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AN EMPIRICAL STUDY ON PRICE-VOLUME RELATIONSHIP OF FIRM SIZE INDICES USING THE DCC-GARCH MODEL

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Abstract

Research on the price-volume relationship of firm size indices for emerging markets has been very few in the past primarily because these markets have not their firm size stock indices. To solve this problem, this study adopts the companies in Taiwan's stock market (listed and over-the-counter) to establish firm size indices, viewing the companies' market value as the proxy variable for firm size. The companies are sequenced after eliminating the bottom 5% with the lowest turnover and then divided into 10 groups. Applying the approach of Taiwan Capitalization Weighted Stock Index, the indices of different firm sizes are obtained respectively. Then, this study uses DCC-GARCH (Engle, 2002) to examine the price-volume relationship before and after financial tsunami. Empirical results show thatthe stock market for all firm sizes in Taiwan shows the lessening persistence of dynamic conditional correlation and trending towards stability. This could be related to the series of policies implemented by the Taiwanese government after the financial tsunami.Research findings also reveal that the fluctuation in Taiwan's stock market before financial tsunami period was a "price before volume" effect. After

the financial tsunami, the price-volume relationship did not exist. The results may suggest that investors can focus on price-volume relationship when there is no sudden financial event.

Keywords: Price-Volume Relationship, Firm Size Index, Financial Tsunami, dynamic conditional correlation, DCC-GARCH

INTRODUCTION

Among the studies regarding the relationship between price and volume in stock markets, Copeland (1976), Jennings, Starks, and Fellingham (1981), and Jennings and Barry (1984) pointed out the process in which market information affects the changes in returns through the changes in trading volume. When a trader reflects the new information they receives in their trade behavior, there would be a carry-over relationship of "volume before price". Price-volume relationship is viewed as the process of trading message transmission. After that, many scholars started studying price-volume relationship. Majority of these studies were limited to the relationship between returns and trading volume, while only a few studies focused on the relationship between returns and fluctuations in trading volume. This study therefore examines the market's price-volume fluctuation changes under different firm sizes before and after the global financial tsunami in 2008.

Since the price-volume relationship is a relationship about the fluctuations between two variables, the empirical analysis in traditional Generalized AutoRegressive Conditional Heteroskedasticity Model (GARCH model) hypothesize that the common variance relationship between the two series is constant. That is, the residuals between the two series have a Constant Conditional Correlation (CCC). However, this hypothesis is unreasonable intuitively, since the estimated correlation coefficient would be biased if a CCC is hypothesized when the time series is faced with structural impact. Moreover, Tse (2000) also pointed out that setting CCC would result in a problem of robust estimated parameters wherein additional tests would be needed. Thus, Engle (2002) used two-stage estimation method to avoid the problem of excessive parameters, and then set the conditional correlation as non-constant. This is the two-variable GARCH model under DCC (Dynamic Conditional Correlation Model). Since the DCC-GARCH model is being widely used in empirical studies on the fluctuations in returns of financial assets, this study adopts this model to study the price-volume relationship of firm size indices.

REVIEW OF LITERATURE

A basic economics concept is both the supply and demand in the market determines the equilibrium price and volume; thus, analysis of financial assets' prices should include trading volume in order to completely analyze trading information. Ying (1966) clearly pointed out that studying only price or only trading volume cannot be considered as a complete analysis,

because price and trading volume are joint products of the market mechanism. Thus, many scholars have proposed theoretical explanations on price-volume relationships. These are: Mixture Distribution Model by Clark (1973) and Epps and Epps (1976), Sequential Arrival of Information Model by Copeland (1976), and Asymmetric Price-Volume Relationship Hypothesis by Karpoff (1986). Later, studies such as Harris (1987), Karpoff (1987), and Cooper (1999) gradually started placing emphasis on the cause and effect relationship between price and volume. Discussions on price-volume relationship generally found that there exists a positive relationship between price and trading volume. However, whether or not the positive relationship between price and volume translates to being able to use a variable to predict the other variable ignited another wave of studies on price-volume causal relationship. This type of studies mainly analyzes the lead-lag relationship of trading volume to price (or price to trading volume) in order to study whether or not there is a causal relationship between price and trading volume. These studies include Campbell et al. (1993), Hiemstra and Jones (1994), Cheuk et al. (2006), etc. Among such kinds of studies, a few pointed out volume-before-price, a few pointed out price-before-volume, while others pointed out that there is a two-way feedback relationship between stock price and volume. Although there are discrepancies in the results of their empirical studies, overall their empirical results support that price-volume relationship exists in the stock market. The methods of previous studies generally hypothesized a fixed variance for the fluctuations in price and volume, but high frequency financial data usually has the problems of autocorrelation and conditional heteroskedasticity. Engle (1982) developed the ARCH model in order to solve these two problems, and Bollerslev (1986) expanded this model into the GARCH model to describe the volatility clustering phenomenon of time series. Many studies (such as Engle (1982), Bollerslev (1986), and Nelson (1991)) proposed that if the time series displays conditional heteroskedasticity, then the variance can be characterized by using the GARCH model. On the topic of overall and financial data, there are often data that rejects the homogeneous variance hypothesis scenario. The GARCH model aptly allows the variance to be dependent on past variances and interference term, which allows for the existence of conditional heteroskedasticity. At the same time, this type of model can catch the volatility clustering phenomenon commonly seen in time series data. Thus, the GARCH model is one of the primary methods for studying price-volume relationship in recent years.

RESEARCH METHODOLOGY

This paper primarily studies the changes in volatility of the Taiwanese stock market before and after the financial tsunami. Thus, for the post-financial tsunami analysis, this paper collects data between September 1, 2007 and August 31, 2010. In order to eliminate the impact in the pre-financial tsunami period and to be consistent, this paper collects data between September 1,

2003 and August 31, 2006 for its pre-financial tsunami analysis. The data used in this paper originates from the Taiwan Economic Journal Data Bank (TEJ).

This paper mainly studies the impact of financial tsunamis, so the number of samples for the post-tsunami period is set as the target. These samples are divided into 10 groups so there are 110 companies per group. Companies with the biggest firm size comprise the big size stocks; companies with the smallest firm size comprise the small size stocks. The medium size indices are selected from the latter half of the fifth group and the former half of the sixth group. For the pre-tsunami period, 110 companies from each type are selected, so the first 110 companies with the biggest market values are classified into big-sized stocks, while the last 110 companies with the smallest market values are classified into small-sized stocks. Companies with sequence numbers 376 to 485 based on market value are classified as medium-sized stocks.

This paper employs the GARCH model as its research methodology. Bollerslev (1986) pointed out that ARCH/ GARCH required leptokurtic distribution and conditional variance. Our data show that the number of observations in this research presented high leptokurtic distribution, thus conditional variance still needs to be taken into consideration.

However, the traditional GARCH empirical analysis assumes that the common variance relationship between two series is CCC, which is a rather unreasonable practice. Thus, this paper will use Engle's (2002) bivariate GARCH model under DCC to proceed with its research.

Study targets to probe into the co-moving relationship of rate of returns and trading volume under different firm sizes. Table 1 shows that all the AIC values in the lagging period are very close to one another. Based on a parsimonious goal, this paper first sets AR(1)-GARCH (1,1) model for its empirical research. The intersecting item's lagging period value in the variance equation is also set as 1. Thus, the models for the co-moving relationship between rate of returns and trading volume are shown in equations 1 to 5:

$$r_t = \alpha_1 + \beta_1 r_{t-1} + \gamma_1 v_{t-1} + \varepsilon_{r_t} \tag{1}$$

$$v_t = \alpha_2 + \beta_2 v_{t-1} + \gamma_2 r_{t-1} + \varepsilon_{v_t} \tag{2}$$

$$h_{rr,t} = \psi_1 + \phi_1 h_{rr,t-1} + \theta_1 h_{vv,t-1} + \omega_1 \varepsilon_{1,t-1}{}^2 \tag{3}$$

$$h_{vv,t} = \psi_2 + \phi_2 h_{vv,t-1} + \theta_2 h_{rr,t-1} + \omega_2 \varepsilon_{2,t-1}{}^2 \tag{4}$$

$$\begin{aligned} q_{rv,t} &= \overline{\rho}_{rv} + \alpha\left(z_{r,t-1} z_{v,t-1} - \overline{\rho}_{rv}\right) + \beta\left(q_{rv,t-1} - \overline{\rho}_{rv}\right), \\ \rho_{rv,t} &= q_{rv,t} \Big/ \sqrt{q_{rr,t} \cdot q_{vv,t}} \end{aligned} \tag{5}$$

EMPIRICA ANALYSIS

Regarding the mean equation coefficient estimation in equations (1) and (5), as mentioned earlier, AR(1) is used to estimate. Since the focal point of this paper is at observing variance equations and covariance equations, thus the determination, estimation process, and results related to mean equations are not presented. Table 1 shows the coefficients of variance equations (3) and (4) and covariance equation (5) under the DCC-GARCH model of each stock market.

In the covariance equation, this paper finds that the coefficients in the covariance equation for price-volume relationship α and β are significant, also that $\alpha + \beta < 1$. This means that the correlation coefficient of price-volume relationship changes according to time. This also shows using DCC-GARCH to study the variations in price-volume relationship is reasonable. Table 1's right half shows the DCC covariance equation coefficients α and β of price-volume at each type of firm size index during pre- and post-financial tsunami period. It can be seen from Table 1 that majority of the coefficients are significant (only small size stocks are insignificant pre-financial tsunami). The implication of this is that using DCC-GARCH model to study the volatility relationship of price-volume is reasonable.

Table 1 Estimated Results of Price-Volume Relationship under DCC-GARCH Model

$$h_{rr,t} = \psi_1 + \phi_1 h_{rr,t-1} + \theta_1 h_{vv,t-1} + \omega_1 \varepsilon_{1,t-1}{}^2$$

$$h_{vv,t} = \psi_2 + \phi_2 h_{vv,t-1} + \theta_2 h_{rr,t-1} + \omega_2 \varepsilon_{2,t-1}{}^2$$

$$q_{rv,t} = \bar{\rho}_{rv} + \alpha\left(z_{r,t-1} z_{v,t-1} - \bar{\rho}_{rv}\right) + \beta\left(q_{rv,t-1} - \bar{\rho}_{rv}\right), \quad \rho_{rv,t} = q_{rv,t} \Big/ \sqrt{q_{rr,t} \cdot q_{vv,t}}$$

Index	Period	ψ_1	ψ_2	ϕ_1	ϕ_2	θ_1	θ_2	ω_1	ω_2	α	β
Big size stocks	Pre-	- (0.7960)	0.0164 (0.6536)	0.2725 * (0.0613)	- (0.6327)	0.0106 (0.7790)	0.0522 * (0.0966)	- (0.1296)	0.0034 (0.8275)	0.0276 ** (0.0111)	0.798 *** (0.0000)
	Post-	- (0.1785)	0.0054 (0.8821)	- (0.9962)	- *** (0.0045)	0.0404 (0.2748)	0.0199 (0.5879)	0.0049 (0.9507)	0.0322 *** (0.0075)	0.0124 (0.2438)	0.859 *** (0.0000)
Medium size stocks	Pre-	- ** (0.0316)	- (0.7104)	0.2041 * (0.0926)	- (0.3107)	0.0185 (0.6259)	0.0422 * (0.0986)	- (0.1394)	0.0027 (0.6285)	0.0124 (0.4150)	0.852 ** (0.0145)
	Post-	- *** (0.0012)	0.0063 (0.8659)	0.2418 * (0.0590)	- (0.8199)	- (0.7659)	0.0263 (0.4813)	- ** (0.0450)	0.0010 (0.9540)	- (0.4320)	0.886 *** (0.0000)
Small Size Stocks	Pre-	- (0.1406)	0.0274 (0.4614)	0.2186 * (0.0534)	- ** (0.0151)	0.0260 (0.4862)	0.0413 * (0.0992)	- * (0.0532)	0.0157 ** (0.0488)	0.0053 (0.5883)	0.680 (0.2970)
	Post-	- *** (0.0051)	- (0.9403)	0.5919 (0.6525)	0.2256 (0.3918)	- (0.9865)	- ** (0.0460)	- (0.6190)	- (0.2819)	0.0616 *** (0.0000)	0.849 *** (0.0000)

The α coefficient represents the effect of the previous period's standardized residual on price-volume's dynamic conditional correlation coefficient, which is also the persistence of dynamic conditional correlation. If the α coefficient is big, this means that the effect of the previous

period's standardized residual on the dynamic conditional correlation coefficient is bigger. This paper finds that most α coefficients were insignificant except for big size index during pre-financial tsunami (0.0276) and small size index during post-financial tsunami (0.0616). This implies that the effect of previous period's standardized residual on dynamic conditional correlation coefficient is not big.

On the other hand, β coefficients represent the effect of the previous period on price-volume's dynamic conditional correlation. If the β coefficient value is big, this means that the dynamic conditional correlation between the two series is rather stable; but if the β coefficient is negative, this means that the volatility of the dynamic conditional correlation is rather severe. The results of this paper show that the β coefficients, regardless if pre- or post-financial tsunami, are significantly positive (0.7981→0.8597, 0.8525→0.8860, 0.6801→0.8494), which shows that the dynamic conditional relation between the two series is more stable. It also significantly increases during post-financial tsunami period to as high as 0.8, which implies that the dynamic conditional correlation between the two series of rate of returns and trading volume variations has a high stability. From the changes in the dynamic conditional coefficient during both pre- and post-financial tsunami period, as in Table 1, it can be seen that the dynamic conditional correlation coefficients significantly increased after the financial tsunami. This means that the dynamic conditional correlation between price and volume is even more stable during post-financial tsunami period. Tying this in with the said results for α coefficients, it can be concluded that the stock market for all firm sizes in Taiwan shows the lessening persistence of dynamic conditional correlation and trending towards stability. This could be related to the series of policies implemented by the Taiwanese government after the financial tsunami.

The coefficients in equations (3) and (4) represent the two-step autocorrelation and the two-step crossing relation, wherein ϕ_1 and ϕ_2 describe the two-step autocorrelation, representing the effect of the previous period's variance on the current period's variance, or in other words, the persistence of volatility. It can be observed that the values in the table that with the exception of each type of indices (0.2725, 0.2041, 0.2186) and the trading volume of small size stocks (-0.4504) during pre-financial tsunami period, and the trading volume of big size stocks (-0.7616) during post-financial tsunami period were significant, all others were insignificant. If the significance is decreased to 0.05, only the small size trading volume (-0.4504) during pre-financial tsunami and big size trading volume (-0.7616) during post-financial tsunami period were significant. This means that in comparing price-volume relationship, the persistence of price variance and trading volume variance are both insignificant.

θ_1 and θ_2 represents the two-step crossing relationship, which is also the transmission of volatility. All θ_1 are insignificant regardless if pre- or post-financial tsunami. This means that the prices of each type of Taiwan's indices are not affected by the pre-period's trading volume, so there is no volume-before-price scenario. On the other hand for θ_2, three type of indices all show as significant and positive during pre-financial tsunami period (0.0522, 0.0422, 0.0413), but only small size stocks show as significantly negative (-0.0741) during post-financial tsunami period. This result shows that during pre-financial tsunami period, all type of indices in Taiwan show price-before-volume relationship.

CONCLUSION AND RECOMMENDATIONS

This study mainly uses the dynamic conditional correlation model to study the spillover effect of volatility. The primary subject it looks into is the price-volume relationship of firm size indices. Using the financial tsunami, it studies the changes of the said factors during pre- and post-financial tsunami period. The results of this study show that the financial tsunami has a significant effect on the dynamic conditional correlation of price-volume. Thus, using the dynamic conditional correlation model is reasonable.

This study find that the dynamic conditional correlation between the two series of rate of returns and rate of change in trading volume has a high stability, and is even more stable after the financial tsunami. On the whole, the stock market for all firm sizes in Taiwan shows the lessening persistence of dynamic conditional correlation and trending towards stability. This could be due to the effects caused by the series of policies implemented by the Taiwanese government after the financial tsunami.

On the price-volume relationship regarding volatility, this study finds that during pre-financial tsunami, the volatilities of each type of index in Taiwan show a price-before-volume scenario. However after the financial tsunami, the causal relationship between price and volume no longer exist in Taiwan's stock market.

The results of this study provide investors with recommendations for decision-making: when there is no sudden financial event, investors can focus on the price-volume relationship; after a sudden financial event, investors may need to focus on some other factors or phenomena. For example, the firm size message transmission effects such as whether the bigger companies affect smaller companies are not discussed in this paper. This is the limitation of this study and worth further investigation.

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