Information leadership in the advanced Asia-Pacific stock markets: Return, volatility and volume information spillovers from the U.S. and Japan

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Abstract:

This paper investigates the nature of the stock market linkages in the advanced Asia-Pacific stock markets of Australia, Hong Kong, Japan and Singapore with the U.S and the information leadership of the U.S. and Japan in the region since the early 1990s. It has been found that both the contemporaneous return and volatility linkages were significant and tended to be more intense after the 1997 Asian crisis period. However, the investigation of the dynamic information spillover effects in terms of returns, volatility and trading volume from the U.S. and Japan did not produce such time-varying influence. In general, significant dynamic information spillover effects from the U.S. were found in all the Asia-Pacific markets, but the Japanese information flows were relatively weak and the effects were country specific.

Keywords: Information spillover, Asia-Pacific stock markets, trade volume

JEL Codes: G15, G14

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1. Introduction

The existence of financial market linkages amongst advanced equity markets is well documented. Numerous researchers find significant contemporaneous return correlations which is not surprising considering the implications of international capital asset pricing models. In addition, dynamic market interdependences which indicate causal relationships were also investigated by many researchers who report significant price and volatility spillovers between advanced markets (*inter alia* Hamao, Masulis and Ng, 1990, Theodossiou and Lee, 1993, Koutmos and Booth, 1995, Connolly and Wang, 2000, Bae, Karolyi and Stulz, 2000). A common finding in these studies is the role of the U.S. market in leading other major markets. In addition to return and volatility spillovers, the information content of the U.S. trading volume had a significant causal influence in other markets (For example, see Lee and Rui, 2002)[1]. These contemporaneous and dynamic inter-market linkages intensified after the 1987 global stock market crash. Arshanapalli and Doukas (1993), among others, find enhanced market linkages with increasing U.S. influence on French, German and the U.K. markets for the post crisis period. However, the literature reports a negligible role of the Japanese market in information leadership, despite the Japanese stock market being world's second largest, and an absence of significant market linkages between Japan and other major markets of the U.S. and Western Europe[2].

Asia-Pacific financial markets also exhibit significant and growing interdependence. The increasing regionalisation of economic activities since the mid-1980s and the liberalisation of stock markets from late 1980s resulted in regional economic integrations

[1] The relationships among return, volatility and trading volume within a market were investigated by many researchers. Significant contemporaneous linkages between return and trading volume are reported in Tauchen and Pitts (1983) and Karpoff (1987), and between variance (mostly measured as absolute price change) and trading volume by Karpoff (1987) and Gallant et. al (1992). In addition, dynamic causal relationships are reported in Lee and Rui (2002), Chen, Firth and Rui (2001) and Chordia and Swaminathan (2000).
[2] Bae and Karolyi (1994), however, report that the degree of market linkages between the U.S. and the Japanese stock markets are significantly understated when good and bad market returns are not investigated separately.

(Phylaktis, 1997 and 1999) and growing stock market interdependence (Janakiramanan and Lamba, 1998, Pan, Liu and Roth, 1999). Market linkages are noticeably greater for the post-1987 period as reported in Arshanapalli, Doukas and Lang (1995), and for the post-1997 period (Chow, 1999, Kaminsky and Schmukler, 1999, Girard and Rahman, 2002). In addition, information leadership of the U.S. market is confirmed in the Asia-Pacific markets as evidenced by significant first and second moment return spillovers (*inter alia* Arshanapalli, et al, 1995, Pan and Fung, 1996, Lin and Pan, 1997, Liu, Ghosh, Saidi and Johnson, 1999, Janakiramanan and Lamba, 1998, Girard and Rahman, 2002). Another potential source of information flow for the Asia-Pacific markets is Japan due to its economic linkages with the rest of the countries in the region. A number of studies report significant spillover effects from both the U.S. and the Japanese markets to the Asia-Pacific markets especially since the East Asian financial crisis of 1997 (Liu and Pan, 1997, Cha and Cheung, 1998, Cha and Oh, 2000, and Ng, 2000). However, despite close economic linkages (especially from the mid to late 1980s) between Japan and other regional countries, the influence of the Japanese stock market had not been very strong until the onslaught of the financial crises in the East Asian countries in 1997 (Chow, 1999, Cha and Oh, 2000).

The existing body of studies concentrates mostly on weekly return horizons (and at best, daily) in their investigations of market linkages and information spillover effects, and it rarely go beyond the examination of the first and second moment spillover effects. Due to the existence of trading time differences between the U.S. and the Asia-Pacific, disaggregating the daily return horizons into overnight and intradaily periods would produce better insights into the nature of the market interdependence as this would allow the investigation of contemporaneous (co-movements) and dynamic (causation) information spillover effects. This research angle has been neglected by many researchers. In addition, the information content of the U.S. and Japanese market trading volumes would potentially prove useful in providing additional tradable information for the Asia-Pacific markets. To the extent that volume information can be used to infer future stock returns (Blume, Easley and O'Hara, 1994) and that U.S. and Japanese market returns lead other Asia-Pacific markets, the inclusion of the volume information in the analysis would allow much richer investigation of the U.S. and Japanese stock market leadership in the region. The aim of this paper is to address these issues. Specifically, the time varying nature of the stock market linkages amongst advanced stock markets in the Asia-Pacific region and the U.S. is investigated and the role of the information leadership of the U.S. and Japan in the region is examined. The major findings of the paper are i) contemporaneous return and volatility correlations amongst the U.S. and the advanced Asia-Pacific stock markets of Australia, Hong Kong, Japan and Singapore are positive and significant, and are considerably higher in the post-1997 Asian crisis period, ii) in addition to return and volatility spillovers, significant dynamic spillover effects of the U.S. trading volume are found in all countries, iii) dynamic information spillover effects from Japan are generally weak and country specific, and iv) there is no evidence of significant difference in the dynamic spillover effects before and after the 1997 Asian crisis period. Thus, this paper makes following contributions to the existing literature: i) provision of updated and comprehensive evidence on the nature of the contemporaneous and dynamic stock market linkages in the region, and ii) new evidence that sheds light on the information leadership of the U.S. and Japan in the region.

The rest of this paper is organized as follows. Section 2 provides the details of the data used in the paper and the results of the preliminary analysis of the data are presented. Section 3 contains the analyses of contemporaneous correlations of the daily returns and volatilities amongst the five countries under investigation. Section 4 provides a further evidence of market linkages in terms of causal influences of the U.S. and Japanese intradaily returns, volatilities and trading volumes. Section 5 presents the investigations of the contemporaneous and dynamic information spillover effects from the U.S. and Japan using the EGARCH modeling methodologies. Finally, conclusions are presented in Section 5.

2. Data and preliminary analysis

The stock markets investigated are the U.S. and four advanced Asia-Pacific stock markets of Australia, Japan, Hong Kong and Singapore. Daily index observations (open, high, low and close) for the five markets and the trading volumes of the U.S. and the Japanese markets were obtained from Commodities Systems, Inc. and Datastream for the period 24 July 1990 to 27 March 2002[3]. The indexes are All Ordinaries, TOPIX, Hang Seng, Straits Times and S&P 500, respectively for each country. Figure 1 shows the time line of the market trading hours of the Asia-Pacific and the U.S. markets. While there are overlaps between trading hours of the Asia-Pacific markets, the U.S. market is closed when the other markets are operating. The information flow from the Japanese market, which can be regarded as a regional information, is thus contemporaneous while the (overnight) U.S. market movements, which constitute global information, can influence the Asia-Pacific markets when they open three to four hours after the close of the U.S. market. Various holding periods for returns and volatilities can be constructed with a view to ascertaining the nature of contemporaneous and lead-lag relationships amongst the five markets. These are daily(D), overnight(ON) and intradaily(ID). The daily return period is from closing price on day *t-1* to closing price on day *t*, which envelopes the overnight return period (closing on day *t-1* to opening on day *t*) and the intradaily return period (opening to closing on day *t*). The daily and overnight return periods on (calendar) day *t* in the Asia-Pacific markets overlap with the U.S. intradaily return period on day *t-1*, whereas intradaily return on day *t* periods do not (see Figure 1).

[3] The choice of the starting point of the sample was due to the unavailability of trade volume data for the TOPIX prior to this date.

The summary statistics of the market returns of the U.S. and the Asia-Pacific markets over the three holding periods are shown in Table 1. The mean is fairly close to zero and the daily variance is spread over the two sub-holding periods in all cases. The variance is higher during the intradaily period than the overnight period in all cases which is consistent with the established empirical observation that points to higher volatility during periods of market trading than periods over which market was not trading. The Negative skewness is observed in all cases, except for the intradaily period for Japan and Singapore, which is the usual finding for the financial return series. Both the skewness and excess kurtosis are significantly larger in magnitude over the overnight period than the intradaily period in all cases except for Australia. This suggests a higher frequency of extreme observations, especially negative ones, during the overnight return period. Both linear and non-linear serial correlations are highly significant in all cases except for the non-linear correlation in Australia and the U.S. for the overnight period. In addition, there is a significant evidence of asymmetric responses of the volatility to innovations as shown by the significant Engle-Ng statistics in all cases. The common characteristics of the index returns overall are thus significant negative skewness, leptokurtosis, highly significant linear and non-linear serial correlation, and asymmetric responses of volatility to innovations. Modelling of these returns must account for these characteristics. The modelling issues are further discussed in section 5.

3. Correlation Analysis

The most common and also the simplest method of investigating market linkages adopted by early researchers is to examine the return and volatility correlation structures amongst the markets under investigation. The aim is to ascertain the degree and the nature of market co-movements without necessarily investigating the drivers of such co-movements.

Ideally, this requires the holding periods for comparison to be contemporaneous, and this can be accomplished by considering daily holding periods for all markets (daily period on day *t* for the Asia-Pacific and on day *t-1* for the U.S. markets) which result in overlapping holding periods. The daily returns on day *t* are calculated as $\ln(P_t^{Close} / P_{t-1}^{Close}) \times 100$ and the volatilities are simply the squared returns, i.e. $[\ln(P_t^{Close} / P_{t-1}^{Close}) \times 100]^2$.

Table 2 reports the contemporaneous correlation analysis of the first and second moments of daily stock market returns. Both the return and volatility correlations are positive in all cases indicating the presence of some common global information that drove them. For the full sample (shown in the first panel), the bilateral correlations of returns range from 0.3016 between the U.S. and Japan, and 0.5531 between Hong Kong and Singapore. The volatility correlations range from 0.1882 between the U.S. and Japan and 0.6122 between Australia and Singapore. The top three pairs in terms of size are Hong Kong-Singapore, Australia-U.S. and Australia-Hong Kong for returns, and Australia-Singapore, Australia-Hong Kong and Hong Kong-Singapore for volatilities. In order to account for the structural break around the 1997 currency crisis, the full sample (full sample) is divided into two subsamples, the pre-crisis period of 24 July 1990 to 30 June 1997 (Sample 1) and the post-crisis period of 1 July 1997 to 27 March 2002 (Sample 2), and then the time-varying nature of market linkages in the region is investigated. The second and the third panels of Table 2 show the return and volatility correlation linkages during the pre- and post-1997 crisis periods, respectively. The last panel reports percentage changes over the two subsamples. Comparing Sample 1 and Sample 2, there is a noticeable rise in the bilateral correlations in the post-crisis period in all cases except for a sizable drop of 29% in the volatility correlation between Japan and Singapore and a marginal 1% drop between the U.S. and Singapore. The largest increase in return correlation is shown between Hong Kong and Japan with a 58% rise, closely followed by a 48% rise between Australia and Japan. The highest volatility correlation rise is between Australia and Singapore with as much as a 112% rise, closely followed by a 108% increase between the U.S. and Hong Kong. The last row of the fourth panel shows the average changes in the bilateral correlations for each market against the other four. The highest average rise in return correlation is against Japan (41% rise) which shows the rising importance of Japan in the region. The highest for the volatility correlation, however, is against Hong Kong (58% rise) which might suggest the sensitivity of the Hong Kong's market to the volatility of the other markets. In short, it has been revealed that both the first and second moment linkages in market returns in the advanced Asia-Pacific markets and the U.S. market were significant and grew over time.

Although the correlation analysis of contemporaneous market returns revealed interesting results regarding the extent of market linkages in the region, the question of causality, that is the direction of information flows, can not be addressed. We turn now to the investigations of the causal flows of information in the region.

4. Direction of Information Flows

It is not clear whether the significant first and second moment return correlations are due to contemporaneous factors or due to dynamic causal relationships. Thus, an investigation of causal flow of information in the region is required to ascertain the nature of information leadership of the U.S. and Japan in the Asia-Pacific region. In this section, Granger causality tests are performed to ascertain the causal direction of information flows. The idea behind this is the premise that if event x occurs before event y and forecasts of y are more accurate with the past values of x in the information set than without, then x is said to Granger cause y. Formerly, a test equation is written as

$$y_t = a + \sum_{i=1}^{m} b_i \cdot y_{t-i} + \sum_{j=1}^{n} c_j \cdot x_{t-i} + e_t \qquad (1)$$

and the Granger causality from x to y, written as $x \xrightarrow{G.C.} y$, is tested as a test of joint significance of c_j's, i.e. H0: x does not Granger cause y is tested as H0: $c_j = 0$ for all j. In the current analysis, the U.S. and Japanese market returns and trading volumes (x variables) are tested to see if they Granger cause the market returns of the other markets (y variables), and also the U.S. and Japanese market volatilities and trading volumes (x variables) are tested for their effect on the market volatilities of the other markets (y variables). The bi-directional causation is tested only between the U.S.-Japan pair[4], and only the one-directional test is carried out for the smaller markets (the U.S. and Japan Granger causing Australia, Hong Kong and Singapore). The holding periods for returns and volatilities under consideration are chosen to eliminate overlaps and this is done by considering intradaily (ID) holding periods with appropriate lags in all cases. The returns are then calculated as $R_{ID,t} = \ln(P_t^{Close} / P_t^{Open}) \times 100$. Instead of using the squared returns for volatilities as in the previous section, the intradaily volatility is calculated as below:

$$VT_{ID,t} = \frac{1}{2} \cdot \left[\ln(P_t^{High}) - \ln(P_t^{Low}) \right]^2 - \left(2\ln(2) - 1 \right) \cdot \left[\ln(P_t^{Open}) - \ln(P_t^{Close}) \right]^2 \qquad (2)$$

This Garman-Klass volatility utilizes all four daily price observations of opening, closing, high and low, and is shown to have a significant efficiency gain over a simpler ones such as squared or absolute price changes (Garman and Klass, 1980). It also has the advantage, compared to alternative measures of daily volatility such as GARCH volatility, of being pre-

[4] Evidence of bi-directional linkages in terms of return spillovers between the two markets are reported in Bae and Karolyi (1994), Karolyi and Stulz (1996), and Connolly and Wang (2000).

determined and observable by market participants at time *t* with a day's lag. The trading volume has been shown to have a positive feedback relationship with return volatilities in the U.S. and Japan, and the U.S. volume has shown to influence the Japanese market variables (Lee and Rui, 2002, see also footnote 1). Thus, it is of great interest to investigate whether the U.S. and Japanese volume have similar causal influence on the other Asia-Pacific markets. Both trading volume series contain significant positive (linear and non-linear) trends, and so the residuals from the detrending equation $Volume_t = a + b \cdot T + c \cdot T^2 + e_t$ are used as detrended volumes, denoted as $VM_{ID,t}$.[5]

The left half of Table 3 presents the U.S. Granger causality test results. The lag length chosen is 5 days (m=n=5) which represent one week[6]. For the full sample, the intradaily U.S. return and volatility Granger caused the returns and volatilities, respectively, in all markets. In addition, the U.S. volume Granger caused the returns in Australia (only marginally at 10%) and Hong Kong (significant at 5%), and Granger caused intradaily volatilities (at least at 5%) of all the Asia-Pacific markets. While a similar pattern of Granger causality is revealed for the U.S. return and volatility in both Sample 1 and Sample 2, the volume information was more relevant in Sample 1[7]. The U.S. volume Granger caused the returns and volatilities of Australia, Japan and Hong Kong in Sample 1, while only the volatility in the Singapore was Granger caused in Sample 2. Thus, the evidence indicates that in addition to the significant contemporaneous correlations in the first and second moments of market returns between the U.S. and the Asia-Pacific markets reported in the previous section, there is a dynamic causal relationship between them confirming the role of the former in generating global information

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[5] Although the volume series do not contain unit roots, significant trends are detected in both cases. Both *b* and *c* are statistically significant. To save space, details of the detrending analysis are not reported, however, interest readers can obtained them from the author upon request.

[6] In addition, BIC was used to determine the optimal lag length for each testing equation. However, there is no noticeable difference in the results compared to the ones reported here.

[7] This may be due to the increasing importance of common shocks that affect all the markets in the similar way as evidenced in the previous section by the increasing correlations in Sample 2. This might suggest that, in relative terms, idiosyncratic shocks emanating from the U.S. are reduced in importance, and so would the information contained in the U.S. market volume movements.

that affects the latter. That is, the U.S. market information leadership is confirmed in the Asia-Pacific.

The right half of Table 3 reports the tests of Granger causality from Japan. In general, the Japanese market information failed to Granger cause other markets to any significant extent. For the full sample, the Japanese return Granger caused the returns in the U.S. and Hong Kong, while only the U.S. volatility was Granger caused by the Japanese volatility. The Japanese volume data had very little influence in all cases, except for the marginally significant (at 10%) influence on the returns in Hong Kong and Singapore. As in the U.S. influences above, Sample 1 has more significant causal influence, in general. In short, the Japanese market movements failed to have a significant causal influence in the other Asia-Pacific markets, however, the U.S. market was shown to be Granger caused by the Japanese information.

In sum, the evidence shows that the U.S. market (returns, volatility and trading volume) Granger caused Asia-Pacific markets, whereas only the U.S. market was consistently Granger caused by the Japanese market information, in general.

5. Information Spillovers

The correlation analysis and the Granger causality tests reported above showed the presence of contemporaneous market linkages in the advanced Asia-Pacific and the U.S., and significant Granger causalities from the U.S. market. This section further investigates the linkages and the nature of information leadership in the region. As reported in Table 1, returns over various holding periods exhibit characteristics common to high frequency financial series: significant skewness, excess kurtosis and significant serial correlations in the second moments. Various researchers find that exponential GARCH models with an appropriate distributional assumption explain the daily stock price movements well (see Bollerslev, et. al, 1992, for an extensive survey of empirical papers). In this section, parsimonious MA (moving average) - EGARCH(1,1) models are used to model the return series with asymmetric response characteristics and they are shown below.

$$y_t = \alpha_c + \alpha_{HOL} \cdot HOL_t + \varepsilon_t + \sum_{k=1}^{q} \alpha_k \cdot \varepsilon_{t-k} \qquad \text{(3a)}$$

$$\varepsilon_t = z_t \sqrt{h_t} \sim (0, h_t), \; z_t \sim iid(0,1)$$

$$\ln h_t = \beta_c + \beta_{HOL} \cdot HOL_t + \beta_h \cdot \ln h_{t-1} + \beta_{\varepsilon 1} \cdot \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} + \beta_{\varepsilon 2} \cdot \left(\frac{|\varepsilon_{t-1}|}{\sqrt{h_{t-1}}} - \sqrt{\frac{2}{\pi}} \right) \qquad \text{(3b)}$$

Where

q = The number of lagged innovations required to remove residual serial correlation

HOL_t = Seasonal dummy that takes the number of days between two successive observations. 1 for normal weekdays, 3 for Mondays and 2 or higher for days immediately following market closures due to holidays.

The U.S. and Japanese market information with appropriate lags (intradaily returns, volatilities and detrended volumes) are then included as exogenous variables in the above model. In order to shed more light on the contemporaneous linkages reported in section 3, contemporaneous as well as dynamic spillover effects from these two major markets are investigated.

5.1 Contemporaneous Spillover Effects

Contemporaneous information spillovers are investigated by using overlapping return horizons between the Asia-Pacific and the U.S. markets. The intradaily holding period on day *t-1* for the U.S. ($US\text{-}ID_{t-1}$) is contemporaneous with the overnight holding period on day *t* for the Asia-Pacific markets ($AP\text{-}ON_t$, see Figure 1). In the case of the Japanese intradaily period on day t, the other Asia-Pacific markets' intradaily periods are contemporaneous on day t (AP-ID_t), whereas the overnight period on day t is contemporaneous for the U.S. market (US-ON_t).

The EGARCH models appropriate for investigating contemporaneous U.S. information spillovers are equations (4a) and (4b) below.

$$R_t = \alpha_{R\_US} \cdot R^{US}_{ID,t-1} + \alpha_{VM\_US} \cdot VM^{US}_{ID,t-1} + M(\cdot) \tag{4a}$$

$$\ln h_t = \beta_{\text{VT\_US}} \cdot VT^{US}_{ID,t-1} + \beta_{VM\_US} \cdot VM^{US}_{ID,t-1} + V(\cdot) \tag{4b}$$

Where

R_t = Overnight returns in the Asia-Pacific markets on day t, $R^{AP}_{ON,t}$

$\ln h_t$ = Conditional variance of overnight returns in the Asia-Pacific markets on day t, $\ln h^{AP}_{ON,t}$

$R^{US}_{ID,t-1}$ = U.S. intradaily returns on day *t-1*.

$VT^{US}_{ID,t-1}$ = Garman-Klass (intradaily) volatility in the U.S. market on day *t-1*.

$VM^{US}_{ID,t-1}$ = Detrended trading volume in the U.S. market on day *t-1*.

M(.)= Right hand side of the conditional variance equation (3a)

V(.)= Right hand side of the conditional variance equation (3b)

The contemporaneous Japanese information spillovers are investigated using the intradaily periods on day t for the Asia-Pacific markets (AP-ID_t) and the overnight return period on day t for the U.S. (US-ON_t) as below (see Figure 1).

$$R_t = \alpha_{R\_JP} \cdot R^{JP}_{ID,t} + \alpha_{VM\_JP} \cdot VM^{JP}_{ID,t} + M(\cdot) \tag{5a}$$

$$\ln h_t = \beta_{VT\_JP} \cdot VT^{JP}_{ID,t} + \beta_{VM\_JP} \cdot VM^{JP}_{ID,t} + V(\cdot) \tag{5b}$$

Where:

R_t = Intradaily returns in the Asia-Pacific markets on day t, $R^{AP}_{ID,t}$, and

Overnight return in the U.S. on day t, $R^{US}_{ON,t}$

$\ln h_t$ = Conditional variance of intradaily returns in the Asia-Pacific markets on day t, $\ln h^{AP}_{ID,t}$, and

Conditional variance of overnight returns in the Asia-Pacific markets on day t, $\ln h^{US}_{ON,t}$

$VT^{JP}_{ID,t}$ = Garman-Klass (intradaily) volatility in the Japanese market on day t.

$VM^{JP}_{ID,t}$ = Detrended trading volume in the Japanese market on day t.

The information spillover effects are then investigated by examining the sign and significance of the exogenous variables included in (4) and (5) above. Specifically, the information content of the intradaily returns and the trading volumes of the U.S. and Japan are used to explain the returns, and the intradaily volatilities and the trading volumes for explaining the conditional volatilities of the other markets.

Table 4 reports the U.S spillover effects[8]. Examining the full sample, the U.S. intradaily return had a significant and positive influence on the Asia-Pacific market returns in all cases. The Hong Kong market was the most responsive judging by the magnitude of the mean spillover coefficient α_{R_US}, 0.3268, which is at least up to three times the size of those of the other markets. This is not surprising due to the close financial linkages between Hong Kong and the U.S. stemming from the currency peg of the Hong Kong Dollar. As a confirmation of higher return correlations in the post-1997 sample reported in Table 2, the contemporaneous mean spillover coefficient in Sample 2 is doubled in Japan and Hong Kong, and nearly ten fold increase is observed in Singapore. This is a clear evidence of increasing market linkages between the U.S. and the Asia-Pacific markets after the 1997 crisis. The volatility spillover is significant in all cases for the full sample except for Japan, and the positive coefficient, β_{VT_US}, indicates a higher (lower) intradaily volatility in the U.S. had a significant market exciting (calming) effect in these markets. It appears that the trading environment that prevailed in the U.S. was transmitted to the Asia-Pacific markets resulting in

[8] Other aspects of the estimations point to the usual properties of the EGARCH models. The asymmetric aspect of the model is shown in all cases, i.e. negative $\beta_{\varepsilon 1}$, however, it is significant only in one instance, Singapore in Sample 1. Return was higher on days following market closures of more than one day in Australia (Sample 1) and Hong Kong (full sample and Sample 1), whereas a lower return was observed for Singapore (full sample and Sample 1). The significant holiday effect found on the volatility is generally positive (i.e. higher volatility) which is consistent with the accepted empirical evidence of higher volatility following market closures. The diagnostics suggest that the EGARCH models were successful in addressing the characteristics of the return series. The skewness and kurtosis of the standardized residuals, z_t, of the models are substantially reduced compared to the ones reported in Table 1 in all cases, and the white noise property of z_t is confirmed, in general, in all cases. The remaining serial correlations in the mean in Australian returns and in Singapore were caused by outliers and their removal reduced the serial correlations.

similar market movements. Similar to the return spillovers, the volatility spillover was at its greatest in Hong Kong, closely followed by Singapore. Interestingly, a significant negative spillover is shown in Sample 1 in Singapore. The information content of the contemporaneous U.S. market volatility apparently was helpful in resolving market uncertainties leading to a lower return volatility in Singapore. However, this evaporated in Sample 2 and the positive relationship was dominant. Information contained in the U.S. trading volume was useful in explaining the returns for Australia and Singapore in full sample and Hong Kong in Sample 2. An increasing volume in the U.S. market was apparently seen as an encouraging sign, on average, and helped to significantly raise the returns of these two markets. This contrasts with the negative coefficient, α_{VM_US}, found in Japan for Sample 2 and Singapore for Sample 1. Although, the market volatility did not respond to the volume in any of the markets considered for the whole sample, a significant positive influence is detected in Hong Kong and Singapore in Sample 2. Higher U.S. trading volumes obviously had the similar influence in raising the volatilities in the Asia-Pacific as did higher U.S. volatility. In general, contemporaneous intradaily U.S. return, volatility and trading volume moved the first and second moments of the Asia-Pacific market returns in the same direction, and the post-1997 sample reports increased responses in the cases of returns linkages.

Table 5 reports the estimation results of the Japanese contemporaneous information spillovers[9]. The contemporaneous return spillovers, measured as α_{R_JP}, had a significant positive influence in all the markets except for the U.S. and, as in the contemporaneous U.S. market influence discussed above, market linkages were considerable higher in Sample 2. The U.S. market, however, moved in the opposite direction in full sample, while the spillovers are individually insignificant in Sample 1 and Sample 2. The Japanese intradaily volatility, β_{VT_JP},

[9] The coefficient for the asymmetric effect, $\beta_{\varepsilon 1}$, is now significant in most of the estimations. The holiday effect is generally insignificant in the mean, except for significant negative impact in Singapore (full sample and Sample 1), and a positive volatility response is reported in all cases except for the U.S. where a significant drop in market volatility is shown in all samples. The diagnostics suggest, in general, that the intradaily (overnight period for the U.S.) period characteristics were well modeled by the EGACRH models.

had a market calming influence, in general. The conditional volatility was significantly reduced in Singapore (full sample and Sample 1) and in the U.S. (full sample). Apparently, the information content of the Japanese volatility was useful for clearing up heterogeneity of market sentiments in these two markets. The volume information had a negative influence on the market returns. A significant coefficient, α_{VM_JP}, is observed for Australia (Sample 2), Singapore (full sample) and the U.S. (Sample 1 and Sample 2) suggesting that market participants, on average, viewed a rise in trading activities in Japan having a negative influence on their markets. On the other hand, the evidence on the volume to volatility spillovers, β_{VM_JP}, is mixed. Higher volume caused higher volatility in Hong Kong (Sample 2) and in Singapore (full sample and Sample 2), but a significant drop is observed in the U.S. (full sample, Sample 1 and Sample 2). The investigation thus revealed the followings. First, except for the mean spillover effects, where post-1997 sample show significantly higher degree of market linkage, there is no obvious pattern of the Japanese information flows in the two subsamples. Second, the U.S. market responses were different from the other markets in some instances (return to return spillovers and volume to volatility spillovers) suggesting that the Japanese market information was interpreted differently. This might be due to the different nature of economic (i.e. trade) relationship between the U.S. and Japan compared to that between Japan and the other Asia-Pacific economies.

5.2 Dynamic Spillover Effects

Dynamic spillover effects from the U.S. and Japan are investigated in this section. The return horizons that avoid overlaps between the Asia-Pacific and the U.S. markets are constructed and the influence of the lagged market information from the U.S. and Japan are then examined. The intradaily U.S. and Japanese information at *t-1* lead the intradaily market movements in the Asia-Pacific on day *t* (AP-ID_t), while the intradaily Japanese information at *t* leads the intradaily U.S. market movements at *t* (US-ID_t).

The dynamic U.S. information spillovers are then investigated using the equations (6a) and (6b) below for all the Asia-Pacific markets.

$$R_t = \alpha_{R\_US} \cdot R^{US}_{ID,t-1} + \alpha_{VM\_US} \cdot VM^{US}_{ID,t-1} + M(\cdot) \tag{6a}$$

$$\ln h_t = \beta_{VT\_US} \cdot VT^{US}_{ID,t-1} + \beta_{VM\_US} \cdot VM^{US}_{ID,t-1} + V(\cdot) \tag{6b}$$

Where

$R_t =$ Intradaily returns in the Asia-Pacific markets on day *t*, $R^{AP}_{ID,t}$

$\ln h_t =$ Conditional variance of intradaily returns in the Asia-Pacific markets on day *t*, $\ln h^{AP}_{ID,t}$

The Japanese information spillovers on day *t-1* are investigated using the intradaily periods on day *t* for the Asia-Pacific markets (AP-ID_t) and the intradaily return period on day *t-1* for the U.S. (US-ID_{t-1}) as below:

$$R_t = \alpha_{R\_JP} \cdot R^{JP}_{ID,t-1} + \alpha_{VM\_JP} \cdot VM^{JP}_{ID,t-1} + M(\cdot) \tag{7a}$$

$$\ln h_t = \beta_{VT\_JP} \cdot VT^{JP}_{ID,t-1} + \beta_{VM\_JP} \cdot VM^{JP}_{ID,t-1} + V(\cdot) \tag{7b}$$

Where

$R_t =$ Intradaily returns in the Asia-Pacific markets on day *t*, $R^{AP}_{ID,t}$, and

Intradaily returns in the U.S. on day t-1, $R^{US}_{ID,t-1}$

$\ln h_t =$ Conditional variance of intradaily returns in the Asia-Pacific markets on day *t*, $\ln h^{AP}_{ID,t}$, and

Conditional variance of overnight returns in the U.S. on day t-1, $\ln h^{US}_{ID,t-1}$

The dynamic U.S. market information spillover effects in the Asia-Pacific are reported in Table 6[10]. A positive and significant coefficient for the mean spillover effect in all cases,

[10] The negative asymmetric effect of the innovation on the conditional variance and the significant volatility raising effect of market closures are significantly present in all cases. The diagnostics suggest the model adequacy in all cases except for Singapore (full sample and Sample 1) where significant serial correlation is still present in the standardized residuals.

except for Singapore in Sample 1, suggests that the lagged U.S. return contained information that was continued to be useful throughout the trading day in the Asia-Pacific markets. However, there is no evidence of more intense information transfers in Sample 2. This is in contrast to the higher contemporaneous correlation in returns and volatilities in Sample 2 documented in previous sections. This suggests that although there is no significant increase in importance of the mechanism that carries the idiosyncratic shocks from the U.S. markets, common shocks, especially generated in the Asia-Pacific region, appeared to have become more important after the 1997 crisis episodes[11]. For Australia and Japan, the spillover coefficient is considerable larger in all three samples compared to the contemporaneous information transfers reported in Table 4. The volatility to volatility spillover is generally positive and significant in Australia and Japan. As in the contemporaneous analysis, the Singaporean market shows different responses over the two subsamples. Although the volume to return spillover effect is generally insignificant, the volume to volatility spillover is positive and significant in all cases, except for Japan in Sample 1 and Hong Kong in Sample 2. Higher trading volumes in the U.S. were, in general, interpreted as a sign of increasingly uncertain market condition which apparently had a similar impact in the Asia-Pacific. This contrasts with the results for the contemporaneous analysis where the volume effect is not present, in general. Interestingly, significantly higher spillover is found in Sample 2 for Australian and Japan, whereas the reverse is the case for Hong Kong and Singapore.

The dynamic information spillovers from Japan are reported in Table 7[12]. The return to return spillover is significant and positive in Hong Kong (full sample and Sample 2) and the U.S. (full sample, Sample 1 and Sample 2), however, both positive and negative

[11] Also, the role of idiosyncratic shocks from Hong Kong and Singapore in the U.S. market appeared to have improved in Sample 2. The estimation results of dynamic spillover effects from these two countries to the U.S. are not reported in this paper to conserve space. Interested readers may obtain these results upon request.

[12] Except for the Australian market (full sample and Sample 2), there is no strong evidence of model misspecification. In the case of Australia, the significant linear and nonlinear serial correlations in z_t were due to a number of influential outliers.

influences are found for the other markets. The volatility to volatility spillover is significant only in Australia where opposite responses in Sample 1 and Sample 2 are shown. The volume effect on the mean is mixed and there is no evidence of a common response to it from the non-Japanese markets. The volume to volatility spillovers, however, are generally positive in all markets and are larger in magnitude compared to the contemporaneous information flows reported in Table 5, as in the case of the dynamic U.S. spillovers reported above.

The investigations of the contemporaneous and dynamic return, volatility and trading volume spillover effects reveal the followings. First, the contemporaneous spillover effects of returns from both markets are positive and significant, and they are more intense in the post-1997 period in all cases. The dynamic return to return spillovers from the U.S. are still positive and significant, but the Japanese information had mixed results. Second, the volatility spillover effects are generally positive for the U.S. information, while both positive and negative Japanese volatility influences are found. Third, although both contemporaneous and dynamic U.S. volume effects on the returns are generally weak and not consistent throughout the markets, there is a clear evidence of significant positive influence of dynamic volume information on the conditional volatilities across the markets. Similar results are observed for the Japanese volume information spillovers.

6. Conclusion

This paper investigated the nature of linkages of the advanced Asia-Pacific stock markets of Australia, Hong Kong, Japan, Singapore with the U.S., and information spillovers from the U.S. and Japan to the other markets. The analyses of contemporaneous correlations of daily market returns show significant first and second moment correlations in all country pairs, and these correlations are significantly higher in the post-1997 sample indicating more intensified market linkages after the crisis period. The Granger causality tests revealed that it is the U.S. market that Granger caused the Asia-Pacific markets. In addition to the return to return and volatility to volatility causations, U.S. volume also Granger caused both the returns and volatilities of the Asia-Pacific markets. The Japanese information, however, failed to Granger cause the other Asia-Pacific markets to any significant extent, although the U.S. market return and volatility were Granger caused by the Japanese return and volatility, respectively with essentially no causal flow from the Japanese volume data. Finally, the investigations of the spillover effects reveal that the U.S. returns had a significant influence on the returns of the other markets both contemporaneously and with a lag, while the Japanese returns had the similar positive spillovers contemporaneously but lagged information had mixed results. In both cases, only the contemporaneous spillovers are considerably larger in the post-1997 sample. While the U.S. volatility spillover is generally positive and significant, especially with a lag, the Japanese volatility spillover effects are inconsistent across markets. The volume information spillovers on the conditional volatilities of the other markets, however, are generally significant and positive especially with a lag. However, the volume spillover effects on the returns are generally weak and not uniform across the markets.

In short, a complex array of market linkages exists in the Asia-Pacific stock markets. Although the contemporaneous market linkages in the region tended to be higher after the 1997 Asian crisis period suggesting increasing market integration, there is no evidence of more intensified dynamic information spillover from the U.S. and Japanese markets in the later sample. The Asia-Pacific markets responded uniformly to the U.S. information flows, in general, and the Japanese information spillovers are market specific and generally weak compared to the U.S. influence. This might be explained by the fact that the regional markets receive significant portfolio investment inflows from the U.S. thus exhibiting significant and consistent information spillovers from the U.S. The Japanese financial flows to the region, however, are mostly via bank lending which would result in indirect financial linkages between the Japanese and the regional stock markets.

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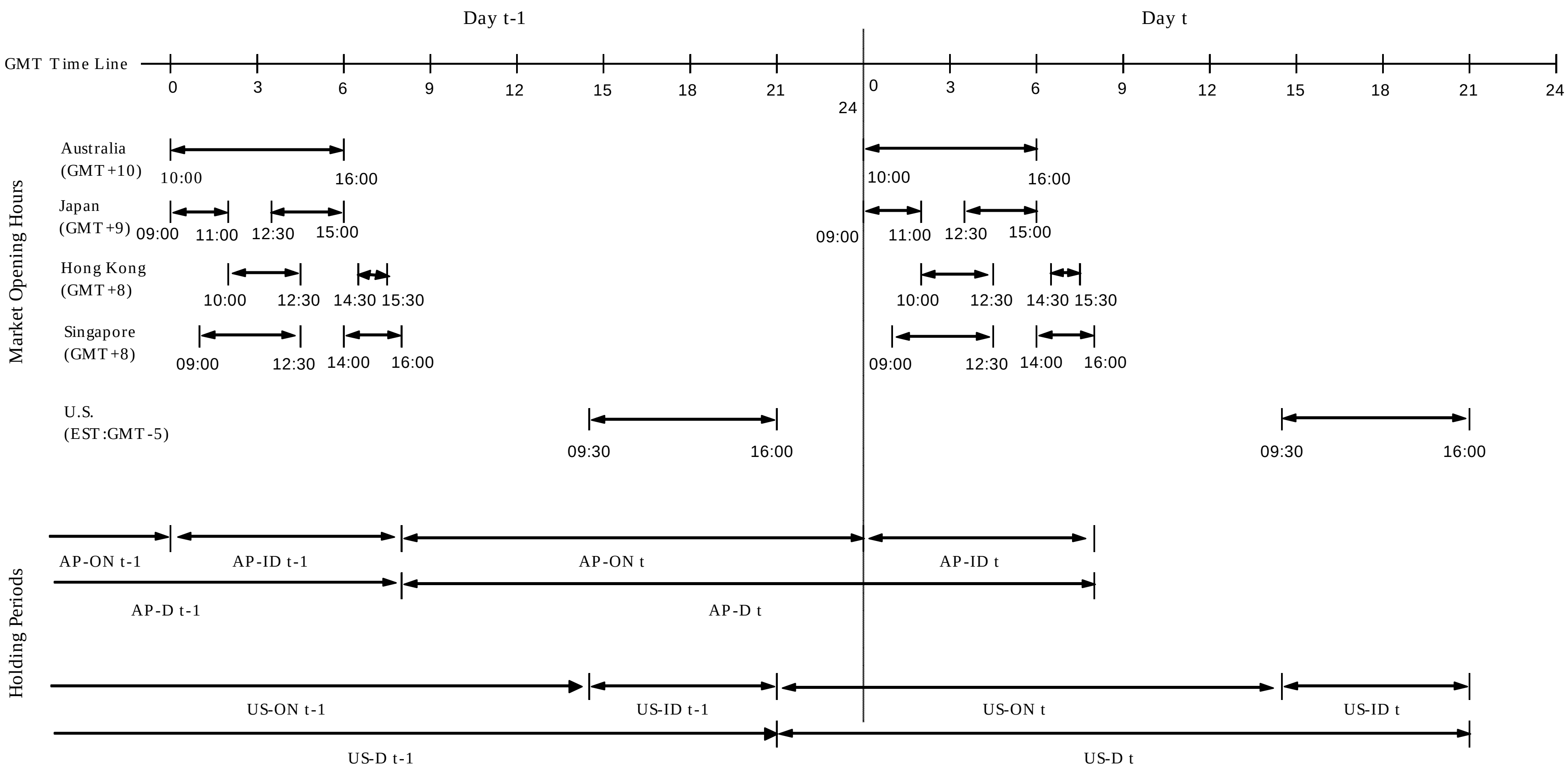
Figure 1: Stock market trading hours in the Asia-Pacific and the U.S.



ON: Overnight - Closing at t-1 to Opening at t
ID: Intradaily - Opening at t to Closing at t
D: Daily - Closing at t-1 to Closing at t
AP: Asia-Pacific markets of Australia, Hong Kong, Japan and Singapore
US: US stock market

Table 1: Statistical properties of overnight and daily stock market index return

Country	Australia			Japan			Hong Kong			Singapore			US		
H. Period	Daily[(a)]	Overnight[(b)]	Intradaily[(c)]	Daily[(a)]	Overnight[(b)]	Intradaily[(c)]	Daily[(a)]	Overnight[(b)]	Intradaily[(c)]	Daily[(a)]	Overnight[(b)]	Intradaily[(c)]	Daily[(a)]	Overnight[(b)]	Intradaily[(c)]
	Summary Statistics														
Mean	0.0340	-0.0016	0.0357	0.0037	0.0032	-0.0285	0.0366	0.0194	0.0172	0.0209	0.0274	-0.0064	0.0430	-0.0039	0.0466
Variance	0.9611	0.0681	0.8378	1.4511	0.1381	1.3931	3.3847	1.3651	1.7324	1.7442	0.6298	1.1393	1.1011	0.0300	1.1204
Skewness	-6.4499	-2.6700	-7.1249	-0.2851	-0.3054	0.2937	-3.4459	-6.0933	-0.6803	-0.4375	-2.0322	0.3693	-2.6405	-2.8198	-2.5700
Kurtosis	172.15	49.75	203.70	11.34	15.07	4.38	73.82	157.18	8.05	15.06	45.74	14.07	55.99	127.15	54.00
	Tests of iid[(d)]														
Q(20)	47.25 ***	83.58 ***	43.91 ***	68.12 ***	53.72 ***	92.11 ***	47.42 ***	56.57 ***	54.39 ***	102.89 ***	62.61 ***	114.80 ***	49.27 ***	52.88 ***	53.54 ***
	{0.0005}	{0.0000}	{0.0015}	{0.0000}	{0.0001}	{0.0000}	{0.0005}	{0.0000}	{0.0001}	{0.0000}	{0.0000}	{0.0000}	{0.0003}	{0.0001}	{0.0001}
$Q^2(20)$	147.37 ***	17.88	473.52 ***	406.95 ***	195.07 ***	441.05 ***	958.18 ***	353.65 ***	1178.40 ***	444.59 ***	103.75 ***	1667.00 ***	644.83 ***	25.94	721.01 ***
	{0.0000}	{0.5954}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.1678}	{0.0000}
E-N	104.62 ***	19.46 ***	213.26 ***	67.65 ***	162.62 ***	109.72 ***	316.97 ***	264.03 ***	177.15 ***	119.96 ***	110.14 ***	322.74 ***	111.21 ***	36.74 ***	141.29 ***
	{0.0000}	{0.0002}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}

Stock market indexes are All ordinaries, TOPIX, Hang Seng, Straits Times, and S&P 500

(a) $\ln(P_t^{Close} / P_{t-1}^{Close}) \times 100$

(b) $\ln(P_t^{Open} / P_{t-1}^{Close}) \times 100$

(c) $\ln(P_t^{Close} / P_t^{Open}) \times 100$

(d) Q(20): Box-Pierce Q-test of serial correlation for returns
Q2(20): Box-Pierce Q-test of serial correlation for squared returns
E-N: Engle and Ng (1993) 's joint sign bias test
***, ** and *: significance at 1, 5 and 10%, respect

Table 2: Correlations of market return and volatility

	Daily Returns Correlations					Daily volatility correlations				
	Full-Sample: 24 July 1990 to 27 March 2002									
	Australia	Japan	Hong Kong	Singapore	US	Australia	Japan	Hong Kong	Singapore	US
Australia	1	0.3732	0.4680	0.4027	0.4838	1	0.2134	0.6043	0.6122	0.3670
Japan	0.3732	1	0.3406	0.3255	0.3016	0.2134	1	0.1902	0.1892	0.1882
Hong Kong	0.4680	0.3406	1	0.5531	0.3800	0.6043	0.1902	1	0.5506	0.3979
Singapore	0.4027	0.3255	0.5531	1	0.3334	0.6122	0.1892	0.5506	1	0.2288
US	0.4838	0.3016	0.3800	0.3334	1	0.3670	0.1882	0.3979	0.2288	1
	Pre-Crisis: 24 July 1990 to 30 June 1997									
Australia	1	0.3036	0.3904	0.3282	0.4482	1	0.2123	0.3958	0.3083	0.3078
Japan	0.3036	1	0.2609	0.3076	0.2458	0.2123	1	0.1861	0.2727	0.1716
Hong Kong	0.3904	0.2609	1	0.4450	0.3333	0.3958	0.1861	1	0.3978	0.1958
Singapore	0.3282	0.3076	0.4450	1	0.2931	0.3083	0.2727	0.3978	1	0.2061
US	0.4482	0.2458	0.3333	0.2931	1	0.3078	0.1716	0.1958	0.2061	1
	Post-Crisis: 1 July 1997 to 27 March 2002									
Australia	1	0.4493	0.5395	0.4705	0.5255	1	0.2627	0.6356	0.6531	0.3743
Japan	0.4493	1	0.4126	0.3522	0.3534	0.2627	1	0.2262	0.1923	0.2267
Hong Kong	0.5395	0.4126	1	0.6097	0.4049	0.6356	0.2262	1	0.5607	0.4076
Singapore	0.4705	0.3522	0.6097	1	0.3525	0.6531	0.1923	0.5607	1	0.2032
US	0.5255	0.3534	0.4049	0.3525	1	0.3743	0.2267	0.4076	0.2032	1
	Percentage difference between Post-crisis correlations and Pre-crisis correlations									
Australia	0%	48%	38%	43%	17%	0%	24%	61%	112%	22%
Japan	48%	0%	58%	14%	44%	24%	0%	22%	-29%	32%
Hong Kong	38%	58%	0%	37%	21%	61%	22%	0%	41%	108%
Singapore	43%	14%	37%	0%	20%	112%	-29%	41%	0%	-1%
US	17%	44%	21%	20%	0%	22%	32%	108%	-1%	0%
Average change	**37%**	**41%**	**39%**	**29%**	**26%**	**54%**	**12%**	**58%**	**30%**	**40%**

Daily returns: $\ln(P_t^{Close} / P_{t-1}^{Close}) \times 100$

Daily volatility: $[\ln(P_t^{Close} / P_{t-1}^{Close}) \times 100]^2$

Table 3: Tests of Granger Causality of the U.S. and Japanese stock market information

$$y_t = a + \sum_{i=1}^{m} b_i \cdot y_{t-i} + \sum_{j=1}^{n} c_j \cdot x_{t-i} + e_t$$, H0: *x* does not Granger Cause *y*, c_j = for all *j*

$x \xrightarrow{G.C.} y$ k =	U.S. Granger Causes: Australia	Japan	HK	SP	$x \xrightarrow{G.C.} y$ k =	Japan Granger Causes: Australia	HK	SP	US
	Full-Sample: 24 July 1990 to 27 March 2002								
$R_{ID}^{US} \xrightarrow{G.C.} R_{ID}^{k}$	158.10 ***	25.20 ***	15.31 ***	15.54 ***	$R_{ID}^{JP} \xrightarrow{G.C.} R_{ID}^{k}$	5.57	10.88 *	3.20	26.75 ***
	{0.0000}	{0.0000}	{0.0000}	{0.0000}		{0.3501}	{0.0539}	{0.6687}	{0.0001}
$VT_{ID}^{US} \xrightarrow{G.C.} VT_{ID}^{k}$	27.49 ***	20.57 ***	5.12 ***	10.83 ***	$VT_{ID}^{JP} \xrightarrow{G.C.} VT_{ID}^{k}$	4.32	7.40	6.84	11.98 **
	{0.0000}	{0.0000}	{0.0001}	{0.0000}		{0.5039}	{0.1926}	{0.2329}	{0.0350}
$VM_{ID}^{US} \xrightarrow{G.C.} R_{ID}^{k}$	1.87 *	1.62	2.25 **	0.88	$VM_{ID}^{JP} \xrightarrow{G.C.} R_{ID}^{k}$	3.67	9.47 *	9.83 *	8.44
	{0.0960}	{0.1510}	{0.0467}	{0.4927}		{0.5978}	{0.0918}	{0.0802}	{0.1334}
$VM_{ID}^{US} \xrightarrow{G.C.} VT_{ID}^{k}$	2.37 **	4.34 ***	3.31 ***	3.39 ***	$VM_{ID}^{JP} \xrightarrow{G.C.} VT_{ID}^{k}$	5.24	3.42	7.37	8.56
	{0.0369}	{0.0006}	{0.0056}	{0.0047}		{0.3868}	{0.6355}	{0.1946}	{0.1281}
	Pre-Crisis: 24 July 1990 to 30 June 1997								
$R_{ID}^{US} \xrightarrow{G.C.} R_{ID}^{k}$	58.02 ***	14.36 ***	18.73 ***	9.48 ***	$R_{ID}^{JP} \xrightarrow{G.C.} R_{ID}^{k}$	3.76	14.73 **	5.92	15.94 ***
	{0.0000}	{0.0000}	{0.0000}	{0.0000}		{0.5837}	{0.0116}	{0.3142}	{0.0070}
$VT_{ID}^{US} \xrightarrow{G.C.} VT_{ID}^{k}$	10.52 ***	5.30 ***	12.45 ***	1.09	$VT_{ID}^{JP} \xrightarrow{G.C.} VT_{ID}^{k}$	5.40	3.78	10.52 *	10.27 *
	{0.0000}	{0.0001}	{0.0000}	{0.3645}		{0.3694}	{0.5808}	{0.0618}	{0.0678}
$VM_{ID}^{US} \xrightarrow{G.C.} R_{ID}^{k}$	2.77 **	3.65 ***	1.86 *	1.09	$VM_{ID}^{JP} \xrightarrow{G.C.} R_{ID}^{k}$	3.42	5.48	4.09	4.52
	{0.0168}	{0.0027}	{0.0987}	{0.3639}		{0.6351}	{0.3604}	{0.5370}	{0.4772}
$VM_{ID}^{US} \xrightarrow{G.C.} VT_{ID}^{k}$	4.97 ***	4.15 ***	4.52 ***	1.10	$VM_{ID}^{JP} \xrightarrow{G.C.} VT_{ID}^{k}$	5.21	2.42	4.91	5.20
	{0.0002}	{0.0009}	{0.0004}	{0.3591}		{0.3904}	{0.7889}	{0.4270}	{0.3919}
	Post-Crisis: 1 July 1997 to 27 March 2002								
$R_{ID}^{US} \xrightarrow{G.C.} R_{ID}^{k}$	96.18 ***	12.95 ***	3.97 ***	6.92 ***	$R_{ID}^{JP} \xrightarrow{G.C.} R_{ID}^{k}$	5.32	7.26	5.05	13.96 **
	{0.0000}	{0.0000}	{0.0014}	{0.0000}		{0.3783}	{0.2023}	{0.4097}	{0.0159}
$VT_{ID}^{US} \xrightarrow{G.C.} VT_{ID}^{k}$	10.52 ***	14.79 ***	1.22	3.47 ***	$VT_{ID}^{JP} \xrightarrow{G.C.} VT_{ID}^{k}$	6.19	6.92	6.50	7.13
	{0.0000}	{0.0000}	{0.2982}	{0.0040}		{0.2879}	{0.2270}	{0.2605}	{0.2110}
$VM_{ID}^{US} \xrightarrow{G.C.} R_{ID}^{k}$	0.39	0.52	0.88	0.39	$VM_{ID}^{JP} \xrightarrow{G.C.} R_{ID}^{k}$	8.09	5.51	8.93	11.34 **
	{0.8533}	{0.7590}	{0.4927}	{0.8536}		{0.1513}	{0.3565}	{0.1117}	{0.0451}
$VM_{ID}^{US} \xrightarrow{G.C.} VT_{ID}^{k}$	1.54	1.75	0.99	4.47 ***	$VM_{ID}^{JP} \xrightarrow{G.C.} VT_{ID}^{k}$	4.74	2.47	5.03	5.68
	{0.1735}	{0.1203}	{0.4217}	{0.0005}		{0.4486}	{0.7813}	{0.4117}	{0.3388}

R = returns, VT = volatility, VM = detrended trading volume.

Superscripts: US - U.S. market, k = {Australia, Japan, Hong Kong and Singapore} for the U.S. causality, and {Australia, Hong Kong, Singapore and U.S.} for the Japanese causality.

Subscript: ID - intradaily holding period of open to close at t., m=n=5.

Test statistics are reported with associated p-values in brackets.

Table 4: U.S. information spillovers – Contemporaneous

$$R^{AP}_{ON,t} = \alpha_{R\_US} \cdot R^{US}_{ID,t-1} + \alpha_{VM\_US} \cdot VM^{US}_{ID,t-1} + M(\cdot), \qquad \ln h^{AP}_{ON,t} = \beta_{VT\_US} \cdot VT^{US}_{ID,t-1} + \beta_{VM\_US} \cdot VM^{US}_{ID,t-1} + V(\cdot)$$

	Australia			Japan			Hong Kong			Singapore		
	full-sample	pre-1997	post-1997	full-sample	pre-1997	post-1997	full-sample	pre-1997	post-1997	full-sample	pre-1997	post-1997
α_c	0.0041***	-0.0113***	-0.0021	0.0068	-0.0005	-0.0019	-0.0449**	-0.0330**	-0.0418	0.0530***	0.0313***	0.0870**
	{0.0036}	{0.0000}	{0.9814}	{0.6220}	{0.9587}	{0.8706}	{0.0242}	{0.0139}	{0.3157}	{0.0000}	{0.0000}	{0.0494}
α_{Hol}	-0.0017	0.0028**	0.0001	0.0001	0.0053	0.0004	0.0283**	0.0212***	0.0240	-0.0182***	-0.0156***	-0.0305
	{0.3146}	{0.0338}	{0.9993}	{0.9912}	{0.3312}	{0.9525}	{0.0362}	{0.0013}	{0.3947}	{0.0000}	{0.0000}	{0.3506}
α_{R_US}	0.0092***	0.0403***	-0.0001	0.1040***	0.0704***	0.1437***	0.3268***	0.2709***	0.4464***	0.1237***	0.0211***	0.2379***
	{0.0019}	{0.0000}	{0.7874}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0001}	{0.0000}
α_{VM_US}	0.0207*	0.0004	0.0043	-0.0075	0.0334	-0.1654**	0.0260	-0.0083	0.1223*	0.0373***	-0.0345***	0.0331
	{0.0625}	{0.9260}	{0.8481}	{0.7426}	{0.5023}	{0.0143}	{0.6249}	{0.8538}	{0.0901}	{0.0000}	{0.0000}	{0.8018}
β_c	-2.9113***	0.2899	-4.8076	-0.3775	-0.6957	0.1739	-0.3372*	-0.4157	-0.9960***	-0.5749***	0.0895**	-1.0320***
	{0.0000}	{0.3247}	{0.3445}	{0.1847}	{0.1239}	{0.2257}	{0.0924}	{0.2881}	{0.0000}	{0.0006}	{0.0453}	{0.0000}
$\beta_{\varepsilon 1}$	-0.0144	-0.0024	0.0989	0.0044	-0.0491	-0.0063	-0.0539	-0.0734	-0.0522	-0.0511	-0.0408**	-0.0264
	{0.2823}	{0.9727}	{0.8971}	{0.9048}	{0.5219}	{0.8564}	{0.1881}	{0.3168}	{0.3259}	{0.1593}	{0.0341}	{0.7338}
$\beta_{\varepsilon 2}$	0.7494***	0.4446***	0.4023***	0.4165***	0.4538***	0.1284**	0.3815***	0.4861***	0.4176***	0.4462***	0.0982***	0.4641***
	{0.0000}	{0.0011}	{0.0000}	{0.0000}	{0.0000}	{0.0458}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0006}
β_h	0.2229***	0.9264***	-0.0706	0.7997***	0.6887***	0.9784***	0.8165***	0.6764***	0.1739**	0.8277***	0.9940***	0.7197***
	{0.0000}	{0.0000}	{0.9497}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0001}	{0.0437}	{0.0000}	{0.0000}	{0.0000}
β_{Hol}	0.3363***	-0.3081	0.8092	-0.0372	-0.0220	-0.1361	0.0473	-0.0972	0.3441***	0.1905***	-0.0360	0.2930*
	{0.0000}	{0.2235}	{0.8299}	{0.7081}	{0.8686}	{0.1599}	{0.4928}	{0.2961}	{0.0000}	{0.0097}	{0.1882}	{0.0519}
β_{VT_US}	0.7364**	0.2941	-7.3244	0.5886	-0.7874	0.0194	1.9586**	2.3127	2.0972***	1.7433***	-0.5524***	2.6559***
	{0.0303}	{0.8784}	{0.9022}	{0.1283}	{0.4607}	{0.8896}	{0.0128}	{0.1226}	{0.0010}	{0.0000}	{0.0032}	{0.0000}
β_{VM_US}	0.1965	1.4821	0.0249	0.2791	0.5314	0.3359	0.1460	-0.1324	0.6767**	0.0927	0.3271	0.3746*
	{0.5061}	{0.1797}	{0.9944}	{0.3400}	{0.3719}	{0.3066}	{0.5808}	{0.6071}	{0.0289}	{0.6873}	{0.3643}	{0.0565}
q	8	6	6	4	4	4	6	6	6	10	10	10
Sk-z	-2.0541	-1.49	0.10	-0.25	-1.14	0.19	-0.60	-0.59	-0.36	-1.66	-2.85	-0.41
Kur-z	45.4380	22.3521	68.41	25.26	31.13	16.67	11.57	12.41	6.73	31.61	40.45	11.09
Q(20)-z	62.28***	59.75***	71.09***	21.22	19.39	14.47	23.88	26.42	22.21	38.13***	23.14	22.94
	{0.0000}	{0.0000}	{0.0000}	{0.3845}	{0.4966}	{0.8058}	{0.2476}	{0.1523}	{0.3292}	{0.0085}	{0.2818}	{0.2920}
Q(20)-z^2	20.04	19.72	17.80	11.32	4.92	10.81	12.25	10.09	25.59	2.01	13.45	19.97
	{0.4555}	{0.4754}	{0.6005}	{0.9374}	{0.9998}	{0.9509}	{0.9071}	{0.9665}	{0.1796}	{1.0000}	{0.8570}	{0.4598}
E-N	1.1081	0.58	3.73	1.71	1.75	1.56	1.03	0.16	1.83	7.72*	10.14**	2.19
	{0.7751}	{0.9015}	{0.2925}	{0.6353}	{0.6257}	{0.6675}	{0.7929}	{0.9838}	{0.6092}	{0.0523}	{0.0174}	{0.5348}

Where: q is the number of error terms in the conditional mean equations included to reduce residual serial correlation; Sk-z and Kur-z are skewness and kurtosis of the standardized residuals z_t, ; Q(20) and $Q^2(20)$ are Box-Pierce Q-test of serial correlation of z_t and z_t^2; E-N is the Engle and Ng's joint sign bias test of z_t,; ***, ** and * are significance at 1, 5 and 10%, respectively; and the numbers in the brackets are p-values.

Table 5: Japanese information spillovers – Contemporaneous

For Australia, HK and SP: $R^{AP}_{ID,t} = \alpha_{R\_JP} \cdot R^{JP}_{ID,t} + \alpha_{VM\_JP} \cdot VM^{JP}_{ID,t} + M(\cdot)$, $\ln h^{AP}_{ID,t} = \beta_{VT\_JP} \cdot VT^{JP}_{ID,t} + \beta_{VM\_JP} \cdot VM^{JP}_{ID,t} + V(\cdot)$

For the U.S.: $R^{US}_{ON,t} = \alpha_{R\_JP} \cdot R^{JP}_{ID,t} + \alpha_{VM\_JP} \cdot VM^{JP}_{ID,t} + M(\cdot)$, $\ln h^{US}_{ON,t} = \beta_{VT\_JP} \cdot VT^{JP}_{ID,t} + \beta_{VM\_JP} \cdot VM^{JP}_{ID,t} + V(\cdot)$

	Australia			Hong Kong			Singapore			U.S.		
	Full-sample	Pre-1997	Post-1997	Full-sample	Pre-1997	Post-1997	Full-sample	Pre-1997	Post-1997	Full-sample	Pre-1997	Post-1997
α_c	0.0181	0.0287	0.0037	0.1047 ***	0.1675 ***	-0.0788	0.0307 **	0.0194	-0.0190	-0.0196 ***	0.0003	0.0022
	{0.4248}	{0.3955}	{0.9207}	{0.0062}	{0.0002}	{0.3054}	{0.0295}	{0.2495}	{0.7287}	{0.0000}	{0.4765}	{0.5371}
α_{Hol}	0.0090	0.0008	0.0191	-0.0266	-0.0377	0.0132	-0.0167 **	-0.0137 **	-0.0068	0.0001	-0.0002	-0.0007
	{0.5587}	{0.9748}	{0.4628}	{0.2853}	{0.1336}	{0.7564}	{0.0435}	{0.0109}	{0.7928}	{0.3736}	{0.4510}	{0.3950}
α_{R_JP}	0.1842 ***	0.1621 ***	0.2217 ***	0.2686 ***	0.2211 ***	0.3533 ***	0.0061 **	0.0019	0.2673 ***	-0.0054 ***	-0.0007	0.0022
	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0213}	{0.4497}	{0.0000}	{0.0000}	{0.1050}	{0.3827}
α_{VM_JP}	-0.0531	-0.0082	-0.0962 **	0.0569	0.0647	0.0821	-0.0255 **	-0.0014	0.0859	0.0112	-0.0023 *	-0.0016 **
	{0.2895}	{0.8909}	{0.0421}	{0.2303}	{0.3124}	{0.3941}	{0.0411}	{0.9097}	{0.2040}	{0.7478}	{0.0701}	{0.0189}
β_c	-0.4523 *	-0.2974 *	-0.4499 **	-0.0961 **	-0.2248 ***	-0.0256	-0.0068	-0.0354	-0.1519 *	2.3114 ***	4.3041 ***	4.0076 ***
	{0.0732}	{0.0595}	{0.0243}	{0.0120}	{0.0067}	{0.6400}	{0.8969}	{0.9325}	{0.0780}	{0.0000}	{0.0000}	{0.0000}
$\beta_{\varepsilon 1}$	-0.0626 *	-0.0293	-0.0944 *	-0.0330 ***	-0.0389	-0.0440 **	-0.0723 ***	-0.1911	-0.0652 ***	-0.0100 ***	-0.1795 **	-1.4100 ***
	{0.0844}	{0.2132}	{0.0532}	{0.0082}	{0.1002}	{0.0171}	{0.0000}	{0.4948}	{0.0024}	{0.0012}	{0.0202}	{0.0000}
$\beta_{\varepsilon 2}$	0.2329 **	0.1441 ***	0.2548 ***	0.1810 ***	0.2117 ***	0.1623 ***	0.3714 ***	0.6906 **	0.2394 ***	0.7913 ***	0.1264 ***	2.6590 ***
	{0.0134}	{0.0065}	{0.0033}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0284}	{0.0000}	{0.0000}	{0.0012}	{0.0000}
β_h	0.7308 ***	0.9075 ***	0.6554 ***	0.9689 ***	0.9474 ***	0.9773 ***	0.9771 ***	0.9665 ***	0.9639 ***	0.9053 ***	0.9880 ***	0.5499 ***
	{0.0084}	{0.0000}	{0.0017}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}
β_{Hol}	0.1462 ***	0.1508 **	0.1015 *	0.0725 ***	0.1562 ***	0.0248	0.0330	0.0838	0.1110 *	-1.6632 ***	-3.0270 ***	-2.8396 ***
	{0.0015}	{0.0352}	{0.0817}	{0.0096}	{0.0070}	{0.5130}	{0.3786}	{0.7919}	{0.0559}	{0.0000}	{0.0000}	{0.0000}
β_{VT_JP}	0.7567	0.1461	1.1960 **	0.0782	0.1195	0.0835	-0.2624 ***	-0.6283 ***	0.2237 *	-0.0707 *	0.1996	-0.2804
	{0.2358}	{0.4090}	{0.0212}	{0.1320}	{0.2047}	{0.3216}	{0.0077}	{0.0036}	{0.0654}	{0.0765}	{0.2474}	{0.5683}
β_{VM_JP}	-0.0036	0.0809	-0.0112	0.2523	0.3806 *	0.1244	0.7300 ***	1.3828	0.2765 *	-1.0569 ***	-2.6937 ***	-3.4014 ***
	{0.9709}	{0.5309}	{0.9382}	{0.1302}	{0.0727}	{0.4050}	{0.0000}	{0.1934}	{0.0780}	{0.0041}	{0.0000}	{0.0000}
q	6	6	6	4	4	4	10	10	10	6	6	6
Sk-z	-0.1344	-0.19	-0.11	-0.25	-0.40	0.08	3.34	5.09	0.41	-1.31	-5.65	3.25
Kur-z	0.6193	1.0001	0.24	2.27	2.76	0.53	66.79	105.31	1.83	117.96	111.40	86.06
Q(20)-z	21.42	19.76	16.10	16.68	16.49	10.62	54.47 ***	185.89 ***	16.54	12.36	38.45 ***	24.01
	{0.3728}	{0.4730}	{0.7107}	{0.6734}	{0.6860}	{0.9556}	{0.0000}	{0.0000}	{0.6826}	{0.9033}	{0.0078}	{0.2420}
Q(20)-z^2	27.93	12.09	14.94	12.08	12.60	17.51	0.31	0.25	18.64	5.13	25.54	29.10 *
	{0.1111}	{0.9128}	{0.7798}	{0.9134}	{0.8941}	{0.6195}	{1.0000}	{1.0000}	{0.5456}	{0.9997}	{0.1817}	{0.0857}
E-N	1.0510	1.01	4.16	2.21	2.38	1.11	0.38	1.93	2.09	8.24 **	2.19	1.70
	{0.7889}	{0.7997}	{0.2446}	{0.5302}	{0.4974}	{0.7744}	{0.9448}	{0.5874}	{0.5543}	{0.0414}	{0.5346}	{0.6364}

Table 6: U.S. information spillovers – Dynamic

$$R^{AP}_{ID,t} = \alpha_{R\_US} \cdot R^{US}_{ID,t-1} + \alpha_{VM\_US} \cdot VM^{US}_{ID,t-1} + M(\cdot)\,, \qquad \ln h^{AP}_{ID,t} = \beta_{VT\_US} \cdot VT^{US}_{ID,t-1} + \beta_{VM\_US} \cdot VM^{US}_{ID,t-1} + V(\cdot)$$

	Australia			Japan			Hong Kong			Singapore		
	full-sample	pre-1997	post-1997	full-sample	pre-1997	post-1997	full-sample	pre-1997	post-1997	full-sample	pre-1997	post-1997
α_c	-0.0168	-0.0166	-0.0143	0.0034	0.0121	0.0060	0.0926 **	0.1511 ***	-0.0988	-0.0285 ***	0.0000	-0.0444
	{0.4342}	{0.5055}	{0.7229}	{0.9003}	{0.7531}	{0.9199}	{0.0210}	{0.0005}	{0.1949}	{0.0035}	{0.9981}	{0.5148}
α_{Hol}	0.0168	0.0156	0.0172	-0.0463 **	-0.0554 ***	-0.0293	-0.0364	-0.0490 *	0.0173	0.0140 **	0.0000	-0.0079
	{0.1820}	{0.3129}	{0.5478}	{0.0114}	{0.0088}	{0.4365}	{0.1181}	{0.0621}	{0.7162}	{0.0133}	{0.9930}	{0.8539}
α_{R_US}	0.3255 ***	0.3442 ***	0.3148 ***	0.1923 ***	0.2136 ***	0.1799 ***	0.2370 ***	0.3033 ***	0.1735 ***	-0.0015 ***	0.0000	0.0363
	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0002}	{0.9988}	{0.1385}
α_{VM_US}	0.0252	0.0859	-0.0652	0.0730	0.0624	-0.2165 *	0.0442	-0.0085	0.1448	0.0174 ***	0.0000	0.0194
	{0.5517}	{0.1073}	{0.3934}	{0.4800}	{0.6074}	{0.0742}	{0.5689}	{0.9171}	{0.5161}	{0.0012}	{0.9929}	{0.8304}
β_c	-0.5341 ***	-0.5086 ***	-0.1015	-0.1811 ***	-0.1387 **	-0.3349 ***	-0.0956 **	-0.1623 *	-0.0279	0.0604	0.1703 **	-0.2044 ***
	{0.0007}	{0.0011}	{0.4763}	{0.0008}	{0.0390}	{0.0003}	{0.0469}	{0.0507}	{0.4902}	{0.3595}	{0.0207}	{0.0068}
$\beta_{\varepsilon 1}$	-0.0220	0.0068	-0.1012 ***	-0.0876 ***	-0.1053 ***	-0.0357	-0.0450 **	-0.0590 **	-0.0438 **	-0.0666 ***	-0.2762 ***	-0.0642 ***
	{0.4549}	{0.8057}	{0.0005}	{0.0000}	{0.0001}	{0.1872}	{0.0200}	{0.0365}	{0.0266}	{0.0001}	{0.0000}	{0.0005}
$\beta_{\varepsilon 2}$	0.2468 ***	0.2301 ***	0.0441	0.2344 ***	0.2397 ***	0.1786 ***	0.1772 ***	0.1901 ***	0.1440 ***	0.3092 ***	0.4057 ***	0.1890 ***
	{0.0000}	{0.0000}	{0.3215}	{0.0000}	{0.0001}	{0.0000}	{0.0000}	{0.0000}	{0.0015}	{0.0000}	{0.0000}	{0.0000}
β_h	0.6747 ***	0.6933 ***	0.9686 ***	0.9496 ***	0.9660 ***	0.8654 ***	0.9637 ***	0.9511 ***	0.9789 ***	0.9727 ***	0.9843 ***	0.9668 ***
	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}
β_{Hol}	0.1414 ***	0.1183 **	0.0490	0.1224 ***	0.0999 **	0.2207 ***	0.0721 **	0.1234 **	0.0252	-0.0236	0.1851 ***	0.1430 ***
	{0.0041}	{0.0196}	{0.5758}	{0.0005}	{0.0234}	{0.0004}	{0.0410}	{0.0373}	{0.3618}	{0.6049}	{0.0000}	{0.0057}
β_{VT_US}	0.9877 ***	1.8398 ***	0.0568	0.2009 **	-0.0160	0.4231 **	0.1388	-0.2266	0.0815	-0.1095	-7.4512 ***	0.1914 **
	{0.0097}	{0.0066}	{0.4858}	{0.0467}	{0.9470}	{0.0139}	{0.1786}	{0.2142}	{0.3526}	{0.3005}	{0.0000}	{0.0295}
β_{VM_US}	0.4808 **	0.4365 *	1.2551 ***	0.3106 **	0.2188	0.8312 ***	0.3893 ***	0.6548 **	0.2122	0.6923 ***	1.9712 ***	1.0919 ***
	{0.0223}	{0.0647}	{0.0001}	{0.0136}	{0.1973}	{0.0002}	{0.0012}	{0.0151}	{0.3594}	{0.0000}	{0.0000}	{0.0002}
q	8	4	6	4	4	4	12	12	12	10	10	10
Sk-z	-0.1052	-0.07	-0.19	0.17	0.32	0.01	-0.35	-0.46	0.02	0.32	0.20	0.32
Kur-z	0.9022	0.6641	1.17	1.77	2.44	0.80	3.15	3.79	0.53	3.45	93.04	1.82
Q(20)-z	5.58	15.58	9.23	19.64	8.88	25.61	9.28	12.07	4.16	43.81 ***	29.95 *	14.61
	{0.7424}	{0.7424}	{0.9801}	{0.4808}	{0.9842}	{0.1791}	{0.9794}	{0.9137}	{0.9999}	{0.0016}	{0.0707}	{0.7981}
Q(20)-z^2	18.53	18.53	20.21	18.33	17.34	21.94	6.31	7.44	17.98	62.65 ***	71.44 ***	24.94
	{0.5522}	{0.5522}	{0.4451}	{0.5655}	{0.6311}	{0.3438}	{0.9984}	{0.9950}	{0.5885}	{0.0000}	{0.0000}	{0.2037}
E-N	2.3034	2.30	3.73	1.58	2.62	0.39	0.83	1.51	1.54	10.42 **	1.23	1.58
	{0.5119}	{0.5119}	{0.2923}	{0.6647}	{0.4541}	{0.9414}	{0.8423}	{0.6794}	{0.6732}	{0.0153}	{0.7456}	{0.6637}

Table 7: Japanese information spillovers – Dynamic

For Australia, HK and SP: $R^{AP}_{ID,t} = \alpha_{R\_JP} \cdot R^{JP}_{ID,t-1} + \alpha_{VM\_JP} \cdot VM^{JP}_{ID,t-1} + M(\cdot)$, $\ln h^{AP}_{ID,t} = \beta_{VT\_JP} \cdot VT^{JP}_{ID,t-1} + \beta_{VM\_JP} \cdot VM^{JP}_{ID,t-1} + V(\cdot)$

For the U.S.: $R^{US}_{ID,t} = \alpha_{R\_JP} \cdot R^{JP}_{ID,t} + \alpha_{VM\_JP} \cdot VM^{JP}_{ID,t} + M(\cdot)$, $\ln h^{US}_{ID,t} = \beta_{VT\_JP} \cdot VT^{JP}_{ID,t} + \beta_{VM\_JP} \cdot VM^{JP}_{ID,t} + V(\cdot)$

	Australia			Hong Kong			Singapore			U.S.		
	Full-sample	Pre-1997	Post-1997	Full-sample	Pre-1997	Post-1997	Full-sample	Pre-1997	Post-1997	Full-sample	Pre-1997	Post-1997
α_c	-0.0015	-0.0025	-0.0056	-0.0507***	-0.0159	0.0042	0.0175***	-0.0077*	0.1190**	0.0000	0.0140	-0.0042
	{0.3496}	{0.1266}	{0.6217}	{0.0014}	{0.2452}	{0.8547}	{0.0000}	{0.0659}	{0.0005}	{0.9989}	{0.6515}	{0.9482}
α_{Hol}	-0.0006	0.0007	0.0014	0.0265***	0.0081*	0.0257	-0.0083*	-0.0006	-0.0286**	0.0195	0.0203	0.0002
	{0.5415}	{0.3738}	{0.9060}	{0.0049}	{0.0727}	{0.1546}	{0.0550}	{0.9420}	{0.0223}	{0.2750}	{0.3297}	{0.9955}
α_{R_JP}	0.0007**	-0.0055***	-0.0007**	0.0074***	0.0021	0.0543**	-0.0166***	-0.0136***	0.0373**	0.0663***	0.0608***	0.1230***
	{0.0430}	{0.0017}	{0.0000}	{0.0061}	{0.6300}	{0.0044}	{0.0000}	{0.0002}	{0.0000}	{0.0000}	{0.0001}	{0.0000}
α_{VM_JP}	-0.0070**	0.0138***	-0.0036	0.0183	0.0208	-0.0278	0.0705***	-0.0654***	0.0449	-0.0629	-0.0973*	0.1247***
	{0.0402}	{0.0000}	{0.2737}	{0.2625}	{0.2408}	{0.1454}	{0.0000}	{0.0000}	{0.2449}	{0.1400}	{0.0639}	{0.0012}
β_c	-0.4576***	-0.0293	-3.6944**	-0.0191	0.1210	-0.2235**	-0.3119*	0.0126	-0.5486**	-0.0525	-0.0199	-0.0733
	{0.0079}	{0.8835}	{0.0000}	{0.8370}	{0.2708}	{0.0002}	{0.0778}	{0.8476}	{0.0039}	{0.4244}	{0.8385}	{0.4128}
$\beta_{\varepsilon 1}$	-0.0186	-0.0547	0.5979**	-0.0869***	-0.0536*	-0.1693**	-0.1095**	-0.0630*	-0.1759**	-0.0853***	-0.0441**	-0.2135***
	{0.7002}	{0.2736}	{0.0057}	{0.0012}	{0.0546}	{0.0321}	{0.0148}	{0.0700}	{0.0061}	{0.0000}	{0.0194}	{0.0000}
$\beta_{\varepsilon 2}$	0.2984***	0.4110***	0.9442**	0.1919***	0.0781	0.6659**	0.4618***	0.0941***	0.6727**	0.1237***	0.0927***	0.0902***
	{0.0000}	{0.0001}	{0.0000}	{0.0003}	{0.1619}	{0.0000}	{0.0000}	{0.0035}	{0.0000}	{0.0000}	{0.0003}	{0.0069}
β_h	0.9301***	0.8784***	0.1994**	0.9590***	0.9696***	0.0963	0.8708***	0.9877***	0.7183**	0.9837***	0.9862***	0.9190***
	{0.0000}	{0.0000}	{0.0078}	{0.0000}	{0.0000}	{0.6043}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}
β_{Hol}	0.2109**	-0.2001	0.6784**	0.0101	-0.1030	0.2472**	0.1449	-0.0142	0.2371*	0.0372	0.0093	0.0625
	{0.0138}	{0.1265}	{0.0000}	{0.8594}	{0.1251}	{0.0000}	{0.1127}	{0.6915}	{0.0702}	{0.4126}	{0.8896}	{0.3362}
β_{VT_JP}	0.5169*	0.7336***	-4.2821**	0.1009	-0.0085	-0.3481	0.4849	0.1822	0.6929	-0.0120	-0.0037	0.1541
	{0.0636}	{0.0066}	{0.0000}	{0.5101}	{0.9577}	{0.2687}	{0.1393}	{0.1531}	{0.1932}	{0.7912}	{0.9392}	{0.2003}
β_{VM_JP}	0.6541*	-0.4189	0.8886	0.8962***	0.8469***	0.6518**	0.5876***	0.6157**	0.7376**	0.0034	0.0453	-0.0266
	{0.0615}	{0.1972}	{0.4466}	{0.0000}	{0.0000}	{0.0285}	{0.0002}	{0.0478}	{0.0001}	{0.9706}	{0.6807}	{0.8439}
q	6	6		4	4	4	10	10	10	6	6	6
Sk-z	-1.7744	-1.58	-0.19	-0.09	0.06	-0.15	-1.57	-3.45	0.28	-0.37	-0.29	-0.21
Kur-z	53.5894	30.2804	53.55	13.03	12.05	3.61	35.21	46.11	12.27	1.86	1.69	0.81
Q(20)-z	54.99***	23.47	73.53**	11.54	12.17	22.49	30.01*	26.62	29.68*	20.52	15.44	20.25
	{0.0000}	{0.2662}	{0.0000}	{0.9311}	{0.9102}	{0.3147}	{0.0698}	{0.1463}	{0.0753}	{0.4261}	{0.7507}	{0.4425}
Q(20)-z^2	133.46***	21.78	50.92**	10.21	17.78	27.42	5.62	7.49	11.72	13.58	15.16	11.12
	{0.0000}	{0.3528}	{0.0002}	{0.9643}	{0.6016}	{0.1239}	{0.9993}	{0.9947}	{0.9255}	{0.8512}	{0.7669}	{0.9431}
E-N	0.5643	2.81	0.15	5.87	7.53*	5.26	3.90	7.21*	0.37	7.29*	2.72	1.33
	{0.9046}	{0.4217}	{0.9851}	{0.1180}	{0.0568}	{0.1540}	{0.2728}	{0.0655}	{0.9460}	{0.0631}	{0.4363}	{0.7210}