Price-to-Earnings Ratios and Option Prices

by

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Abstract

In May of 1997 the average month end P/E ratio for software industry was 44. However, the five year historical average was 31. In this study we examine the effect of this industry value fluctuation on the effects of option prices. We examine the relationship between the level of relative valuation and option pricing via deviations in put-call parity and a two factor option pricing model incorporating relative valuation. We find support that the increase in relative industry valuation Granger causes put-call parity deviations, implying investors price options with greater expectation of downward movement. Additionally, we develop a model and find support that the two factor option pricing model which incorporates relative industry valuation prices options better than the standard Black-Scholes (1973) model.

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I. Introduction

Industry valuations vary month to month, sometimes greatly diverging from their time-series average. For example, the month end industry price-to-earnings (P/E) ratio for software firms in May 1997 were 44, but the historical five year moving average at that time was 31. Although, by March of 2001, the industry wide P/E ratio dropped to 25 while the five year moving average was 44. Many studies examine the relation between P/E ratios and stock pricing. However, the option pricing models described in literature assume that these variations in relative valuations have no impact on the option prices. In this study we ask the question: "Will option buyers adjust the premium they pay when the industry valuation deviates from the historical average?" If the industry level valuation is significantly different from the historical level, would investors believe that the prices would regress back to historical levels. Thus, if the prevailing industry valuation is 42% greater than the historical average, would the market participants believe the stock values in the industry have a tendency to decrease? If so, how would they protect their investments? Conversely, if the current valuation level is 43% lower than the historical average, would the market participants expect the values to increase. And if so, could they take advantage of the expected price movements? We contribute to the existing literature by demonstrating the relative industry price-to-earnings ratio Granger causes put-call parity deviations in the options market and presenting a model which incorporates the P/E ratio into the option price. The evidence from the model calibration is consistent with P/E ratio being priced by option investors.

There is voluminous literature showing P/E ratios are useful in valuing stocks. Basu (1977, 1983) directly shows that firms with low price to earnings ratio outperform firms with high price to earnings ratio. Lie and Lie (2002) demonstrate that pricing multiples are important in valuing firms. Liu, Nissim and Thomas (2002, 2007) find that the price to earnings ratio is the most important pricing multiple tool in assessing the value of the firm, even more so than multiples based on cash flows measures or dividends. Yee (2004) observes the discounted cash flow valuation method to be extremely noisy, and suggests analysts incorporate P/E ratios in their final valuation calculations for better precision. Chua (2013) shows that investment bankers price IPOs partially due to the historical price to earnings ratio. The use of P/E valuations is not limited to financial industry professionals. For example, Doran and Wright (2010) indicate that Finance professors, despite having extensive knowledge of market anomalies, trading strategies, and varieties of stock valuation methods, make investment decisions based largely on the price to earnings ratios. Alford (1992) shows that the industry membership is an important criterion in assessing firm value when using the price to earnings ratio, a result that is important in relation to our study. Thus, the price to earnings ratio is an important factor in determining the value of the stock. Regardless of the mechanism of price to earnings ratio's effect on the stock returns, there is little doubt in the literature that it does affect the future asset returns.

Based on Gordon (1962), the price to earnings ratio can be interpreted as:

$$\frac{P_o}{Y_o} = \frac{(1-b)}{k-br}, \tag{1}$$

where P_o is the current price, Y_o is the earnings, b is the retention rate, k is the cost of capital, and br is the earnings growth of the firm. This has been traditionally been interpreted as high (low) P/E is attributable to large (small) growth prospects, or br is large (small). Conversely, high (low) P/E ratios could have low (high) cost of capital, or where investors have high (low) risk tolerances: k is low (high). Thus, if the risk profile of the industry changes because of an event that is idiosyncratic to the industry, the P/E of industry firms would adjust accordingly. Thus, if the risk profile of an industry increases then decreases or vice versa, the industry P/E would mechanically revert back to the historical levels.

If large segments of investors (ranging from retail to professional) value stocks based on the price to earnings ratios, will the fluctuations of the price to earnings ratio affect the values of options? As Baker and Wurgler (2006, 2007) have shown, something as abstract as the investor sentiment is significantly correlated to the future returns of assets. Han (2008) shows that the investor sentiment described by Baker and Wurgler (2006, 2007) is indeed accounted for and priced in option premiums. Thus, it seems that option investors price in market conditions that may affect the future underlying asset price. Motivated by the literature demonstrating the effect of P/E ratio on stock prices, we examine the role of the price to earnings ratio and its overall effects on option prices.

Options traditionally have two main functions: first, as a protective hedge against a detrimental movement in asset prices, and second, as an instrument to leverage expected price movements (Black, 1975). If options traders price such information, then P/E ratios indicating stock or industry overvaluation (undervaluation) would cause puts (calls) to become expensive relative to calls (puts) as the traders act on this information. Many studies empirically show options have a predictive power over the future returns of the underlying asset. Typically, such studies focus on the Black and Scholes (1973) model (BSM) implied volatilities of the options as the predictor of future returns. For example, Doran, Peterson, and Tarrant (2007) find the implied volatility skew (or smirk, defined as the differences in implied volatilities of out-, at-, and in-the-money options) of S&P 100 options can predict market crashes and spikes. In the cross-section of stocks, Cremers and Weinbaum (2010) and Xing, Zhang, and Zhao (2010) document that the implied volatility spread (deviations in put-call parity) and skew (the slope of the implied volatility smirk), respectively, are predictive of the future equity returns.[1] Thus, through the examination of option implied volatilities, these studies demonstrate that option traders price information into options before it is priced into the underlying stocks. However, these studies do not attempt to examine the sources of stock return predictability.[2] Using Panel-VAR analysis, we find the industry scaled P/E ratio Granger-causes the implied volatility spread in firms' options, but not vice-versa.[3] We also demonstrate both P/E and implied volatility spread Granger-cause stock returns. These results suggest the information contained in deviations in the industry scaled P/E ratio is incorporated into options prices, as reflected in the deviations in put-call parity.

Further, we develop a closed form option pricing model that includes the relative industry valuations and test the relationship of the option prices with the deviation of P/E valuation with the historical averages. The framework of most of the studies in options derives its roots from the BSM. Underlying in these models the discounted processes fundamentally follow a martingale process by which the market participants do not predict the value of the underlying asset rather believe that the asset value follows a geometric Brownian motion. However, in many fields in Finance, there are many outside factors that are correlated to the returns of stocks. Bates (1991) shows that the option market predicted the 1987 market crash two months prior to the event. While Bates states that the option traders anticipated the crash, he does not discuss the

[1] For brevity, we do not provide a comprehensive list of studies on the predictive ability of options. However, DeLisle, Lee, and Mauck (2013) provide a thorough discussion of the related literature.

[2] In addition to stock return predictability, extant literature documents the options market's ability predict corporate events. For example, Patell and Wolfson (1981) investigate implied volatilities prior to earnings announcements, and find that their ex ante time series behavior is proportional to stock returns after the announcements. Levy and Yoder (1993), Jayaraman, Frye, and Sabherwal (2001), and Cao, Chen, and Griffin (2005) show how the options market can predict merger and acquisition announcements. Futher, Barone-Adesi, Brown, and Harlow (1994) demonstrate option-implied volatility can predict the success or failure of the proposed takeover. These findings imply that perhaps options traders are acting on private inside information. However, it is highly improbable option traders have continuous inside information across the entire universe of optionable stocks.

[3] We focus our tests on the Cremers and Weinbaum implied volatility spread, as Doran and Krieger (2010) find this measure to possess the most predictive power over future stock returns. However, in unreported results, we find qualitatively similar results with the implied volatility skew measure of Xing, Zhang and Zhao.

mechanism by which the option traders would be able to make such a prediction. Much of the current option pricing models expand on the standard BSM to include the price and volatility jumps. Bates (2000) shows that these expected jumps are priced into the value of the options, especially after the significant market crash of 1987. Pan (2002) shows that the jump risk premium is priced in the S&P 500 index options. Eraker (2004) develops a state-dependent correlated jump diffusion model where the volatility shocks and the price jumps are correlated. However, none of these models predict the direction of the price jump. In our model, the investors' expected direction of the price movement is directly related to the relationship between the current and historical P/E valuation. Thus, in the case of the software firm industry in May 1997, if the price movement is related to the level of industry overvaluation, will the correlated volatility shock be priced in due to industry overvaluation as well? The results from the calibration of our model are consistent with the notion that option traders consider the P/E ratio when valuing options. Taken collectively, the evidence from our analyses suggests the relative industry valuation is a significant driver in the pricing of options.

The rest of the paper is structured as follows: Section II discusses the data and methodology. Section III develops the closed form model we test. Section IV discusses the findings, and Section V concludes our study.

II. Data and Methodology

The option data for this study is obtained from OptionMetrics Ivy Database for the period from January 1996 through December 2011. Following conventions in the literature, we remove options with zero bid prices or open interest, bid-ask spread midpoints of less than \$0.125, and implied volatilities that are less than 0.03 or greater than 2. We also limit the sample to options with maturities in the range of 7 to 60 days and moneyness (defined as spot price divided by exercise price, *S*/*K*) between 0.8 and 1.2. Stock price valuation is obtained from CRSP. Balance sheet and income statement data are obtained from Compustat. Industry classifications are obtained from Kenneth French's website.[4] At each month end, we collect the previous four quarters' net income for every firm on Compustat. If the sum of the previous four quarters' net income is less than zero then the firm is dropped. Additionally, if the month end per share price of the firm is below $5, the firm is also dropped. The firms are then sorted into the 49 Fama and French (1997) industries. The industry-specific market value weighted average price to earnings ratio is computed for each calendar month end. For each calendar month, the historical valuation is estimated as the five year average price to earnings ratios beginning with 6 months prior to the current month. Thus the scaled P/E ratio for the issue month is computed as:

$$Scaled\ P/E_{indus,T} = \frac{P/E_{indus,T}}{\frac{\sum_{t=7}^{66} P/E_{indus,T-t}}{60}}. \tag{2}$$

Since the literature demonstrates both *P/E* ratio and option traits (particularly implied volatility) can forecast stock returns, we wish to determine if options are achieving their stock return predictability by pricing in the *P/E* ratio information. For parsimony, in this analysis we use the put-call parity deviation measure constructed by Cremers and Weinbaum (2010) as the variable representing information contained in option prices. Doran and Krieger (2010) show this measure is superior in predicting stock returns to other realized and implied volatility measures such as those from Bali and Hovakimian (2009) and Xing, Zhang, and Zhao (2010). Cremers and Weinbaum (2010) start with the original put-call parity relation developed by Stoll (1969):

$$C - P = S - PV(K), \tag{3}$$

[4] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

where C and P are call and put prices, respectively, with the same expiration date, S is the spot price of the stock, $PV(\cdot)$ denotes the present value, and K is the exercise price (the same for both the call and put options). They then show that, if the BSM is used to price the options, this relation implies:

$$IV^{c} = IV^{p} \ , \tag{4}$$

where IV is the Black-Scholes implied volatility and c (p) denotes the call (put) option. Thus, put-call parity deviations can be measured by the differences in the implied volatility of the call and put options with the same maturity and exercise price. We follow Cremers and Weinbaum (2010) and at the end of each month on day t for each stock i with traded options we calculate the volatility spread (VS):

$$VS_{i,t} = IV_{i,t}^{c} - IV_{i,t}^{p} = \sum_{j=1}^{N_{i,t}} w_{j,t}^{i}(IV_{j,t}^{c} - IV_{j,t}^{p}), \tag{5}$$

where j denotes pairs of call and put options with the same maturities and exercise prices, there are $N_{i,t}$ pairs of options, and $w_{j,t}^{i}$ indicates the weights computed from the average open interest in the call and put pair. Thus, a positive (negative) VS indicates calls (puts) are expensive relative to puts (calls).

Table 1 presents the summary statistics of the monthly stock returns (*Return*), the end of the month volatility spreads (*VS*), and the end-of-the month scaled price-to earnings ratios (*P/E*). Panel A shows that there are 56,500 monthly observations. The mean monthly return, *VS*, and *P/E*, respectively are 0.012 (120 basis points), -0.008, and 1.048. Panel B presents the correlations between *Return*, *VS*, and *P/E*, as well as the correlations of their lags of up to two months.

In order to investigate the relation between *P/E* and *VS*, we estimate a panel VAR using system GMM methodology used by Love and Zicchino (2006), which allows for firm heterogeneity and overcomes the restriction that each cross-sectional unit has the same underlying structure. We specify a second-order VAR model as:

$$x_{i,t} = \mu + \sum_{j=1}^{2} \beta_j x_{i,t-j} + f_i + e_t, \tag{6}$$

where x_t denotes a vector of firm-level variables including month-end *VS*, *P/E*, and/or monthly stock returns (*Return*), f_i represents firm fixed effects, and e_t are the residuals. We then test the null hypothesis that, with VS_t as the dependent variable, the estimated coefficients of P/E_t are zero (i.e., $\beta_{j,P/E}$ = 0 for all j). If the null is rejected, then P/E_t Granger-causes VS_t. Similarly, we can test if VS_t Granger-causes P/E_t. In addition, we can test the cumulative affect (i.e., $\sum_{j=1}^{2} \beta_j$ = 0 for all j) to see if the overall effect is in the expected direction. In this circumstance, if P/E_t Granger-causes VS_t, we hypothesize that overall effect will be negative, as undervaluation (overvaluation) as displayed by the *P/E* should increase (decrease) the volatility spread. The rationale being that option traders with information indicating stock undervaluation (overvaluation) expect the underlying stock price to increase (decrease) and drive the price of calls (puts) up relative to puts (calls).

III. Panel-VAR Results

Table 2 presents the results from various specifications of the base panel-VAR model. Panel A displays the results from using only *VS* and *Return* in a bivariate model. These results demonstrate that the implied volatility spread Granger-causes returns at the monthly level, and in a positive manner (e.g., higher *VS* causes higher future *Return*). This time-series based result is consistent with the portfolio-style analysis results by Cremers and Weinbaum (2010), who show *VS* is predictive of future stock returns. However, we additionally show that *Return* also Granger-cause *VS*, and in a negative way. Thus, as returns get very high (low), future *VS* decreases (increases). This result suggests the options market consists of contrarian, and not momentum, traders.

Panel B presents the results from a bivariate model with industry-scaled *P/E* and *VS*. *P/E* strongly Granger-causes *VS* (p-value<0.0000) and, as predicted by our hypothesis, the cumulative effect of *P/E* on *VS* is negative. There is no evidence that *VS* Granger-causes *P/E*, thus the effect only goes in one direction. Panel C extends the model in Panel B to a trivariate model, and includes *Return*. The results show that *P/E* and *Return* Granger-cause *VS*, and both have negative impacts on *VS*. Both *VS* and *P/E* Granger-cause *Return* (p-value<0.000 and p-value=0.0759, respectively), but the cumulative effects of each are not statistically significant. Neither *VS* nor *Return* Granger-cause *P/E*. These results suggest that investors take *P/E* into account when pricing options, and, thus, encourage the evaluation of an option pricing model which incorporates *P/E*.

IV. Option Pricing Model with *P/E*

The Granger causality evidence from the panel-VAR analyses suggests the industry-scaled P/E is not affected by past stock or option prices, but past industry-scaled P/E affects both current stock and options prices. This is consistent with the notion that, not only do investors use P/E to value stocks (Basu 1977, 1983; Lie and Lie 2002; Liu et al. 2002, 2007; Doran and Wright 2010), but they also use P/E to value options. Thus, since this study focuses on the relationship of the relative valuation and the option prices, we develop a model that relates the observed option prices with the expected price movement due to the relative industry valuation. The model is closely related to the Gibson and Schwartz (1990) model, which prices the contingent claim of oil with convenience yield.

We denote that $X_t = \ln(S_t)$ and $Y_t = \ln(Scaled\ P/E_{indus,t})$, where S_t is the stock price at time t. Our basic assumption is that the price process is described by the following Stochastic Differential Equation:

$$dX_t = \alpha(\beta - Y_t)dt + \sigma dW_t, \tag{7}$$

$$dY_t = a(b - Y_t)dt + kdB_t, \tag{8}$$

$$dX_t dB_t = \varrho dt, \tag{9}$$

where α is the speed of adjustment of the stock price to historical industry P/E levels, a is the expected speed of adjustment to historical P/E levels priced in to the option value, β is the risk free rate, σ is the volatility of the underlying stock, k is the volatility of the Scaled Industry P/E, ϱ is the correlation between the underlying stock, the Scaled Industry P/E. b is the value that $\ln(Scaled\ P/E_{indus,t})$ is expected to drift toward, dWt and dBt are standard Brownian motion increments. Since the paper hypothesizes that the investors expect the option prices to adjust to historical values, then b is expected to be zero.

By redefining:

$$\delta(t) = \alpha Y_t, \tag{10}$$

we can see that this model is similar to the Gibson-Schwartz (1990) model, where:

$$dX_t = (\alpha\beta - \delta_t)dt + \sigma dW_t, \tag{11}$$

$$d\delta_t = a(\alpha b - \delta_t)dt + k\alpha dB_t. \tag{12}$$

Compare this with the results from Bjerksund (1991), we have:

$$e^{-rt}E[S_t|\mathcal{F}_t] \ = \ S_t \exp\ [-\frac{1}{a}\delta_t(1-\theta) + A\left(\tau - \frac{1-\theta}{a}\right) + \frac{\alpha^2}{4a^3}(1-\theta^2)], \tag{13}$$

where:

$$A = -\alpha b - \varrho\sigma\frac{k\alpha}{a} + \frac{1}{2}\frac{\alpha^2}{a^2}, \tag{14}$$

$$\theta = e^{-a\tau}, \tag{15}$$

$$\tau = T - t. \tag{16}$$

Thus, the futures price is:

$$F_{t,T} = E[S_t|\mathcal{F}_t]. \tag{17}$$

The European Call Option is modeled as:

$$C(S_t, Y_t) = e^{-r\tau}E[(S_t - K)^+|\mathcal{F}_t] = e^{-r\tau}E[S_t|\mathcal{F}_t]N(d_1) - e^{-r\tau}KN(d_2), \tag{18}$$

where:

$$d_1 = \frac{ln\frac{E[S_t|\mathcal{F}_t]}{K} + \frac{1}{2}\hat{\sigma}^2}{\hat{\sigma}}, \tag{19}$$

$$d_2 = \frac{ln\frac{E[S_t|\mathcal{F}_t]}{K} - \frac{1}{2}\hat{\sigma}^2}{\hat{\sigma}}, \tag{20}$$

$$\hat{\sigma}^2 = \left(\sigma^2 - \frac{2}{a}k\alpha\sigma\varrho + \frac{k^2\alpha^2}{a^2}\right)\tau + 2\left(\frac{k\alpha\sigma\varrho}{a^2} - \frac{k^2\alpha^2}{a^3}\right)(1-\theta) + \frac{k^2\alpha^2}{2a^3}(1-\theta^2), \tag{21}$$

$$r = \alpha\beta + \frac{1}{2}\hat{\sigma}^2. \tag{22}$$

Similarly, the European Put Option is modeled as:

$$P(S_t, Y_t) = e^{-r\tau}E[(K - S_t)^+|\mathcal{F}_t] = -e^{-r\tau}E[S_t|\mathcal{F}_t]N(-d_1) + e^{-r\tau}KN(-d_2). \tag{23}$$

IV. Model performance

A. Model fitting

The parameters of the model were calibrated using the least squares method. Option prices with missing implied volatilities are dropped from the sample. In order to be consistent with the Panel VAR regressions, the sample was limited to the options where the time to maturity was less than sixty days. Options traded from 1996 to 2010 were included in the calibration. The last trading day for each month was included for the sample. For each calendar month, the volatility of each stock is estimated using the previous five years. Also, for each calendar month, the volatility of the Scaled Industry *P/E* ratio is estimated using the previous five years. The correlation between the each individual stock and Scaled Industry *P/E* is also estimated using the previous five years. Since the model has two explicit forms, the sample was separated into the call and put options.

Table 3 shows the results of the calibration of the parameters of the model. Panel A highlights only the call options. The parameter “a” in the model shows the expected speed of adjustment of the model. The calibrated parameter is 7518.2, and this shows that the investors price the call option with the expectation that the industry *P/E* ratio will converge to the mean ratio very quickly. However, the coefficient for the parameter “b” is estimated to be .0005. The parameter α is 8.87, which shows that the call options are priced with the expectations that the stock price will converge to the historical industry P/E. Thus, it seems that the investors price the call options with the expectations that the industry *P/E* will converge quickly to the historical mean. This finding suggests that investors price the call options with the belief that the industry value converge to the historical average *P/E*.

In Panel B we examine the results of the model calibration for the put options. We find that the parameter "a" is calibrated to .0493. Thus, it seems that the speed of adjustment for the put options is lower. Also, the investors seem to price the put option will continually decrease. The calibrated value for "b" is -221.8. It seems that investors price the put options with the expectation the industry P/E will decrease. This is consistent with the hypothesis that the investors purchase put options as a hedge against downward movement. The parameter α is -.01, which shows that the put options are priced with the expectations that the stock price will move away from the historical industry P/E, though the magnitude is small. Additionally, consistent with the model, the investors increase the premium paid for the put option with the increase in the Scaled Industry P/E.

B. In-sample test

We test the in-sample pricing errors of the model. We examine the results in Table 4. In order to calculate the Squared Error, the predicted value of each option is calculated based on the calibrated parameters. The Squared Error of the model is computed as:

$$Squared\ Error_{model} = (\hat{p}_{i,model} - p_i)^2 \ , \tag{24}$$

where $\hat{p}_{i,model}$ is the predicted option value based on our Scaled Industry P/E model and p_i is the actual premium of the option. The Squared Error based on the Black-Scholes model is likewise computed. The historical volatility is used to compute the estimated premium for the Black-Scholes model. The implied volatility is specifically not used because the implied volatility is the value which specifically fits the Black-Scholes model.

In Panel A, we examine the goodness of fit of the call options. The mean squared error for the two factor model is 1.45 and the mean squared error for the Black-Scholes model is 1.51. This model which prices the industry level P/E into account is significantly better at pricing the options. The mean squared error is 4 percent lower for the two factor model. When the root mean squared is computed as:

$$Root\ Mean\ Squared\ Error_{model} = \sqrt{\frac{\sum_{i=1}^{N}(\hat{p}_{i,model} - p_i)^2}{N}} \tag{25}$$

This implies that the root mean square for the model is lower by $.027.

In Panel B, we examine the goodness of fit for the put options. We find that the mean squared error is 1.22 for the two factor model and 1.35 for the Black-Scholes model. This represents a decrease in the squared error of 9.4 percent. This also implies that the root mean square for the model is lower by $.056. These decreases in pricing error are significant statistically as well as economically. We demonstrate that including the relative industry P/E, the model is a better predictor of observed option premiums relative to the Black-Scholes model.

Also, the decrease in the Mean Squared Error is lower with the put model relative to the call model. This implies that the ability of the model to predict the price is better with the put options. It seems that the option investors may value the put options more extensively based on the historical industry P/E. This is expected because one of the main uses for options is as a hedge against downward movement and the high scaled industry valuation seems to increase the value of the hedge.

C. Out-of-sample test

We test the out-of-sample pricing errors of the model. For options traded in 2011, we selected the sub-sample with the same criteria: The implied volatility must not be missing and the maturity of the option must be within sixty days. We examine the results in Table 5. The Squared Error of the model and the Black-Scholes is computed similar to above.

In Panel A we examine the Mean Squared Errors of the call options for this model and the Black-Scholes model. We find that the mean of the Squared Error is 1.33 for our Scaled Industry P/E model and 1.41 for the Black-Scholes model. This represents a decrease of 5.5 percent of the Squared Error. This represents a decrease of $.034 in the root mean error. This is both statistically and economically significant in the pricing the value of the option. In Panel B, we limit the sample to the put options. We find that the mean of the Squared Error is 1.21 for the Scaled P/E model and 1.30 for the Black-Scholes model. The mean Squared Error is lower by 6.5%. Again, this represents a decrease of $.038 in the root mean error. This difference is both statistically and economically significant. We consistently find that the Scaled Industry P/E model is also significantly better at predicting the put option valuation. We again show that the option pricing model that incorporates the relative industry valuation more accurately predicts the prices observed.

Also, from the out-of-sample findings, the spread between the Scaled Industry P/E model and the Black-Scholes model is greater with the put options relative to the call options. This implies that the ability of the model to predict the price is better with the put options. It seems that the option investors do indeed value the put options more extensively based on the historical industry P/E.

V. Conclusion

Price-to-earnings ratio is an important metric in evaluating investment opportunities. Many studies, including Basu (1977, 1983), Lie and Lie (2002), Liu et al. (2002, 2007), Doran and Wright (2010) show that retail investors and other finance professionals use the P/E ratio to gauge investment opportunities. The P/E ratio has been traditionally been used to denote growth or value firms, where firms with high P/E are expected to have large growth opportunities. Conversely, the change in the P/E may be attributed to the change in the risk profile of the firm. Thus the firm specific P/E ratio in itself will be highly variable based on the changes of the firm's growth prospect and risk profile. These changes may be idiosyncratic or could be industry wide. And these industry-wide shocks will inherently affect the P/E of all firms in the industry. Thus, in this study we examine if the increase or decrease in industry level P/E is priced into the option premiums. We expect that the high (low) industry P/E relative to the historical level would prompt investors to expect that the price will decrease (increase). Thus, the option premiums will reflect the expected price movements of investors.

We examine the effects of the scaled industry-wide P/E in two ways: The skewness of the implied volatility spread and develop a model that incorporates the expected mean reversion of the industry level P/E. Consistent with the expectation, we find that the scaled industry P/E Granger causes the put-call parity deviation. Also consistent with the expectation, increases in scaled industry P/E Granger causes an increase in the implied volatility of the put option and a decrease in the implied volatility of the call option. This supports the notion that option investors price the scaled industry-wide P/E.

Additionally, we develop a model which prices the expectation of the industry P/E to revert to historical values. Based on the model calibration, the two factor option model is significantly better in modeling the observed option prices relative to the standard Black-Scholes model. Also, the model is better at predicting the put option relative to the call option. This highlights the use of the put option in hedging against the downward movement when the industry P/E increases above the historical mean.

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Table 1 - Summary statistics

Panel A of this table reports the summary statistics for the monthly stock returns (*Return*), the Cremers and Weinbaum (2010) measure of end-of-month implied volatility spread of the options (*VS*), and the end-of-month industry-scaled price-to-earnings ratios (*P/E*). Panel B reports the correlations between these measures and their one- and two-month lags. The data spans from January 1996 to December 2010.

Panel A: Summary Statistics

Variable	N	Mean	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	Maximum
Return	56500	0.012	0.106	-0.666	-0.042	0.010	0.063	1.468
VS	56500	-0.008	0.040	-1.106	-0.022	-0.007	0.007	1.252
P/E	56500	1.048	0.372	0.205	0.821	0.978	1.196	13.734

Panel B: Correlations

	Return (t=0)	*Return* (t=-1)	*Return* (t=-2)	*VS* (t=0)	*VS* (t=-1)	*VS* (t=-2)	*P/E* (t=0)	*P/E* (t=-1)	*P/E* (t=-2)
Return (t=0)	1								
Return (t=-1)	-0.0237	1							
Return (t=-2)	-0.0377	-0.0269	1						
VS (t=0)	-0.0799	-0.0199	-0.0103	1					
VS (t=-1)	0.0363	-0.0815	-0.0204	0.0533	1				
VS (t=-2)	-0.0149	0.0379	-0.0840	0.0399	0.0542	1			
P/E (t=0)	-0.0671	0.0589	0.0582	-0.0269	-0.0246	-0.0256	1		
P/E (t=-1)	0.0347	0.0660	0.0606	-0.0227	-0.0253	-0.0261	0.9343	1	
P/E (t=-2)	0.0361	-0.0381	0.0681	-0.0215	-0.0209	-0.0268	0.8684	0.9324	1

Table 2 - Granger causality tests

This table reports the results from panel-VAR analyses which are estimated using the GMM method of Love and Zicchino (2006). $Return_{i,t}$ is the monthly return of stock i in month t. $P/E_{i,t}$ is the industry-scaled price-to-earnings ratio for stock i in month t (Panels B and C). $VS_{i,t}$ is the Cremers and Weinbaum (2010) measure of implied volatility spread of the options on stock i at the end of month t. In each analysis, a chi-square test is performed to test the null hypothesis of $\beta_j = 0$ for $j = 1, 2$ (Granger causality test). Additionally, a chi-square test of cumulative significance ($\sum_{j=1}^{2}\beta_j = 0$) is performed to determine the overall impact on the dependent variable.

Panel A. *VS* and *Return*

$$Return_{i,t} = \mu + \sum_{j=1}^{2}\alpha_j Return_{i,t-j} + \sum_{j=1}^{2}\beta_j\, VS_{i,t-j}$$

H_0: $\beta_j = 0$ for j = 1, 2	χ^2 (2) = 49.76	p-value = 0.0000
H_0: $\sum_{j=1}^{2}\beta_j = 0$; sum = 0.1115	χ^2 (1) = 24.86	p-value = 0.0000

$$VS_{i,t} = \mu + \sum_{j=1}^{2}\alpha_j VS_{i,t-j} + \sum_{j=1}^{2}\beta_j\, Return_{i,t-j}$$

H_0: $\beta_j = 0$ for j = 1, 2	χ^2 (2) = 10.24	p-value = 0.0060
H_0: $\sum_{j=1}^{2}\beta_j = 0$; sum = -0.0056	χ^2 (1) = 7.72	p-value = 0.0054

Panel B. Industry scaled *P/E* and *VS*

$$VS_{i,t} = \mu + \sum_{j=1}^{2}\alpha_j VS_{i,t-j} + \sum_{j=1}^{2}\beta_j\, P/E_{i,t-j}$$

H_0: $\beta_j = 0$ for j = 1, 2	χ^2 (2) = 147.50	p-value = 0.0000
H_0: $\sum_{j=1}^{2}\beta_j = 0$; sum = -0.0146	χ^2 (1) = 147.27	p-value = 0.0000

$$P/E_{i,t} = \mu + \sum_{j=1}^{2}\alpha_j P/E_{i,t-j} + \sum_{j=1}^{2}\beta_j\, VS_{i,t-j}$$

H_0: $\beta_j = 0$ for j = 1, 2	χ^2 (2) = 1.84	p-value = 0.3987
H_0: $\sum_{j=1}^{2}\beta_j = 0$; sum = -0.0320	χ^2 (1) = 1.82	p-value = 0.1767

Panel C. Industry scaled *P/E*, *VS*, and *Return*

$$VS_{i,t} = \mu + \sum_{j=1}^{2}\alpha_j VS_{i,t-j} + \sum_{j=1}^{2}\beta_j\, P/E_{i,t-j} + \sum_{j=1}^{2}\gamma_j\, Return_{i,t-j}$$

H_0: $\beta_j = 0$ for j = 1, 2	χ^2 (2) = 135.26	p-value = 0.0000
H_0: $\sum_{j=1}^{2}\beta_j = 0$; sum = -0.0142	χ^2 (1) = 135.08	p-value = 0.0000
H_0: $\gamma_j = 0$ for j = 1, 2	χ^2 (2) = 7.83	p-value = 0.0200
H_0: $\sum_{j=1}^{2}\gamma_j = 0$; sum = -0.0046	χ^2 (1) = 4.53	p-value = 0.0333

$$P/E_{i,t} = \mu + \sum_{j=1}^{2} \alpha_j P/E_{i,t-j} + \sum_{j=1}^{2} \beta_j \, VS_{i,t-j} + \sum_{j=1}^{2} \gamma_j \, Return_{i,t-j}$$

H_0 : $\beta_j = 0$ for j = 1, 2	χ^2 (2) = 2.33	p-value = 0.3127
H_0 : $\sum_{j=1}^{2} \beta_j = 0$; sum = -0.0368	χ^2 (1) = 2.31	p-value = 0.1286
H_0 : $\gamma_j = 0$ for j = 1, 2	χ^2 (2) = 1.33	p-value = 0.5147
H_0 : $\sum_{j=1}^{2} \gamma_j = 0$; sum = -0.0098	χ^2 (1) = 0.61	p-value = 0.4366

$$Return_{i,t} = \mu + \sum_{j=1}^{2} \alpha_j Return_{i,t-j} + \sum_{j=1}^{2} \beta_j \, VS_{i,t-j} + \sum_{j=1}^{2} \gamma_j \, P/E_{i,t-j}$$

H_0 : $\beta_j = 0$ for j = 1, 2	χ^2 (2) = 33.23	p-value = 0.0000
H_0 : $\sum_{j=1}^{2} \beta_j = 0$; sum = 0.0321	χ^2 (1) = 1.93	p-value = 0.1645
H_0 : $\gamma_j = 0$ for j = 1, 2	χ^2 (2) = 5.16	p-value = 0.0759
H_0 : $\sum_{j=1}^{2} \gamma_j = 0$; sum = 0.0048	χ^2 (1) = 2.14	p-value = 0.1431

Table 3 - Option Model Calibration
This table reports the estimated parameters from calibrating the following models:
Call option value (Panel A):

$$C(S_t, Y_t) = e^{-r\tau}E[(S_t - K)^+|\mathcal{F}_t] = e^{-r\tau}E[S_t|\mathcal{F}_t]N(d_1) - e^{-r\tau}KN(d_2)$$

Put option value (Panel B):

$$P(S_t, Y_t) = e^{-r\tau}E[(K - S_t)^+|\mathcal{F}_t] = -e^{-r\tau}E[S_t|\mathcal{F}_t]N(-d_1) + e^{-r\tau}KN(-d_2)$$

where

$$d_1 = \frac{ln\frac{E[S_t|\mathcal{F}_t]}{K} + \frac{1}{2}\hat{\sigma}^2}{\hat{\sigma}}$$

$$d_2 = \frac{ln\frac{E[S_t|\mathcal{F}_t]}{K} - \frac{1}{2}\hat{\sigma}^2}{\hat{\sigma}}$$

$$\hat{\sigma}^2 = \left(\sigma^2 - \frac{2}{a}k\alpha\sigma\varrho + \frac{k^2\alpha^2}{a^2}\right)\tau + 2\left(\frac{k\alpha\sigma\varrho}{a^2} - \frac{k^2\alpha^2}{a^3}\right)(1-\theta) + \frac{k^2\alpha^2}{2a^3}(1-\theta^2)$$

$$r = \alpha\beta + \frac{1}{2}\hat{\sigma}^2$$

$$\theta = e^{-a\tau}$$

$$\tau = T - t$$

and a is the expected speed of adjustment to historical P/E levels priced in to the option value, β is the risk free rate, σ is the volatility of the underlying stock, k is the volatility of the Scaled Industry P/E, ϱ is the correlation between the underlying stock and the Scaled Industry P/E. b is the value that ln $(Scaled\ P/E_{indus,t})$ is expected to drift toward.

Panel A: Call Option Model		
Parameter	Estimate	Standard error
a	7518.20	279.800
α	8.8711	0.0347
b	0.0005	0.0000

Panel B: Put Option Model		
Parameter	Estimate	Standard error
a	0.0493	0.00346
α	-0.0103	0.000660
b	-221.80	52.9301

Table 4 - In-Sample Option Model Goodness of Fit

This table reports the mean squared errors from the proposed models and those from the Black-Scholes (1973) model. Predicted values were obtained by using in-sample data used for calibrating the proposed model (January 1996 - December 2010). Panel A reports the mean and median squared errors from both call options models, as well as a t-test of the difference in means and a Wilcoxon signed rank test of difference in medians. Panel B reports similar results from the put option models.

Panel A: Call Option				
Model	N	Mean	Standard Error	Median
Scaled Industry P/E	1611245	1.448	0.019	0.0697
Black-Scholes	1611334	1.514	0.020	0.0598
	t-test	(0.000)	Signed Rank	(0.000)

Panel B: Put Option				
Model	N	Mean	Standard Error	Median
Scaled Industry P/E	1437853	1.221	0.014	0.0728
Black-Scholes	1437930	1.347	0.016	0.0693
	t-test	(0.000)	Signed Rank	(0.000)

Table 5 - Out-of-Sample Option Model Goodness of Fit

This table reports the mean squared errors from the proposed models and those from the Black-Scholes (1973) model. Predicted values were obtained by using out-of-sample data (January 2011 - December 2011) from that used for calibrating the proposed model (January 1996 - December 2010). Panel A reports the mean and median squared errors from both call options models, as well as a t-test of the difference in means and a Wilcoxon signed rank test of difference in medians. Panel B reports similar results from the put option models.

Panel A: Call Option				
Model	N	Mean	Standard Error	Median
Scaled Industry P/E	105887	1.332	0.024	0.0728
Black-Scholes	105888	1.410	0.025	0.0778
	t-test	(0.000)	Signed Rank	(0.000)

Panel B: Put Option				
Model	N	Mean	Standard Error	Median
Scaled Industry P/E	104215	1.213	0.023	0.0564
Black-Scholes	104216	1.297	0.024	0.0586
	t-test	(0.000)	Signed Rank	(0.000)