DYNAMIC STOCK RETURN–VOLUME RELATION: EVIDENCE FROM EMERGING ASIAN MARKETS

Hsin-Yi Lin

Department of Economics, National Chengchi University, Taipei, Taiwan

ABSTRACT

This paper empirically examines the dynamic stock return–volume relations for six emerging Asian markets: Indonesia, Malaysia, Singapore, South Korea, Taiwan, and Thailand. Evidence is found that trading volume Granger causes stock return in quantiles and the causal effects of volume are heterogeneous across quantiles. This shows that volume carries some information to the return and could be interpreted in light of theoretical models. In addition, we find that there is bi-directional causality between stock return and trading volume in most of the markets. The finding indicates that those Asian emerging markets with different institutions and information flows than more mature markets have present similar causal effects on the stock return–volume relation. Furthermore, the cross-country evidence shows that the US market helps to predict the returns of the emerging Asian markets.

Keywords: Asian stock market, causality, emerging market, quantile regression, return–volume relation

JEL classification numbers: G14, G15

I. INTRODUCTION

The relationship between financial asset return and trading volume has received considerable attention over the past decades. Theoretical models related to this topic include the sequential information model (Copeland, 1976; Jennings *et al.*, 1981; Jennings and Barry, 1983), the mixture of distributions hypothesis (Clark, 1973; Epps and Epps, 1976; Tauchen and Pitts, 1983), market models of asymmetry in information endowment (Kyle, 1985; He and Wang, 1995), a rational expectation asset pricing model (Wang, 1994), and a differences of opinion model (Harris and Raviv, 1993; Kandel and Pearson, 1995). These researches indicate that trading volume contains information about the distribution of future return and most of them support a positive relationship between absolute price change and volume (see Karpoff, 1987).

There is an extensive literature on the empirical aspects of the return–volume relation. A number of research papers have included the relation between contemporaneous absolute price

change and trading volume (Jennings *et al.*, 1981), between contemporaneous price change and trading volume (Tauchen and Pitts, 1983; Karpoff, 1987), between the variance (squares) of price change and trading volume (Clark, 1973; Epps and Epps, 1976; Andersen, 1996; Lee and Rui, 2002), and between dynamic price change and trading volume (Jain and Joh, 1988; Campbell *et al.*, 1993; Blume *et al.*, 1994; *Chen et al.*, 2001; Lee and Rui, 2002; Chuang *et al.*, 2009).

Furthermore, numerous studies have been conducted on the dynamic relation in emerging markets, such as: Moosa and Al-Loughani (1995), Kamath, and Wang (2006), Pisedtasalasai and Gunasekarage (2007) and Gebka (2012) for South-East Asian stock markets; Silvapulle and Choi (1999) for the South Korean stock market; Gündüz and Hatemi-J (2005) for markets of Central and Eastern European countries and Turkey; Başci *et al.* (1996) for the Turkey market; Saatcioglu and Starks (1998) for six Latin American markets; and Assogbavi and Osagie (2006) for 26 emerging stock markets. The advantages of employing emerging markets are that the information flows in emerging markets are not equivalent to the information flows in the more developed markets, and there are differences in institutions across the markets (Saatcioglu and Starks, 1998). However, there are divergent conclusions of the empirical research; results range from no, to weak and strong relationships between return and volume. Therefore, further insight should be obtained through different econometric methods.

Causal relations between stock return and volume are examined by testing Granger non-causality: Granger (1969, 1980) considers testing non-causality in conditional mean; Granger *et al.* (1986) and Cheung and Ng (1996) test non-causality in conditional variance; and Hiemstra and Jones (1994) consider a test for non-linear causality. In addition, since Granger non-causality is defined in terms of conditional distribution, Chuangn *et al.* (2009) define non-causality in all quantiles and derive a test for non-causality in conditional quantiles. They use the quantile regression (QR) of Koenker and Bassett (1978) to estimate the quantile causal effects and apply the sup-Wald test to evaluate the hypothesis of non-causality in all quantiles. Their test provides a complete description of the causal relation between stock return and trading volume.

This paper tests Granger non-causality in quantiles in six emerging Asian markets: Indonesia, Malaysia, Singapore, South Korea, Taiwan, and Thailand. Evidence is found that for all markets except Taiwan, trading volume Granger causes stock return in quantiles and the causal effects of volume are heterogeneous across quantiles; that is, they have positive causal effects for upper quantiles and negative effects for lower quantiles, and the effects are stronger at more extreme quantiles. This finding is consistent with the theoretical models that trading volume contributes information to the distribution of stock return (e.g., the sequential information model, the mixture of distribution hypothesis, and a differences of opinion model). Putting volume on the vertical axis and return on the horizontal axis, the quantile causal effects of volume on return present a spectrum of a symmetric V-shape relation for those markets. The V spectrum represents the distribution dispersion of return and corresponds to the location-scale shift QR model that the dispersion increases with volume. The relation is consistent with Karpoff's (1987) 'asymmetric volume-price change hypotheses', indicating the relation is fundamentally different for positive and negative price change. The finding also complements the empirical researches, such as Chuang *et al.* (2009) for more mature markets. On the other hand, this result differs from the empirical studies that do not find causality in mean from volume to return in emerging markets (e.g., Kamath and Wang, 2006; Pisedtasalasai and Gunasekarage, 2007; Gebka, 2012).

Furthermore, we observe a bi-directional causality in quantiles in the sense that trading volume Granger causes stock return as well as return causes volume in five of the six markets (except Singapore). This extends the results of causality in mean for emerging markets (see Moosa and Al-Loughani, 1995; Kamath and Wang, 2006) and also complements those based on more mature markets such as Chen *et al.* (2001) and Chuang *et al.* (2009). Therefore, empirical

findings conclude that those emerging Asian markets with different institutions and information flows to those of more mature markets have exhibited similar patterns of causal effects from volume to return and have two-way causal relation between return and volume. In addition, the cross-country spillover effect from US and Japanese markets to the emerging Asian markets are investigated. The causal relation between return and volume is robust with respect to the inclusion of US and Japanese markets. Also, it is interesting to find that US return helps to predict the future returns of all emerging Asian markets and the causal effects of US volume are heterogeneous across quantiles. In contrast, the spillover effects from the Japanese market to the emerging Asian markets are mixed.

This paper proceeds as follows. In Section II, Granger non-causality in quantiles and the resulting test are introduced. In Section III, the empirical results of different causal models in emerging Asian markets are presented. Section IV concludes the paper.

II. CAUSALITY IN QUANTILES

Granger non-causality is defined such that the random variable x does not Granger cause the random variable y if

$$F_{y_t}(\eta|(\mathcal{Y}, \mathcal{X})_{t-1}) = F_{y_t}(\eta|\mathcal{Y}_{t-1}), \quad \forall \eta \in \mathbb{R} \tag{1}$$

where $F_{y_t}(\cdot|\mathcal{F})$ is the conditional distribution of y_t, and $(\mathcal{Y}, \mathcal{X})_{t-1}$ is the information set generated by y_i and x_i up to time $t-1$; that is, the past information of x does not alter the conditional distribution of y. In the literature, it is common to evaluate the necessary condition of (1) to test Granger non-causality:

$$\mathbb{E}[y_t|(\mathcal{Y}, \mathcal{X})_{t-1}] = \mathbb{E}(y_t|\mathcal{Y}_{t-1}) \ a.s.$$

where $\mathbb{E}(y_t|\mathcal{F})$ is the mean of $F_{y_t}(\cdot|\mathcal{F})$. However, failing to reject the necessary condition may not consistently reject (1). Since a distribution is completely determined by its quantiles, Granger non-causality can also be represented by conditional quantiles. Let $Q_{y_t}(\tau|\mathcal{F})$ denote the τ-th quantile of $F_{y_t}(\cdot|\mathcal{F})$, (1) equals

$$Q_{y_t}(\tau|(\mathcal{Y}, \mathcal{X})_{t-1}) = Q_{y_t}(\tau|\mathcal{Y}_{t-1}), \quad \forall \tau \in (0, 1) \ a.s. \tag{2}$$

If (2) holds for all quantiles, then we can say that x does not Granger cause y. Thus, we obtain that Granger non-causality in quantiles, (2), is equivalent to Granger non-causality in distribution, (1).

Writing $\boldsymbol{y}_{t-1,p} = [y_{t-1}, \dots, y_{t-p}]'$ and $\boldsymbol{x}_{t-1,q} = [x_{t-1}, \dots, x_{t-q}]'$, consider a location shift QR model:

$$y_t = \alpha_0 + \boldsymbol{y}'_{t-1,p}\boldsymbol{\alpha} + \boldsymbol{x}'_{t-1,q}\boldsymbol{\beta} + e_t$$

where $\boldsymbol{\alpha}$ is a $p \times 1$ vector of parameters, $\boldsymbol{\beta}$ is a $q \times 1$ vector of parameters, and the e_t are independent and identically distributed (i.i.d.) from distribution $F_e(\cdot)$. For the location shift QR model, the conditional quantile function can be written as

$$Q_{y_t}(\tau|\boldsymbol{z}_{t-1}) = \alpha_0 + \boldsymbol{y}'_{t-1,p}\boldsymbol{\alpha} + \boldsymbol{x}'_{t-1,q}\boldsymbol{\beta} + F_e^{-1}(\tau)$$

Given different values of τ, the fitted regression quantile lines are parallel to each other. More generally, consider a location-scale shift QR model:

$$y_t = \alpha_0 + \boldsymbol{y}'_{t-1,p}\boldsymbol{\alpha}_1 + \boldsymbol{x}'_{t-1,q}\boldsymbol{\beta}_1 + (\boldsymbol{y}'_{t-1,p}\boldsymbol{\alpha}_2 + \boldsymbol{x}'_{t-1,q}\boldsymbol{\beta}_2)\, e_t$$

where $\boldsymbol{\alpha}_1$ and $\boldsymbol{\alpha}_2$ are $p \times 1$ vectors of parameters, $\boldsymbol{\beta}_1$ and $\boldsymbol{\beta}_2$ are $q \times 1$ vectors of parameters, and the e_t are i.i.d. from the distribution $F_e(\cdot)$. The resulting conditional quantile function of the location-scale shift model can be written as

$$Q_{y_t}(\tau|\boldsymbol{z}_{t-1}) = \alpha_0 + \boldsymbol{y}'_{t-1,p}\boldsymbol{\alpha}_1 + \boldsymbol{x}'_{t-1,q}\boldsymbol{\beta}_1 + [\boldsymbol{y}'_{t-1,p}\boldsymbol{\alpha}_2 + \boldsymbol{x}'_{t-1,q}\boldsymbol{\beta}_2]F_e^{-1}(\tau) \qquad (3)$$

In this more complicated model which takes a heteroscedastic form, the dispersion of dependent variable can be modelled and increases with regressors.

Letting $\boldsymbol{\alpha}(\tau) = \boldsymbol{\alpha}_1 + \boldsymbol{\alpha}_2 F_e^{-1}(\tau)$, $\boldsymbol{\beta}(\tau) = \boldsymbol{\beta}_1 + \boldsymbol{\beta}_2 F_e^{-1}(\tau)$, and $\boldsymbol{z}_{t-1} = [1, \boldsymbol{y}'_{t-1,p}, \boldsymbol{x}'_{t-1,q}]'$, rewrite Equation (3):[1]

$$Q_{y_t}(\tau|\boldsymbol{z}_{t-1}) = \alpha_0 + \boldsymbol{y}'_{t-1,p}\boldsymbol{\alpha}(\tau) + \boldsymbol{x}'_{t-1,q}\boldsymbol{\beta}(\tau) = \boldsymbol{z}'_{t-1}\boldsymbol{\theta}(\tau)$$

where $\boldsymbol{\theta}(\tau) = [\alpha_0, \boldsymbol{\alpha}(\tau)', \boldsymbol{\beta}(\tau)']'$ is the k-dimensional parameter vector with $k = 1 + p + q$. Given a linear location-scale shift model for conditional quantiles, testing (2) amounts to testing

$$H_0 : \boldsymbol{\beta}(\tau) = \boldsymbol{0}, \quad \forall \tau \in (0, 1) \qquad (4)$$

Koenker and Machado (1999) and Chuang *et al.* (2009) suggest testing the entire process using a sup-Wald test, i.e., the supremum of a sequence of Wald statistics. The Wald statistic is

$$\mathcal{W}_T(\tau) := T\hat{\boldsymbol{\beta}}_T(\tau)'\widehat{\boldsymbol{\Omega}}^{-1}\hat{\boldsymbol{\beta}}_T(\tau)/[\tau(1-\tau)]$$

where T is the sample size, $\hat{\boldsymbol{\beta}}_T(\tau)$ is the QR estimator of $\boldsymbol{\beta}(\tau)$, and $\widehat{\boldsymbol{\Omega}}$ is a consistent estimator of $\boldsymbol{\Omega} = \boldsymbol{\Psi} \boldsymbol{D}(\tau)^{-1}\boldsymbol{M}_{zz}\boldsymbol{D}(\tau)^{-1}\boldsymbol{\Psi}'$ with $\boldsymbol{\Psi} = [\boldsymbol{0}\ \boldsymbol{1}_q]$, $\boldsymbol{M}_{zz} := \lim_{T\to\infty} T^{-1}\sum_{t=1}^{T} \boldsymbol{z}_{t-1}\boldsymbol{z}'_{t-1}$, and $\boldsymbol{D}(\tau) := \lim_{T\to\infty} T^{-1}\sum_{t=1}^{T} f_t(F_t^{-1}(\tau))\boldsymbol{z}_{t-1}\boldsymbol{z}'_{t-1}$, with f_t and F_t being the conditional density and distribution functions of y_t given $\boldsymbol{z}_{t-1}$, respectively. Under the null hypothesis (4),

$$\sup_{\tau \in \mathcal{T}} \mathcal{W}_T(\tau) \Rightarrow \sup_{\tau \in \mathcal{T}} \left\| \frac{\boldsymbol{B}_q(\tau)}{\sqrt{\tau(1-\tau)}} \right\|^2$$

where $||\boldsymbol{B}_q(\tau)/\sqrt{\tau(1-\tau)}||^2$ is the sum of squares of q independent Bessel processes, with $\mathcal{T} = [\epsilon, 1-\epsilon]$ for some ϵ in $(0, 0.5)$.[2] The critical values of the sup-Wald test on $[0.05, 0.95]$ at the 1% significance level are 13.01, 16.30 and 19.21 for $q = 1, 2, 3$ respectively. See Chuang *et al.* (2009) for a detailed description of the calculation of the statistics and other critical values.

III. EMPIRICAL RESULTS

III.1 Data

The following empirical results have been obtained by applying the sup-Wald test described in Section II to price and volume data for six countries in Asia: Indonesia, Malaysia, Singapore, South Korea, Taiwan, and Thailand.[3] The daily data from the beginning of 1990 to 30 June

---

[1] In this representation, the location-scale shift QR model can also be written as follows:

$$y_t = \boldsymbol{z}'_{t-1}\boldsymbol{\theta}(\tau) + u_{t,\tau}$$

where $u_{t,\tau}$ is the error term under the QR specification such that the τ-th conditional quantile of the error is zero, i.e., $Q_{u_{t,\tau}}(\tau|\boldsymbol{z}_{t-1}) = 0$.

[2] It is noted that $\mathcal{W}_T(\tau)$, $\tau \in \mathcal{T}$, has a well defined limit when $\mathcal{T}$ is a closed interval in $(0, 1)$. Thus, we set $\mathcal{T} = [\epsilon, 1-\epsilon]$ for some ϵ in $(0, 0.5)$.

[3] Existing studies of emerging Asian markets are Moosa and Al-Loughani (1995), Silvapulle and Choi (1999), Kamath and Wang (2006) and Pisedtasalasai and Gunasekarage (2007), which contain 5, 1, 6, and

2008[4] are taken from the *Datastream* database,[5] and the basic summary statistics are collected in Table 1. In this paper, stock return is calculated as $r_t = 100 \times (\ln(p_t) - \ln(p_{t-1}))$, where p_t and p_{t-1} are daily stock prices at t and $t-1$ respectively, and volume v_t is the traded share volume of these stock markets. Singapore is the largest market in our study. From Table 1, it is seen that the mean and median returns are all close to zero and their standard deviations are close to one. For each volume, the mean and median are quite different. The volume series are right-skewed and have trending patterns. Both the stock return and volume series exhibit excess kurtosis.

III.2 Causal effects of volume on return

Since stock return is a stationary series and volume has a trending pattern, following Chuang *et al.* (2009), we consider the QR model:

$$r_t = a + b(\tau)\frac{t}{T} + c(\tau)\left(\frac{t}{T}\right)^2 + \sum_{j=1}^{q}\alpha_j(\tau)r_{t-j} + \sum_{j=1}^{q}\beta_j(\tau)\ln v_{t-j} + u_{t,\tau} \qquad (5)$$

where T is the sample size and $q \geq 1$ and $u_{t,\tau}$ is the error term of the location-scale shift QR specification. In (5), t/T and $(t/T)^2$ are used to control the trending effect in $\ln v_t$. For simplicity, we let the lag order of return equal that of volume and the resulting model is named the lag-q model. To consider possible return volatility, we also have an extension of (5), which includes lagged r_{t-j}^2 as additional regressors:

$$r_t = a + b(\tau)\frac{t}{T} + c(\tau)\left(\frac{t}{T}\right)^2 + \sum_{j=1}^{q}\alpha_j(\tau)r_{t-j} + \sum_{j=1}^{q}\beta_j(\tau)\ln v_{t-j} + \sum_{j=1}^{q}\gamma_j(\tau)r_{t-j}^2 + u_{t,\tau} \quad (6)$$

To determine a lag order q^*, if the null of $\beta_q(\tau) = 0$ for τ in [0.05, 0.95] is not rejected for the lag-q model, but the null of $\beta_{q-1}(\tau) = 0$ for τ in [0.05, 0.95] is rejected for the lag-$(q-1)$ model, then the lag order is set as $q^* = q - 1$. The appropriate lag orders in six emerging Asian markets are presented in Table 2. It is seen that for models (5) and (6), volume Granger causes return with lag order $q^* = 1$ for Indonesia, Malaysia, Singapore, South Korea and Thailand.[6] In Taiwan, we set $q^* = 2$ for both models (5) and (6).[7]

TABLE 1

Summary statistics for stock return r_t and volume v_t

Country		Mean	SD	q1	Median	q3	Skewness	Kurtosis	Minimum	Maximum
Indonesia	r_t	0.04	1.55	−0.61	0.04	0.71	0.09	11.96	−12.73	13.13
(4439)	v_t	851.33	1326.28	24.55	331.65	1065.45	2.94	15.81	0.00	14007.28
Malaysia	r_t	−0.01	1.77	−0.65	−0.01	0.60	0.57	42.14	−24.15	20.82
(2290)	v_t	7256.92	4840.32	4130.18	5939.45	8777.18	2.38	11.46	41.90	45568.00
Singapore	r_t	0.02	1.22	−0.54	0.03	0.57	0.13	12.23	−8.94	13.22
(4640)	v_t	107272.00	110633.10	24439.00	65862.50	158567.50	1.74	6.87	2249.00	882664.00
South Korea	r_t	0.01	1.89	−0.91	0.04	0.94	−0.07	6.75	−12.80	10.02
(4514)	v_t	2401.39	2591.21	285.89	1931.25	3827.18	1.87	9.62	13.58	23792.94
Taiwan	r_t	−0.01	1.89	−0.86	−0.01	0.91	−0.08	6.48	−10.29	12.84
(4504)	v_t	2470.42	1694.99	1142.25	2161.00	3434.00	1.08	4.41	130.00	11631.00
Thailand	r_t	0.02	1.90	−0.93	−0.04	0.90	0.25	9.58	−17.80	12.12
(4539)	v_t	16976.64	23098.53	1612.25	6019.10	26416.25	2.28	10.55	57.00	232293.60

Note: Numbers of observations are in parentheses and volumes here are traded share volume times 10^{-3}.

TABLE 2
Appropriate lag order q^* in QR models for causal effect

Country	Volume on return		Return on volume	
	Model without r^2	Model with r^2	Model without r^2	Model with r^2
Indonesia	1	1	1	1
Malaysia	1	1	2	2
Singapore	1	1	0	0
South Korea	1	1	2	2
Taiwan	2	2	3	2
Thailand	1	1	2	2

Plotted against τ, Figure 1 shows the QR estimates of $\beta_1(\tau)$ in the solid line and their 95% confidence intervals in the shaded area,[8] together with the least squares (LS) estimate in the dashed line and its 95% confidence interval in the dotted lines for the model without r_{t-j}^2. It can be seen that in Indonesia, Malaysia, Singapore, South Korea and Thailand, the LS estimates of β_1 are all insignificantly different from zero; this suggests no causality in mean in these markets' returns. On the other hand, the QR estimates of $\beta_1(\tau)$ vary with quantiles and are negative at lower quantiles and positive at upper quantiles. The estimates are significant at tail quantiles. Therefore, log volume has opposite quantile effects on the return in model (5) and the causal effects of volume are heterogeneous across quantiles; this can be explained by the location-scale shift QR model in Section II. The finding supports the dynamic relationship between return and volume and is consistent with the sequential information arrival model of Copeland (1976) and Jennings *et al.* (1981), where new information disseminates sequentially into the market. The QR results also show that trading volume, as a measure of the disagreement among traders, contributes information to the distribution of stock return; this finding is in line with some theoretical models, such as the mixture of distributions hypothesis of Epps and Epps (1976) and Tauchen and Pitts (1983), the rational expectation asset pricing model of Wang (1994) and the differences of opinion model of Harris and Raviv (1993).

In addition, with log volume on the vertical axis and return on the horizontal axis, the quantile causal effects of volume on return exhibit a spectrum of a symmetric V-shape relation. The relation is consistent with Karpoff's (1987, p. 121) 'asymmetric volume-price change hypotheses', indicating that the relation is fundamentally different for positive and negative price change. This finding differs from the existing studies that do not find causality in mean in mature markets (see Lee and Rui, 2002) and in emerging markets (see Kamath and Wang, 2006; Pisedtasalasai and Gunasekarage, 2007; Gebka, 2012), and complements those based on more mature markets such as Karpoff (1987), Chen *et al.* (2001) and Chuang *et al.* (2009).

Figure 2 plots the QR and LS estimates for models with r_{t-j}^2 in all markets except Taiwan. Similar to the previous results, the results here suggest that volume does not Granger cause return in mean but Granger causes return in quantiles. One difference is that the magnitude of the QR estimates at tail quantiles in Figure 2 is weaker than that of the corresponding estimates in Figure 1. The quantile causal effects of volume on return weaken under the inclusion of the squares of lagged returns in the QR model. It is interesting to note that the V spectrum presents and lagged volume still contributes some information that is not contained in the squares of

---

[8] In all subfigures, one LS estimate and 90 quantile regression (QR) estimates of coefficients are presented. For example, for regression coefficient β_1 in each model, there are 90 QR estimates; they are estimates of $\beta_1(0.05), \beta_1(0.06), \beta_1(0.07), \ldots, \beta_1(0.95)$.
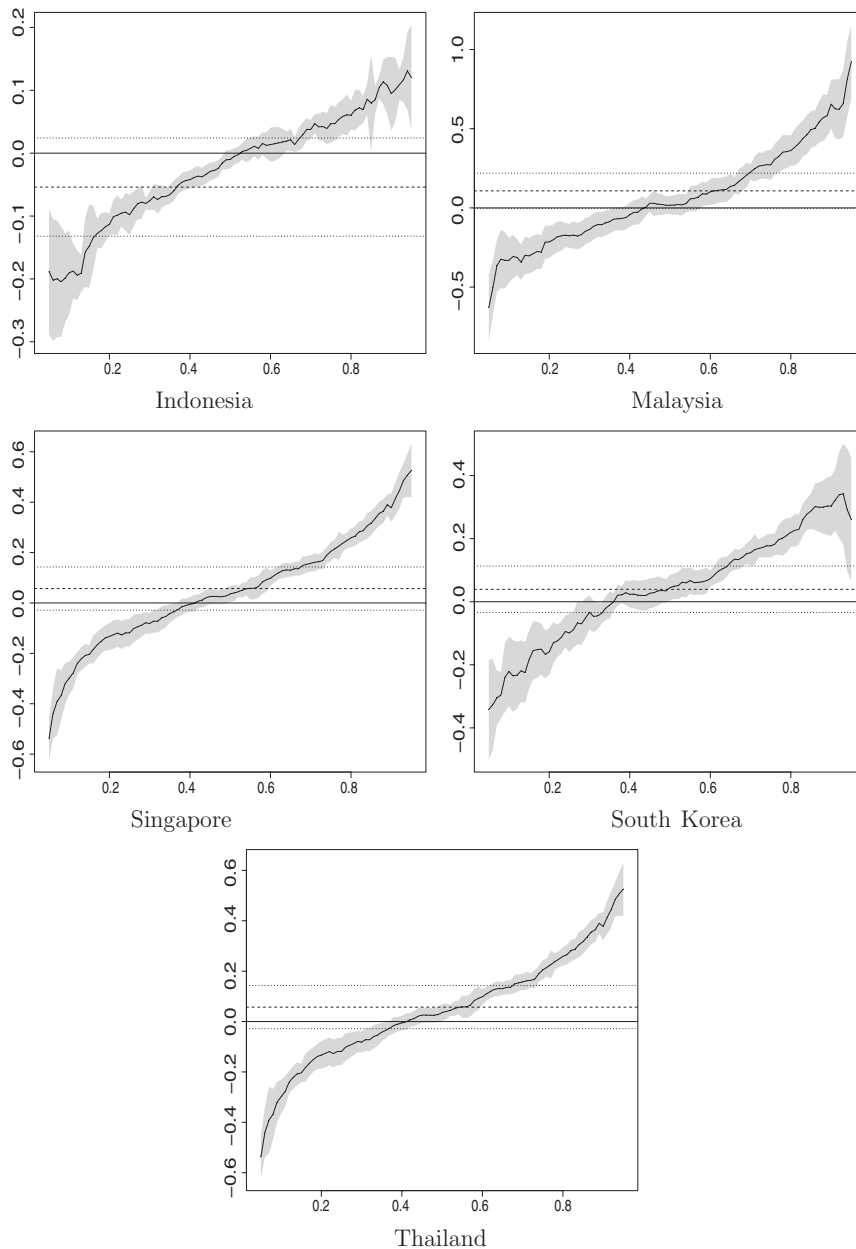
Fig. 1. QR and LS estimates of the causal effects of log volume on return: model without r_{t-j}^2.

lagged return. Yet, the estimation results of Taiwan are quite different. In Figures 3 and 4, the LS estimates of β_1 and the QR estimates of $\beta_1(\tau)$ are significantly positive and the LS estimates of β_2 and the QR estimates of $\beta_2(\tau)$ are significantly negative at the 5% level. This shows that, in the stock market of Taiwan, trading volume Granger causes return both in mean and in quantiles, but the causal effects of $\beta_1(\tau)$ and $\beta_2(\tau)$ are the opposite. The causal effects of
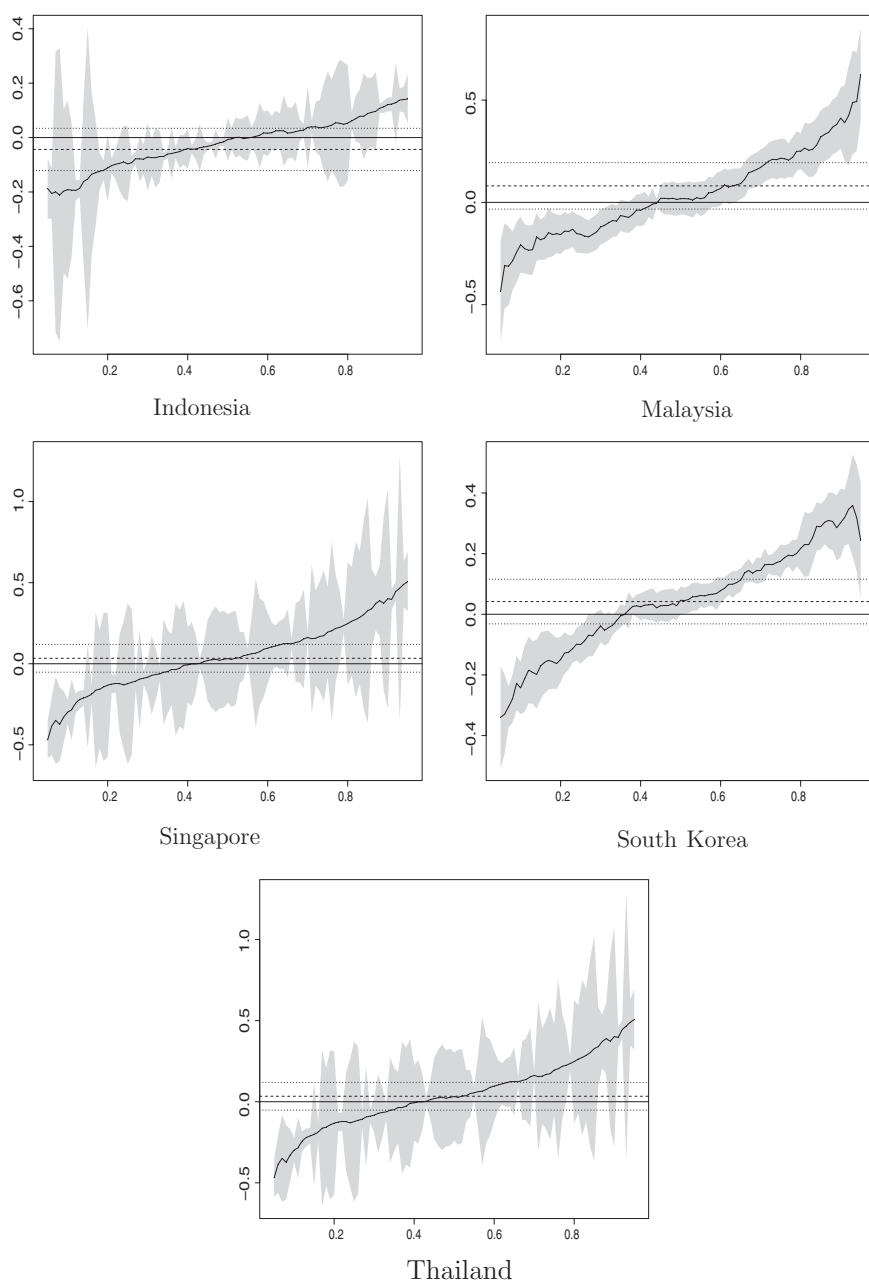
Fig. 2. QR and LS estimates of the causal effects of log volume on return: model with r_{t-j}^2.

volume are more homogeneous; which may be the price limit in Taiwan's stock market that has the most restricted price limit among the emerging Asian markets.[9]

---

[9] Taiwan imposes a 7 percent price limit; Indonesia, Malaysia, and Thailand impose a 30 percent price limit; and South Korea imposes a 15 percent price limit.
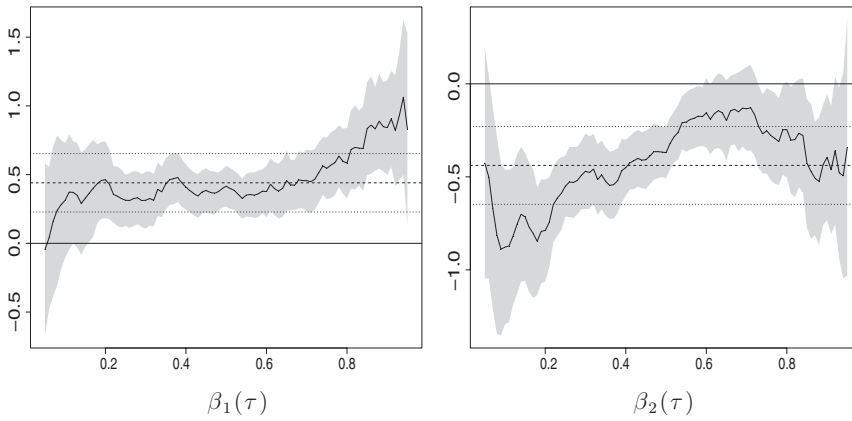
Fig. 3. QR and LS estimates of the causal effects of log volume on return in Taiwan: model without r^2_{t-j}.
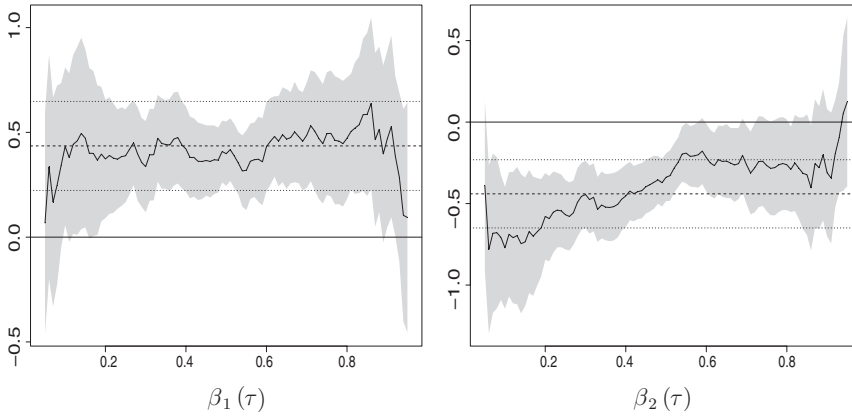

Fig. 4. QR and LS estimates of the causal effects of log volume on return in Taiwan: model with r^2_{t-j}.

III.3 Causal effects of return on volume

To see if there is bi-directional causality between stock return and trading volume, we consider the following models:

$$\ln v_t = a^* + b^*(\tau)\frac{t}{T} + c(\tau)^*\left(\frac{t}{T}\right)^2 + \sum_{j=1}^{q}\alpha_j^*(\tau)\ln v_{t-j} + \sum_{j=1}^{q}\beta_j^*(\tau)r_{t-j} + u_{t,\tau}$$

$$\ln v_t = a^* + b^*(\tau)\frac{t}{T} + c(\tau)^*\left(\frac{t}{T}\right)^2 + \sum_{j=1}^{q}\alpha_j^*(\tau)\ln v_{t-j} + \sum_{j=1}^{q}\beta_j^*(\tau)r_{t-j} + \sum_{j=1}^{q}\gamma_j^*(\tau)r^2_{t-j} + u_{t,\tau}$$

We use the sup-Wald test to determine an appropriate lag order q^*; see Table 2.[10,11] From Table 2, we find bi-directional causality in quantiles between return and volume in Indonesia, Malaysia, South Korea, Taiwan and Thailand. This finding extends the evidence of Moosa and Al-Loughani (1995) and Kamath and Wang (2006), but differs from that reported by Assogbavi and Osagie (2006) and Pisedtasalasai and Gunasekarage (2007) in emerging markets. Such a result also complements the existing studies based on more mature markets, such as Chen *et al.* (2001) and Chuang *et al.* (2009). In addition, there exists a unidirectional causality running from trading volume to stock return in Singapore. It is shown that volume leads return in the stock market of Singapore.

Figure 5 presents the LS estimates of β_1^* and QR estimates of $\beta_1^*(\tau)$ in the models without r_{t-j}^2.[12] It is seen that both the LS and QR estimates of $\beta_1^*(\tau)$ are significantly positive at the 5% level. This shows that stock return has positive effects on trading volume both in mean and in quantiles in all markets when lag order equals 1. In addition, the QR estimates are relatively stable across quantiles and stay within the confidence interval of the corresponding LS estimates at most quantiles in all markets. These results show that the causal effects of return are homogeneous and are consistent with the existing finding of Chuang *et al.* (2009) in more mature markets.

III.4 Cross-country spillover effects

In this subsection, the causal relations among return and trading volume are investigated with consideration of cross-country spillover effects. Following Lee and Rui (2002) and Kim (2005), the lagged return and lagged trading volume of US and Japanese markets are considered in the dynamic causality model in Equation (5). Two indices, New York Stock Exchange (NYSE) and Tokyo Stock Price Index (TOPIX), are used. There is non-overlapping in trading time between New York or Tokyo at time $t-1$ and the emerging Asian markets at time t. The causal effects of volume for all emerging Asian markets except Taiwan are presented in Figure 6. Comparing Figure 1 and Figure 6, it is seen that the patterns of all markets are very similar, which shows that the causal relation between return and volume in emerging Asian markets is robust with respect to the inclusion of US and Japanese markets.

Moreover, to capture the cross-country spillover effect, the estimates of lagged return and lagged trading volume of US and Japanese markets on returns of the emerging Asian markets are reported in Table 3. The table indicates that all estimates of lagged US returns are positive and significant at the 1% level, which shows that the lagged US return plays an important role in return of the emerging Asian markets. However, the finding is different from that in

---

[10] When the model is considered without r_{t-j}^2, for the markets of Indonesia, the sup-Wald test of $\beta_1^*(\tau)$ in the lag-1 model is 22.27, and that of $\beta_2^*(\tau)$ in the lag-2 model is 3.33. The former is significant at the 1% level, but the latter is not; $q^* = 1$. In addition, for Malaysia, South Korea and Thailand, the sup-Wald tests of $\beta_3^*(\tau)$ in the lag-3 model are 10.99, 2.86 and 5.82, and those in the lag-2 model are 15.43, 59.53 and 19.41, respectively. The latter is significant at the 1% level but the former is not. Therefore, $q^* = 2$ in these markets. In Singapore, the sup-Wald test of $\beta_1^*(\tau)$ is 3.07 in the lag-1 model and $q^* = 0$. In Taiwan, the sup-Wald test of $\beta_4^*(\tau)$ in the lag-4 model is 12.37, and that of $\beta_3^*(\tau)$ in the lag-3 model is 13.65, and $q^* = 3$.
[11] When the model is considered with r_{t-j}^2, for Indonesia, the sup-Wald test of $\beta_1^*(\tau)$ in the lag-1 model is 14.89, and $\beta_2^*(\tau)$ in the lag-2 model is 7.39. The former is significant at the 1% level but the latter is not; $q^* = 1$. In addition, in Malaysia, South Korea, Taiwan and Thailand, the sup-Wald tests of $\beta_2^*(\tau)$ in the lag-2 model are 24.25, 52.02, 25.37 and 20.48, and those of $\beta_3^*(\tau)$ in the lag-3 model are 6.43, 1.22, 11.49 and 12.53, respectively. The former is significant at the 1% level but the latter is not. Therefore, $q^* = 2$ in these markets. For Singapore, the sup-Wald test of $\beta_1^*(\tau)$ is 8.2 and $q^* = 0$.
[12] To conserve space, we do not plot other LS and QR estimates in the model without r_{t-j}^2 and those in the model with r_{t-j}^2.
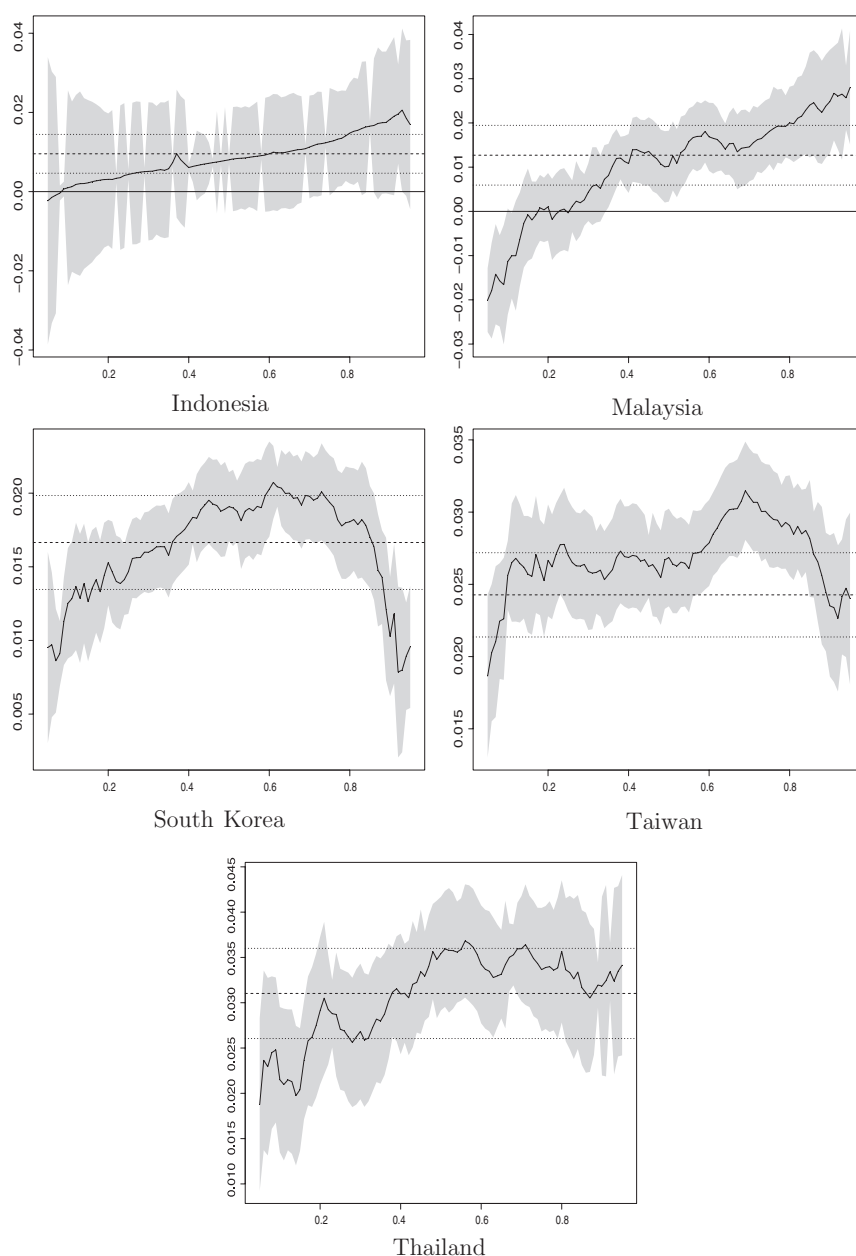
Fig. 5. QR and LS estimates of the causal effects of return on log volume: model without r^2_{t-j}.

Gebka (2012), in which cross-border spillovers in returns are found to be non-existent. The estimates of the lagged US trading volume are negative at low quantiles and are positive at quantiles above 0.5, and increase along with quantiles, except for Malaysia at the 0.1 quantile. It is seen that both the lagged US return and volume help to predict the returns of the emerging Asian markets, similar to Lee and Rui (2002) and Kim (2005). In contrast, the spillover effects from the Japanese market to the Asian emerging markets are mixed. For Indonesia and Singapore,
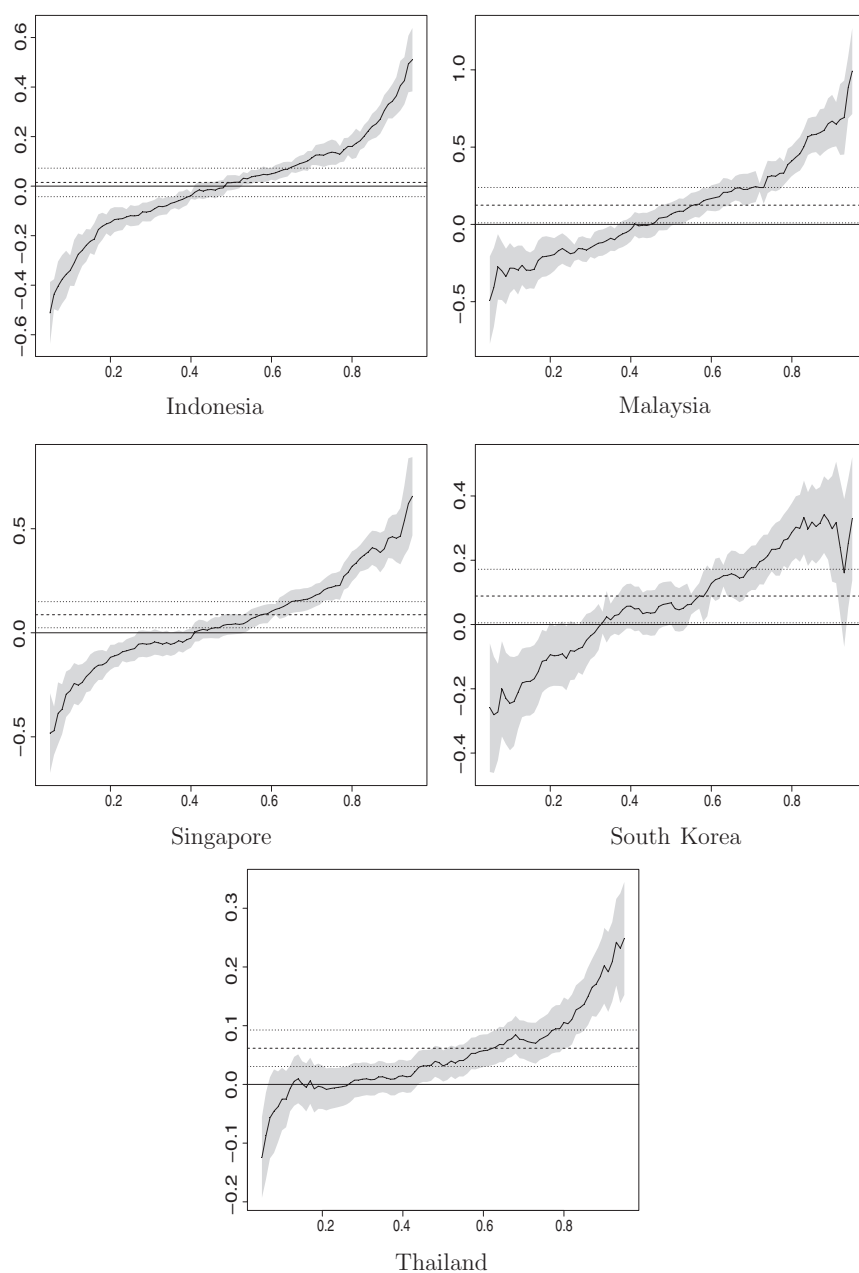
Fig. 6. QR and LS estimates of the causal effects of return on log volume: model with
cross-country spillover effects.

the estimates of lagged Japanese return are significant at most quantiles and are insignificant
at the 0.1 quantiles. For Malaysia, South Korea and Thailand, the effects of lagged Japanese
returns are insignificant. For Taiwan, one-period lagged Japanese return Granger causes Taiwan
return, but two-period lagged Japanese return does not. Lastly, the spillover effect of lagged

TABLE 3

QR estimates of the causal effects of return on log volume: model with cross-country spillover effects

		Quantile						Quantile				
		0.1	0.3	0.5	0.7	0.9		0.1	0.3	0.5	0.7	0.9
Indonesia	US(r_{t-1})	0.363***	0.273***	0.280***	0.235***	0.323***	US(v_{t-1})	−0.854***	−0.290***	−0.056	0.215***	0.711***
	Japan(r_{t-1})	0.003	−0.044***	−0.031***	−0.039***	−0.030	Japan(v_{t-1})	−0.057	0.018	0.023	0.034	−0.068
Malaysia	US(r_{t-1})	0.203***	0.214***	0.198***	0.226***	0.318***	US(v_{t-1})	0.060	−0.028	−0.105	−0.263**	−0.431*
	Japan(r_{t-1})	0.027	−0.007	−0.011	0.007	−0.048	Japan(v_{t-1})	0.291*	−0.016	−0.007	−0.118	−0.184
Singapore	US(r_{t-1})	0.426***	0.378***	0.364***	0.394***	0.383***	US(v_{t-1})	−0.496***	−0.247***	−0.027	0.083*	0.339***
	Japan(r_{t-1})	−0.035	−0.053***	−0.046***	−0.057***	−0.086***	Japan(v_{t-1})	0.073	0.084*	−0.035	−0.050	−0.057
South Korea	US(r_{t-1})	0.551***	0.426***	0.360***	0.383***	0.516***	US(v_{t-1})	−0.813***	−0.334***	−0.069	0.211**	0.695***
	Japan(r_{t-1})	0.012	−0.022	−0.032	−0.016	−0.015	Japan(v_{t-1})	−0.002	0.141*	0.014	−0.175**	−0.165
Taiwan	US(r_{t-1})	0.195***	0.201***	0.187***	0.234***	0.259***	US(v_{t-1})	−0.356	−0.279***	0.012	0.398***	0.699***
	US(r_{t-2})	0.254***	0.200***	0.160***	0.188***	0.176***	US(v_{t-2})	−0.854***	−0.348***	−0.071	0.165	0.890***
	Japan(r_{t-1})	0.221***	0.172***	0.205***	0.231***	0.234***	Japan(v_{t-1})	−0.226***	−0.071	−0.043	0.040	−0.264
	Japan(r_{t-2})	0.009	−0.003	−0.009	0.006	0.040	Japan(v_{t-2})	0.073	0.057	0.101	−0.055	−0.130
Thailand	US(r_{t-1})	0.171***	0.135***	0.147***	0.167***	0.186***	US(v_{t-1})	−0.206**	−0.076	0.051	0.147***	0.288***
	Japan(r_{t-1})	0.006	0.002	−0.011	−0.002	0.006	Japan(v_{t-1})	−0.031	−0.043	−0.037	−0.037	−0.159**

Note: Standard errors in parentheses. ***, **, and * indicate significance at 1%, 5% and 10%, respectively.

Japanese volume is generally insignificant, which shows that Japanese volume can not help to predict the return of the Asian emerging markets.

IV. CONCLUSIONS

This paper uses the test of Granger non-causality in quantiles to examine the dynamic stock return–volume relation for six emerging Asian markets. Empirical findings show that causal effects of volume are heterogeneous across quantiles and exhibit a spectrum of a symmetric V-shape in all Asian markets except Taiwan. The results imply that QR reveals causalities in which volume carries some information to the return and could be interpreted in light of some theoretical models. The relations are robust to the inclusion of US and Japanese markets. In addition, testing for Granger causality in quantiles shows that volume Granger causes return as well as return Granger causes volume in most of the emerging Asian markets studied in this paper.

REFERENCES

Anderson, T. (1996). 'Return volatility and trading volume: an information flow interpretation of stochastic volatility', *Journal of Finance*, LI, pp. 169–204.

Assogbavi, T. and Osagie, J. (2006). 'Equity valuation process and price-volume relationship on emerging stock markets', *International Business & Economics Research Journal*, 5, pp. 7–18.

Başci, E., Özyildirim, S. and Aydoğan, K. (1996). 'A note on price-volume dynamics in an emerging stock market', *Journal of Banking and Fiance*, 20, pp. 389–400.

Blume, L., Easley, D. and O'Hara, M. (1994). 'Market statistics and technical analysis: the role of volume', *Journal of Finance*, XLIX, pp. 153–81.

Campbell, J. Y., Grossman, S. J. and Wang, J. (1993). 'Trading volume and serial correlation in stock returns', *Quarterly Journal of Economics*, 108, pp. 905–39.

Chen, G., Firth, M. and Rui, O. (2001). 'The dynamic relation between stock returns, trading volume and volatility', *The Financial Review*, 38, pp. 153–74.

Cheung, Y.-W. and Ng, L. (1996). 'A causality-in-variance test and its application to financial market prices', *Journal of Econometrics*, 72, pp. 33–48.

Chuang, C.-C., Kuan, C.-M. and Lin, H.-Y. (2009). 'Causality in quantiles and dynamic stock return-volume relations', *Journal of Banking and Fiance*, 33, pp. 1351–60.

Clark, P. (1973). 'A subordinated stochastic process model with finite variance for speculative prices', *Econometrica*, 41, pp. 135–55.

Copeland, T. (1976). 'A model of asset trading under the assumption of sequential information arrival', *Journal of Finance*, XXXI, pp. 1149–68.

Epps, T. and Epps, M. L. (1976). 'The stochastic dependence of security price changes and transaction volumes: implication for the mixture-of-distributions hypothesis', *Econometrica*, 44, pp. 305–21.

Fujihara, R. and Mougoué, M. (1997). 'An examination of linear and nonlinear causal relationships between price variability and volume in petroleum futures markets', *Journal of Futures Markets*, 17, pp. 385–416.

Gebka, B. (2012). 'The dynamic relation between returns, trading volume, and volatility: lessons from spillovers between Asia and the United States', *Bulletin of Economic Research* 64, pp. 65–90.

Granger, C. W. J. (1969). 'Investigating causal relations by econometric models and cross-spectral methods', *Econometrica*, 37, pp. 424–38.

Granger, C. W. J. (1980). 'Testing for causality: a personal viewpoint', *Journal of Economic Dynamic and Control*, 2, pp. 329–52.

Granger, C. W. J., Robins, R. and Engle, R. (1986). 'Wholesale and retail prices: bivariate time-series modeling with forecastable error variances', in Belsley, D. and Kuh, E. (eds), *Model Reliability*, pp. 1–17, Cambridge: MIT Press.

Gündüz, L. and Hatemi-J, A. (2005). 'Stock price and volume relation in emerging markets', *Emerging Markets Finance and Trade*, 41, pp. 29–44.

Harris, M. and Raviv, A. (1993). 'Differences of opinion make a horse race', *Review of Financial Studies*, 6, pp. 473–506.

He, W. and Wang, W. (1995). 'Differential information and dynamic behavior of stock trading volume', *Review of Financial Studies*, 8, pp. 919–72.

Hiemstra, C. and Jones, J. (1994). 'Testing for linear and nonlinear Granger causality in the stock price-volume relation', *Journal of Finance*, XLIX, pp. 1639–64.

Jain, P. and Joh, G.-H. (1988). 'The dependence between hourly prices and trading volume', *Journal of Financial and Quantitative Analysis*, 23, pp. 269–83.

Jennings, R. and Barry, C. (1983). 'Information dissemination and portfolio choice', *Journal of Financial and Quantitative Analysis*, 18, pp. 1–19.

Jennings, R., Starks, L. and Fellingham, J. (1981). 'An equilibrium model of asset trading with sequential information arrival', *Journal of Finance*, XXXVI, pp. 143–61.

Kamath, R. and Wang, Y. (2006). 'The causality between stock index returns and volumes in the Asian equity markets', *Journal of International Business Research*, 5, pp. 63–74.

Kandel, E. and Pearson, N. (1995). 'Differential interpretation of public signals and trade in speculative markets', *Journal of Political Economy*, 103, pp. 831–72.

Karpoff, J. (1987). 'The relation between price changes and trading volume: a survey', *Journal of Financial and Quantitative Analysis*, 22, pp. 109–26.

Kim, S.-J. (2005). 'Information leadership in the advanced Asia-Pacific stock markets: returns, volatility and volume information spillovers from the U.S. and Japan', *Journal of the Japanese and International Economies*, 19, pp. 338–65.

Koenker, R. and Bassett, G. (1978). 'Regression quantile', *Econometrica*, 46, pp. 33–50.

Koenker, R. and Machado, J. (1999). 'Goodness of fit and related inference processes for quantile regression', *Journal of the American Statistical Association*, 94, pp. 1296–310.

Kyle, A. (1985). 'Continuous auctions and insider trading', *Econometrica*, 53, pp. 1315–35.

Lee, B.-S. and Rui, O. (2002). 'The dynamic relationship between stock return and trading volume: domestic and cross-country evidence', *Journal of Banking and Finance*, 26, pp. 51–78.

Moosa, I. and Al Loughani, N. (1995). 'Testing the price-volume relation in emerging Asian stock markets', *Journal of Asian Economics*, 6, pp. 407–22.

Pisedtasalasai, A. and Gunasekarage, A. (2007). 'Causal and dynamic relationships among stock returns, return volatility and trading volume: evidence from emerging markets in south-east Asia', *Asia-Pacific Financial Markets*, 14, pp. 277–97.

Saatcioglu, K. and Starks, L. (1998). 'The stock price–volume relationship in emerging stock markets: the case of Latin America', *International Journal of Forecasting*, 14, pp. 215–25.

Silvapulle, P. and Choi, J.-S. (1999). 'Testing for linear and nonlinear Granger causality in the stock price-volume relation: Korean evidence', *Quarterly Review of Economics and Finance*, 39, pp. 59–76.

Tauchen, G. and Pitts, M. (1983). 'The price variability–volume relationship on speculative markets', *Econometrica*, 51, pp. 485–505.

Wang, J. (1994). 'A model of competitive stock trading volume', *Journal of Political Economy*, 102, pp. 127–68.