THE RELATIONSHIPS BETWEEN THE CHICAGO BOARD OPTIONS EXCHANGE (CBOE) VOLATILITY INDEX (VIX) AND FIRM VALUATION: A STATISTICAL ANALYSIS

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ABSTRACT

Given the presidential election, changing monetary policy, potential rising interest rates, deteriorating corporate earnings, high stock valuation, the budget and trade deficit, we expect the stock market to be volatile. Yet the market is registering some of the lowest volatility readings in nearly 10 years, as measured by the Chicago Board Options Exchange (CBEO) Volatility Index (VIX). The VIX is calculated using current options prices, and since options are short-lived instruments, the prices incorporate some expectation of market volatility. In this paper, we investigate the statistical relationships between VIX and valuation of firms. This statistical analysis reveals that the CBOE Volatility Index (VIX) has a negative impact upon the firm's intrinsic value.

INTRODUCTION

In 1993, the Chicago Board Options Exchange® (CBOE®) introduced the CBOE Volatility Index®, VIX®, and it quickly became the benchmark for stock market volatility. The Chicago Board Options Exchange CBOE Volatility Index (VIX), also known as the CBOE Market Volatility Index, sometimes referred to as the "Investor Fear Gauge", indicates the level of anxiety or complacency of the market. It does this by measuring how much people are willing to pay to buy options on the S&P 100 index (OEX), typically "put" options which are a bet that the market will decline.

The CBOE developed a formula for averaging various options for S&P 100 futures to get a hypothetical, normalized option. The volatility component can be isolated from the price of this option and called VIX. Although both "put" and "call" options are included in the calculation, it is the "put" options that lead to most of the excess demand that VIX measures. VIX is considered to be a good surrogate for market sentiment.

The objective of this study is to examine the relationship between VIX and valuation of large public firms. The remaining sections of this paper are organized as follows. Section II presents the statistical model, methodology and data. Section III discusses the empirical results. The conclusions are in Section IV.

METHODOLOGY AND DATA

The generalized formula for VIX calculation is:

$$\sigma^2 = \frac{2}{T}\sum_i \frac{\Delta K_i}{K_i^2} e^{RT} Q(K_i) - \frac{1}{T}\left[\frac{F}{K_0} - 1\right]^2 \qquad (1)$$

Where…

σ is VIX/100 -> VIX = σ x 100

T Time to expiration

F Forward index level derived from index option prices

K_i Strike price of i^{th} out-of-the money option; a call if $K_i > F$ and a put if $K_i < F$

ΔK_i Interval between strike prices – half the distance between the strike on either side if K_i:

$$\Delta K_i = \frac{K_{i+1} - K_{i-1}}{2}$$

(Note: ΔK_i for the lowest strike is simply the difference between the lowest strike and the next higher price. Likewise, ΔK for the highest strike is the difference between the highest strike and the next lower strike.)

K0 First strike below the forward index level, F

R Risk-free interest rate to expiration

Q (K_i) The midpoint of the bid-ask spread for each option with strike K_i

The statistical model constructed for this study is based on the generally accepted theory of common stock valuation. This approach is based on the principle that rational investors evaluate the expected returns and risks of securities in the financial market and set a price for a particular security which adequately compensates investors for the risks. The Discounted Cash Flow valuation approach is based on the proposition that the maximum price that a rational investor will pay for a security is an amount equal to the present value of the expected dividends plus its resale price, including capital gains. Therefore, the present market price or a stock is given by the formula:

$$P_0 = \frac{D_1}{(1+K)^1} + \frac{D_2}{(1+K)^2} + \dots + \frac{D_t}{(1+K)^t} + \frac{P_t}{(1+K)^t} \qquad (2)$$

Equation (1) was simplified by Gordon (1962) as follows:

$$P_0 = \frac{D_1}{K-g} \qquad (3)$$

Where g is the expected dividend growth rate. Equation (2) can be expressed as follows:

$$\frac{P_0}{B_0} = \frac{D_1/B_0}{K-g} = f(D_1/B_0, K, g) \qquad (4)$$

Where P_0 / B_0 = market price-to-book ratio
B_0 = book value
D_1 / B_0 = book yield
K = R_f + risk
R_f = Risk-free rate

Equation (3) attempts to quantify the impact and the relationship between stock prices and a number of economic, financial and risk factors associated with each company. The ratio of market price and book values of security i can be written as a function of several explanatory variables and can be expressed as follows:

$$P_i/B_i = f(RF, \text{book yield}, g, \text{risk}) \qquad (5)$$

There are four types of variables which were hypothesized to affect the market price-to-book ratio of companies:

(1) Economic Variables: Interest rates and inflation should have an effect on market price-to-book ratio.
(2) Dividend Policy: High book yield, retention ratio, and expected earnings growth rate should have a positive effect on market price-to-book ratio.
(3) Risk Factors: CBOE Volatility Index (VIX), %Cash to Net Asset Value, high beta, and low Value Line Safety Rank should have a negative impact on market price-to-book ratio.
(4) Financial Factors: High return on equity, high percent of cash to total asset, good Value Line Timeliness Rank, % Return on Total Asset, and high annual return should have a positive impact upon market price-to-book ratio.

In specifying (3), our intent is to construct a statistical model to quantify the changes in the market price-to-book ratio and to examine the relative importance of CBOE Volatility Index (VIX) versus other economic and financial factors in the valuation of stock prices.

This empirical study is based on monthly Value Line financial and economic data from January 2007 through September 2016 of 1,810 companies (98 industries). The monthly data was obtained from Value Line and Federal Reserve Statistical Release. The dependent and independent variables were defined as follows:

Market/book ratio (P_0/B_0): The month-end market price divided by book value per share.
Book yield (BYD): Indicated declared dividend divided by book value per share.
Risk-free rate (I): The interest rate of the 30-year U. S. Treasury Bonds.
CBOE Volatility Index (VIX): The Index calculated by the Chicago Board Options Exchange

- **Timeliness Rank (TR)** measures probable price performance during the next 6 to 12 months, relative to all other 1700 stocks. Stocks ranked 1 (Highest) and 2 (Above Average) are likely to outpace the year-ahead market. Those ranked 4 (Below Average) and 5 (Lowest) are not expected to outperform most stocks over the next 12 months.

- **Safety Rank (SR):** A measurement of potential risk associated with individual common stocks. The Safety Rank is computed by averaging two other Value Line indexes – the Price Stability Index and the financial strength Rating. Safety Ranks range from 1 (Highest) to 5 (Lowest).

- **Beta (B):** A relative measure of the historical sensitivity of the stock's price to overall fluctuations in the New York Stock Exchange Composite Index.

- **Relative P/E Ratio (RPE)**: A stocks price-earnings ratio divided by the price-earnings ratio for a market measure.

- **% Retained to Common Equity (RR):** Net profit less all common and preferred dividends divided by common equity including intangible assets, expressed as a percentage.

- **Estimated Return on Shareholders Equity (ROE):** Indicator of profitability. Determined by dividing net income for the past 12 months by common stockholder equity (adjusted for stock splits). Result is shown as a percentage.

- **% Return on Total Asset (Latest Quarter) (RTA):** Percent of net profit to total assets

- **Total Return 1-Year (TT):** The capital gain or loss for the stock price plus the sum of dividends reinvested at year-end for the past year, expressed as a percentage.

- **Relative Strength 1 Week (RS):** The stock's price over time divided by the Value Line Composite Average over the same time span. Arising relative strength line means the stock has been outperforming the market; a declining line means just the opposite.

- **% Cash to Net Asset Value (CA)**

- **Projected 3-5 Year Relative P/E (PPE)**

- **Projected Earning Per Share Growth Rate (PEG):** The estimated growth rate in earnings expressed as a percentage.

- **% Book Value Growth (BG)**

Utilizing a cross sectional time series data, this model may be expressed as follows:

$$P_{it}/B_{it} = a + b_1TR_{it} + b_2SR_{it} + b_3B_{it} + b_4RPE5_{it} + b_5RR_{it} + b_6ROE_{it} + b_7BG_{it} + b_8TT_{it} + b_9RS_{it} + b_{10}RTA_{it} + b_{11}PPE_{it} + b_{12}PEG_{it} + b_{13}CA_{it} + b_{14}BYD_{it} + b_{15}I_{it} + b_{17}VIX_{it}\, e_{it} \quad (6)$$

Where: i = company i
t = time t
a = the intercept
b = regression coefficient
e_{it} = the random error

EMPIRICAL RESULT

As shown in Table 2, a cross-sectional regression estimate of expression (4) and (5) yield the following result:

$$P/B = -1.199 - .0323\ VIX - .081\ TR - 0.037\ SR - 0.472\ B + 0.834\ RPE + 0.087\ RR + 0.115\ ROE + 0.0015\ BG + 0.0081\ TT + 0.002\ RS + 1.084\ PPE + 0.018\ PEG + 0.00088\ CA + 7.747\ BYD - 0.0164\ I + 0.066\ RTA + e_{it} \quad (7)$$

(-66.378) (-15.13) (-4.944) (-24.278) (76.863) (138.495) (139.602)
(8.895) (58.547) (12.628) (85.835) (33.689)
(2.63) (73.593) (-2.798) (28.228)

(t-statistics in parentheses below the coefficients) ($R2 = 0.742$)

Durbin-Watson *test* was utilized to test the hypothesis of no autoregression. As shown in Table 2, the Durbin-Watson statistic indicates that there is no autoregression and we can retain the statistical estimates without concerning a bias of the estimated standard error. The low correlation coefficients of the correlation matrix indicate little multicolinearity between the independent variables.

TABLE 2

Statistical Results

Dependent Variable: P/B: Market Price/Book Value

Independent Variables	B	Standard Error B	t
VIX: Volatility Index	-.033	.000	-66.378
TR: Timeliness Rank	-.082	.005	-15.13
SR: Safety Rank	-.037	.009	-4.944
B: Beta	-.472	.019	-24.278
RPE: Relative P/E Ratio	.834	.011	76.863

RR: % Retained to Common Equity	.087	.001	138.495
ROE: Est Return on Shareholders Equity	.115	.001	139.602
BG: Book Value Growth 1-Year	.001	.000	8.895
TT: Total Return 1-Year	.008	.000	58.547
RS: Relative Strength 1 Week	.002	.000	12.628
PPE: Proj 3-5 Yr Relative P/E	1.083	.013	85.835
PEG: Proj EPS Growth Rate	.018	.001	33.689
CA: % Cash to Net Asset Value	.0009	.000	2.630
BYD: Dividend Declared/Book Value	7.747	.105	73.593
I: 30-Year Treasury	-.016	.006	-2.798
RTA: % Return on Total Asset	.066	.002	28.228
(CONSTANT)	-1.199		
R Square	.742		
Adjusted R Square	.742		
Durbin-Watson Statistic	1.901		

With a t-statistic of -66.378, the empirical results indicated that there is a strong negative correlation between the stock prices and the Chicago Board Options Exchange (CBEO) Volatility Index (VIX).

In addition, the statistical results indicated that investors respond positively to the stocks with high dividend and quality earnings, which is reflected in the book yield and return on equity variables. The results also suggest that expected growth in earnings or capital appreciation is an investment objective of stockholders. This is consistent with the discounted cash flow approach in the valuation theory of common stock.

CONCLUSIONS

This study examines the relationships between stock prices and insider stock holdings. The empirical results led to the following conclusions:

- The empirical analysis of Section III demonstrated that the contemporaneous increases in the Chicago Board Options Exchange (CBEO) Volatility Index (VIX) has a negative impact on the valuation of common stocks.

- The empirical evidence suggests that Value Line Timeliness and Safety ranks are important for stock selection.

- The empirical evidence also suggest that high projected earnings growth, return on equity, quality earnings and good balance sheet would have a positive impact upon the value of common stocks.