports such comprehensive target interest rate news spillovers effects from the U.S. Fed and the ECB in terms of not only establishing the first and second moment effects but also detailing the country specific responses in (i) the directions and the strengths of the news effects and (ii) the varying degrees of speed of market adjustments to the news.

The key findings of this paper are summarized as follows. First, in general, the Asia Pacific stock market returns fell (rose) significantly in response to unexpected interest rate rises (cuts) from both the Fed and the ECB which is largely consistent with the previous literature. Second, the interest rate news from the two central banks significantly raised the return volatility in most of the markets. Third, both the Fed and the ECB news were absorbed gradually leading to tardy or persisting volatility responses. These results are robust when we control for the joint impact of the Fed's and the ECB's policy rate news.

The rest of the paper is organized as follows. Section 2 discusses data and empirical modeling issues, Section 3 reports and analyzes the estimation results, and Section 4 concludes the paper.

2. Data and empirical modeling issues

2.1. Monetary policy announcement data

Since 1994, the Federal Open Market Committee (FOMC) in the U.S. has been announcing the Fed funds target rate after its regularly scheduled (eight meetings a year) and *ad hoc* meetings at 2:00 pm U.S. Eastern Standard Time (EST, GMT-5) unless otherwise specified. For the ECB, the interest rate on the main refinancing operations (MRO) is perceived to be the target policy interest rate as it plays a pivotal role in pursuing the ECB's open market operations. Although the governing council meets twice a month, it normally makes a monetary policy decision at the first of the two meetings, after which a press release announcing the decision on the key ECB interest rate is made at 1:45 pm Central European

Time (CET, GMT+1). Thus, the ECB's governing council has aligned its policy interest rate decision frequency closely with that of the Fed. [3]

The target interest rate data of the two central banks were obtained from their respective websites.[4] Panel A of Table 1 reports the breakdown of target rate announcements into rate rises, rate falls and unchanged sub-components. From January 1999 to December 2006, the Fed and the ECB made 69 and 131 target rate announcements, respectively. Of these, the Fed had 19 announcements with rate changes (13 rate rises and 6 cuts) and 50 with no changes. The ECB made 21 announcements of the target rate changes (13 rises and 8 cuts) and 110 with no change. Thus, most of the interest rate announcements contained no change (72% for the Fed and 84% for the ECB).

In order to examine the extent to which unexpected changes in a direction or the extent of target rate movements affect financial markets, it is necessary to model properly the news component of the announcements. Some of the earlier studies employed market survey expectations to proxy for expected target rate announcements (e.g. Reinhart and Simin, 1997). However, recent studies have instead relied on market price-based proxies. Krueger and Kuttner (1996) find that the Fed funds futures rate is an efficient predictor of the Fed funds target rate and therefore an appropriate market-based measure of policy expectations. This finding is later confirmed by Gürkaynak et. al. (2002). Kuttner (2001) uses the Fed funds

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[3] This is the case since November 8, 2001 as announced by the President of the ECB. However, the governing council can still decide to change the target rate at any time regardless of previously scheduled meetings if needed.

[4] These data are available at http://www.federalreserve.gov/FOMC/#calendars for the Fed, and http://www.ecb.int/stats/monetary/rates/html/index.en.html for the ECB.

futures rates to separate the target rate changes into anticipated and unanticipated components. He finds that the responses of the U.S. Treasury bill, note and bond yields to anticipated changes in the target rate are small, while the responses to unanticipated changes are large and significant. Bomfim (2003) extends Kuttner (2001) to asset return volatilities and finds that asset returns are more volatile following announcements containing unexpected rate changes.

The early literature on the ECB's news employed price-based proxies to gauge the market expectations on the ECB's target rate announcements. However, the choice of market instruments differs across researchers. Gaspar et al. (2001) use EONIA (Euro OverNight Index Average, the effective overnight reference rate for the Euro) to gauge the probability attached to a change in the ECB's target interest rate before the governing council's meeting. Perez-Quiros and Sicilia (2002) propose a principal components approach that utilizes the daily changes of different money market interest rates including the EONIA, the one-week, one-, two- and three-month EONIA swap rates and the closest three-month EURIBOR futures rates. Their approach is to extract the key common component that shapes the evolution in all the above rates. Würtz (2003) measures the interest rate change expectations from the forward rate implied by the one- and two-month EONIA swap rates. However, due to the high volatility and the impacts of liquidity considerations rather than the monetary policy considerations as identified by Bindseil (2002) in underbidding scenarios, it seems that the EONIA is not the best proxy for the market expectation on the ECB's upcoming interest rate announcements. More recently, Ehrmann and Fratzscher (2003, 2005) utilize the Reuters's survey of 25-30 market participants conducted on the Friday before each meeting of the ECB's governing council as a proxy for the market expectations on the upcoming interest rate decision. However, Bernoth and Von Hagen (2004) find that the three-month EURIBOR futures rate is an unbiased predictor of the euro area policy rate changes. Thus, the literature suggests that a market-based approach using futures rates would provide us with the market's

unbiased expectations on the upcoming interest rate announcements. In this paper, we employ Kuttner (2001)'s methodology to generate the unexpected components of the two central banks' target rate announcements. We use the current-month Fed funds futures contracts traded on the Chicago Board of Trade (CBOT) to extract the Fed's news, and the three-month EURIBOR futures contracts traded on the EUREX for the ECB's surprises.[5]

The news component of the Fed's target rate announcement on day *d* of month *m* can be derived from the implied change in the price of the futures contract. Since the Fed funds futures settlement price is based on the monthly average of the spot Fed Funds rate, it is necessary to account for the number of days affected by the announcement in that particular month as in equation (1). The 3-month EURIBOR futures settlement price is based on the reference interest rate (EURIBOR) for three-month euro term deposits on the last trading day, and so the news component of the ECB's target interest rate announcement is calculated as in equation (1) without the scaling factor *D*/(*D*-*d*).

$$\Delta i^{u} = \frac{D}{D-d}\left(f^{0}_{m,d} - f^{0}_{m,d-1}\right) \tag{1}$$

where: Δi^{u} is the unexpected target rate change; $f^{0}_{m,\,d}$ is the current month Fed funds futures rate for the Fed and three-month EURIBOR futures rate for the ECB; $f^{0}_{m,\,d-1}$ is the futures rate on the day prior to the announcement; *D* is the number of days in the month; and *D*-*d* is the number of days in the month affected by the announcement.

Panel B of Table 1 reports the summary statistics for the interest rate news series. While 35% of the Fed's interest rate announcements were correctly anticipated, only 26% of

[5] Although 1-month EONIA and EURIBOR futures are better proxies, the former was introduced only on January 27, 2003, and the latter was delisted on March 16, 2004, hence they are not practical for our study.

the ECB's interest rate announcements were correctly expected. Whereas more negative than positive surprises were observed for the ECB (44% compared with 31%), there were more positive than negative surprises for the Fed (36% compared to 29%). On average, the Fed's and the ECB's target rate change announcements were lower than the market's expectation (-0.0639 and -0.0050 percent, respectively). The variance of the ECB's news is much lower than that of the Fed's (0.0009 and 0.1027 respectively). Furthermore, the news series demonstrate strong evidence of negative skewness and leptokurtosis.

2.2. Asia Pacific stock index returns

While most of the previous studies utilize daily closing data to explore the impacts of the target rate shocks, we employ market opening and closing prices to disaggregate the daily investigation horizon into overnight and intradaily periods. We obtained from Bloomberg daily open and close prices of the stock indices of twelve Asia-Pacific countries: Australia, China, Hong Kong, Indonesia, Japan, Korea, Malaysia, New Zealand, the Philippines, Singapore, Taiwan and Thailand for the period January 1999 to December 2006.[6] We calculate stock index returns over three time horizons. These are daily horizon (H0) of close to close from day *t-1* to day *t*; Overnight horizon (H1) of close to open from day *t-1* to day *t*; and Intradaily horizon (H2) of open to close on day *t*. Since both the Fed's and the ECB's

[6] The stock indices examined are Standard & Poors/Australian Stock Exchange 200 (S&P/ASX 200), Shanghai Stock Exchange Composite, Hang Seng, Jakarta Stock Exchange Composite Index, NIKKEI 225, Korea Exchange 100, Kuala Lumpur Stock Exchange Composite, New Zealand Exchange Limited 50 Free Float Total Return Index, Philippine Stock Exchange Index, Straits Times Index, Taiwan TWSE and Stock Exchange of Thailand Index. Due to data limitations, data for New Zealand and Korea are from January 03, 2001, and from April 27, 2004 for Indonesia.

target interest rate announcements were made when the Asia-Pacific markets were closed, H1 captures the Asia-Pacific stock markets' first reaction to the news, whereas H2 captures any delayed reactions during the trading day in the Asia-Pacific.[7]

Panel C of Table 1 reports the summary statistics of the stock market returns across the three horizons. There are significant differences across the three horizons in various aspects. For the mean, in most cases the series have a positive mean for the daily and overnight horizons, and a negative mean for intradaily. In addition, the returns are generally higher during overnight than intradaily. In all cases, the return volatility as measured by the standard errors is higher during overnight than during the other horizons and this is consistent with the literature. In most cases, stock returns are negatively skewed over daily and overnight, and positively skewed over the intradaily horizon. The reverse is observed for the Philippines and China. The Australian stock market returns show a negative skewness over all three horizons. In most cases, the returns exhibit leptokurtosis with the highest excess kurtosis

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[7] Hamao, et al. (1990) suggest that information spillovers from foreign markets would be expected to show up only in the close to open returns as predicted by international asset pricing model. On the other hand, volatility spillovers to the conditional variances of the close to open and open to close horizons can occur. (pp. 282-3). However, we hypothesize that it is possible to have significant responses during the open to close horizon if there are delayed responses to the overnight interest rate news from the Fed and the ECB. We put forward an argument that if the interest rate signal is clear and the individual country's central bank reaction is fairly predictable, then we expect to find the spillover influence only on the mean returns during the close to open horizon as Hamao et at. (1990) suggest. However, if market participants are unsure about their authority's monetary policy responses (whether to follow the overnight leads of the Fed and the ECB and adjust their policy rates in the same direction) or if the implication of the news is unclear, then this indecision may be shown in both the conditional mean and the variance of the open to close returns.

over intradaily except for Japan. Furthermore, the returns show significant serial correlation in the second moments over all three time horizons.

2.3. Empirical modeling

The empirical literature on financial time series shows that the GARCH family of models is well-suited to modeling daily returns series, which are characterized as skewed, leptokurtic and non-normally distributed with time-varying second moments as shown in Table 1. We employ EGARCH(1,1) models to address these characteristics, as a parsimonious specification often outperforms more profligate ones and the exponential specification allows negative coefficients in the conditional variance equation that has an important implication in this study. This methodology also enables us to measure the news and the spillover effects on both the conditional mean and variance of daily returns.[8] In this section, we start with a baseline univariate EGARCH(1,1) model and then progress to specific modeling of the impacts of the Fed's and the ECB's news on the Asia-Pacific stock markets.

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[8] Our decision to adopt the EGARCH framework over the ubiquitous GARCH modeling strategies is because the latter requires the coefficients in the conditional variance equations to be all positive in order to satisfy the positivity constraint of the conditional variance. Thus the latter is incapable of detecting a market calming reaction to the interest rate news which would require a negative news coefficient in the conditional variance equation. The hypotheses we are testing include not only a volatility increasing but also a volatility reducing (market calming) influence of the news. If the former dominates then we would see a positive news coefficient in the second moment and the positivity restriction of GARCH would not be an issue. However, if the market calming influence dominates, then there would be a negative relationship between the news and the conditional variance and so the news coefficient would be expected to be negative. The GARCH models are incapable of detecting this negative relationship. However, the EGARCH specifications allow both positive and negative coefficients and so are better suited to testing the hypotheses of volatility raising and market calming effects of the interest rate news.

The baseline EGARCH (1,1) model employed in our study is described by the conditional mean and the conditional variance equations (2a) and (2b) shown below.

$$y_t = \alpha_c + \alpha_{Lag}\, y_{t-1} + \alpha_{Hol} Hol_t + \varepsilon_t \tag{2a}$$

$$\ln h_t = \beta_c + \beta_h \ln h_{t-1} + \beta_{\varepsilon 1} \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} + \beta_{\varepsilon 2} \frac{|\varepsilon_{t-1}|}{\sqrt{h_{t-1}}} + \beta_{Hol} Hol_t \tag{2b}$$

The conditional mean equation for the returns (y_t) is expressed as a function of a one day lag of returns and a holiday dummy in relevant markets. We elect to include one lag of the dependant variable and this addressed the residual serial correlations in most cases.[9] The holiday dummy accounts for the potential impacts of differences in trading days across stock markets due to market closure. It is assigned to each stock market and takes the number of days of market closure between two successive market prices. For example, for normal consecutive daily observations (i.e. returns calculated over two days – Monday close to

[9] We do not to report the baseline estimation results to save space and focus on the target interest rate news effect. Instead, we provide a summary in this footnote. In general, the holiday dummy tends to reduce returns over H0 and H2 while it has a positive effect during H1. In the conditional variance equations, the lagged variance term (β_h) is close to one in all cases suggesting volatility persistence as found in the literature. There is evidence for an asymmetric influence of the past innovations as shown by a negative $\beta_{\varepsilon 1}$, in all cases for H0 and H1. The volume effect is positive in all cases ($\beta_{\varepsilon 2}>0$) indicating that regardless of sign, the higher is the previous period's unexpected stock movements, the higher is its impact on the conditional variance in the next period. The conditional variances are generally higher on the days immediately following a market closure due to holidays. The serial correlations in the first and second moments of the standardized residuals are removed in all cases by adding more than one lag of the dependent variable in the mean equation and by varying the lag structures of the EGARCH model in the variance equation. However, the news coefficients from these estimations are qualitatively the same as the one we report in this paper. Thus, for consistency, we adopt the same model specification for all twelve stock indices in our investigation.

Tuesday close price) the value of zero is assigned, whereas values of one or higher will be assigned for returns observations calculated over a longer horizon due to market closure. This seasonal dummy helps to control for the days of more intense information flows following a longer period of market closure. The conditional variance equation (h_t) is expressed as a function of one period lags of the variance and the residuals, and the holiday dummy.

To investigate the spillover impacts of the Fed's and the ECB's news on the Asia-Pacific stock market returns and volatilities, we extend the baseline model with a news variable for each of the Fed and the ECB, $News_t$ ($FedNews_t$ for the Fed, and $ECBNews_t$ for the ECB estimated separately). We lag the news variable by one period to account for the time difference between the U.S. and the European trading hours on the one hand and the Asia-Pacific trading hours on the other.

In addition, during the course of a trading day, other macroeconomic announcements from the U.S. and the euro area might arrive. Thus, Asia-Pacific stock markets would also be influenced by these macro announcements in addition to the target interest rate news when they open for trading after the close of the U.S. and the euro area's stock markets. Furthermore, as all macroeconomic announcements of the U.S. and the euro area are released at earlier times in a day than the Fed's and the ECB's target rate announcements,[10] we include a dummy variable ($MacroAnn_{i,t}$) for each of the major macroeconomic announcements only in the conditional variance equation in order to isolate the influence of the target interest rate

[10] The U.S.'s macroeconomic announcements are normally released at 8:30 AM EST, while the euro area's macroeconomic announcements are made at 11:00 CET.

news on these days of multiple information arrivals.[11] For the U.S. we consider the following announcements: GDP, CPI, Unemployment rate, Trade deficit, and Retail sales growth rate. For the ECB's target rate news estimations, we include a dummy for each of the following euro area announcements: GDP, CPI, Unemployment rate, External trade, Current account balance, and Retail trade growth rate.[12] Out of 69 and 131 target rate announcements made by the Fed and the ECB, respectively, 13 and 27 macroeconomic announcements were on the same days as the target rate announcements. This represents 18.84% and 20.61% of the Fed's and the ECB's announcement sample, respectively.

The extended model is shown in equations (3a) and (3b) below:

$$y_t = [\text{RHS of (2a)}] + \alpha_{News} News_{t-1} \tag{3a}$$

[11] We do not include the macro announcement dummies in the conditional mean equations because they represent an average impact of positive and negative macro news (e.g. higher or lower than expected announcements which would have opposite impacts on stock returns). Macro dummies are stripped of sign and as such, macro news coefficients would be difficult to interpret. Disaggregated data would be required to unravel the surprise components of each announcement (deviations of actual from expected figures) and investigate the differential impacts of various aspects of announcements on the first moments of market returns. However, macroeconomic announcements, irrespective of the types of news contents, could influence market volatility in a similar fashion. For example, unexpectedly higher or lower CPI announcements could both increase market volatility if they further increase the level of information uncertainty in the market on the days of CPI announcements. Alternatively, market volatility could be lower in response to both types of news if the release of new information resolves the heterogeneity in market expectations leading to lower levels of market uncertainty. Thus, we use the macro announcement dummies only in the conditional variance equations to control for the second moment effects on the days of macro announcements.

[12] Due to data limitation, we use data on the euro area's macroeconomic announcements from January 2002.

$$\ln h_t = [\text{RHS of (2b)}] + \beta_{News} \left| News_{t-1} \right| + \sum_i \beta_{MacroAnn,i} MacroAnn_{i,t-1} \quad (3b)$$

In general, the target news coefficient in the conditional mean equation is expected to be negative as Wongswan (2006, 2008), Bernanke and Kuttner (2005), Ehrmann and Frantzscher (2006), and Rigobon and Sack (2004) documented for various stock markets. Unexpected interest rate rises from the Fed and the ECB could have similar market depressing influences in the Asia-Pacific (a negative news coefficient) through (i) higher financing costs in general and lower stock prices of cross-listed foreign companies in these markets, and (ii) lower demand for imports from the Asia Pacific.

The news effect on the conditional volatilities would depend on whether the news adds to or resolves uncertainties in the market. As our volatility specification allows negative coefficients in the conditional volatility equation, it is possible to have both positive and negative signs for the interest rate news coefficient, β_{News}. If an unexpected change in the rate leads to further speculation in the market regarding the future direction of the target rate, this heightened heterogeneity would lead to increased trading activities and trading volume, which in turn would lead to higher conditional volatility. If so, we would observe a positive β_{News}. On the other hand, if an unexpected rate change announcement resolves the accumulated heterogeneity in the market and hence reduces the level of uncertainty, a significant volatility reduction would be observed (i.e. a negative β_{News}).

In addition, to the extent that the Fed's rate decisions can influence those of the ECB, it is possible that the impacts of the ECB's rate decisions on the Asia-Pacific stock markets might be weaker as the market participants might regard the ECB's news as less newsworthy. Granger causality tests revealed that there is a strong evidence of the Fed's FOMC Granger causing the ECB's governing council in making interest rate decisions, while the evidence for

the reverse is weak.[13] Thus, it is necessary to control for the other central bank's news effect to check for the robustness of the target rate news impacts, especially in the case of the ECB's news investigation. Equations (4a) and (4b) below include both the Fed's and ECB's target news coefficients ($FedNews_t$ and $ECBNews_t$) and both the US's and the euro area's macroeconomic announcements dummies.

$$y_t = [\text{RHS of (2a)}] + \alpha_{FedNews} FedNews_{t-1} + \alpha_{ECBNews} ECBNews_{t-1} \tag{4a}$$

$$\begin{aligned} \ln h_t &= [\text{RHS of (2b)}] + \beta_{FedNews} \left| FedNews_{t-1} \right| + \sum_i \beta_{USMacroAnn,i} USMacroAnn_{i,t-1} \\ &+ \beta_{ECBNews} \left| ECBNews_{t-1} \right| + \sum_i \beta_{EuroareaMacroAnn,i} EuroareaMacroAnn_{i,t-1} \end{aligned} \tag{4b}$$

The ECB's news coefficient on the mean would be insignificant if the ECB's news is stale when it hits the Asia-Pacific markets. However, if the ECB's news is also relevant its news coefficient is expected to be significant. On the variance equation, the impact of the ECB's news would depend on its supplemental role for the Fed's news in either raising or lowering the level of market uncertainty in the Asia-Pacific.

3. Empirical results

3.1. The U.S. Fed's target interest rate news

The quasi-maximum likelihood estimates of the EGARCH model for the spillover effects of the Fed's and the ECB's target rate surprises as modeled in (3a) and (3b) are reported in Table 2. The impacts of the spillover news effects on the Asia-Pacific stock

[13] Interested readers can obtain Granger causality test results from the corresponding author upon request.

markets are investigated by examining the sign and the magnitude of the news variables in each estimation over different time horizons.[14]

Consistent with the findings in the literature, we find that unexpected hike in the Fed's target rate significantly reduced the Asia Pacific stock market returns, in general. Eight out of twelve stock markets show significant responses to the news and the news coefficient is negative in all cases. We suggest that this may be due to the impact of the Fed's unexpected hike on the financing costs for foreign borrowers, and/or the expected reduction in U.S. demand for imports. Ultimately, these adverse impacts are reflected in significantly lower returns in the Asia-Pacific stock markets. On the other hand, there is mixed evidence on the speed of news absorption. Some markets responded quickly as evidenced by significant news coefficient during H1 only (Hong Kong and Singapore), while in one market (Taiwan) the news effect shows up only during H2.[15] In three other markets (China, Malaysia and Thailand), the new effects are significant during both H1 and H2.

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[14] We also investigated the indirect news effects by including source market index returns (the S&P500 for the U.S. and the DAX and the CAC for the euro area) in equations (3a) and (3b). In Appendix, we report the tests of additional contribution of the direct news effect given this indirect effect. There is some evidence of reduced number of significant direct news effects for the Fed news during H1, but during other horizons for the Fed news and for the ECB news, the additional contributions of the direct news as reported in Table 2 remain significant. This shows that the target interest rate news had a direct impact on the first and the second moments of the stock returns in the Asia Pacific over and above the indirect influence (via U.S. and euro area index spillovers). Interested readers may obtain detailed results upon request.

[15] There is a possibility that in some markets an opening value of the index may not always incorporate active opening prices of all stocks in the index due to delays in some stocks generating opening prices. This may have contributed to the significant responses during the intradaily horizon.

There are also significant volatility responses to the Fed's news. Significant responses are shown in eight out of twelve markets, and except for two markets all show positive news coefficients suggesting significantly higher volatilities in response to the news.[16]. Given the leading role of the U.S. economy, the Asia-Pacific market participants would closely monitor the U.S.'s policy announcements. As such, even when the Asia-Pacific market participants correctly judge the direction of the target rate change they may still be surprised by the magnitude of rate changes. When an unexpected announcements are made homogeneity evaporates which then leads to a higher trading activities and eventually results in a higher volatility. However, in two markets (Hong Kong and Malaysia), the interest rate news shows a volatility calming effect during H0. For Malaysia, there is a mixed response where the volatility was higher during H1 but was lower during subsequent H2.[17]

As for the speed of adjustment to the news, we have some evidence of tardiness in volatility response. In four cases (Indonesia, New Zealand, the Philippines and Singapore),

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[16] We conducted separate estimations for the positive and negative news (unexpected rate rises and falls) effects and found that this volatility increasing effect is coming exclusively from the positive news in four countries (Korea, the Philippines, Singapore and Taiwan), however, in other countries there is no definitive pattern. In addition, we find no consistent patterns for the two types of news for the ECB news.

[17] For brevity, we omit reporting the results of the macroeconomic announcement dummies. Instead, the main results are summarized here. Interested readers might obtain full estimation results upon request. The U.S.'s Macroeconomic announcement dummies show significant influence on the conditional volatilities of Asia-Pacific stock markets' returns. In general, the U.S.'s GDP, Unemployment and Retail sales announcements tend to increase the volatilities of the Asia-Pacific market returns. Meanwhile, CPI announcements tend to reduce volatility in five markets. In addition, we find that the inclusion of the macro dummies does not significantly alter the interest rate news coefficients. We re-estimated all models without the macro announcement dummies and the resulting estimates for the interest rate news coefficients are qualitatively the same.

volatility response is significant only during H2, and during both H1 and H2 in two other cases (Korea and Malaysia).[18]

3.2. The ECB's target interest rate news

Similar to the Fed's new effects, the ECB's news had a negative spillover influence on the conditional means of all twelve stock returns over at least one horizon. We suggest that given the increasing real integration between the Asia-Pacific region and the euro area, an unexpected rise in the ECB's main refinancing rate would have a negative impact on the euro area economic activities leading to an expectation of lower demand for imports from the Asia-Pacific. This could ultimately prove to be a negative influence for the Asia-Pacific stock markets. In general, the ECB's news was absorbed slowly in six markets as shown by the news coefficient being significant only during H2. This is in contrast to what we report for the Fed's news where the results of the speed of adjustment are mixed across the markets. It

[18] During the sample, both the Fed and the ECB went through both tightening and loosening cycles in their policy stance. In order to investigate a potential for differential market responses to these opposite cycles, we conducted subample analyses where the whole sample is split into the expansion and contraction periods. For the Fed the tightening cycle was during Jan 1999 to May 2004 and the expansion phase was during Jun 2004 to Dec 2006. For the ECB, these were Jan 1999 to Apr 2001 and May 2001 to Nov 2005, respectively. For the Fed's news spillovers, there is some evidence to suggest that the sensitivity to the news is larger during the contraction cycle. Although, the signs of the news coefficients are consistent between the two cycles, the magnitudes are larger, in general, for both the first and second moment responses during the tightening period. This suggests that the markets were more sensitive to unexpected movements in the Fed's target rate during the period of rising interest rate cycle. This is consistent with Basistha and Kurov (2008) who report stronger U.S. stock market responses to unexpected rate changes of the Fed during the periods of recessions and tight credit conditions. However, there is no clear evidence for such sample specific market responses to the ECB's news. Detailed results of the subample analyses may be obtained form the authors upon request.

appears that the market participants in the Asia Pacific were less clear on the information contents of the ECB's news, specifically on their additional contribution to tradable information on the heels of the Fed's interest rate movements.

We also find strong evidence for a volatility raising influence of the ECB's target rate news. Five out of twelve markets show a significantly higher volatility in response to the news. On the other hand, China and Singapore show a volatility reducing influence. Considering the volatility stimulating effect of the Fed's news on these two markets as reported above, this market calming effect suggests that the ECB's news helps to resolves the additional uncertainty created by the earlier arrival of the Fed's news in these two markets.

There is some evidence that the volatility response is concentrated or persisting into H2. A significant volatility response is shown only during H2 in four countries (Indonesia, Malaysia, New Zealand and Singapore), and only during H1 for Korea. Further two markets (China and the Philippines) reveal higher volatility during H1 that is persisting into H2.[19]

3.3. Joint spillover effects of the target interest rate news

We investigate the joint spillover effects of the Fed's and the ECB's target rate news as modeled in (4a) and (4b) and the results are reported in Table 3. Overall, the results suggest that the separate investigation results of the Fed's and the ECB's news as reported in the previous sections are robust. In general, while the Fed's news effect (on both moments) and the ECB's news effect on the conditional mean are now marginally weaker, the ECB's news

[19] The euro area's macroeconomic announcements tend to have different impacts on the volatility of the Asia-Pacific stock markets compared to the U.S.'s ones. The euro area's GDP, Unemployment and Current account balance announcements tend to reduce the volatilities while the reverse is observed for CPI and External trade. The Retail trade announcements show mixed impacts with four positive and four negative influences.

effect on the conditional volatility is much stronger with five markets showing a significantly lower volatility. In addition to China and Singapore as reported above, the ECB's market calming effect is now shown in Indonesia, Korea (overnight only) and Malaysia (intradaily only). This finding suggests that the ECB's news contained further information that helped to resolve heterogeneous beliefs caused by the earlier arrival of the Fed's news.

4. Conclusion

In this paper, we documented and discussed the existence and the nature of the transmission of the policy interest rate news from the U.S. Fed and the ECB on the first two moments of the market returns of twelve Asia-Pacific stock markets for the period January 1999 to December 2006. The U.S. and the euro area economies are the two most important economic blocs in the world and their monetary policy shocks have been reported to elicit significant stock market movements not only in their respective markets but also in others. This paper makes significant contribution to the literature by providing comprehensive evidence on the spillover effects of these interest rate news in the stock markets of the Asia-Pacific region.

In general, we reveal that the spillover news effects of both the Fed's and ECB's news on the Asia-Pacific market returns are generally consistent with the literature where a majority of stock markets show negative returns in response to unexpected rate hikes, and there is some evidence that the ECB's news is absorbed slowly. This might be to some extent due to a supplementary role of the ECB's news in the Asia-Pacific stock markets.

In addition, we report significant volatility responses to the interest rate news from the two central banks, and to our best knowledge, this paper is the first to document comprehensive empirical evidence on volatility spillovers. Unexpected hikes in the Fed's and the ECB's target rates increased the return volatility in most of the Asia-Pacific stock markets.

Although the ECB's interest rate decisions may have been influenced by those of the Fed, the ECB's news was also an important informational provider in the Asia-Pacific. We also report, in general, tardy volatility responses. In most of the markets, the volatility response was significant only during the intradaily trading hours. In other cases, both interest rate news elicited a significant volatility response during the overnight horizon that persisted into the intradaily trading hours.

These findings have important implications for policy makers and market participants alike. A worthwhile extension of this research would be to examine the spillover effects of the Fed's and the ECB's target rate news on various segments of the Asia-Pacific financial markets including money, debt and foreign exchange markets. Furthermore, we report that macroeconomic announcements from the two economic blocs have significant volatility consequences for the Asia-Pacific stock markets. Therefore, an in-depth analysis of the role of the U.S.'s and the euro area's macroeconomic news on the Asia-Pacific markets would make further contributions to the literature. We reserve these avenues for future studies.

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Table 1 - Descriptive statistics

This table reports descriptive statistics for the U.S. Fed's and the ECB's target interest rate announcements (Panel A), the surprise components (Panel B) and the Asia-Pacific stock index returns series (Panel C) for the period January 1999 to December 2006.

Panel A. Target interest rate announcements

	Fed funds target rate announcements				ECB target rate announcements			
	Total	**Rate rise**	**Rate cut**	**No change**	**Total**	**Rate rise**	**Rate cut**	**No change**
No. of announcements	69	13	6	50	131	13	8	110
Proportions	(100%)	(19%)	(9%)	(72%)	(100%)	(10%)	(6%)	(84%)

Panel B. Target interest rate surprises

	Fed funds rate surprises				ECB policy surprises			
	Total	**Positive suprises**	**Negative surprises**	**No surprise**	**Total**	**Positive suprises**	**Negative surprises**	**No surprise**
No. of observations	69	25	20	24	131	40	57	34
Proportions	(100%)	(36%)	(29%)	(35%)	(100%)	(31%)	(44%)	(26%)
Summary statistics								
Mean	-0.0639	0.0994	-0.3447		-0.0050	0.0223	-0.0270	
Variance	0.1027	0.0075	0.2349		0.0009	0.0006	0.0007	
Skewness	-3.5799	0.8090	-1.8831		-0.2408	3.9062	-2.1255	
Excess Kurtosis	18.6141	2.1375	6.4368		10.3984	20.5803	7.3462	
Min	-1.9140	0.0055	-1.9140		-0.1300	0.0100	-0.1300	
Max	0.2760	0.2760	-0.0050		0.1500	0.1500	-0.0100	

Note: The numbers of surprises shown in Panel B are different from the actual rate change announcements for both central banks. This is because even when there was no rate change announcement, markets might have expected a rate rise or fall and so the surprise component is non zero.

Table 1 - Descriptive statistics (Continued)

Panel C. Stock market returns

	Australia			China			Hongkong			Indonesia		
	H0	**H1**	**H2**	**H0**	**H1**	**H2**	**H0**	**H1**	**H2**	**H0**	**H1**	**H2**
No. of observations	2084	2084	2084	2084	2084	2084	2084	2084	2084	698	698	698
Mean	0.0352	0.0421	-0.0071	0.0387	0.0206	0.0182	0.0330	0.0631	-0.0297	0.1144	0.0861	0.0282
Std. deviation	0.7200	0.8060	0.3507	1.3588	1.5893	0.5659	1.3268	1.5508	0.7740	1.2318	1.2698	0.4558
Skewness	-0.5415	-0.2841	-0.0425	0.5900	0.9240	-3.2757	-0.2728	-0.0823	0.3994	-0.9368	-1.1398	1.6434
Kurtosis	3.7404	3.1327	11.2917	5.6265	7.3291	57.2628	3.6180	2.2099	6.5412	5.8670	5.7333	17.9737
Jarque-Bera	1316.70	880.21	11077.42	2869.85	4960.84	288593.99	1162.47	426.41	3772.56	1103.21	1107.11	9723.56
Ljung-Box Q test												
Return	20.1589	112.4802 ***	83.8408 ***	35.1171 **	79.5264 ***	719.7540 ***	21.6317	209.8833 ***	25.0182	25.8521	43.9239 ***	29.7625 *
P-Value	{0.4480}	{0.0000}	{0.0000}	{0.0195}	{0.0000}	{0.0000}	{0.3608}	{0.0000}	{0.2007}	{0.1708}	{0.0015}	{0.0738}
Volatility	241.7752 ***	487.0293 ***	2838.2129 ***	237.5584 ***	234.8783 ***	117.1691 ***	340.1265 ***	503.7688 ***	189.0722 ***	155.7645 ***	156.0778 ***	58.4805 ***
P-Value	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}

	Japan			Korea			Malaysia			New Zealand		
	H0	**H1**	**H2**	**H0**	**H1**	**H2**	**H0**	**H1**	**H2**	**H0**	**H1**	**H2**
No. of observations	2084	2084	2084	1562	1562	1562	2084	2084	2084	1562	1562	1562
Mean	0.0120	0.0574	-0.0455	0.0695	0.1731	-0.1034	0.0297	0.0514	-0.0209	0.0565	0.0651	-0.0097
Std. deviation	1.3512	1.4398	0.5803	1.6552	2.4608	1.8129	1.0175	1.1030	0.3805	0.6725	0.8347	0.5191
Skewness	-0.1171	-0.0824	0.0590	-0.4191	-0.3460	0.4165	-0.1592	0.4549	-1.1818	-0.6334	-0.2064	0.9222
Kurtosis	1.8822	1.0871	1.7939	4.1435	1.9268	2.7251	6.4206	9.9974	58.1411	5.4663	5.2015	17.5585
Jarque-Bera	312.37	104.97	280.79	1163.10	272.80	528.81	3588.42	8750.68	294156.58	2049.16	1771.98	20299.70
Ljung-Box Q test												
Return	14.1155	79.6269 ***	37.3035 **	23.2339	496.3204 ***	84.9173 ***	96.8672 ***	154.5961 ***	105.7054 ***	38.3396 ***	300.2574 ***	84.5225 ***
P-Value	{0.8246}	{0.0000}	{0.0108}	{0.2775}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0080}	{0.0000}	{0.0000}
Volatility	306.3368 ***	253.6935 ***	127.8315 ***	120.2963 ***	354.3115 ***	203.2037 ***	594.8878 ***	516.0267 ***	57.5496 ***	276.9891 ***	943.5128 ***	636.6785 ***
P-Value	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}

	Philippines			Singapore			Taiwan			Thailand		
	H0	**H1**	**H2**	**H0**	**H1**	**H2**	**H0**	**H1**	**H2**	**H0**	**H1**	**H2**
No. of observations	2084	2084	2084	2084	2084	2084	2084	2084	2084	2084	2084	2084
Mean	0.0190	0.0313	-0.0124	0.0362	0.0992	-0.0632	0.0089	0.1181	-0.1083	0.0310	0.0939	-0.0627
Std. deviation	1.2974	1.3884	0.4869	1.1634	1.3432	0.6099	1.5668	1.9545	0.9434	1.5411	1.6144	0.6260
Skewness	1.5492	1.4065	-5.0148	-0.3801	-0.0058	1.4045	-0.0780	-0.4690	0.7083	-0.1760	-0.1276	3.3490
Kurtosis	21.6387	15.8593	118.6021	4.8030	3.9919	22.1588	3.0127	3.2690	5.1557	9.8920	7.8058	45.8782
Jarque-Bera	41491.76	22527.08	1230761.57	2053.33	1383.73	43342.38	790.23	1004.31	2483.56	8507.47	5296.39	186753.05
Ljung-Box Q test												
Return	50.9570 ***	173.6484 ***	40.2383 ***	27.7714	161.7326 ***	28.0720	44.0922 ***	179.1819 ***	96.7493 ***	41.7871 ***	75.2960 ***	49.1880 ***
P-Value	{0.0002}	{0.0000}	{0.0047}	{0.1149}	{0.0000}	{0.1077}	{0.0015}	{0.0000}	{0.0000}	{0.0029}	{0.0000}	{0.0003}
Volatility	15.7768	250.4691 ***	32.3908 **	291.1947 ***	517.2748 ***	50.8729 ***	569.8466 ***	776.3626 ***	542.9126 ***	184.6199 ***	215.9278 ***	73.0767 ***
P-Value	{0.7304}	{0.0000}	{0.0393}	{0.0000}	{0.0000}	{0.0002}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}

Note: *, **, *** denotes significance at 10%, 5% and 1%, respectively.

Table 2 – The target interest rate news spillover effects

This table reports the estimation results of the EGARCH models described in (3a) and (3b) for Asia-Pacific stock markets' daily returns against the overall surprises of the Fed. H0 is daily horizon over the close on calendar day *t-1* to the close on calendar day *t*; H1 is overnight horizon over the close of day *t-1* to the open on day *t*; and H2 is intradaily horizon measured over the open on day *t* to the close on day *t*. P-values are in braces.

$$y_t = [\text{RHS of (2a)}] + \alpha_{News} News_{t-1} \quad (3a)$$

$$\ln h_t = [\text{RHS of (2b)}] + \beta_{News} \left| News_{t-1} \right| + \sum_i \beta_{MacroAnn,i} MacroAnn_{i,t-1} \quad (3b)$$

	The Feds' target interest rate news spillover effects						The ECB' target interest rate news spillover effects					
	$\alpha_{FedNews}$			$\beta_{FedNews}$			$\alpha_{ECBNews}$			$\beta_{ECBNews}$		
	H0	**H1**	**H2**	**H0**	**H1**	**H2**	**H0**	**H1**	**H2**	**H0**	**H1**	**H2**
Australia	-0.1745 **	-0.1018	0.0112	0.0549	-0.0320	-0.2721	-2.1945 *	-0.8273	-0.5315 ***	2.6766	0.2084	1.7222
	{0.0413}	{0.6925}	{0.8601}	{0.7617}	{0.8655}	{0.6435}	{0.0673}	{0.6622}	{0.0000}	{0.1581}	{0.9108}	{0.5071}
China	-0.4491 ***	-0.3315 *	-0.4178 **	0.4271 **	0.4293 **	0.2423	-1.8207	-1.8471	-1.3179 *	-4.4646 **	-5.3809 ***	-8.4784 *
	{0.0036}	{0.0661}	{0.0216}	{0.0212}	{0.0346}	{0.7922}	{0.2300}	{0.3802}	{0.0741}	{0.0283}	{0.0078}	{0.0955}
Hongkong	0.5395	-0.7201 *	0.5448	-0.2305 **	-0.1731	-0.2326	-2.6935	-0.3287 ***	-2.0008	1.1340	0.1320	2.1926
	{0.2629}	{0.0528}	{0.2423}	{0.0475}	{0.3559}	{0.2880}	{0.5553}	{0.0000}	{0.2333}	{0.3654}	{0.9107}	{0.1108}
Indonesia	-0.1590	1.5096	-0.8898	1.1608	0.6583	3.3660 **	-2.6802	-1.8256 **	-3.8748 ***	-7.5952	-7.5083	7.3878 ***
	{0.9026}	{0.2122}	{0.2290}	{0.5380}	{0.7025}	{0.0253}	{0.2069}	{0.0494}	{0.0000}	{0.8727}	{0.6584}	{0.0000}
Japan	-0.3141 **	-0.1471	-0.2895	0.7834	1.1273	0.1770	-0.1910 **	0.9374	-0.2346 ***	2.1867	7.2784 **	0.3567
	{0.0157}	{0.5456}	{0.8864}	{0.7306}	{0.1352}	{0.8716}	{0.0440}	{0.1356}	{0.0000}	{0.5753}	{0.0459}	{0.9352}
Korea	-0.0651	-0.0031	-0.0043	2.7768 **	2.7770 *	2.7767 **	-3.7367	-4.4567 **	-3.7688	-1.7551	-4.5725	-2.7765
	{0.2768}	{0.9005}	{0.7487}	{0.0182}	{0.0832}	{0.0407}	{0.4744}	{0.0377}	{0.4532}	{0.1991}	{0.7678}	{0.2274}
Malaysia	-0.2030 **	-0.3826 **	-0.3015 ***	-0.6926 ***	-1.0084 ***	2.2832 **	-2.0355 ***	-2.3611	-0.1056	-0.6804	-3.2632	1.0452 **
	{0.0490}	{0.0365}	{0.0000}	{0.0000}	{0.0000}	{0.0284}	{0.0000}	{0.1955}	{0.6583}	{0.7925}	{0.2638}	{0.0366}
New Zealand	-0.1598	-0.3660	-0.0022	0.6645 ***	0.5507	0.0146 **	-2.2772	-0.3030	-3.4020 ***	3.6224 *	2.7669	2.8093 *
	{0.6918}	{0.3833}	{0.9615}	{0.0018}	{0.2143}	{0.0173}	{0.3952}	{0.9110}	{0.0000}	{0.0815}	{0.1839}	{0.0980}
Philippines	0.1713	0.4646	-0.0593	0.4078 **	0.6727	1.7377 *	-0.2813 **	-0.1393 ***	-1.1326 ***	9.8749 **	4.0324 **	8.7012 ***
	{0.8014}	{0.3969}	{0.7984}	{0.0212}	{0.1641}	{0.0766}	{0.0142}	{0.0000}	{0.0006}	{0.0142}	{0.0236}	{0.0000}
Singapore	-0.3190	-0.8209 **	0.1699	-0.0051	-0.2001	0.6754 ***	-0.3190	-0.8209 **	0.1699	-0.0051	-0.2001	0.6754 ***
	{0.4699}	{0.0181}	{0.4997}	{0.9834}	{0.4596}	{0.0012}	{0.4699}	{0.0181}	{0.4997}	{0.9834}	{0.4596}	{0.0012}
Taiwan	-0.4076 *	-0.9175	-0.9194 **	0.0800	0.0275	-0.2459	-3.3250	-1.3015	-2.2022 ***	1.1363	0.0115	-1.0157
	{0.0552}	{0.2626}	{0.0127}	{0.5518}	{0.8837}	{0.3544}	{0.4022}	{0.7568}	{0.0000}	{0.4545}	{0.9955}	{0.5102}
Thailand	-0.0828 **	-0.0811 **	-0.0812 *	-0.2599	0.3290	-0.0824	-2.9932	-3.3298	-1.4382 ***	-1.8600	0.5023	16.0166
	{0.0106}	{0.0141}	{0.0836}	{0.5914}	{0.7446}	{0.7262}	{0.3112}	{0.4280}	{0.0000}	{0.4071}	{0.9040}	{0.1439}

Note: *, **, *** denotes significance at 10%, 5% and 1%, respectively

Table 3 – Joint spillover effects of the U.S. Fed's and the ECB's target interest rate news

This table reports the estimation results of EGARCH models described in (4a) and (4b) for Asia-Pacific stock markets' daily returns against the Fed's and the ECB's news. H0 is daily horizon over the close on calendar day *t-1* to the close on calendar day *t*; H1 is overnight horizon over the close of day *t-1* to the open on day *t*; and H2 is intradailyy horizon measured over the open on day *t* to the close on day *t*. P-values are in braces.

$$y_t = [\text{RHS of (2a)}] + \alpha_{FedNews} FedNews_{t-1} + \alpha_{ECBNews} ECBNews_{t-1} \quad (4a)$$

$$\ln h_t = [\text{RHS of (2b)}] + \beta_{FedNews} \left| FedNews_{t-1} \right| + \sum_i \beta_{USMacroAnn,i} USMacroAnn_{i,t-1} + \beta_{ECBNews} \left| ECBNews_{t-1} \right| + \sum_i \beta_{EuroareaMacroAnn,i} EuroareaMacroAnn_{i,t-1} \quad (4b)$$

	Conditional mean equation						Conditional variance equation					
	$\alpha_{FedNews}$			$\alpha_{ECBNews}$			$\beta_{FedNews}$			$\beta_{ECBNews}$		
	H0	**H1**	**H2**	**H0**	**H1**	**H2**	**H0**	**H1**	**H2**	**H0**	**H1**	**H2**
Australia	-0.1232	-0.1079 ***	0.0172	-2.4434	-1.0608	-0.6397	-0.1610	-0.0771	-0.7153	2.5155 **	-0.4095	5.3135
	{0.4961}	{0.0000}	{0.5221}	{0.1559}	{0.5968}	{0.1956}	{0.4272}	{0.7237}	{0.2175}	{0.0151}	{0.8040}	{0.1280}
China	-0.5441 **	-0.4180	-0.9594 ***	-0.3621	-1.7944	-0.7935 ***	1.4542 ***	0.6417 **	1.8971 **	-6.3297 ***	-7.2225 ***	-5.1569 ***
	{0.0112}	{0.2562}	{0.0057}	{0.4394}	{0.3286}	{0.0071}	{0.0000}	{0.0129}	{0.0138}	{0.0057}	{0.0000}	{0.0000}
Hongkong	0.6150	-0.5520 ***	0.6353	-1.4131	0.0553	-1.5302	-0.4011	-0.0686	-0.3970 ***	1.6597	1.8742	-1.7758
	{0.1881}	{0.0014}	{0.1082}	{0.4840}	{0.9941}	{0.4525}	{0.1916}	{0.7446}	{0.0022}	{0.2009}	{0.2915}	{0.1997}
Indonesia	-0.2089	1.3655	-0.6528	-3.6856 ***	-2.5274	-0.7014	1.0634	1.5114	5.0306 ***	2.4692	-4.7839 *	4.5096
	{0.8750}	{0.3687}	{0.3662}	{0.0003}	{0.6220}	{0.5371}	{0.3595}	{0.4824}	{0.0042}	{0.8383}	{0.0941}	{0.4189}
Japan	-0.0611	-0.4797	-0.1120 ***	-0.1769 ***	0.1476	-0.2941 ***	1.0114	1.0046	0.2962 **	8.3465 **	6.7227 *	1.6115 *
	{0.4584}	{0.5720}	{0.0088}	{0.0000}	{0.1380}	{0.0003}	{0.1933}	{0.1071}	{0.0475}	{0.0411}	{0.0573}	{0.0839}
Korea	-0.1463	-1.2331	-0.1217	-2.0348	-4.2634	-2.1445	-0.4939	-0.2800	-0.4797	-1.6817	-4.0809 **	-1.4904
	{0.8751}	{0.3341}	{0.8894}	{0.7047}	{0.1063}	{0.6198}	{0.4039}	{0.3153}	{0.1463}	{0.2031}	{0.0215}	{0.5218}
Malaysia	-0.1589	-0.3695	-0.0964	-2.1111	-2.2535	-0.1356	-0.9978 ***	-1.3450 **	0.7659	1.5115	-0.3509	-1.8658 ***
	{0.3746}	{0.1381}	{0.6229}	{0.3290}	{0.3209}	{0.7009}	{0.0000}	{0.0268}	{0.2079}	{0.1427}	{0.9017}	{0.0000}
New Zealand	-0.5335	-0.5449	-0.6298	0.0839	0.2627	0.2969	0.1584	0.1122	-0.3292	2.0956 ***	3.0473 ***	2.4559 ***
	{0.5293}	{0.1184}	{0.2641}	{0.2123}	{0.9284}	{0.9398}	{0.9085}	{0.5580}	{0.3490}	{0.0000}	{0.0073}	{0.0000}
Philippines	-0.1060	-0.0991	-0.0964	-0.9632 ***	-0.4072	-0.9475 *	0.6913 **	0.5517	0.7117 **	1.4917 ***	4.2443 **	2.5414 ***
	{0.3299}	{0.8464}	{0.5388}	{0.0000}	{0.8702}	{0.0519}	{0.0417}	{0.2589}	{0.0253}	{0.0000}	{0.0196}	{0.0003}
Singapore	-0.4212	-1.2050 **	0.3874	-4.7732 **	-4.3616 *	0.4173	0.2237	0.1366	0.5970 ***	-4.9674 ***	-5.5828 ***	-11.9295 ***
	{0.1575}	{0.0159}	{0.1086}	{0.0206}	{0.0687}	{0.3776}	{0.4425}	{0.3534}	{0.0002}	{0.0064}	{0.0060}	{0.0000}
Taiwan	-0.8217 **	-1.1363	-0.9822 ***	-2.4362	-1.0057	-2.5276	-0.2630	0.0060	-0.2395	-0.8588	-0.1335	-0.9898
	{0.0451}	{0.1200}	{0.0021}	{0.8595}	{0.8186}	{0.2628}	{0.3678}	{0.9721}	{0.2664}	{0.4233}	{0.9325}	{0.5784}
Thailand	-0.1932	-0.1023	0.1110	3.2088	2.8950	0.3418	0.3154	0.1165	-0.7192	-1.8230	0.8077	4.6496 **
	{0.6641}	{0.8369}	{0.7759}	{0.3429}	{0.4883}	{0.3014}	{0.1895}	{0.6752}	{0.3441}	{0.5634}	{0.7177}	{0.0466}

Note: *, **, *** denotes significance at 10%, 5% and 1%, respectively

Appendix: Tests of additional contribution of direct effects of the Fed's and ECB's news given indirect effects (via index return spillovers)

This table reports the tests of additional contributions of the direct impact of the news over and above the indirect news impact (via index return spillovers). Model (3a) and (3b) are extended by including the U.S. and the euro area stock index returns and return volatilities as shown below:

$$y_t = [\text{RHS of (2a)}] + \alpha_{Direct\_News} News_{t-1} + \alpha_{Indirect\_News} \cdot Index\,\text{Return}_{t-1}$$

$$\ln h_t = [\text{RHS of (2b)}] + \beta_{Direct\_News} |News_{t-1}| + \sum_i \beta_{MacroAnn,i} MacroAnn_{i,t-1} + \beta_{Indirect\_News} \cdot Index\,\text{Returns}^2_{t-1}$$

Where IndexReturns is S&P500 for the Fed and DAX for the ECB estimations. The tests of additional contributions of the direct news effects is conducted by restricting the direct impact news coefficients, α_{Direct_News} and β_{Direct_News} to zero and comparing the log likelihoods of the restricted and the unrestricted models. The null is no significant additional contributions made by the inclusion of the direct news effects. The Chi-square test statistics are reported with associated p-values in curly braces.

	U.S. Fed's News						ECB's News					
	Mean equation			Variance equation			Mean equation			Variance equation		
	H0	H1	H2	H0	H1	H2	H0	H1	H2	H0	H1	H2
Australia	0.3911	0.0044	1.6083	1.0021	0.9908	3.2501 ***	3.3291 *	1.3315	3.4110 *	4.1405 **	0.0032	14.3748 ***
	{0.5317}	{0.9472}	{0.2047}	{0.3168}	{0.3195}	{0.0000}	{0.0681}	{0.2485}	{0.0648}	{0.0419}	{0.9549}	{0.0001}
China	2.6732 ***	5.6056 **	4.7154 ***	1.3456 ***	8.7563 ***	0.5976	1.5239	0.9489	9.8611 ***	4.3473 **	8.9218 ***	7.5472 ***
	{0.0000}	{0.0200}	{0.0000}	{0.0000}	{0.0031}	{0.4395}	{0.2170}	{0.3300}	{0.0000}	{0.0371}	{0.0028}	{0.0060}
Hongkong	0.4299	-0.2608	7.3039 ***	5.2919 **	-0.0212	0.0343	1.0126	1.0517	0.4300	8.5290 ***	0.8391	2.9337 *
	{0.5121}	{0.4647}	{0.0000}	{0.0214}	{0.9189}	{0.8531}	{0.3143}	{0.3051}	{0.5120}	{0.0035}	{0.3596}	{0.0867}
Indonesia	0.0002	1.2458	3.3575 *	3.9220 **	0.1609	5.0389 **	0.0259	0.0710	0.7205	0.2822	0.1111	6.6381 ***
	{0.9879}	{0.2644}	{0.0669}	{0.0477}	{0.6884}	{0.0248}	{0.8722}	{0.7898}	{0.3960}	{0.5953}	{0.7389}	{0.0100}
Japan	0.1081	0.0459	1.4256	1.1654	0.0007	0.0447	8.1232 ***	0.4205	0.0858	2.7608 *	4.9059 **	0.0080
	{0.7423}	{0.8303}	{0.2325}	{0.2803}	{0.9786}	{0.8325}	{0.0000}	{0.5167}	{0.7696}	{0.0966}	{0.0268}	{0.9286}
Korea	4.9530 **	0.0153	4.4166 ***	0.3001	6.3934 ***	5.5970 **	4.4123 **	3.1422 *	0.4252	5.8880 **	5.2698 **	1.8176
	{0.0260}	{0.9017}	{0.0000}	{0.5838}	{0.0000}	{0.0180}	{0.0357}	{0.0763}	{0.5144}	{0.0152}	{0.0217}	{0.1776}
Malaysia	0.2404 **	0.6644	4.8559 **	2.8756 ***	4.6555 ***	1.3855 **	6.7167 ***	0.7728	0.0333	0.8594	3.6670 *	12.9656 ***
	{0.0239}	{0.4150}	{0.0276}	{0.0000}	{0.0000}	{0.0239}	{0.0000}	{0.3793}	{0.8553}	{0.3539}	{0.0555}	{0.0003}
New Zealand	0.0933	0.4852	5.8499 ***	1.6632	1.8040	5.4501 **	0.6313	0.0056	0.0097	10.5827 ***	3.7228 *	9.2866 ***
	{0.7600}	{0.4861}	{0.0000}	{0.1972}	{0.1792}	{0.0196}	{0.4269}	{0.9404}	{0.9217}	{0.0011}	{0.0537}	{0.0000}
Philippines	0.2568	0.2792	0.2974 ***	4.1451 ***	1.0141	1.5672 ***	2.6948	0.0051	4.0465 ***	1.9829 ***	3.5862 *	5.2427 ***
	{0.6123}	{0.5972}	{0.0050}	{0.0002}	{0.3139}	{0.0007}	{0.1007}	{0.9431}	{0.0000}	{0.0000}	{0.0583}	{0.0000}
Singapore	0.6270	1.9742 **	0.0059	0.1542	0.0287	5.4829 **	3.9904 **	6.1521 **	1.0700	7.9483 ***	7.4145 ***	9.2804 ***
	{0.4285}	{0.0160}	{0.9388}	{0.6946}	{0.9181}	{0.0192}	{0.0458}	{0.0131}	{0.3010}	{0.0048}	{0.0065}	{0.0000}
Taiwan	1.1616	0.1257	2.2832	0.1572	0.0449	3.2086 *	6.3426 ***	0.5285	0.4782	0.0634	0.2686	3.3282 *
	{0.2811}	{0.7230}	{0.1308}	{0.6917}	{0.8322}	{0.0733}	{0.0000}	{0.4672}	{0.4892}	{0.8013}	{0.6043}	{0.0681}
Thailand	0.6547	0.0297	0.2040	2.1310	1.4927	0.7856	0.2872	0.0805	0.5929	0.5285	0.1759	1.1606
	{0.4184}	{0.8669}	{0.6515}	{0.1444}	{0.2218}	{0.6515}	{0.5920}	{0.7766}	{0.4413}	{0.4672}	{0.6749}	{0.2813}

Note: *, **, *** denotes significance at 10%, 5% and 1%, respectively