# Price volatility of Indonesian stocks 

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#### Abstract

The first-order serial dependence between overnight returns and following daytime returns and between overnight returns and preceding daytime returns is evaluated to gain insight into the intraday volatility behavior of Indonesian stocks. The pattern of price reversals and price continuations observed for Indonesian stocks is different from the U.S. and Japanese markets, reflecting differences in market microstructure of the three markets. Price reversals are dominant over price continuations at the market open as well as market close for Indonesian stocks. These results are different from the U.S. experience since high-volume U.S. stocks tend to show price continuity at the market close, an attribute that is associated with the stabilization activities by market-makers. These results are also different from the Japanese experience which also shows strong price continuations at the market close.


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JEL classification: G15

## 1. Introduction

Past studies document empirical evidence that open-to-open return volatility is greater than close-to-close return volatility. Greater volatility at the market open is attributed to: (i) lack of market-makers' price stabilizing under the call market method (Amihud and Mendelson, 1987); (ii) preceding overnight nontrading period (Amihud and Mendelson, 1991); and (iii) monopoly power exercised by

[^0]market-makers as evidenced by profit maximizing through offsetting order imbalance on their account (Stoll and Whaley, 1990). In a recent study, George and Hwang (1994) observe Tokyo Stock Exchange (TSE) stocks and find greater volatility at the open only for the most actively traded stocks, while other stocks do not exhibit this behavior. To explain this anomaly, they identify maximum price variation rules designed to slow trade flows. ${ }^{1}$ Under the transaction-bytransaction price variation rules, they find that price continuations are stronger for actively traded stocks at the close than at the open, thus causing opening volatility to be greater than closing volatility in the TSE market. This result contradicts U.S. evidence where price continuities prevail across different trading level intensities (Stoll and Whaley, 1990).

The main purpose of this study is to analyze the intraday price volatility of Indonesian common stocks in light of some unique microstructure features of the Jakarta Stock Exchange (JSX). First of all, the JSX utilizes the continuous auction throughout the entire trading session including the market open. ${ }^{2}$ Under the continuous auction method, orders are submitted continuously over time and transactions occur whenever orders cross. In contrast, in Tokyo and New York, opening prices are determined by the call market method, which is followed by the continuous auction method. The call market method batches buy and sell orders for execution at a single price in order to maximize trading volume. ${ }^{3}$ Thus, an examination of JSX-listed stock price behavior adds an interesting dimension to the relationship between price volatility and trading methods. For example, if volatility at the market open is greater than at the market close for Indonesian stocks, then the trading method-based explanation offered by Amihud and Mendelson (1987) loses its credibility.

Second, there are no market-makers at the JSX who trade against the market by buying (selling) when the public is a net seller (buyer) on their own accounts. If JSX-listed stocks show greater open-to-open return volatility than close-to-close return volatility, then the market-maker-related explanation offered by Stoll and Whaley (1990) loses its validity. In addition, if return volatility observed at the market open is not greater than at the market close, then the prolonged nontrading period-related explanation offered by Amihud and Mendelson (1990) becomes questionable.

Third, price stabilization mechanisms on the JSX differ from those on the NYSE and the TSE. While the NYSE relies on market-makers for price stabiliza-

[^1]tion and provision of liquidity, the TSE, in the absence of market-makers, utilizes elaborate price stabilization mechanisms in the form of warning quotes or special quotes based on maximum allowable price variation. In addition, the TSE also employs daily price limits. There is no daily price limit imposed by the JSX, but it does not allow price movement of more than Rp 200 for each transaction. However, unlike the TSE's maximum price variation rules, no built-in special quote system exists to slow down the trade flow on the JSX in the presence of extreme order imbalance. In contrast, George and Hwang (1994) contend that the TSE trading system slows down the price adjustment process, thus allowing for only partial price adjustment to occur at the market close. This behavior naturally induces price continuations at the close. In contrast, in the absence of the TSE-type price stabilizing mechanisms, JSX-listed stocks are expected to show a lesser degree of price continuations at the market close. If Indonesian stocks exhibit price continuities at the market close, similar to that of Tokyo stocks, then the price-limits-based explanation offered by George and Hwang (1994) becomes questionable.

Fourth, the JSX relies on traditional floor trading. With the floor trading system, trading costs tend to be higher, order processing time is longer, and price information is disseminated slower than under the automated floorless trading. Price volatility increases with the adoption of complete automation of trading (Chang et al., 1993a; Naidu and Rozeff, 1994). The impact of traditional floor trading on the relative magnitude of volatility at the morning open and afternoon close is not clear.

Our analysis is conducted at the individual firm level. The sample firms are partitioned into four categories depending on rupiah trading value to examine the relationship between trading value and price volatility. The remainder of this paper is organized as follows: Section 2 discusses the institutional background of the JSX market. Intraday and interday price volatility of Indonesian stocks are analyzed in Section 3. Further analyses of price reversals and price continuations will be examined using regressions in which price volatility and trading volume are modeled in Section 4. Summary and conclusions are presented in the last section.

## 2. Institutional background of the Jakarta stock exchange

A very unusual institutional framework was introduced by the Indonesian government for domestic securities when the Capital Market Supervisory Agency (BAPEPAM) of the Ministry of Finance was established in 1976. In addition to acting as a regulator of the securities market, the BAPEPAM served as an organized stock exchange. In December 1991, the JSX was established as a privately owned organization to take over the exchange operation from the

BAPEPAM, effective in April 1992. This marked the separation of regulatory function and daily operational function of the stock exchange. ${ }^{4}$

At present, three major types of securities including common stocks, rights, and convertible bonds are traded on the JSX, with common stock accounting for $99 \%$ of JSX trading volume. At the end of February 1994, the market capitalization of the JSX-listed stocks totaled Rp 69.9 trillion (or US\$ 33.13 billion) for 176 listed companies with reported annual trading value of Rp 19.7 trillion (or US\$ 9.30 billion) for 1993. ${ }^{5}$ Brokerage commission is negotiable between exchange members and customers within the band of $0.5 \%$ and $1 \%$ of the transaction value.

Transactions on the JSX trading floor can be classified into two major categories, regular trades and non-regular trades. Regular trades are conducted using the continuous auction method according to price and time priorities. Round-lots of 500 shares make up a trading unit. Non-regular trades, which are conducted through direct negotiation between exchange members, are classified into: (i) block trades; (ii) cross trades; (iii) cash trades; (iv) odd-lot trades; and (v) foreign board trades. ${ }^{6}$ Block trades are performed through negotiations between buying and selling member brokers in the minimum amount of 200,000 shares, whereas cross trades are performed by any exchange member who has buying and selling orders at the same price and quantity. Cash trades are for exchange members who fail to deliver securities on the $T+4$ settlement date and have to buy the shares for immediate payment and delivery (cash-and-carry). Odd-lot trades deal with order sizes fewer than 500 shares. Foreign ownership is currently restricted to $49 \%$ of a listed issue. Once the $49 \%$ ceiling is reached, foreigners can not buy additional shares from local investors, but foreign-owned shares can be traded among foreign investors on the foreign board. Regular trades account for approximately $60 \%$ of the total trading value. Cross trades and block trades follow with $20 \%$ and $18 \%$, respectively. Although approximately $25 \%$ of listed shares are owned by foreign investors, foreign board trades are fairly thin, representing about $2 \%$ of JSX's total trading value. ${ }^{7}$

[^2]The JSX has two trading sessions on Monday through Thursday: a morning session between 10:00 a.m. and 12:00 noon and an afternoon session between 1:30 p.m. and 3:00 p.m. On Fridays the morning session begins at 9:30 a.m. and ends at 11:30 a.m., followed by a shorter afternoon session between 2:00 p.m. and 3:00 p.m. Transactions on the JSX are required to be settled on the fourth trading day ( $T+4$ ) after the date of the transaction. Physical delivery of share certificates is required. The creation of a central clearing and depository function is progressed with the establishment of the Securities Clearing and Depository Corporation (KDEI). Also, scripless trading and immobilization plans are currently under review.

At the end of February 1994, there were 161 active brokerage firms registered with the JSX, but the 20 most active members, on average, handle approximately $60 \%$ of the total trading value.

## 3. Characteristics of Indonesian stocks and intraday trading pattern

### 3.1. Data

We have obtained JSX's daily transaction data for all listed firms during the study period from September 1, 1992 and February 28, 1994. The data contains information on stock code, price, volume, buying and selling broker codes, types of buying and selling investors (local or foreign), and types of trades (regular, block, odd-lot, cross, cash, and foreign) for each transaction. However, no bid and ask prices are reported and transactions are not time-stamped. Since reported transactions appear in the order of execution, for each stock and for each trading day, opening and closing prices can be identified along with the corresponding trading volume. For the purpose of this study, the analysis is limited to regular transactions which are conducted by the competitive auction system (unlike non-regular trades which determine prices through negotiations). ${ }^{8}$

A total of 182 firms (including six delisted firms) is listed during the study period. ${ }^{9}$ Of the 182 listed firms, infrequent trading in the form of no trading days or extremely thin trading is prevalent. Frequently, we observe only one single trade on a trading day for these thin issues, which makes the distinction between daily opening and closing prices or distinction between daily high and low prices meaningless. These single-trade day are usually followed by a few no-trading days, which also makes interday close-to-close returns and open-to-open returns difficult to estimate. Therefore, we have imposed the following exclusionary

[^3]Table 1
Characteristics of Indonesian stocks: Table 1 presents summary statistics of 85 stocks in the sample. Cross-sectional averages of market capitalization, share price level, the number of daily transactions, the number of shares traded, and market liquidity are reported along with cross-sectional standard deviations in parentheses. To facilitate comparison, the 85 sample firms are divided into four subgroups based on daily trading value. At the individual firm level, market capitalization is measured by the mean of the beginning and ending value of common equity. Share price level is the average of daily closing prices. The number of daily transactions and shares traded are defined as the cumulative value of each of the two variables during the study period divided by 371 trading days. Market liquidity is measured by the ratio of daily trading value to open-to-close return variance as defined by ( $\ln P_{c}$ $\left.\ln P_{\mathrm{o}}\right)^{2}$, where $P_{\mathrm{o}}$ and $P_{\mathrm{c}}$ denote opening and closing prices. This ratio measures the market impact of volume shocks caused by large orders. Five relevant measures are calculated for each stock and then averaged across all stocks in the whole sample and the stocks within each trading value quartile. The study period is from September 1, 1992 to February 28, 1994

|  | Whole |
| :--- | :---: | :---: | :---: | :---: | :---: |
| sample |  |$\quad$| Subgroup sorted by trading value |  |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
|  |  | Lowest | 2 |  | 3 |
| Largest |  |  |  |  |  |
| Market capitalization | 314.38 | 40.94 | 99.02 | 211.47 | 916.37 |
| $\left(\mathrm{Rp} \times 10^{9}\right)$ | $(100.44)$ | $(63.39)$ | $(123.25)$ | $(209.30)$ | $(1,991.00)$ |
| Share price level (Rp) | $4,106.44$ | $2,616.24$ | $3,192.27$ | $4,948.52$ | $5,712.25$ |
|  | $(2,616.00)$ | $(965.73)$ | $(1,415.08)$ | $(2,812.81)$ | $(3,330.50)$ |
| Average number of daily | 11.10 | 3.65 | 9.64 | 14.09 | 17.09 |
| transactions | $(9.41)$ | $(1.49)$ | $(5.19)$ | $(10.02)$ | $(11.55)$ |
| Average number of shares | 81.51 | 12.47 | 50.37 | 82.87 | 181.83 |
| traded $\left(\times 10^{3}\right)$ | $(85.17)$ | $(6.63)$ | $(38.06)$ | $(50.46)$ | $(98.55)$ |
| Market liquidity $\left(\times 10^{12}\right)$ | 4.37 | 0.12 | 0.82 | 4.04 | 12.66 |
|  | $(7.57)$ | $(0.17)$ | $(1.22)$ | $(2.68)$ | $(11.25)$ |
| Number of stocks | 85 | 21 | 22 | 21 | 21 |

criteria. Newly listed firms in 1994 are excluded from the sample. Any stock with daily close-to-close returns with fewer than 60 observations during the study period are eliminated from the sample. Any stock with the average number of daily trades smaller than three are also excluded. These criteria are not mutually exclusive. A total of 85 firms has survived the exclusionary criteria. In addition, daily returns greater (less) than $+30 \%(-30 \%)$ are treated as missing after stock prices are adjusted for right offerings, stock dividends, and stock splits.

### 3.2. Characteristics of Indonesian stocks

Table 1 presents summary statistics of 85 stocks in the sample. Cross-sectional averages of market capitalization, share price level, the number of daily transactions, the number of shares traded, and market liquidity are reported along with cross-sectional standard deviations in parentheses. To facilitate comparison, the 85
sample firms are divided into four subgroups based on daily trading value. At the individual firm level, market capitalization is measured by the mean of the beginning and ending value of common equity. Share price level is the average of daily closing prices. The number of daily transactions and shares traded are defined as the cumulative value of each of the two variables during the study period divided by 371 trading days. Market liquidity is measured by the ratio of daily trading value to open-to-close return variance as defined by $\left(\ln P_{\mathrm{c}}-\ln P_{\mathrm{o}}\right)^{2}$, where $P_{\mathrm{o}}$ and $P_{\mathrm{c}}$ denote opening and closing prices. This ratio measures the market impact of volume shocks caused by large orders. A low ratio indicates that a single large order may adversely affect price, while a high ratio indicates that volume shocks can be accommodated with a small price movement (Naidu and Rozeff, 1994; Rhee et al., 1994). Five relevant measures are calculated for each stock and then averaged across all stocks in the whole sample and within each trading value quartile.

Average market capitalization of Indonesian stocks is Rp 314.38 billion (or US\$ 149 million). Trading value and market capitalization show a positive relationship as expected. Significant differences in market capitalization are observed among four subgroups classified by trading value. For example, firms in the largest trading value quartile have a market capitalization 20 times greater than firms in the lowest quartile.

The average share price for the whole sample is $\mathrm{Rp} 4,106$. Share price level rises monotonically with trading value. The average number of daily transactions ranges from 3.65 for stocks in the lowest trading value quartile to 17.09 for stocks in the largest quartile, whereas the average for the whole sample is 11.10 . The average number of shares traded daily ranges from 12,470 shares estimated for stocks in the lower trading value quartile to 181,830 shares for stocks in the largest quartile. Market liquidity ratios show a drastic contrast between the most actively traded stocks and the least actively traded stocks. The liquidity ratio measured for stocks in the largest quartile is more than 100 times greater than the ratio measured for stocks in the lowest quartile.

### 3.3. Intraday trading pattern

Table 2 summarizes the average proportions of total daily trading value (volume) accounted for by the opening and closing trades and "throughput'' value (volume) which is the daily trading value (volume) net of opening and closing trading value (volume). Opening trading value as a percentage of daily trading value is $15.93 \%$ for the whole sample. This percentage is higher than the 1986 NYSE average of $10.59 \%$ reported by Stoll and Whaley (1990) and is similar to the $15-19 \%$ estimated by Lehman and Modest (1994) for Japanese stocks. The relative trading value at the market close is approximately one-half of the morning opening value. Throughput value accounts for about three-quarters of the total daily trading value for the whole sample. Stocks in the lowest trading value

Table 2
Trading value (volume) at market open and close as a proportion of daily value (volume): Table 2 summarizes the average proportions of total daily trading value (volume) accounted for by the opening and closing trades and "throughput" value (volume) which is the daily trading value (volume) net of opening and closing trading value (volume). Trading volume data reported in Panel B is based on the number of shares traded

|  | Whole sample | Subgroup sorted by trading value |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Lowest | 2 | 3 | Largest |
| A. Trading value |  |  |  |  |  |
| 1. At the market open (\%) | 15.93 | 30.02 | 13.57 | 15.81 | 15.84 |
| 2. At the market close (\%) | 7.47 | 12.74 | 8.26 | 6.58 | 7.48 |
| 3. Throughput value (\%) | 76.60 | 57.24 | 78.17 | 77.61 | 76.68 |
| 4. Average daily value ( $\mathrm{Rp} \times 10^{6}$ ) | 346.81 | 33.57 | 146.09 | 332.68 | 884.47 |
| B. Trading volume |  |  |  |  |  |
| 1. At the market open (\%) | 13.84 | 31.53 | 12.33 | 10.22 | 14.72 |
| 2. At the market close (\%) | 6.56 | 12.27 | 1.99 | 5.21 | 6.57 |
| 3. Throughput volume (\%) | 79.60 | 56.30 | 80.33 | 84.58 | 78.71 |
| 4. Average daily number of shares trades $\left(\times 10^{3}\right)$ | 81.51 | 12.47 | 50.37 | 82.87 | 181.83 |

quartile show a dissimilar trading pattern from the remaining three quartiles. The relative trading value at the market open estimated for the stocks in the lowest quartile amounts to $30.02 \%$ which is more than twice the other quartiles. The relative trading value at the market close is also greater for the lowest quartile stocks than for the other. As a result, throughput value is the smallest for the least active stocks.

An analysis of the intraday trading pattern based on the number of shares traded draw a similar picture. As reported in Panel B of Table 2, trading volume at the market open and close represent $13.84 \%$ and $6.56 \%$, respectively, leaving throughput volume at $79.60 \%$ for the whole sample. For stocks in the two middle quartiles, the proportion of closing volume is much smaller than the proportion measured using trading value.

## 4. Intraday price volatility

### 4.1. Price reversals, price continuations, and variance ratios

Since an open-to-open return $\left(r_{\mathrm{o}, t}\right)$ is a sum of an overnight nontrading period return ( $r_{\mathrm{n}, t}$ ) and a trading period return during the preceding day ( $r_{\mathrm{d}, t-1}$ ), we have $r_{\mathrm{o}, t}=r_{\mathrm{n}, t}+r_{\mathrm{d}, t-1}$. Similarly, a close-to-close return $\left(r_{\mathrm{c}, t}\right)$ is a sum of an overnight return $\left(r_{\mathrm{n}, t}\right)$ and a return on the following day ( $r_{\mathrm{d}, t}$ ), thus $r_{\mathrm{c}, t}=r_{\mathrm{n}, t}+r_{\mathrm{d}, t}$. The
variance ratio of open-to-open return volatility to close-to-close return volatility is expressed as:

$$
\begin{equation*}
\frac{\sigma^{2}\left(r_{\mathrm{o}, t}\right)}{\sigma^{2}\left(r_{\mathrm{c}, t}\right)}=\frac{\sigma^{2}\left(r_{\mathrm{d}, t-1}\right)+\sigma^{2}\left(r_{\mathrm{n}, t}\right)+2 \operatorname{Cov}\left(r_{\mathrm{d}, t-1}, r_{\mathrm{n}, t}\right)}{\sigma^{2}\left(r_{\mathrm{d}, t}\right)+\sigma^{2}\left(r_{\mathrm{n}, t}\right)+2 \operatorname{Cov}\left(r_{\mathrm{d}, t}, r_{\mathrm{n}, t}\right)} \tag{1}
\end{equation*}
$$

Since $\sigma^{2}\left(r_{\mathrm{d}, t}\right)$ and $\sigma^{2}\left(r_{\mathrm{d}, \mathrm{t}-1}\right)$ would be equal over a long time-period, the variance ratio is determined by the two covariance terms in the numerator and denominator. $\operatorname{Cov}\left(r_{\mathrm{d}, t-1}, r_{\mathrm{n}, t}\right)$ in the numerator is the serial covariance between returns straddling the close of trade, while $\operatorname{Cov}\left(r_{\mathrm{n}, t}, r_{\mathrm{d}, t}\right)$ in the denominator is the serial covariance between returns straddling the opening of trade. At the market open and close, two opposing forces affect the sign and magnitude of these serial covariances: price continuations and price reversals. Price continuations are shown by positive correlations between the two neighboring return series, while price reversals are indicated by negative correlations.

Empirical evidence based on NYSE-listed stocks suggests that: first, $\rho\left(r_{\mathrm{d}, t-1}\right.$, $r_{\mathrm{n}, t}$ ) in the numerator is negative for low-volume stocks and positive for highvolume stocks; and second, $\rho\left(r_{\mathrm{n}, t}, r_{\mathrm{d}, t}\right)$ is negative for both low- and high-volume stocks, with negative correlations more pronounced for low-volume stocks (Stoll and Whaley, 1990). These results imply that: (i) at the market close, price continuations tend to dominate price reversals for high-volume stocks, while the opposite is true for low-volume stocks; (ii) at the market open, price reversals tend to dominate price continuations for both low- and high-volume stocks, but price reversals are more pronounced for low-volume stocks; and (iii) as a result, variance ratios are greater than one for NYSE-listed stocks since $\rho\left(r_{\mathrm{d}, t-1}, r_{\mathrm{n}, t}\right)$ tends to be greater than $\rho\left(r_{\mathrm{n}, t}, r_{\mathrm{d}, t}\right)$. Empirical evidence based on Japanese stocks, however, shows different characteristics. First, only extreme high-volume stocks show positive $\rho\left(r_{\mathrm{d}, t-1}, r_{\mathrm{n}, t}\right)$, while the majority of TSE-listed stocks tend to have negative covariance terms. Second, the estimates of $\rho\left(r_{\mathrm{n}, t}, r_{\mathrm{d}, t}\right)$ do not decline monotonically from high- to low-volume stocks unlike U.S. stocks. Instead, negative correlations are less pronounced for the most and least actively traded stocks than the stocks in the middle categories of trading activity. Third, average variance ratios are not different from one with the exception of extremely active stocks.

Table 3 presents correlations between returns over neighboring intervals and variance ratios for Indonesian stocks. Correlations are calculated for each stock for the entire study period and are then averaged across all stocks in the whole sample and stocks within each rupiah trading value quartile. Variance ratios are also computed for each stock using its open-to-open and close-to-close return variances for the entire study period and then averaged cross-sectionally. Estimates of $\rho\left(r_{\mathrm{d}, t-1}, r_{\mathrm{n}, t}\right)$ for the whole sample and all quartiles are negative, implying that price reversals are dominant over price continuations at the market close. In contrast, high-volume U.S. and Japanese stocks have positive correlations between

Table 3
Correlations between intraday returns and ratios of open-to-open return variance to close-to-close return variance: Table 3 presents correlations between overnight returns and following daytime returns and between overnight returns and preceding daytime returns and the ratios of open-to-open return variance to close-to-close return variance. Correlations are calculated for each stock for the entire study period and are then averaged across all stocks in the whole sample and within each rupiah trading value quartile. Variance ratios are also computed for each stock using its open-to-open and close-to-close return variances for the entire study period and then averaged cross-sectionally.

|  | Whole sample | Subgroup sorted by trading value |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Lowest | 2 | 3 | Largest |
| A. $\rho\left(r_{\mathrm{d}, t-1}, r_{\mathrm{n}, t}\right)$ |  |  |  |  |  |
| Mean | -0.0422 | -0.0821 | -0.0317 | -0.0378 | -0.0179 |
| Standard deviation | 0.1403 | 0.1677 | 0.1257 | 9.1113 | 0.1520 |
| Median | -0.0223 | -0.0810 | -0.0017 | -0.0483 | -0.0157 |
| Number < 0 | 58.82\% | 66.67\% | 54.44\% | 57.14\% | 57.14\% |
| B. $\rho\left(r_{\mathrm{n}, t}, r_{\mathrm{d}, t}\right)$ |  |  |  |  |  |
| Mean | -0.0920 | -0.0348 | -0.1550 | -0.0853 | -0.0897 |
| Standard deviation | 0.1494 | 0.1927 | 0.1171 | 0.1265 | 0.1353 |
| Median | -0.1041 | -0.0704 | -0.1735 | -0.0536 | -0.1041 |
| Number < 0 | 70.59\% | 57.14\% | 86.36\% | 66.67\% | 71.43\% |
| C. Ratio of open-to-open return variance to close-to-close return variance |  |  |  |  |  |
| Mean | 1.1083 | 1.0321 | 1.1722 | 1.0741 | 1.1578 |
| Standard deviation | 0.1987 | 0.2185 | 0.2175 | 0.1657 | 0.1653 |
| Median | 1.0937 | 0.9986 | 1.1738 | 1.0766 | 1.1255 |
| Minimum | 0.5931 | 0.6909 | 0.5931 | 0.8169 | 0.8670 |
| Maximum | 1.6078 | 1.5728 | 1.5286 | 1.4285 | 1.6078 |

the daytime and the following overnight returns, indicating stronger influence of price continuations over price reversals at the close of trade.

Estimates of $\rho\left(r_{\mathrm{n}, t}, r_{\mathrm{d}, t}\right)$ are also all negative for the whole sample and all quartiles. With the exception of stocks in the lowest trading value quartile, the estimates of $\rho\left(r_{\mathrm{n}, t}, r_{\mathrm{d}, t}\right)$ are more negative than the estimates of $\rho\left(r_{\mathrm{d}, t-1}, r_{\mathrm{n}, t}\right)$, which implies that price reversals at the market open are more pronounced than at the market close. It is not obvious why stocks in the lowest quartile show more price reversals at the market close than at the market open. Also, no clear pattern emerges in the relationship between estimates of $\rho\left(r_{\mathrm{n}, t}, r_{\mathrm{d}, t}\right)$ and trading volume.

Variance ratios are reported in Panel C. On average, open-to-open return variance is $10.83 \%$ greater than close-to-close return variance for the whole sample. This is comparable with $13.29 \%$ computed for NYSE-listed stocks by Stoll and Whaley (1990), but less than $35.54 \%$ computed for Malaysian stocks by Chang et al. (1994). Variance ratios are consistently greater than one across all four trading value subgroups. This is not surprising considering that $\rho\left(r_{\mathrm{d}, t-1}\right.$, $\left.r_{\mathrm{n}, \mathrm{t}}\right)>\rho\left(r_{\mathrm{n}, \mathrm{t}}, r_{\mathrm{d}, \mathrm{t}}\right) .{ }^{10}$ Unlike U.S. and Japanese stocks whose variance ratios
increase with trading volume, no systematic pattern is observed from JSX-listed stocks. While George and Hwang (1994) report that variance ratios are greater than one only for the most actively traded stocks in Tokyo, the highest variance ratio of 1.1722 is found from stocks in the second quartile for Indonesian stocks. Since the JSX does not employ different trading methods at the market open and at the market close, greater volatility observed at the market open can not be attributed to the trading method. Additionally, since trade at the JSX does not rely on market-makers, greater volatility at the market open can not be attributed to monopoly power of specialists. As a result, the explanation offered by Amihud and Mendelson (1991) appears to gain support: the preceding nontrading period causes the greater volatility at the market open.

### 4.2. Return volatility over trading and nontrading periods

It is well-documented that the variance of daytime open-to-close returns is far greater than the variance of overnight close-to-open returns (French and Roll, 1986). Table 4 summarizes variance ratios of daytime returns to overnight returns for Indonesian stocks. The ratio is computed for each stock for the entire period and then averaged across all stocks in the sample and within rupiah trading value-based categories. The cross-sectional average ratio is 1.6671 , which is substantially smaller than the comparable measure of 5.3968 for NYSE-listed stocks. Even after adjusting for the number of trading hours per day, the average per-hour ratio for Indonesian stocks is 5.60 as opposed to the ratio of 16.20 for U.S. stocks.

One possible explanation for these low ratios can be attributed to the relationship between variance ratios and trading volume: the variance ratio increases with trading volume. Therefore, it is not surprising that low variance ratios are observed for a thin market such as the JSX. A similar range of variance ratios is observed for KLSE-listed issues which include a large proportion of thinly traded stocks (Chang et al., 1994). Panel B of Table 4 presents cross-sectional averages of open-to-close and close-to-open variances. One interesting finding is the large overnight return variance for the stocks in the lowest trading value quartile, which is even greater than its daytime return variance. This implies that thinly traded issues are subject to price reversals even during the nontrading period. Typically, thinly traded issues open after the open of active issues. At the market close, thinly traded issues stop trading far before actual market closing. Naturally, there tends

[^4]Table 4
Ratios of daytime return variance to overnight return variance and the magnitude of daytime return and overnight return variances: Table 4 summarizes the ratios of daytime return variance to overnight return variance. The ratio is computed for each stock for the entire period and then averaged across all stocks in the whole sample and within rupiah trading value-based categories. In Panels B and C, the actual magnitude of daytime return and overnight return variances are reported

to be more price fluctuations between the close and the open of trade for small-sized and thinly-traded issues, causing greater overnight volatility.

### 4.3. Transaction volume and price reversals

As presented in Table 3, serial dependence between neighboring intraday returns are all negative, indicating a stronger influence of price reversals than price continuations for Indonesian stocks. Price reversals are usually considered a form of compensation for market-makers who are required to buy and sell against the market. Without price reversals, market-makers would consistently lose after they take positions. Under the continuous auction market system where no marketmakers exist, this explanation for price reversals does not hold. Therefore, we examine whether the reversals observed for Indonesian stocks are related to trading volume and compare this evidence with U.S. results. To facilitate the comparison between the U.S. and Indonesian markets, pooled regression models
of time-series and cross-sectional variables developed by Stoll and Whaley (1990) are used with slight modifications: ${ }^{11}$

$$
\begin{align*}
r_{\mathrm{d}, t}= & a_{0}+a_{1} r_{\mathrm{n}, t}+a_{2}\left(r_{\mathrm{n}, t} D_{1, t}\right)+a_{3}\left(r_{\mathrm{n}, t} D_{2, t}\right)+a_{4}\left(r_{\mathrm{n}, t} D_{3, t}\right) \\
& +a_{5}\left(r_{\mathrm{n}, t} D_{4, t}\right)+a_{6}\left(r_{\mathrm{n}, t} v_{\mathrm{c}, t-1}\right)+a_{7}\left(r_{\mathrm{n}, t} v_{0, t}\right)+a_{8}\left(r_{\mathrm{n}, t} v_{\mathrm{c}, t}\right) \\
& +a_{9}\left(r_{\mathrm{n}, t} v_{\mathrm{p}, t}\right)+a_{10}\left(r_{\mathrm{n}, t} d_{t}\right)+u_{t} \tag{2}
\end{align*}
$$

where the first-order serial dependence between the overnight returns and the following daytime returns is measured by $a_{1} . D_{1}=1$ if Monday and 0 otherwise, $D_{2}=1$ if Tuesday and 0 otherwise, $D_{3}=1$ if Thursday and 0 otherwise, and $D_{4}=1$ if Friday and 0 otherwise. Three standardized volume measures are introduced: standardized trading value at the market close, $v_{\mathrm{c}}$; at the market open, $v_{0}$; and standardized throughput value between the open and the close, $v_{\mathrm{p}}$. Since the JSX daily trades are not time-stamped, it is not possible to determine time lapse between the market open and the first transaction. Thus, the standardized number of daily trades, $d_{t}$, is used as a proxy for time lapse under the assumption that the smaller the number of trades, the longer the delay. Each observation for a stock is standardized by subtracting the mean and dividing by the estimated standard deviation.

Table 5 presents the regression results. Consistent with estimates of serial correlations reported in Table 3, coefficient $a_{1}$ is significantly negative for the whole sample. However, only the stocks in the low-volume quartiles have significant coefficients, while high-volume stocks do not have significant coefficients after controlling for the volume effects. The results are similar to the U.S. experience in that the absolute magnitude of the coefficients decreases as trading volume increases, but dissimilar to the U.S. results in that the coefficient $a_{1}$ is consistently significant in all volume categories for U.S. stocks. The U.S. evidence is interpreted as an indication that market-makers are compensated for providing market immediacy at the market open. The Indonesian evidence may be interpreted as an indication of the continuous auction method at work without market-makers.

Of the four volume variables introduced, only the volume at the market open on day $t$ and at the market close on day $t-1$ show a statistically significant impact on serial dependence between $r_{\mathrm{d}, t}$ and $r_{\mathrm{n}, t}$. The coefficient $a_{7}$ is significantly

[^5]Combining two equations produces Eq. (2).

Table 5
Serial dependence between the overnight returns and the following daytime returns and price reversals and continuations: To examine whether the serial dependence between the overnight returns and the following daytime returns are related to trading volume and delayed openings, the following pooled regression model of time-series and cross-sectional variables developed by Stoll and Whaley (1990) are used with slight modifications:
$r_{\mathrm{d}, t}=a_{0}+a_{1} r_{\mathrm{n}, t}+a_{2}\left(r_{\mathrm{n}, t} D_{1, t}\right)+a_{3}\left(r_{\mathrm{n}, t} D_{2, t}\right)+a_{4}\left(r_{\mathrm{n}, t} D_{3, t}\right)+a_{5}\left(r_{\mathrm{n}, t} D_{4, t}\right)+a_{6}\left(r_{\mathrm{n}, t} v_{\mathrm{c}, t-1}\right)$
$+a_{7}\left(r_{\mathrm{n}, t} v_{\mathrm{o}, t}\right)+a_{8}\left(r_{\mathrm{n}, t} v_{\mathrm{c}, t}\right)+a_{9}\left(r_{\mathrm{n}, t} v_{\mathrm{p}, t}\right)+a_{10}\left(r_{\mathrm{n}, t} d_{t}\right)+u_{t}$,
where the first-order serial dependence between overnight returns ( $r_{\mathrm{n}, t}$ ) and following daytime returns $\left(r_{\mathrm{d}, t}\right)$ is measured by $a_{1}, D_{1}=1$ if Monday and 0 otherwise, $D_{2}=1$ if Tuesday and 0 otherwise, $D_{3}=1$ if Thursday and 0 otherwise, and $D_{4}=1$ if Friday and 0 otherwise. Three standardized volume measures are introduced: standardized trading value at the market close, $v_{c}$; at the market open, $v_{0}$; and standardized throughput value between the open and the close, $v_{\mathrm{p}}$. The standardized number of daily trades, $d_{t}$, is used as a proxy for the time lapse under the assumption that the smaller the number of trades, the longer the delay. Each observation for a stock is standardized by subtracting the mean and dividing by standard deviation estimated. $t$-values are shown in parentheses. Statistical significance is denoted by: ${ }^{* *}$ at the 0.01 level, ${ }^{*}$ at the 0.05 level, and ${ }^{+}$at the 0.10 level

|  | Whole sample | Subgroup sorted by trading value |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Lowest | 2 | 3 | Largest |
| $a_{0}$ | $\begin{gathered} 0.3744 \\ (18.68)^{* *} \end{gathered}$ | $\begin{gathered} 0.5101 \\ (8.40)^{*} \end{gathered}$ | $\begin{gathered} 0.3395 \\ (8.02)^{* *} \end{gathered}$ | $\begin{gathered} 0.3171 \\ (9.67)^{* *} \end{gathered}$ | $\begin{gathered} 0.3845 \\ (11.31)^{* *} \end{gathered}$ |
| $a_{1}$ | $\begin{gathered} -0.1147 \\ (-5.48)^{* *} \end{gathered}$ | $\begin{gathered} -0.1472 \\ (-3.57)^{* *} \end{gathered}$ | $\begin{gathered} -0.1319 \\ (-3.10)^{* *} \end{gathered}$ | $\begin{aligned} & -0.0699 \\ & (-1.55) \end{aligned}$ | $\begin{aligned} & -0.0610 \\ & (-1.31) \end{aligned}$ |
| $a_{2}$ | $\begin{aligned} & -0.0134 \\ & (-0.46) \end{aligned}$ | $\begin{aligned} & 0.0947 \\ & (1.59) \end{aligned}$ | $\begin{aligned} & 0.0379 \\ & (0.63) \end{aligned}$ | $\begin{aligned} & 0.0198 \\ & (0.34) \end{aligned}$ | $\begin{gathered} -0.3384 \\ (-5.17)^{* *} \end{gathered}$ |
| $a_{3}$ | $\begin{aligned} & -0.0162 \\ & (-0.55) \end{aligned}$ | $\begin{gathered} 0.1349 \\ (2.26)^{*} \end{gathered}$ | $\begin{aligned} & -0.0606 \\ & (-1.03) \end{aligned}$ | $\begin{gathered} -0.2120 \\ (-3.45)^{* *} \end{gathered}$ | $\begin{aligned} & 0.0622 \\ & (0.95) \end{aligned}$ |
| $a_{4}$ | $\begin{gathered} -0.0514 \\ (-1.76)^{+} \end{gathered}$ | $\begin{aligned} & 0.0658 \\ & (1.13) \end{aligned}$ | $\begin{gathered} -0.1792 \\ (-3.10)^{* *} \end{gathered}$ | $\begin{aligned} & -0.0356 \\ & (-0.57) \end{aligned}$ | $\begin{aligned} & -0.0135 \\ & (-0.20) \end{aligned}$ |
| $a_{5}$ | $\begin{array}{r} -0.0615 \\ (-2.06)^{*} \end{array}$ | $\begin{aligned} & 0.0915 \\ & (1.43) \end{aligned}$ | $\begin{aligned} & -0.0020 \\ & (-0.04) \end{aligned}$ | $\begin{gathered} -0.1731 \\ (-2.81)^{* *} \end{gathered}$ | $\begin{gathered} -0.3155 \\ (-4.88)^{* *} \end{gathered}$ |
| $a_{6}$ | $\begin{aligned} & 0.0056 \\ & (0.62) \end{aligned}$ | $\begin{gathered} -0.0578 \\ (-3.57)^{* *} \end{gathered}$ | $\begin{gathered} 0.0835 \\ (4.60)^{* *} \end{gathered}$ | $\begin{gathered} 0.0558 \\ (2.77)^{*} \end{gathered}$ | $\begin{gathered} -0.0552 \\ (-2.16)^{*} \end{gathered}$ |
| $a_{7}$ | $\begin{gathered} 0.0357 \\ (3.16)^{*} \end{gathered}$ | $\begin{gathered} 0.0666 \\ (2.27)^{*} \end{gathered}$ | $\begin{gathered} -0.0465 \\ (-1.92)^{*} \end{gathered}$ | $\begin{gathered} 0.0567 \\ (2.76)^{*} \end{gathered}$ | $\begin{gathered} 0.0767 \\ (3.88)^{*} \end{gathered}$ |
| $a_{8}$ | $\begin{aligned} & 0.0077 \\ & (0.75) \end{aligned}$ | $\begin{aligned} & 0.0059 \\ & (0.36) \end{aligned}$ | $\begin{aligned} & -0.0260 \\ & (-0.97) \end{aligned}$ | $\begin{aligned} & 0.0377 \\ & (1.52) \end{aligned}$ | $\begin{aligned} & 0.0156 \\ & (0.57) \end{aligned}$ |
| $a_{9}$ | $\begin{aligned} & -0.0037 \\ & (-0.89) \end{aligned}$ | $\begin{aligned} & -0.0408 \\ & (-0.60) \end{aligned}$ | $\begin{gathered} 0.1935 \\ (4.17)^{*} \end{gathered}$ | $\begin{gathered} -0.0783 \\ (-2.47)^{* *} \end{gathered}$ | $\begin{aligned} & -0.0422 \\ & (-1.25) \end{aligned}$ |
| $a_{10}$ | $\begin{gathered} -0.0427 \\ (-2.32) \end{gathered}$ | $\begin{aligned} & 0.0135 \\ & (0.26) \end{aligned}$ | $\begin{gathered} -0.1609 \\ (-3.75)^{* *} \end{gathered}$ | $\begin{aligned} & -0.0216 \\ & (-0.65) \end{aligned}$ | $\begin{aligned} & -0.0010 \\ & (-0.03) \end{aligned}$ |
| $R^{2}$ | 0.0158 | 0.0162 | 0.0383 | 0.0295 | 0.0320 |
| $F$ | 26.64 ** | $4.16{ }^{* *}$ | 16.68 ** | 14.69 ** | $16.42{ }^{* *}$ |
| \# | 16,555 | 2,537 | 4,202 | 4,841 | 4,972 |

positive in all volume categories (except the second quartile), while $a_{6}$ is significant only in the regressions for the four subgroups. A positive coefficient may imply both price continuations and price reversals depending upon the
magnitude of trading volume. If the opening volume is above average (i.e., standardized opening volume is positive) and the overnight return is positive (negative), then the subsequent daytime return will also be positive (negative), implying price continuations. On the other hand, if the opening volume is below average and the overnight return is positive (negative), then the subsequent daytime return will be negative (positive), implying price reversals. For Indonesian stocks, price continuations should be observed at the market open during a period of successive above-average volume, whereas price reversals should be common during a period of successive below-average volume. This result is also observed for U.S. stocks (Stoll and Whaley, 1990).

The coefficient $a_{6}$ is negative for stocks in the lowest and largest trading value quartiles, while it is positive for stocks in the middle quartiles. This negative coefficient implies that price reversals dominate at the market close on aboveaverage volume days and price continuations dominate on below-average volume days for stocks in the lowest and largest trading value quartiles. This result is unusual. In a market where market-makers are active, low-volume days or thinly traded stocks tend to experience more price reversals. At the JSX, no market-makers exist. With above-average volume, both thinly traded and heavily traded stocks experience price reversals at the market open. There appears to be an interesting phenomenon at work. ${ }^{12}$

Surprisingly, the coefficient $a_{10}$ is negative for the whole sample. This negative coefficient implies that delayed openings do not accentuate price reversals. Rather, they induce price continuations. Also, the day-of-the-week effect is not consistently significant. Only Friday seems to reinforce price reversals by causing $a_{1}$ to be more negative.

The results reported in Table 6 examine the serial dependence between overnight returns and the preceding day's returns using the following model:

$$
\begin{align*}
r_{\mathrm{n}, t}= & a_{0}+a_{1} r_{\mathrm{d}, t-1}+a_{2}\left(r_{\mathrm{d}, t-1} D_{1, t}\right)+a_{3}\left(r_{\mathrm{d}, t-1} D_{2, t}\right)+a_{4}\left(r_{\mathrm{d}, t-1} D_{3, t}\right) \\
& +a_{5}\left(r_{\mathrm{d}, t-1} D_{4, t}\right)+a_{6}\left(r_{\mathrm{d}, t-1} v_{\mathrm{o}, t-1}\right)+a_{7}\left(r_{\mathrm{d}, t-1} v_{\mathrm{c}, t-1}\right) \\
& +a_{8}\left(r_{\mathrm{d}, t-1} v_{0, t}\right)+a_{9}\left(r_{\mathrm{d}, t-1} v_{\mathrm{p}, t-1}\right)+a_{10}\left(r_{\mathrm{d}, t-1} d_{t-1}\right) \\
& +a_{11}\left(r_{\mathrm{d}, t-1} d_{t}\right)+u_{t} . \tag{3}
\end{align*}
$$

Consistent with correlation estimates reported in Table 3, the coefficient $a_{1}$ is negative for the whole sample, indicating strong price reversals at the market close. For trading value-based subgroups, this coefficient is not consistently significant even though its sign is negative. U.S. stocks, however, show a different pattern. High-volume stocks tend to have a positive $a_{1}$, whereas low-volume stocks tend to have a negative $a_{1}$. This indicates that market-makers may have

[^6]Table 6
Serial dependence between the overnight returns and the preceding daytime returns and price reversals and continuations: To examine whether the serial dependence between overnight returns and preceding daytime returns are related to trading volume and delayed openings, the following pooled regression model of time-series and cross-sectional variables developed by Stoll and Whaley (1990) are used with slight modifications:

$$
\begin{aligned}
r_{\mathrm{n}, t}= & a_{0}+a_{1} r_{\mathrm{d}, t-1}+a_{2}\left(r_{\mathrm{d}, t-1} D_{1, t}\right)+a_{3}\left(r_{\mathrm{d}, t-1} D_{2, t}\right)+a_{4}\left(r_{\mathrm{d}, t-1} D_{3, t}\right)+a_{5}\left(r_{\mathrm{d}, t-1} D_{4, t}\right) \\
& +a_{6}\left(\mathrm{r}_{d, t-1} v_{\mathrm{o}, t-1}\right)+a_{7}\left(r_{\mathrm{d}, t-1} v_{\mathrm{c}, t-1}\right)+a_{8}\left(r_{\mathrm{d}, t-1} v_{\mathrm{o}, t}\right)+a_{9}\left(r_{\mathrm{d}, t-1} v_{\mathrm{p}, t-1}\right) \\
& +a_{10}\left(r_{\mathrm{d}, t-1} d_{t-1}\right)+a_{11}\left(r_{\mathrm{d}, t-1} d_{t}\right)+u_{t},
\end{aligned}
$$

where the first-order serial dependence between the overnight returns ( $r_{\mathrm{n}, \mathrm{t}}$ ) and the following daytime returns ( $r_{\mathrm{d}, t-1}$ ) is measured by $a_{1} . D_{1}=1$ if Monday and 0 otherwise, $D_{2}=1$ if Tuesday and 0 otherwise, $D_{3}=1$ if Thursday and 0 otherwise, and $D_{4}=1$ if Friday and 0 otherwise. Four standardized volume measures are introduced: standardized trading value at the market open on day $t-1, v_{0, t-1}$; at the market open on day $t-1, v_{\mathrm{c}, t-1}$; and standardized trading value at the market open on day $t, v_{0, i}$; standardized throughput value between the open and the close on day $t, v_{\mathrm{p}, t-1}$. The standardized number of daily trades, $d_{t}$, is used as a proxy for the time lapse under the assumption that the smaller the number of trades, the longer the delay. Each observation for a stock is standardized by subtracting the mean and dividing by standard deviation estimated. $t$-values are shown in parentheses. Statistical significance is denoted by: ** at the 0.01 level, * at the 0.05 level, and ${ }^{+}$at the 0.10 level

|  | Whole sample | Subgroup sorted by trading value |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Lowest | 2 | 3 | Largest |
| $a_{0}$ | $\begin{aligned} & 0.0028 \\ & (0.15) \end{aligned}$ | $\begin{gathered} 0.1962 \\ (2.38)^{*} \end{gathered}$ | $\begin{gathered} 0.0948 \\ (2.24)^{*} \end{gathered}$ | $\begin{aligned} & -0.0224 \\ & (-0.81) \end{aligned}$ | $\begin{gathered} -0.1029 \\ (-4.10)^{* *} \end{gathered}$ |
| $a_{1}$ | $\begin{gathered} -0.0351 \\ (-2.28)^{*} \end{gathered}$ | $\begin{aligned} & -0.0246 \\ & (-0.42) \end{aligned}$ | $\begin{gathered} -0.0584 \\ (-1.80)^{+} \end{gathered}$ | $\begin{aligned} & -0.0048 \\ & (-0.19) \end{aligned}$ | $\begin{gathered} -0.0494 \\ (-2.09)^{*} \end{gathered}$ |
| $a_{2}$ | $\begin{aligned} & 0.0033 \\ & (0.15) \end{aligned}$ | $\begin{aligned} & -0.0184 \\ & (-0.24) \end{aligned}$ | $\begin{aligned} & 0.0713 \\ & (1.43) \end{aligned}$ | $\begin{aligned} & -0.0601 \\ & (-1.61) \end{aligned}$ | $\begin{aligned} & 0.0140 \\ & (0.42) \end{aligned}$ |
| $a_{3}$ | $\underbrace{(-1.78)^{+}}_{(-0.0396}$ | $\begin{aligned} & -0.0919 \\ & (-0.99) \end{aligned}$ | $\begin{aligned} & -0.0579 \\ & (-1.23) \end{aligned}$ | $\begin{gathered} -0.0758 \\ (-2.06)^{*} \end{gathered}$ | $\begin{aligned} & 0.0348 \\ & (1.06) \end{aligned}$ |
| $a_{4}$ | $\begin{aligned} & -0.0237 \\ & (-1.08) \end{aligned}$ | $\begin{aligned} & -0.0707 \\ & (-0.84) \end{aligned}$ | $\begin{aligned} & 0.0225 \\ & (0.47) \end{aligned}$ | $\begin{gathered} -0.0677 \\ (-1.86)^{+} \end{gathered}$ | $\begin{aligned} & -0.0128 \\ & (-0.40) \end{aligned}$ |
| $a_{5}$ | $\begin{gathered} -0.0572 \\ (-2.53)^{*} \end{gathered}$ | $\begin{aligned} & -0.1517 \\ & (-1.53) \end{aligned}$ | $\begin{aligned} & -0.0587 \\ & (-1.20) \end{aligned}$ | $\begin{gathered} -0.0719 \\ (-1.91)^{+} \end{gathered}$ | $\begin{aligned} & -0.0159 \\ & (-0.49) \end{aligned}$ |
| $a_{6}$ | $\begin{aligned} & 0.0085 \\ & (1.14) \end{aligned}$ | $\begin{aligned} & 0.0417 \\ & (1.26) \end{aligned}$ | $\begin{aligned} & 0.0220 \\ & (1.36) \end{aligned}$ | $\begin{aligned} & -0.0015 \\ & (-0.12) \end{aligned}$ | $\begin{aligned} & -0.0025 \\ & (-0.23) \end{aligned}$ |
| $a_{7}$ | $\begin{gathered} 0.0128 \\ (1.66)^{+} \end{gathered}$ | $\begin{aligned} & 0.0146 \\ & (0.54) \end{aligned}$ | $\begin{aligned} & 0.0234 \\ & (1.13) \end{aligned}$ | $\begin{gathered} 0.0238 \\ (1.68)^{+} \end{gathered}$ | $\begin{aligned} & -0.0018 \\ & (-0.16) \end{aligned}$ |
| $a_{8}$ | $\begin{aligned} & -0.0093 \\ & (-1.20) \end{aligned}$ | $\begin{aligned} & 0.0083 \\ & (0.23) \end{aligned}$ | $\begin{aligned} & 0.0068 \\ & (0.43) \end{aligned}$ | $\begin{aligned} & -0.0009 \\ & (-0.07) \end{aligned}$ | $\begin{gathered} -0.0337 \\ (-2.88)^{* *} \end{gathered}$ |
| $a_{9}$ | $\begin{gathered} 0.0034 \\ (0.260) \end{gathered}$ | $\begin{aligned} & -0.0326 \\ & (-0.58) \end{aligned}$ | $\begin{aligned} & 0.0340 \\ & (1.10) \end{aligned}$ | $\begin{aligned} & -0.0019 \\ & (-0.09) \end{aligned}$ | $\begin{aligned} & 0.0102 \\ & (0.61) \end{aligned}$ |
| $a_{10}$ | $\begin{aligned} & 0.0083 \\ & (0.64) \end{aligned}$ | $\begin{aligned} & 0.0720 \\ & (1.41) \end{aligned}$ | $\begin{aligned} & -0.0272 \\ & (-0.83) \end{aligned}$ | $\begin{aligned} & 0.0052 \\ & (0.24) \end{aligned}$ | $\begin{aligned} & 0.0029 \\ & (0.16) \end{aligned}$ |
| $a_{11}$ | $\begin{gathered} 0.0197 \\ (3.72)^{*} \end{gathered}$ | $\begin{gathered} 0.0699 \\ (3.16)^{*} \end{gathered}$ | $\begin{aligned} & 0.0078 \\ & (0.61) \end{aligned}$ | $\begin{gathered} 0.0169 \\ (2.08)^{*} \end{gathered}$ | $\begin{gathered} 0.0154 \\ (1.83)^{+} \end{gathered}$ |
| $R^{2}$ | 0.0064 | 0.0155 | 0.0096 | 0.0073 | 0.0072 |
| $F$ | 7.73 ** | 1.96 * | 2.79 ** | 2.90 ** | 2.88 * |
| \# | 13,266 | 1,382 | 3,187 | 4,316 | 4,380 |

more discretion in establishing favorable prices for low-volume stocks, but not for high-volume stocks.

As indicated in Table 6, volume variables are relatively unimportant in explaining price reversals or price continuations at the market close. This result is very different from what is observed in the U.S. market where the volume variables have a significant effect on price reversals (continuations). Stoll and Whaley (1990) report that the coefficients of the volume variables are significantly negative for high-volume stocks, while they are positive for low-volume stocks. This implies that high-volume stocks show price continuations when trading volume is below average, whereas low-volume stocks show price continuations when trading volume is above average. In contrast, price reversals are more pronounced than price continuity for high-volume stocks when trading volume is above normal, and for low-volume stocks when trading volume is below normal. This evidence from the U.S. market is associated with the market-makers' price stabilization activities. The reason why Indonesian stocks do not exhibit any particular relationship between trading volume and price reversals (continuations) may be, in part, attributed to the lack of market-makers. Empirical evidence based on Japanese stocks show different results. George and Hwang (1994) report that trading volume induces strong price continuations and suggest that price continuations are caused by transaction-by-transaction price limit rules which are unique to the Japanese market. Since the volume effect on price reversals and price continuations differs between the Japanese and the Indonesian markets, the price-limits-based explanation for price continuity offered by George and Hwang can not be rejected.

Interestingly, the day-of-the-week effects are pronounced only for Friday for the whole sample, but not for four quartiles. The coefficients for the day-of-theweek effects are mostly negative although they are not all significant. Positive $a_{11}$ implies that delayed openings accentuate price reversals.

## 5. Conclusion

We have examined the structure of the JSX market at the market open and market close. Using transaction data which covers a period from September 1992 to February 1994, the first-order serial dependence between overnight returns and the following daytime returns, and between overnight returns and preceding daytime returns, is evaluated to gain insight into the intraday volatility behavior of Indonesian stocks.

The following major findings emerge from our examination. First, the combined trading value of opening and closing transactions at the JSX market account for $23 \%$ of total daily value. Trading value at the market open alone represents $16 \%$ of the total daily trading value, which is surprisingly large since the JSX does not use the call market method to determine opening prices unlike the TSE or the

NYSE. Second, average open-to-open return variance is $10.83 \%$ greater than close-to-close return variance, and variance ratios are consistently greater than one across all four subgroups of stocks sorted by trading value. The results are consistent with past evidence reported for U.S. stocks, but not with results based on Japanese stocks. Since the JSX does not use different trading methods at the market open and at the market close, greater volatility observed at the market open can not be attributed to the trading method. Additionally, since trade at the JSX does not rely on market-makers, greater volatility at the market open can not be attributed to the monopoly power of specialists. As a result, the explanation offered by Amihud and Mendelson (1991) appears to gain support: the preceding nontrading period causes the greater volatility at the market open.

Third, estimates of correlations between overnight returns and the following daytime returns, and between the overnight returns and the preceding day returns, are all negative. This implies price reversals are dominant over price continuations at the market open as well as market close. These results are different from the U.S. experience since high-volume U.S. stocks tend to show price continuity at the market close, an attribute that is associated with the stabilization activities by market-makers. Fourth, the ratio of daytime return volatility to overnight return volatility is substantially smaller than ratios measured for U.S. stocks and Japanese stocks, but closely approximates the ratio estimated for Malaysian stocks. One possible explanation for the low ratios may be due to the thinness of the market.

Regression analyses of the first-order serial dependence between overnight returns and following day returns, and between overnight returns and preceding daytime returns, indicate that the pattern of price reversals and price continuations on the JSX market is different from the U.S. market, reflecting differences in market microstructure of the two markets.

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[^1]:    ${ }^{1}$ For details of maximum price variation rules, see Lehman and Modest (1994).
    ${ }^{2}$ Stock exchanges in Hong Kong and Singapore also rely on the continuous auction method without the call market method. For comparison of trading methods in the Asian stock exchanges, see Rhee (1992) and Rhee and Chang (1992).
    ${ }^{3}$ The Kuala Lumpur Stock Exchange and the Taiwan Stock Exchange have adopted the call market method with complete automation of their trading systems.

[^2]:    ${ }^{4}$ While the JSX operated as a government-run exchange, the Surabaya Stock Exchange (SSE), a privately owned exchange, was established in June 1989 as part of the deregulation measures introduced in December 1987 and October 1988 by the Indonesian government. The majority of the JSX-listed shares are also listed on the SSE, while the listing requirements on the JSX are stricter. An over-the-counter market, the Bursa Parallel, was established in 1989 to provide fund-raising opportunities for smaller and less well-known firms.
    ${ }^{5}$ At the end of February 1994, market capitalization for convertible bonds and corporate bonds amounted to US $\$ 125$ million (or Rp 263.12 billion) and US $\$ 438$ million (or Rp 925 billion), respectively. However, the secondary market activities for corporate bonds are almost non-existent.
    ${ }^{6}$ Share prices determined in the non-regular trading market are not used to compute the JSX Composite Index.
    ${ }^{7}$ The percentage figures are based on the 1992 trading data.

[^3]:    ${ }^{8}$ Stock prices determined by non-regular trades are not used for computation of the JSX Composite Index.
    ${ }^{9}$ At the end of February 1994, 176 firms were listed.

[^4]:    ${ }^{10}$ One exception is the stocks in the lowest trading value quartile. Its variance ratio, however, is greater than one.

[^5]:    ${ }^{11}$ Muliplicative independent variables are introduced since two regressions are combined. The first-order serial dependence between $r_{\mathrm{d}, t}$ and $r_{\mathrm{n}, t}$ is measured by the slope coefficient in the following regression:
    $r_{\mathrm{d}, t}=a_{0}+\beta r_{\mathrm{n}, t}+u_{t}$.
    The impact of trading volume and the time-lapse between the market open and the opening transaction on $\beta$ is expressed as:
    $\beta=a_{1}+a_{2} D_{1, t}+a_{3} D_{2, t}+a_{4} D_{3, t}+a_{5} D_{4, t}+a_{6} v_{\mathrm{c}, \mathrm{t}}+a_{7} v_{0, t}+a_{8} v_{\mathrm{p}, t}+a_{9} d_{t}$.

[^6]:    ${ }^{12}$ One possibility is that price manipulation by speculators may occur prior to the close of trade.

