Information content of volume:  
An investigation of Tokyo commodity futures markets  
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Received 28 April 2001; accepted 23 June 2001

Abstract

This study examines the relationship between volume and price changes for Tokyo commodity futures contracts by focusing on the predictive power of volume. The findings indicate a positive simultaneous relation between volume and absolute returns. The relation is not entirely contemporaneous since lagged volume contains predictive power for absolute returns. However, linear and nonlinear causality tests show that volume does not forecast returns. The results are qualitatively the same for contracts traded with different methods. © 2002 Elsevier Science B.V. All rights reserved.

JEL classification: G10; G15

Keywords: Volume; Nonlinear causality; Call markets

1. Introduction

The nature of price–volume relationship in asset markets has long been a subject of financial research. Many papers document a positive contemporaneous relation between volume and absolute value of returns in both futures and equity markets. This is usually explained as a result of the same variable, the flow of information, directing changes in prices and volume as in the mixture of distributions hypothesis (MDH) of Clark (1973). Gallant et al. (1992) conducted an extensive analysis of stock price–volume relation for

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the U.S. equity market and concluded that more can be learned by studying prices jointly with volume than by examining them alone.

This paper investigates the relationship between price changes and trading volume for gold, platinum and rubber futures contracts traded on the Tokyo Commodity Exchange (TOCOM). The main research question of the study is whether volume contains information useful for predicting future price movements. The information content of volume is examined for the direction and magnitude of price changes, i.e. for returns and absolute value of returns.

The theoretical motivation for the study is provided by Blume et al. (1994), who argue that volume conveys information to the market that cannot be deduced from price alone. Specifically, their model suggests that volume contains information about the precision of price’s signal and, therefore, current trading volume could improve forecast of price movements. Their analysis is consistent with the use of technical analysis in financial markets.

An investigation of the TOCOM is of interest for two main reasons. First, the evidence on price–volume relation in futures markets is mainly from U.S. futures exchanges. Results from an international market can be useful for comparison. Second and more importantly, the TOCOM provides an opportunity to examine whether market structure affects price–volume relation in futures markets since two different methods of trading are used on the TOCOM.

The first is systems trading, which is continuous trading similar to the methods used by U.S. futures exchanges. Gold and platinum futures contracts on the TOCOM are traded with the systems method. The second is Itayose trading, an auction-like periodic call market trading, under which all orders are treated as having arrived at the same time. The Itayose system closely resembles a classical Walrasian auction, where recontracting is allowed at provisional futures prices until an equilibrium (market consensus) price is determined. Rubber futures contract is traded using the Itayose method.

Currently, no theory exists to link market structure to information content of trading volume. However, it can be argued that the predictive power of volume for future price movements should be greater for continuous trading systems. On a continuous trading market, trades occur one at a time and prices are not market consensus. The price in any transaction will differ depending on a number of factors, whether the trade is large or small being one of them. Hence, as Schwartz (2000) argues, price discovery will be more accurate on periodic call markets since trades are executed only at market consensus prices.1 Webb (1995) similarly notes that prices produced by periodic call markets will be less noisy compared to those produced by continuous trading systems. These arguments suggest that prices will be more revealing on a periodic call market and, hence, trading volume as an additional statistic should be less informative. In fact, consistent with this argument, trading volume emerges as a useful statistic in the Blume et al. (1994) model only because prices are noisy and traders cannot obtain the full information signal from price alone.

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1 The author thanks an anonymous referee for pointing out Schwartz’s (2000) study.
The empirical analysis begins with an examination of the relationship between daily trading volume and absolute value of returns. It is important to account for a simultaneous relationship between the variables in modeling. A structural model, which treats volume as an endogenous variable and controls for the simultaneity bias, is constructed and estimated using an instrumental variable (IV) estimator as a GMM estimator. The findings indicate a positive contemporaneous relationship between volume and absolute value of returns, supporting the MDH and consistent with prior studies from U.S. futures markets. Moreover, it is documented that past volume contains information to predict absolute value of returns, consistent with the arguments of Blume et al. (1994). The results are similar for all three of the contracts.

The second part of the empirical analysis examines the dynamic relationship between volume and returns. A finding suggesting that volume can be used to predict returns could cast doubt on market efficiency. However, linear Granger causality tests, conducted within the context of vector autoregression (VAR) models, do not suggest that volume contains information to forecast returns.

Hiemstra and Jones (1994) and Fujihara and Mougoue (1997) show that, for equity and futures markets, respectively, volume can have nonlinear predictive power. These studies use the modified Baek and Brock (1992) test, a nonparametric test designed to detect relations that cannot be captured by conventional linear causality tests, to examine nonlinear Granger causality dynamics. Indeed, an application of the modified Baek and Brock (1992) test suggests that bidirectional nonlinear Granger causality exists between volume and returns.

However, this nonlinear Granger causality from volume to returns can be due to simple volatility effects. The MDH implies that a latent-variable representing daily information flow to the market affects trading volume and price contemporaneously. If lagged volume captures persistence in daily information flow, spurious causality may be detected. To investigate this possibility, returns are adjusted for conditional variance using an ARCH-type model and nonlinear causality tests are reconducted. Consistent with the implications of the MDH, nonlinear causality from volume to returns disappears after this adjustment.

The remainder of the paper is organized as follows: The next section provides a brief review of prior work. Econometric approach of the study is discussed in the third section, while the fourth section presents the data set. The fifth section provides the empirical findings and the final section contains the concluding remarks of the study.

2. Prior work

Empirical studies on price–volume relation mainly examine the correlation between volume and absolute value of returns. A survey of this work can be found in Karpoff (1987). In futures markets, Cornell (1981) and Grammatikos and Saunders (1986) find positive correlation between volume and absolute value of returns for commodity and
currency futures contracts, respectively. While Cornell (1981) argues that the relationship is almost entirely contemporaneous, others such as, Foster (1995), find that lagged volume forecasts absolute value of returns in futures markets.

Several studies examine causal linkages between volume and returns in futures markets. Fujihara and Mougoue (1997) use linear and nonlinear causality tests and find bidirectional nonlinear causality for petroleum futures markets. Malliaris and Urrutia (1998) argue that volume is nonstationary and apply cointegration techniques to test for causal relations between volume and returns for U.S. agricultural commodity futures contracts.

On the theoretical front, the MDH, by Clark (1973), Epps and Epps (1976) and Harris (1987) and the sequential information flow model (SIF), by Copeland (1976) and Smirlock and Starks (1985), are frequently used to explain the positive correlation between volume and absolute value of returns. The MDH proposes that prices and volume have a joint response to the same directing variable, the flow of information to the market. The response to new information is synchronous and a new equilibrium is immediately reached. As a result, positive correlation between volume and absolute value of returns is observed. The SIF, on the other hand, argues that the information is not received simultaneously by all traders, but is observed by each trader sequentially. Each participant’s trade in response to the signal represents one of a series of incomplete equilibria, until a final market equilibrium is achieved. Consequently, absolute value of returns is predictable by trading volume.

Blume et al. (1994) also study the role of volume. However, rather than describing the correlation between volume and price, they set out to show how volume could affect market behavior. Their model suggests that volume provides information on the precision and dispersion of information signals, which price alone does not. Specifically, markets are assumed to have noise, due to lack of information contained in prices. Hence, traders cannot obtain the full information signal from price and could use volume as an additional statistic to observe that signal. Market participants, therefore, condition their expectations about price movements on volume as well as price. As mentioned in the Introduction, their analysis is consistent with the use of technical analysis in financial markets.

3. Econometric approach

3.1. Volume and absolute returns

The empirical analysis begins by examining the linkage between volume and absolute value of returns. If there is a simultaneous relationship between volume and absolute value of returns, as suggested by the MDH, it becomes crucial to control for the simultaneity bias in estimation. The approach in this study, adopted from Foster (1995), uses an instrumental variable (IV) estimator as a GMM estimator and constructs the following structural model:

\[
V_t = a_0 + a_1 |R_t| + a_2 V_{t-1} + a_3 V_{t-2} + u_{1t},
\]

\[
|R_t| = b_0 + b_1 V_t + b_2 V_{t-1} + b_3 |R_{t-1}| + u_{2t},
\]

where \(V_t\) is trading volume and \(|R_t|\) is absolute value of (log) price changes.
The model treats $V_t$ and $|R_t|$ as endogenous variables; hence, OLS estimates will be inconsistent. To estimate Eq. (1), lagged values of $V_t$ and $|R_t|$ are used as instrumental variables and the system is estimated by the GMM. The IV approach controls for the simultaneity bias and the GMM estimation controls for possible heteroskedasticity in error terms. Within the context of this system, the significance of $a_1$ and $b_1$ would indicate a contemporaneous relation between volume and absolute value of returns, and the significance of $b_2$ would indicate that lagged volume contains information about absolute value of returns.

3.2. Volume and returns

The study proceeds to investigate whether volume contains information for the direction of price changes, i.e. returns. The dynamic relationship between volume and returns is investigated using a VAR model. VAR models treat each variable as exogenous and are suited to investigate dynamic linkages, without employing any a priori restrictions. The following VAR model is constructed:

$$R_t = \gamma_0 + \sum_{i=1}^{l} \gamma_1 V_{t-i} + \sum_{i=1}^{l} \gamma_2 R_{t-i} + \epsilon_{R,t}, \quad (2)$$

$$V_t = \alpha_0 + \sum_{i=1}^{l} \alpha_1 V_{t-i} + \sum_{i=1}^{l} \alpha_2 R_{t-i} + \epsilon_{V,t}, \quad (3)$$

where $V_t$ is trading volume and $R_t$ is (log) price changes.

Within the context of this model, Granger causality relations between $V_t$ and $R_t$ can be examined. Granger causality testing investigates whether the past of one variable contains information to improve the forecast of another. If the null hypothesis that all $\gamma_1$ jointly equal zero is rejected, it is argued that volume Granger causes returns. Similarly, if all $\alpha_2$ are not jointly equal to zero, returns Granger cause volume. If both of the null hypotheses are rejected, bidirectional Granger causality (feedback) exists between the variables.

The VAR model is estimated by the OLS and White's (1980) heteroskedasticity-consistent errors are calculated. Several methods for Granger causality testing are offered in the literature. This study uses the conventional $\chi^2$-test for joint exclusion restrictions. Monte Carlo studies, such as Geweke et al. (1983), suggest that this simplest form of testing is the most powerful.

In addition to linear linkages, volume and returns could have nonlinear linkages. For example, the heterogeneous investor model of Campbell et al. (1993) predicts a nonlinear relationship between returns and volume. In their model, volume may act as a filter to distinguish between price movements associated with public information and those that are associated with liquidity investors. Their model suggests that price reversals will be
observed following days with large trading volume. Wang (1994) constructs a similar model; however, assuming a world of informed investors as well as liquidity traders. His model suggests that price continuations will be observed following days with large trading volume, if speculation is the primary motive for trading. LeBaron (1992) and Duffee (1992) provide empirical evidence of significant nonlinear interactions between stock returns and trading volume. Hiemstra and Jones (1994) and Fujihara and Mougoue (1997) show that bidirectional nonlinear Granger causality exists between trading volume and returns in U.S. equity and futures markets, respectively, although linear Granger causality tests cannot capture it.

This study uses the modified Baek and Brock (1992) test, fully developed in Hiemstra and Jones (1994), to examine nonlinear causality relations. Baek and Brock (1992) offer a nonparametric statistical method to detect nonlinear causal relations that, by construction, cannot be uncovered by linear causality tests. Hiemstra and Jones (1994) modify their test to allow the variables to which the test is applied to exhibit short-term temporal dependence, rather than the Baek and Brock (1992) assumption that the variables are mutually independent and identically distributed.

The Baek and Brock (1992) approach begins with a testable implication of the definition of strict Granger noncausality. Consider two strictly stationary and weakly dependent time series \( \{X_t\} \) and \( \{Y_t\} \), \( t = 1, 2, \ldots \). Denote the \( m \)-length lead vector of \( X_t \) by and the \( L_x \)-Length and \( L_y \) length lag vectors of \( X_t \) and \( Y_t \), respectively. For given values of \( m \), \( L_x \), and \( L_y \) \( \geq 1 \) and for \( e > 0 \), \( Y \) does not strictly Granger cause \( X \) if

\[
\Pr(L_x \| X_t^{m} - X_s^{m} \| < e | L_x \| X_t^{L_x} - X_s^{L_x} \| < e, L_y \| Y_t^{L_y} - Y_s^{L_y} \| < e) = \Pr(L_x \| X_t^{m} - X_s^{m} \| < e | L_x \| X_t^{L_x} - X_s^{L_x} \| < e),
\]

where \( \Pr(\cdot) \) denotes probability and \( \| \cdot \| \) denotes the maximum norm. The probability on the left side of Eq. (4) is the conditional probability that two arbitrary \( m \)-length lead vectors of \( \{X_t\} \) are within a distance, \( e \), of each other, given that the corresponding \( L_x \)-length lag vectors of \( \{X_t\} \) and \( L_y \)-length lag vectors of \( \{Y_t\} \) are within, \( e \), of each other.

The strict Granger non-causality condition in Eq. (4) can then be expressed as

\[
\frac{C_1(m + L_x, L_y, e)}{C_2(L_x, L_y, e)} = \frac{C_3(m + L_x, e)}{C_4(L_x, e)}
\]

for given values of \( m \), \( L_x \), and \( L_y \geq 1 \) and \( e > 0 \), where \( C_1, \ldots, C_4 \) are the correlation-integral estimates of the joint probabilities. Hiemstra and Jones (1994) discuss how to derive the joint probabilities and their corresponding correlation-integral estimators.

\footnote{Empirical studies by Conrad et al. (1994) and Cooper (1999) test the predictions of these two models. Conrad et al. (1994) argue that trading volume induces negative return autocorrelations, while Cooper (1999) finds that trading volume decreases them. Cooper (1999) suggests that the different results are due to size of the stock samples used in the two papers.}
Assuming that $X_t$ and $Y_t$ are strictly stationary, weakly dependent, and satisfy the mixing conditions of Denker and Keller (1983), if $Y_t$ does not Granger cause $X_t$, then,

$$
\sqrt{n}\left( \frac{C_1(m + Lx, Ly, e, n)}{C_2(Lx, Ly, e, n)} \right) = \frac{C_3(m + Lx, e, n)}{C_4(Lx, e, n)} \sim N\left(0, \sigma^2(m, Lx, Ly, e)\right)
$$

(6)

Hiemstra and Jones (1994) show that a consistent estimator of the variance is, $\sigma^2(m, Lx, Ly, e) = \delta(n) \cdot \Sigma(n) \cdot \delta(n)$. To test for nonlinear causality between volume and returns, the test in Eq. (6) is applied to obtained residual series from the VAR models. Since the VAR model accounts for any linear dependencies, any remaining predictive power of one residual series for another can be considered nonlinear predictive power.

4. Data and market structure

The data set consists of daily closing prices and trading volume for gold, platinum and rubber futures contracts traded on the TOCOM, between January 4, 1992 and September 29, 2000. The data are provided by the TOCOM. Table 1 provides a display of contract specifications and trading methods, while some sample summary statistics are available in Table 2. It is observed that returns have zero mean, negative skewness and excess kurtosis. Augmented Dickey–Fuller (ADF) tests are used to test for unit roots in returns and trading volume. The null hypothesis of nonstationarity is rejected in all cases.

As mentioned in the Introduction, the TOCOM uses two different methods of trading. Gold and platinum futures contracts are traded using the systems method, while rubber futures contract is traded with the Itayose method. The systems method is continuous computerized trading. Two different mechanisms are used under this method, depending on the time in the trading process. There are two trading sessions in a day, a morning session between 9:00 and 11:00 and an afternoon session between 12:30 and 15:30. The first trade of each session is determined by the Ita-Awase procedure, under which the price for the first trade is determined by order accumulation. Trade takes place where the largest number of transactions will occur. After the opening price is determined, the Zaraba, a continuous double-auction-type market mechanism, is employed throughout the remainder of the session. Prices for gold and platinum futures contracts are the closing prices of the last afternoon session.

The Itayose method, however, closely resembles a Walrasian auction and generates a single equilibrium price for each of several trading sessions. There are five different trading sessions each day for the rubber futures contract: two in the morning (at 9:45 and 10:45) and three in the afternoon (at 13:45, 14:45 and 15:30). At the beginning of each

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5 A significantly positive value for the test statistic in Eq. (6) indicates that past values of $Y$ help to forecast $X$, while a significantly negative value indicates that past values of $Y$ confound the forecast of $X$. Therefore, Hiemstra and Jones (1994) argue that the test statistic should be evaluated with right-tailed critical values when testing for Granger causality.

6 Although the Itayose method was used for all contracts initially, the systems method has been used for the precious metals futures contracts since April 1991.
session, a provisional price is announced by an exchange official and subsequently, sell and buy orders are collected from the members in response to the provisional price. The price is raised or lowered in accordance with the number of buy and sell orders. When the number of buy and sell orders are equal, all the orders are instantly executed at a single price. As stated in the Introduction, Webb (1995) argues that the Itayose system produces futures prices less noisy than those generated on continuous double-auctions systems. In an earlier article, Webb (1991) studies the path to convergence of provisional futures prices in the Itayose method and finds that convergence to equilibrium is reached quickly.

There is a notable difference in trading patterns between U.S. and Japanese futures markets. The most actively traded contracts are almost always the most deferred contracts on Japanese futures exchanges, while nearby contracts are more active in the US. One explanation for this, advocated by Webb (1995), is that speculators on Japanese futures

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Notes: This table provides the specifications and trading methods for gold, platinum and rubber futures contracts traded on the TOCOM.

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Notes: This table provides the descriptive statistics of the sample. Returns are calculated as daily log price changes. The row labeled ADF refers to the Augmented Dickey Fuller test for unit root. The lag lengths in the ADF test, which are determined by the AIC, are 12 and 5 for gold futures, 17 and 8 for platinum futures and 23 and 4 for rubber futures contracts for returns and volume, respectively. The ADF test is calculated with an intercept and a trend variable for volume, where the 5% critical value is −3.41, and with an intercept for returns, where the 5% critical value is −2.86.
markets prefer deferred contracts since there is more time for their futures position to become profitable.\(^7\)

Futures prices, therefore, are collected from the most deferred contracts. Gold and platinum futures contracts are traded in all even months within a year, while rubber futures contracts are traded six consecutive months from the current month. Contracts are rolled over when a new contract is introduced.

### 5. Volume and absolute returns

The system of equations in Eq. (1) is estimated by the GMM and the results are reported in Table 3. An important point is to determine that a unique set of estimates for the coefficients in the model exists, i.e. that the system is exactly identified. If the system is overidentified, there will be multiple estimates for the coefficients. Hansen’s (1982) test is used in this study to test for overidentification. The test statistics, also reported in Table 3, are very small in all of the cases, indicating a good fit of the model to the data.

Both of the coefficients of interest in Eq. (1), i.e. \(a_1\) and \(b_1\), are statistically significant, suggesting a positive contemporaneous relationship between trading volume and absolute value of returns for all of the contracts. This finding suggests that volume and absolute value of returns are endogenously determined and respond to the same exogenous variable, the daily flow of information to the market in the MDH context.

The results also indicate that there is a statistically significant negative relationship between lagged volume and absolute value of returns, again for all of the cases examined. This finding, consistent with the analysis in Blume et al. (1994), suggests that lagged

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\(^7\) As another explanation, Booth and Ciner (1997) suggest that this phenomenon could be due to the fact that the nearest contract is auctioned first in the Itayose system. However, this is unlikely the reason since the same pattern is observed also for continuous trading contracts.
volume contains information useful for forecasting price variability. It is noteworthy that Foster (1995) reports similar findings from an investigation of the US crude oil futures contract.

### 6. Volume and returns

#### 6.1. Linear Granger causality analysis

The results of linear Granger causality tests examining the predictive power of lagged volume for returns are discussed in this section. The VAR model in Eqs. (2) and (3) are estimated by the OLS and the \( \chi^2 \)-tests for joint exclusion restrictions are reported in Table 4. The lag lengths in the VAR models are determined according to Akaike’s Information Criteria (AIC). It is established in the previous section that both variables can be described as stationary variables; hence, they are used in the VAR model directly.

The test statistics do not suggest Granger causality from volume to returns for any of the contracts. In other words, consistent with informational efficiency, trading volume does not seem to contain information useful to forecast returns. However, the results indicate that returns Granger cause volume in platinum and rubber futures markets, although not in gold futures markets.

Two sets of diagnostic tests are conducted on the residuals from the VAR models. The Ljung–Box \( Q \)-test is used to determine whether any linear dependency remains in the residuals, while the \( Q^2 \)-test of McLeod and Li (1983) is used to test for nonlinear depen-

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8 This result is also consistent with the prediction of the sequential information model.
dency. The null hypothesis of the $Q$-test is no serial correlation in residuals and the null hypothesis of the $Q^2$-test is no serial correlation in squared residuals. The results of diagnostic tests, which are also reported in Table 3, point out that the VAR models successfully account for linear dependency, as indicated by insignificant values of $Q$-tests. However, there is nonlinear dependency remaining in the residuals, as suggested by $Q^2$-tests.

6.2. Nonlinear Granger causality analysis

As argued above, returns and volume could exhibit nonlinear linkages, in addition to linear dependencies. Although the $\chi^2$-test is useful to detect linear causality, it does not have power to detect nonlinear causality. In fact, the significant values of the $Q^2$-test suggest that there may be uncovered nonlinear linkages. This section discusses the application of the modified Baek and Brock test to the obtained residuals from the VAR models to test for nonlinear Granger causality between volume and returns.

To implement the modified Baek and Brock test, values for the lead length, $m$, and the lag lengths, $L_x$ and $L_y$, and the scale parameter, $e$, have to be selected. Unlike in testing for linear causality, no methods have been developed in the literature to select optimal values. This study, following Hiemstra and Jones (1994) and Fujihara and Mougoue (1997), relies on Monte Carlo evidence in Hiemstra and Jones (1993) and sets the lead lag length at $m = 1$ and $L_x = L_y$ in all cases. Also, common lag lengths of 1–8 lags and a common scale parameter of $e = 1.0\sigma$ are used, where $\sigma = 1$ denotes the standard deviation of standardized series.

The results of nonlinear Granger causality tests, which are reported in Table 5, reverse the conclusion based on linear causality tests. The modified Baek and Brock test statistics are significant at all lags, supporting the presence of significant bidirectional causality between volume and returns. Hence, it appears that volume contains information useful for predicting the direction of price changes, albeit in a nonlinear framework.

6.3. Adjusting for conditional variance

This section examines if the observed nonlinear causality from volume to returns is due to simple volatility effects. Hsieh (1991) argues that much of the nonlinear dependency in asset returns is due to ARCH effects. The results of the $Q^2$-tests also indicate the presence of significant ARCH effects. According to the MDH, ARCH effects can be explained as a consequence of persistence in the latent variable, representing daily information flow to the market, affecting prices and volume, synchronously. Hence, if lagged trading volume captures the latent speed of information flow, the modified Baek and Brock test could be spuriously detecting causality.

To investigate this possibility, the study adjusts the returns for conditional variance using a GARCH-type model and reexamines the nonlinear causality from trading volume...
to returns. A GARCH (1,1) model with Student’s t-distribution is estimated to account for volatility persistence. Many papers, such as Baillie and Bollerslev (1989), argue that the GARCH (1,1) model parsimoniously accounts for temporal dependence in variance and excess kurtosis. The GARCH (1,1) model estimated can be described as:

\[
R_t = \varepsilon_{R,t},
\]

\[
\varepsilon_{R,t} | \Omega_{t-1} \sim t.d(0, h_{R,t}, v),
\]

\[
h_{R,t} = \alpha_0 + \alpha_1 \varepsilon_{R,t-1}^2 + \alpha_2 h_{R,t-1}^2 + \epsilon_t.
\]

The residual term \(\varepsilon_{R,t}\) follows a conditional Student’s t distribution (t.d) with \(v\) degrees of freedom and a conditional variance \(h_{R,t}\). \(\Omega_{t-1}\) is the information set that contains all relevant information at time \(t-1\). Conditionally standardized returns, \(R_t/h_{R,t}\), are used in Eq. (2) to obtain new residual series. This modified version of the linear regression in Eq. (2) is

\[
R_t/h_{R,t} = \gamma_0 + \sum_{i=1}^{l} \gamma_1 V_{t-i} + \sum_{i=1}^{l} \gamma_2 (R_{t-i}/h_{R,t-i}) + \varepsilon_{AR,t}
\]  

(7)
where $e_{AR,t}$ represents residuals for conditionally adjusted returns. The modified Baek and Brock test is now applied to $e_{AR,t}$ and $e_{V,t}$, the estimated residuals for volume.

The results of the modified Brock and Baek tests are reported in Table 6. It is observed that the test statistics are now much smaller and statistically insignificant. In other words, the nonlinear Granger causality disappears when futures returns are adjusted for persistence in conditional variance. This is different from the evidence reported by Hiemstra and Jones (1994) and Fujihara and Mougoue (1997), who find that the nonlinear Granger causality tests continue to be significant in US equity and futures markets, respectively, when returns are adjusted for GARCH effects in a similar fashion.

### 7. Concluding remarks

This paper extends the understanding on price–volume relations in futures markets by examining the relationship between daily price changes and trading volume for gold, platinum and rubber futures contracts traded on the TOCOM. The investigation focuses on the information content of volume for the magnitude and direction of price changes. A structural model, which controls for the simultaneity bias, is estimated by the GMM to model the relationship between volume and absolute value of returns. The results suggest a positive contemporaneous relationship for all of the cases examined, consistent with evidence from U.S. futures markets. This can be explained by the MDH, which states that daily flow of information, acting as a directing variable, impacts price movements and volume synchronously.

The findings further state that there is a statistically significant relationship between lagged volume and absolute value of returns. Consistent with the arguments raised by Blume et al. (1994), this suggests that volume conveys valuable information to the market about price variability. One explanation for this finding is that market participants use
volume as an indication of market sentiment and condition prices on previous trading volume (Foster, 1995).

The study also investigates the dynamic relationship between volume and returns. The predictive power of volume for returns is examined by linear as well as nonlinear tests. Linear Granger causality tests, conducted within the context of VAR models, detect no predictive power for lagged volume, although there is causality running from returns to volume, while the modified Baek and Brock nonlinear Granger causality tests support bidirectional causality between volume and returns. However, causality from volume to returns disappears when returns are adjusted for persistence in conditional volatility, again consistent with the MDH.

The results of the study support the argument, raised by Gallant et al. (1992), that more can be learned by studying prices together with volume, than by studying them alone. Statistical analysis, overall, shows that volume conveys information to the market about the magnitude of price changes, but not about the direction of price changes, which supports informational efficiency. Also, the study has argued that trading volume should be less informative as a statistic on periodic call markets, since prices produced by these markets are market consensus and more revealing. However, the findings are qualitatively the same for continuous trading and periodic call markets. Hence, the evidence does not suggest that market structure is influential on conclusions about daily price–volume relation in futures markets.

Acknowledgements

I am grateful to the late Craig Hiemstra for sharing his software to calculate the nonlinear causality tests used in this study. The paper has benefited significantly from the comments by Andrew Karolyi (the editor) and two anonymous referees. Any remaining errors are solely my responsibility.

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