# RELATIONSHIPS BETWEEN STOCK PRICE, TRADING VOLUME, AND BID-ASK SPREAD ON THE US STOCK EXCHANGE: AN EMPIRICAL INVESTIGATION

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## ABSTRACT

*This study investigates the relationships between stock price, stock trading volume, and bid-ask spread for 45 firms on the US stock market. To study the nature, extent, and direction of these relationships, we used the Johansen co-integration test, the Vector Error Correction Model (VECM), and the Vector Autoregressive Model (VAR).*

*The analysis indicated that in 62% of the firms, price and volume were co-integrated in the sense that they had a long-run positive equilibrium relationship. On the other hand, the majority of firms showed no relationship between price and spread or volume and spread. In 73% of the firms, there was no relationship between price and spread. Also, 78% of the firms showed no relationship between volume and spread. There was little evidence for co-integration between price and spread or volume and spread. Price and spread were co-integrated in only three firms and volume and spread in two firms.*

*Of interest was the fact that the group of firms that showed a co-integrated relationship between price and volume had group means for return on equity (ROE), return on equity per share, (ROE-S) and return on assets (ROA) that were twice as high as those for the group of firms where volume and price were not related. Also, they had a smaller group mean for total debt to assets ratio than the firms with no relationship between price and volume. These financial ratios are of importance in investment. They give investors the ability to assess a company's financial structure and determine if the company is a suitable investment. Hence, they could be a driving force behind the co-integrated relationship between price and volume.*

## INTRODUCTION

Investors in the stock market have three indicators that could help them make informed investment decisions. These indicators are stock price, stock trading volume, and stock bid-ask spread. The trading value of a stock is often a reflection of the company's market value. As ascertained from its financial statement, the company's value can determine its stock price since investors will trade in securities of companies that are strong financially. The price of a stock is important in making investment decisions. However, this can be misleading since a stock's price is not necessarily a reflection of a company's strength or fundamentals. The stock price can be influenced by stock buyback, stock dividends, and stock splits, without a significant change in the company's value.

The trading volume of a security represents the number of shares traded. Volume is often an indicator of the performance of the market. An increase in volume can be an indication of a healthy and bullish market. There is evidence in the literature that volume and price are related.

It is known that trading volume affects price movement, but there is a lack of agreement about the nature and direction of the relationship between returns and trading volume (Gagnon and Karoivi (2009). Volume can also indicate price reversal and can occur when a stock price is stagnant, but stock volume is high. Volume is also an indicator of stock liquidity. A stock with high volume is good to buy since many buyers and sellers are ready to trade the stock. Furthermore, the trading volume reveals important information about trading activities by speculators. As a result, the trading volume may be important in forecasting stock price (Blume et al., 1994).

The difference between the bid and ask prices of a stock is known as the bid-ask spread. The bid-ask spread is set by a market maker to address inventory-holding cost, order processing cost, and information cost, resulting from information asymmetry (Stoll (1989)). The liquidity of a security is important in trading. The main measure of liquidity is the bid-ask spread. One expects that the larger the trading volume of a security, the narrower is its spread. A narrow spread indicates that the stock is liquid and has a high trading volume. As such, one would expect a negative relationship between spread and volume. Spread is also known to be related to volatility. A small spread indicates low volatility (https://www.investopedia.com/).

Price, volume, and spread provide useful information for investors in the stock market. There are indications that the three variables are related, but it is not clear about the extent, nature, and direction of this relationship. Most of the literature analyses use least squares regression on time series data, which can lead to misleading results due to non-stationarity and the autocorrelation in the residuals. Hence, this study's interest is to determine, using time series methodology, the extent, nature, and direction of the relationship between price and volume, price and spread, and volume and spread. In particular, we investigate the relationships between price, volume, and spread using the Johansen co-integration test, the Vector Error Correction Model (VECM), and the Vector Autoregressive Model (VAR).

## REVIEW OF LITERATURE

Amihud et al. (1999), in a study of the Japanese stock market, reported that when a company reduces its minimum trading unit or lot size of its stock, it increases the number of shareholders. The increase in the number of shareholders has the effect of increasing the stock price. This result confirmed the hypothesis put forth by Merton (1987), which states that stock price appreciation is positively associated with an increase in the stock's investor base. Boujedra and Ismaliia (2019) examined the relationship between stock return and trading volume on the Tunisian stock market. In their study, the authors were interested in testing the investor overconfidence hypothesis of Gervais and Odean (2001), which predicts a causality running from stock returns to trading volume. Authors used the Granger causality test and the vector autoregressive (VAR) test, over the period from April 1, 1999 to July 10, 2016, to test for a relationship between stock return and trading volume. Both tests showed that there was no significant relationship between stock returns and trading volume. Dodonova (2016) using least squares regression models on monthly data for the 2005–2014-time period reported on the effects of lagged stock returns and lagged dispersion of stock returns on trade volume. Dispersion of stock returns and the absolute value of returns positively affected future trade volume. Extreme negative returns caused high future trade volume, while extreme positive returns did not affect future trade volume.

Lee and Swanminathan (2000) reported that past trading volume could predict future stock price momentum. This observation was supported in later studies by Chen et al. (2001) and Gervais et al. (2001). A study by Westerhoff (2006) found that high trading volumes were associated with persistent positive price trends. On the other hand, low trading volume was considered to be associated with uncertainty on investors, causing a reversal in positive price trends. Murphy [1999] reported that volume was positively related to the price trend. A high volume indicates a strong positive trend and a low volume, a weakening trend. In his study, Brown et al. (2009) found a positive relationship between trading volume and stock returns. Stocks with high trading volume tend to have higher future returns than stocks with lower trading volume.

Tuna and Bektur (2015) investigated daily temperature shocks' psychological effect on trading volume and stock returns on the Istanbul market for 1987-2006. The temperature has an impact on investors' moods, which in turn can affect investment decision making. Hacker and Hatemy-J (2006) bootstrap causality test showed that there was causality from temperature to trading volume and stock returns, which proved true for high-temperature and low-temperature shocks. An increase in temperature caused returns and trading volume to increase, and a negative temperature change caused returns and volume to decrease. Returns and trading volume were, in this case, positively related, but due to a third factor. Wang (1994) showed in his study, using a model involving information asymmetry, that trading volume can predict future returns. Volume was positively related to absolute changes in prices and dividends.

Kuo et al. (2004) examined the relationship between trading volume and cross autocorrelations in stock returns in the Taiwan stock market. Using cross-correlations and vector autoregressive analysis and controlling for portfolio size, the authors found that the correlation between low volume portfolio returns at time t and high volume returns at time t-1 exceeded that between high volume returns at time t and low volume returns at time t-1. The result indicated that returns on high trading volume lead returns on low trading volume. Also, trading volume had a significant effect on lead-lag cross-autocorrelations of stock returns.

Tripathy (2011) studied the relationship between stock return and trading volume on the Indian Stock Exchange. The author used a bivariate regression model, Johansen's co-integration test, and the VAR and VECM models for the analysis. Results showed that stock returns were co-integrated with the trading volume, indicating a long term relationship. Also, there was a bidirectional causality between the two variables. Zerena and Konukb (2016) investigated the relationship between trading volume and stock prices in 12 countries belonging to the Organization for Economic Co-operation and Development (OECD**)**. The authors used **a** panel causality test developed by Dumitrescu-Hurlin (2012). Results showed that the stock market index caused trading volume. However, trading volume did not cause the stock market index.

Sawkut et al. (2008) investigated the determinants of bid-ask spread on 12 stocks of the Stock Exchange of Mauritius (SEM). Regression analyses were performed on individual stocks, pooled stocks, and panel data. Results indicated that trading volume did not affect the spread. However, the closing price of the stock and spread were positively related. Howe and Liu (1999) investigated the relationship between dividend policy and the bid-ask spread using stocks traded on the (OTC)/NASDAQ stock market for 1984 to 1987. The firms selected for the study were those that paid no dividends and those that paid only a cash dividend. Regression analysis was used on both firms and the dividend-paying firms only with control variables such as dividend yield, volume, price, return variance, firm size, and listing length. It was concluded from the analysis that dividend yield was negatively related to spread. An increase in dividend yield narrowed the spread.

Menyah and Paudyal (1996) studied the determinants of bid-ask spread on the London Stock Exchange. The authors used a log-linear regression model where spread per share was the dependent variable and price per share, trading volume, number of market makers, and risk were the independent variables. All four independent variables were significant, and the model explained 91% of the variation in the spread. Price and risk were positively related to the spread. However, volume was negatively related to spread.

Narayana et al. (2015), using panel regression, examined the determinants of bid-ask spread using daily data for 734 US firms on the NYSE over the period from January 1998 to December 31, 2008. The independent variables used were average bid-ask spread, average trading volume, the average price per share, and share price volatility. It was found that price had a mixed effect on the spread, which was negative for some industry sectors and positive for others. Trading volume had a positive effect on the spread of all industry sectors. Also, volatility had a negative effect on the spread for all the industry sectors. Analysis by firm showed that a small percentage of firms showed a significant relationship between price and spread or between volume and spread.

## RESEARCH OBJECTIVE

There are indications from the literature that Price, volume, and spread may be related, but it is not clear about the extent, nature, and direction of this relationship. Most of the analyses use least squares regression on time series data, which can lead to misleading results due to non-stationarity and the autocorrelation in the residuals. Hence, the interest in this study is to determine, using the appropriate time series methodology, the extent, nature, and direction of the relationships between price, volume, and spread. The paper contributes to the literature by investigating the long- term and short-term relationships between price, volume, and spread using the Johansen co-integration test, the Vector Error Correction Model (VECM), and the Vector Autoregressive Model (VAR).

## DATA AND METHODS

### Data

Utilizing the Wharton Research Data Services (WRDS), quarterly stock price, stock trading volume, and stock bid-ask spreads were obtained for each of forty-five companies for the years 1998 to 2017. Fifty companies were selected at random from a Compustat file in WRDS. Forty-five of the companies had complete data for the analysis. The sample size of 45 was deemed adequate for statistical analysis and inference. Also, the sample size per company was large enough (over 50 observations) for a meaningful time series analysis with no estimation bias (Wei, 2006). Our interest was in determining the long-term relationships over years between price, volume, and spread. For this reason, we chose a 20-year period from a data file that had, in addition to the quarterly data on price, volume, and spread, quarterly data on financial variables for each company. The same quarterly frequency enables one to study the effects of a company's financial variables on price, volume, or spread and their relationships.

**Statistical Analysis**

We tested the 45 companies for relationships between stock price, stock trading volume, and bid-ask spread using SAS. We first determined if a long-term relationship or an equilibrium existed between two series based on the Johansen co-integration test. The test requires that the two series are both nonstationary and become stationary upon first differencing (i.e., I (1) stationary). If the two series were nonstationary, we determined the number or rank r of the co-integration vectors by the Johansen trace test. The null hypothesis for the trace test is that the number $r = r^* < k$, vs. the alternative $r = k$. Testing proceeds sequentially for $r^* = 1,2, \ldots$ and the first non-rejection of the null hypothesis is taken as an estimate of $r$. For all the bivariate series that were co-integrated, r = 1, as expected. When the two series were co-integrated, we ran the Vector Error Correction Model (Johansen, 1988, 1991) with r =1, VECM (1), to determine the equational relationship between the two series. In the results, we present VECM (1) in terms of its equivalent Vector Autoregressive, VAR (1), representation. If the two series were not both I (1) stationary, we determined their relationship using the VAR (1) model, which was done after the series was made stationary through first differencing.

For two variables with one co-integrated vector, the VECM (1) can be expressed as:

$$D\_Y_{it} = C + \alpha\beta' Y_{it-1} + \sum_{i=1}^{p-1} \delta i \, D\_Y_{it-1} + E \quad (1)$$

Where C is a constant, $D\_Y_{it}$ is a 2x1 column vector of first differences for the two variables ($y_{1t}$, $y_{2t}$), α is a 2x1 column vector, β' is a 1x2 row vector, $\delta_i$ is a 2x2 matrix, and E is the random error term. The expression $\alpha\beta' Y_{it-1}$ gives the long-term relationship or equilibrium between the two variables and $\sum_{i=1}^{p-1} \delta i \, D\_Y_{it-1}$ gives the short- term relationship. The value p, for the number of lags, was chosen based on the Schwartz and Akaike criteria

The equations for the VAR (1) relating two series $Y_1$ and $Y_2$ are expressed as:

$$Y_{1t} = ø_{11}\, Y_{1t-1} + ø_{12}\, Y_{2t-1}$$
$$Y_{2t} = ø_{21}\, Y_{1t-1} + ø_{22}\, Y_{2t-1} \quad (2)$$

To test for stationarity, we used the Augmented Dickey-Fuller test and the Phillips-Perron test. Since these tests are model specific, we relied also on plots of the time series over time for trends and on the series autocorrelation function over lags (Wei, 2006).

Table 2 presents the results of the analysis. In all cases, we present only the equation (from Equation (2)) that showed significant relationships between price and volume, price and spread, and volume and spread. When a series was differenced for stationarity, this was indicated by the symbol Δ. For instance, the first difference for price is represented as $\Delta Price_t = Price_t - Price_{t-1}$. The Vecm (1) in the Table is expressed in its VAR (1) representation.

We used the Chow test (Chow, 1960) to test for structural breaks in the time series due to the 2008/2009 recession. A structural *break* is when a *time series* abruptly changes at a point in time. The Chow test tests whether the true coefficients in two linear regressions on different data sets (before and after a structural break point) are equal. It is commonly used to test for structural change. It is an application of the F-test, and it requires the sum of squared errors from three regressions - one for each sample period (before and after the break point being tested) and one for the pooled data.

## RESULTS AND DISCUSSION

Of importance in the results is the co-integration relationship between price and volume. This implies (Equation (1) that, in the long-run, there is an equilibrium positive relationship between price and volume. The two series move together and the equilibrium is stable in the sense that if the two series were to deviate from the equilibrium, they will in time return to their equilibrium value.

As far as structural breaks are concerned, the Chow test did not show any significant breaks in the data. Structural breaks can affect parameter estimates if one is using the regression analysis on time series data, since regression is affected by a sudden change in the trend of a time series. For the time series analysis in this study, the time series data were stationary, which means that there was no trend in the series over time. Hence, one does not expect a structural break as shown by the Chow test. Therefore, our models are accurate in determining the nature of the long-term relationships between price, volume, and spread.

### Price and Volume

Results in Table 1 show that price and volume are co-integrated (r=1) in 28 (62%) out of the 45 companies. The two series are co-integrated in the sense that they move together over time and have a long-run equilibrium relationship from which they cannot deviate. The relationship at equilibrium is positive.

Only the VAR (1) equations, Equation (2), where the relationship between price and volume; price and spread; or spread and volume was significant, are presented in Table 2. From the equations in Table 2 for the price and volume column and from Table 3, 25 cases showed that price at time t-1 affected volume at time t, but volume did not affect price. In three cases, volume affected price, but price did not affect volume. In five cases, volume affected price and price affected volume. In 12 cases, there was no relationship between volume and price. These results point to the fact that, in the majority of cases, price and volume were related in the short-run and had an equilibrium relationship in the long-run. When they were related in the short-run, price predominantly had a positive effect on volume.

### Price and Spread

Tables 2 and 4 show that in 33 out of 45 cases (73%), there was no significant relationship between price and spread. In only three firms were price and spread co-integrated. In 8.9% of the cases price affected spread and in 11% of the cases spread affected price. In 6.6% of the firms, spread affected price and price affected spread. Hence, in the majority of cases or companies, price and spread were not related.

### Spread and Volume

Results in Tables 2 and 5 show that in 35 out of 45 cases, there was no significant relationship between spread and volume. In three cases, volume affected spread, and in three cases, spread had an effect on volume. In four cases, spread affected volume and volume affected spread. There were only two cases where spread and volume were co-integrated.

It is clear from Tables 2, 3, 4, and 5 that price and volume were most related, and volume and spread were least related. In 56% of the cases, price affected volume. This effect was predominantly positive. The positive effect between price and volume is according to expectation and in agreement with the literature. In 62% of the companies, price and volume were co-integrated with a long-term equilibrium. In 73% of the firms, price and spread were not related. Also, there was little support for a relationship between spread and volume. In 77.7% of the cases, there was no relationship between them. That most firms did not show a relationship between price and spread and volume and spread, is in agreement with results by Narayana et. al. (2015).

Table 6 lists the financial variables (measured on a quarterly basis over the same time period) that were used to determine if they differ between the two groups of companies (Table 2): those that had a relationship between price, volume, and spread and those that did not. Table 7 presents the financial variables that differed significantly between the two groups of companies concerning the price and volume relationship. There was no difference between group of companies in the case of the price and spread relationship or the volume and spread relationship.

It is seen from Table 7 that the group of companies that showed a relationship between price and volume (PVR) differed significantly in mean from the group of companies that did not show a relationship between price and volume (NPVR). The difference was with regard to return on equity (ROE), return on assets (ROA), return on equity per share (ROE-S), and total debt divided by total assets (leverage). Group means for ROE, ROE-S, and ROA were higher for the PVR group than for the NPVR group. On the other hand, the leverage group mean was lower for the PVR group than for the NPVR group.

These financial ratios are of importance for investors to consider. They give investors the ability to assess a company's financial structure and determine if the company is a suitable investment. The ROE and ROE-S ratios provide investors an assessment of the efficiency of the company. They measure the profitability of a corporation in relation to stockholders' equity. The ROA is a measure of how efficient a company is in generating profit. The higher the ROA, the more efficient the company. A debt to asset ratio is a measurement of a company's financial leverage. It assesses the ability of a company to meet its financial obligations. The higher the ratio, the riskier the company.

**Table 1**
**Frequencies of Co-Integrations (Rank r=1) Between Price and Volume, Price and Spread, and Volume and Spread**

| **Co-integration, r=1** | **Frequency** |
|---|---|
| Price and volume | **28** |
| Price and spread | **3** |
| Volume and spread | **2** |

**TABLE 2**
**Vector Auto-Regression Models, VAR (1), and Vector Error Correction Models, VECM (1), For Price and Volume, Price and Spread, And Spread and Volume**

| Company | Price and volume (Vol), VAR | Price and spread , VAR | Spread and Volume (Vol), VAR |
|---|---|---|---|
| *Bank of America* | $\Delta Vol_t$ = -472964 $\Delta Price_{t-1}$ - 0.236 $\Delta Vol_{t-1}$ | Vecm(1)<br>$Price_t$ = 0.962 $Price_{t-1}$<br>- 10.21 $Spread_{t-1}$<br>$Spread_t$ = -.00183 $Price_{t-1}$ + 0.506 $Spread_{t-1}$ | |
| *Bristol-Myers* | Vecm(1)<br>$Vol_t$ = o.894 $Vol_{t-1}$ + 35636 $Price_{t-1}$ | | |
| *Caterpillar* | $\Delta Price_t$ = -0.028 $\Delta Price_{t-1}$ – 0.69E-5 $\Delta Vol_{t-1}$ | | |
| *Chase* | Vecm(1)<br>$\Delta Vol_t$ = 0.642 $\Delta Vol_{t-1}$ +19.52 $\Delta Price_{t-1}$ | Vecm(1)<br>$Spread_t$ = 0.381 $spread_{t-1}$ - 0.00540 Pricet-1 | |
| *Community health* | $\Delta Vol_t$ = -0.392$\Delta Vol_{t-1}$ -6795.34 $\Delta Price_{t-1}$ | | |
| *Diamond drilling* | Vecm(1)<br>$Vol_t$ = 0.730 $Vol_{t-1}$ + 1770.18 $Price_{t-1}$ | | |
| *DTE Energy* | Vecm(1)<br>$\Delta Vol_t$ = - 0.276 $\Delta Vol_{t-1}$ +982.68 $\Delta Price_{t-1}$ | | $\Delta Vol_t$ = -0.504 $\Delta Vol_{t-1}$ -24288 $Spread_{t-1}$ |
| *Edwards life sciences* | Vecm(1)<br>$Vol_t$ = 0.543 $Vol_{t-1}$ + 1069.75 $Price_{t-1}$<br>$Price_t$ = 0.848 $Price_{t-1}$ + 0.64E-4 $Vol_{t-1}$ | | |
| *Eli Lilli* | | | $\Delta Vol_t$ = -0.374 $\Delta Vol_{t-1}$ -90836 $\Delta Spread_{t-1}$<br>$\Delta Spread_t$ = -0.067 $\Delta Spread_{t-1}$ + 4.914E-7 $\Delta Vol_{t-1}$ |
| *First Energy* | | | |
| *Fiserv Inc.* | | | |
| *G&K Services* | | | $Spread_{t-1}$ = -0.0476$Spread_{t-1}$ |

| | | | |
|---|---|---|---|
| | | | $- 0.00000302Vol_{t-1}$ |
| *GAP Inc* | Vecm(1)<br>$Price_t = 0.936\ Price_{t-1} + 1.36E\text{-}6\ Vol_{t-1}$<br>$Vol_t = 0.919\ Vol_{t-1} + 3818.71Price_{t-1}$ | $\Delta Price_t = -0.1004\ \Delta Price_{t-1} + 9.305\ \Delta Spread_{t-1}$<br>$\Delta Spread_t = -0.513\Delta Spread_{t-1} - 0.0112\ \Delta Price_{t-1}$ | |
| *Hain Celestial* | Vecm(1):<br>$Vol_t = 0.665\ Vol_{t-1} + 1168.528\ Price_{t-1}$ | | |
| *Halliburton* | | | |
| *Harris Corp* | Vecm(1)<br>$Vol_t = 0.745\ Vol_{t-1} + 675.35\ Price_{t-1}$ | | |
| *Hershey* | Vecm(1)<br>$Vol_t = 0.726\ Vol_{t-1} + 749.58\ Price_{t-1}$ | | |
| *I.D.Systems* | Vecm(1)<br>$Vol_t = 0.408\ Vol_{t-1} + 1161.84\ Price_{t-1}$ | | |
| *ICU Medical* | $\Delta Price_t = 0.430\ \Delta Price_{t-1} + 0.000168\ \Delta Vol_{t-1}$ | | |
| *J.B.Hunt* | Vecm(1)<br>$Vol_t = 0.89\ Vol_{t-1} + 383.025\ Price_{t-1}$ | | |
| *J.C. Penny* | Vecm(1)<br>$Vol_{t-} = 0.858\ Vol_{t-1} + 6498.13\ Price_{t-1}$ | | |
| *Jewett-Cameron* | Vecm(1)<br>$Vol_t = 0.246Vol_{t-1} + 185.35\ Price_{t-1}$<br>$Price_t = 0.801Price_{t-1} + 0.000807\ Vol_{t-1}$ | | $Vol_t = 0.146\ Vol_{t-1} -1764.41Spread_{t-1}$ |
| *Kellog* | Vecm(1):<br>$Vol_t = 0.598\ Vol_{t-1} + 2805.125\ Price_{t-1}$ | $\Delta Price_t = -.103\ \Delta Price_{t-1} - 3.944\ \Delta Spreadt_{-1}$ | |
| *Kewaunee Scientific* | Vecm (1)<br>$Price_t = 0.647\ Price_{t-1} + 0.0043Vol_{t-1}$<br>$Vol_t = 0.523\ Vol_{t-1} + 39.14\ Price_{t-1}$ | | $\Delta Vol_t = -0.604\ \Delta Vol_{t-1} + 629.489\ \Delta Spread_{t-1}$ |
| *L.B. Foster* | Vecm (1)<br>$Vol_t = 0.725\ Vol_{t-1} + 140.88\ Price_{t-1}$ | | |
| *Laboratory Corp* | Vecm(1)<br>$Vol_t = 0.663\ Vol_{t-1} + 631.12\ Price_{t-1}$ | $\Delta Spread_t = -0.494\Delta Spread_{t-1} -0.0029\Delta Price_{t-1}$<br>$\Delta Price_t = 0.356\Delta Price_{t-1} +45.19\Delta Spread_{t-1}$ | |

| | | | |
|---|---|---|---|
| *M.D.C. Holding* | Vecm(1)<br><br>$Vol_t = 0.651Vol_{t-1} + 884.95\ Price_{t-1}$ | | Vecm(1)<br>$Vol_t = 0.967Vol_{t-1} + 68619\ Spread_{t-1}$<br>$Spread_t = 0.344Spread_{t-1} + 3.09E\text{-}7Vol_{t-1}$ |
| *Manpower Group* | Vecm(1)<br>$Vol_t = 0.648Vol_{t-1} + 786.43Price_{t-1}$ | $\Delta Price_t = 0.077\ \Delta Price_{t-1}$<br>$-20.987\ \Delta spread_{t-1}$ | |
| *Nanometrics* | Vecm(1)<br>$Vol_t = 0.671\ Vol_{t-1} + 709.78\ Price_{t-1}$ | | |
| *Nanophase* | | $\Delta Spread_t = -0.554\ Spread_{t-1}$<br>$-0.0073\Delta Price_{t-1}$ | |
| *Ocean Biochemical* | | | $Spread_t = 0.618Spread_{t-1} - 0.00000255Vol_{t-1}$<br><br>$Vol_{t-} = 0.248Vol_{t-1} - 19783\ Spead_{t-1}$ |
| *Oceaneering International* | Vecm(1)<br><br>$Vol_t = 0.727Vol_{t-1} + 1077.959Price_{t-1}$ | | |
| *Panhandle Oil and Gas* | Vecm(1)<br>$Vol_t = 0.761Vol_{t-1} + 61.31Price_{t-1}$ | | |
| *Par Technology* | Vecm(1)<br><br>$Vol_t = 0.443\ Vol_{t-1} + 563.74\ Price_{t-1}$ | | |
| *Quacker Chemicals* | | | |
| *Quanta Service* | Vecm(1)<br><br>$Vol_t = 0.84\ Vol_{t-1} +2292.34\ Price_{t-1}$ | $\Delta spread_t = -0.0159\ \Delta Price_{t-1}$<br>$-0.711\ \Delta spread_{t-1}$ | |
| *Radisys Corp* | | $\Delta Price_t = 0.154\ \Delta Price_{t-1}$<br>$-12.347\ \Delta Spread_{t-1}$ | |
| *Rambus Inc* | $\Delta Price_t = 0.112\ \Delta Price_{t-1}$<br>$-0.0000039\ Vol_{t-1}$ | $\Delta Price_t = 0.086\Delta Price_{t-1} + 71.45\ Spread_{t-1}$ | $Spread_t = 0.435Spread_{t-1}$<br>$-1.47E\text{-}8Vol_{t-1}$<br>$Vol_t = 0.51Vol_{t-1}$<br>$-8685767\ Spread_{t-1}$ |
| *Salem Media Group, Inc.* | | | |
| *Take-Two Interactive Software* | Vecm(1)<br><br>$Vol_t = 0.587Vol_{t-1} + 3078.29Price_{t-1}$<br><br>$Price_{t-1} = 0.965Price_{t-1} + 0.0000046\ Vol_{t-1}$ | | Vecm(1)<br><br>$Spread_t = 3.12E\text{-}9Vol_{t-1} +0.396spread_{t-1}$ |
| *Tampa Electric* | Vecm(1) | $\Delta Price_t = -0.013\ \Delta Price_{t-1}$<br>$-6.119\ \Delta Spread_{t-1}$ | |

| | | | |
|---|---|---|---|
| | $Vol_t = 0.732\ Vol_{t-1} + 4291.06\ Price_{t-1}$ | | |
| *UGI Corp* | Vecm(1)<br>$Vol_t = 0.727\ Vol_{t-1} + 1021.005\ Price_{t-1}$ | | |
| *W.R.Grace & CO* | Vecm (1)<br>$Vol_t = 0.814 Vol_{t-1} + 376.58\ Price_{t-1}$ | | |
| *Walt Disney* | | | $\Delta Spread_t = 5.069E\text{-}8\ \Delta Vol_{t-1} + 0.0567\ \Delta Spread_{t-1}$ |
| *WW Grainger Inc.* | | Vecm(1) :<br>$Spread_t = 0.706 Spread_{t-1}$ - 0.0000718Pricet-1 | |

Table 3
Frequencies of the Effects of Price On Volume, Volume On Price, and Dual Effects

| | Price affected volume. Volume did not affect price. | Volume affected price. Price did not affect volume. | Volume affected price and price affected volume | No relationship between price and volume |
|---|---|---|---|---|
| Frequency | 25 (56%) | 3 (6.7%) | 5 (11.1%) | 12 (26.6%) |

Table 4
Frequencies of The Effects of Price On Spread, Spread On Price, and Dual Effects

| | Price affected spread. Spread did not affect price | Spread affected price. Price did not affect spread. | Spread affected price and price affected spread. | No relationship between price and spread |
|---|---|---|---|---|
| Frequency | 4 (8.9%) | 5 (11.1%) | 3 (6.6%) | 33 (73.3%) |

Table 5
Frequencies of The Effects of Volume On Spread, Spread On Volume, and Dual Effects

| | Volume affected spread. Spread did not affect volume. | Spread affected volume. Volume did not affect spread. | Spread affected volume and volume affected spread | No relationship between spread and volume |
|---|---|---|---|---|
| Frequency | 3 (6.7%) | 3 (6.7%) | 4 (8.9%) | 35 (77.7%) |

| Table 6<br>Financial Variables Used to Compare Two Groups of Companies: Those That Showed Relationships Between Price, Volume, and Spread and Those That Did Not. |
|---|
| Financial Variables |
| Income (Billion) |
| Return on equity- ROE |
| Return on assets-ROA |
| Return on equity per share-ROE-S |
| Long term debt divided by total assets-LTD/TA |
| Total debt divided by total assets-Leverage |
| Cash and short term investment divided by total assets- CI/TA |
| Cash and short term investment divided by current assets- CI/CA |
| Current equity-CE (billion) |
| Current ratio-CR |

**Table 7**
Financial Variables That Differed Significantly Between the Group of Companies That Had a Relationship Between Volume and Price (PVR) and Those That Did Not (NPVR)

| | PVR- Group Mean | NPVR- Group Mean | t-value | p-value |
|---|---|---|---|---|
| ROE-S | 17.873 | 8.662 | 1.93 | 0.06 |
| ROE | 16.045 | 8.01 | 1.66 | 0.10 |
| ROA | 6.985 | 3.443 | 1.78 | 0.08 |
| Leverage | 0.227 | 0.291 | 1.64 | 0.10 |

## CONCLUSION

Stock price, stock trading volume, and bid-ask spread are three important stock market measures for investment. Of interest was to determine the relationships between any two of these variables. In this study, we investigated the extent, nature, and direction of these relationships for 45 firms on the US stock market using the Johansen co-integration test and the Vector Error Correction Model of order one (VECM (1) as well as the Vector Autoregressive Model, VAR (1).

Results indicated that price and volume were co-integrated in 62% of the companies. This means that the two variables have a long-term equilibrium relationship that is positive. On the other hand, there was no relationship between price and spread and volume and spread for most firms. In 73% of the cases there was no relationship between price and spread. Also, in 77.7% of the cases, there was no relationship between volume and spread.

With regard to the co-integration relationship, only in three firms were spread and price co-integrated in the sense of having a long-term relationship. Also, in only two companies volume and spread were co-integrated. Hence, investors cannot rely on a long-term relationship between price and spread or spread and volume in making investment decisions. Any relationship seems to be short-term. The most significant relationship was the co-integration between price and volume with an equilibrium relationship in which they are positively related.

As a result, the trading volume of a stock may be important in forecasting its price. An increase in the trading volume of a stock could be a signal for the investor that the price of the stock would increase.

Of significance is the fact that companies that had a relationship between price and volume were significantly larger with regard to ROE, ROE-S, ROA and lower with regard to leverage than those that did not show a relationship between price and volume. These financial variables are of importance in decision making regarding investment. Hence, they could be a significant driving force behind the co-integrated relationship between price and volume.

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