Fundamental Capital Valuation for IT Companies: A Real Options Approach

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Abstract

This study attempts to estimate the fundamental capital value of a growing firm by combining two separate capital valuation techniques, namely the corporate debt valuation of Merton (1974) and the rational pricing technique of internet companies of Schwartz and Moon (2000). For simplicity, the Black and Scholes (1973) approach is used to infer an estimate of the value of the debt of the firm, while the valuation technique of Schwartz and Moon (2000) has been used to estimate the total value of the firm. Making use of the fact that firm value is a function of the value of debt and equity, we first derive a closed-form solution for the value of the debt and then estimate the implied fundamental equity values for sample firms in the information technology sector, and show how the share prices are either undervalued or overvalued. Inferences on the risk premium on the debt are also provided.

Keywords : Fundamental valuation, Real options, Monte Carlo simulation
JEL Classification : G3, G12, G31, M13, M41

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1 - Introduction

The valuation of firms in the field of Information Technology (IT from here on) is an important issue in finance because companies in this line of business often do not show any earnings in their early years and thus render traditional valuation techniques that rely on past and recent free cash flows nearly useless. The challenges associated with the pricing of young IT firms were never made more obvious than during the late nineties where companies such as Amazon and Yahoo were trading at such high price levels that investors were considered "irrational" and the term "internet bubble" was coined. Although some market correction took place in 2000 where many information technology firms returned to more reasonable price levels, the finance community has since then strived to reach a better understanding of how to value corporations with little financial history and negative free cash flows.

Various explanations and fixes have been proposed in order to reconcile finance theory with seemingly outrageous observed firm prices. Faugere and Shawky (2000) develop a valuation formula for high-growth firms using the stages of an industry lifecycle. The model is able to handle low or even negative earnings combined with low sales in the early stages of the firm's development, but is applicable mostly to small size firms and does not account for the probability of bankruptcy. Berk, Green and Naik (1999) use a stochastic investment process to model the cash flow of the firm, but their model does not readily lend itself to the valuation of individual firms. Damodaran (2000) provides some ways to deal with various issues such as negative earnings as well as the absence of historical data or of comparable firms. Rice and Tarhouni (2003) point out that one only needs to disentangle the revenue growth rate from the cost growth rate in order to explain the price levels and dynamics of most information technology start-ups. Boner (2004) adopts the Schwartz and Moon

(2000) real option simulation method to study *Amazon.com* but is unable to match the company's market capitalization value.

Real options are often associated with the pricing of concerns considered having significant growth opportunities and therefore usually tend to be involved with the valuation of high-tech firms such as electronics and pharmaceutical companies. Lint and Pennings (2001) demonstrate how real options are able to capture the value of the flexibility present at each stage of a new product development. Banerjee (2003) shows how valuation by real options of the R&D component of a pharmaceutical company can help account for a high market price otherwise unexplained by more traditional valuation tools.

In this paper we propose to use the concept of options at two levels. First, we implement and apply Schwartz and Moon (2000)'s real option simulation methodology to six IT firms to derive the total value of each of these firms. The methodology is deemed to be a real option one because it applies the stochastic processes in the valuation mode which automatically considers the intertemporal nature of revenues and costs. Furthermore, since the value of the firm never falls below zero (thanks to the limited liability feature) the resulting spectrum of payoff (total firm value) displays an asymmetry analogous to that found in the payoffs of a call option. The limited downside can, for instance, be interpreted as the option to get out without cost should things go awry. We use Merton (1974)'s risky bond pricing technique to estimate the value of the debt, as only the face value is observable. The advantage of this approach is that one does not have to assume that all debt is convertible and gets converted "at the end", as it has been done in some of the references mentioned above. Armed with these two elements, we are then able to infer the firm's equity value as the difference between the total firm value and the debt value. Despite the common perception that IT firms are often not worth their share price, our results show that two of the IT firms studied are actually undervalued while the rest of them remain overvalued. Note that in our implementation of Schwartz and Moon (2000) we have extended the model by allowing for stochastic volatility of percentage revenue changes, adding to the uncertainty associated with the stream of cash inflows and thus permitting even greater terminal firm value.

We also study the debt characteristics of these firms, and since observing the current market value of the debt is a challenge[1], we are unable to estimate whether the debt itself is over- or undervalued. Instead, we focus on the risk premiums associated with the bonds. Under the assumption that the firm's debt can be expressed as a zero-coupon bond, we find that two of the firms have debt with fundamental risk premiums close to 0% and for the rest, ranging from 0.1% to 1.87%. In other words, the first two are close to the risk-free rate while the other four seem to be a bit riskier but still at reasonably low levels.

The paper is organized as follows. Section II describes our real option approach including the simulation and the stochastic modeling. In Section III we describe the procedure used for data collection. In Section IV the valuation techniques are described to estimate the fundamental value of the firms' debt and equity and empirical results are discussed. We conclude this paper with a brief summary and some observations in Section V.

2 – The Real Options Approach

Applying real option theory to both debt and equity, we are able to estimate the fundamental values of the firm as well as its debt. We then find the fundamental value of the equity by taking the difference between these two values. In doing so, we essentially combine two separate capital valuation techniques: the corporate debt valuation of Merton (1974) and the rational pricing technique of internet companies by Schwartz and Moon (2000). The Black and Scholes (1973) approach as used by Merton (1974), is used to obtain an estimate of the fundamental value of the debt, and the valuation methodology of Schwartz and Moon (2000) is used to estimate the fundamental value of the firm. While traditional models are subject to somewhat unrealistic restrictions[2] due to their simplicity, our approach allows for more realistic variable states using stochastic modeling. Unlike the traditional methods that require constant estimated parameters, our method depends on the intertemporal evolution of the parameter since future states are dependent on the path taken by the simulation. Some of the limitations imposed by traditional methods are therefore avoided. For the valuation of young IT companies that are experiencing significant changes in their operations, the more flexible approach is preferred.

Fundamental firm value

Even though the methodology proposed by Schwartz and Moon (2000) is of great help in estimating the true value of a firm in a stochastic environment, the drawback of the methodology, however, is the large number of parameters that must be estimated prior to the implementation of the Monte Carlo simulation. Therefore, for tractability purposes, we make a few simplifying assumptions which will enable us to reduce the number of parameters.

The key aspect of the internet company valuation method is the use of a risk-neutral discounted cash flow analysis to derive the value of the firm. The present value of the firm is the sum of the after-tax expected cash flows under the risk-neutral measure, discounted back to the present at the risk-free rate. The value today is therefore:

$$X_0 = E^*(TCF_T e^{-rT}) \tag{1}$$

where X_0 is the present value of the firm at time 0, TCF_T is the total after-tax expected cash flow accumulated up to time T, r is the risk-free rate and E^* is the risk-adjusted expectation operator. Following Schwartz and Moon (2000), we assume that all cash flows generated are kept as retained earnings, earn a rate of return equal to the risk-free rate and are distributed to the shareholders at a long-term horizon T. The liquidation value of the firm TCF_T is calculated as the total expected cash flows accumulated up to time T plus a multiple of EBITDA at time T. This implies that when the firm is liquidated at time T, the terminal value of the firm is assumed to be a multiple of EBITDA. We select the same multiple (10 times) as Schwartz and Moon (2000)[3]. Earnings are driven by revenues which are generated according to the following stochastic differential equations under the risk-neutral measure[4]:

$$\frac{dR_t}{R_t} = (g_t - \lambda\sqrt{V_t})dt + \sqrt{V_t}\, dW_{1t} \tag{2}$$

$$d\log V_t = \kappa\,(\log V^M - \log V_t)dt + \varphi_1 dW_{2t} \tag{3}$$

$$dg_t = \kappa\,(g^M - g_t)dt + \varphi_2 dW_{3t} \qquad (4)$$

$$d\varphi_2 = -\kappa\varphi_2 dt \qquad (5)$$

where R_t is the revenue, the drift g_t is the expected growth rate on revenues, λ is the price of risk, V_t is a volatility of the percentage change on revenue, and W_t is a standard wiener process. V_t and g_t follow a mean-reverting process. Unlike Schwartz and Moon (2000), V_t in our model is assumed to be a stochastic volatility. Figure 1 indicates that all the sample firms have time-varying stochastic volatilities on revenue growth. Since V_t is directly involved in revenue process, it is certain that the stochastic volatility assumption has an important impact in our valuation. V^M and g^M are the long-term average volatility and growth rate respectively and κ is the speed of mean-reversion. The volatility φ_1 of the change in V_t is assumed to be constant and the volatility φ_2 of the change in the growth rate is assumed to decrease along with a deterministic path because in the long-run, the growth rate is expected to be stable. As Schwartz and Moon (2000) do, we assume that all the processes other than the revenue process are uncorrelated with aggregate wealth, implying that the market price of risk associated with these processes is null and that all the Wiener processes are independent of each other. The net after-tax income N_t can be written as follows:

$$N_t = \Pr etax\ Income_t \qquad if\ \ LC_{t-1} > \Pr etax\ Income_t \qquad (6)$$

$$N_t = \Pr etax\ Income_t(1-Tc) + Tc \bullet LC_{t-1} \quad if\ \ \Pr etax_t Income_t > LC_{t-1}$$

where LC_t is the loss carry-forward, and Tc represents the corporate tax rate. The dynamics of the loss carry-forward, LC_t, are described by

$$dLC_t = Max(-M_t dt, 0) \quad \text{If} \quad LC_t = 0 \qquad (7)$$
$$dLC_t = -M_t dt \quad \text{if} \quad LC_t > 0$$

where M_t is the pretax income. We assume that the total cost is proportional to revenue in the same way as Schwartz and Moon (2000). We however propose a different method for estimating the total cost as a percentage of revenue. The ratio of the total cost to revenue can be described as the following stochastic differential equation.

$$d\alpha_t = \kappa\,(\alpha^M - \alpha_t)dt + \varphi_3 dW_{4t} \qquad (8)$$

where α_t is the ratio process, α^M is the long-run average ratio, φ_3 is the volatility of change in the ratio, and κ is the speed of adjustment. The mean-reverting process for the ratio is reasonable because in the long run, the earning margin associated with this ratio is expected to be stable. The most important benefit from using this stochastic ratio process is that we are able to overcome a critical issue of Schwartz and Moon's (2000) valuation approach. .For example, Schwartz and Moon (2000) assume that the ratio is constant; therefore the ratio may be estimated from past data as being greater than 1, implying that the firm always has negative earnings[5]. Letting the ratio in our model evolves stochastically provides a solution to this problem. That is, with proper estimates for α^M and φ_3, even though as a starting value, the ratio may be greater than 1, it will revert to the long-run average that stays well below 1. In order to conduct the simulation, we transform the continuous-time processes of equation (2) through (8) into discrete-time.. Since all the state variables are path-dependent, we approximately obtain the risk-adjusted discrete-time versions of equation (2) through (8) as follows:

$$R_{t+\Delta t} = R_t e^{(g_t - \lambda \sqrt{V_t} - 0.5V_t) + \sqrt{V_t}\varepsilon_1} \tag{9}$$

$$\log V_{t+\Delta t} = \log V^M (1-e^{-\kappa}) + e^{-\kappa} \log V_t + \varphi_1 \sqrt{\frac{1-e^{-2\kappa}}{2\kappa}}\,\varepsilon_2 \tag{10}$$

$$g_{t+\Delta t} = g^M (1-e^{-\kappa}) + e^{-\kappa} g_t + \varphi_{2,t+\Delta t} \sqrt{\frac{1-e^{-2\kappa}}{2\kappa}}\,\varepsilon_3 \tag{11}$$

$$\varphi_{2,t+\Delta t} = \varphi_0 e^{-\kappa t} \tag{12}$$

$$\alpha_{t+\Delta t} = \alpha^M (1-e^{-\kappa}) + e^{-\kappa} \alpha_t + \varphi_3 \sqrt{\frac{1-e^{-2\kappa}}{2\kappa}}\,\varepsilon_4 \tag{13}$$

where ε follows the standard normal distribution[6]. Although the number of parameters to be estimated is not small, we can estimate these parameters under reasonable assumptions. Finally, the true value of the firm is estimated by equation (1) using a Monte Carlo simulation and the fact that the total expected cash flows accumulated up to the future long-term horizon, T are:

$$TCF_T = e^{r\Delta t} TCF_{T-\Delta t} + N_T + Dp + 10EBITDA_T \tag{14}$$

where Dp is a depreciation expense.

Fundamental debt and equity value (a closed-form solution)

We derive the fundamental value of the firm's debt using a method proposed by Merton (1974). A zero-return portfolio is constructed and the resulting partial differential equation is solved in order to obtain a closed-form solution for the fundamental debt value. Then, since the fundamental firm value X is the sum of the fundamental values equity E and debt D, the fundamental equity value can be recovered by taking the difference X-D. Assuming perfect market conditions and a known term structure, the continuous-time dynamics for the value of the firm can be expressed by the following stochastic differential equation:

$$dX_t = (\mu X_t - \theta_s - \theta_d)dt + \sigma X dW_t \tag{15}$$

where X is the total value of the firm, μ is the instantaneous expected rate of return on the value of the firm per unit of time, θ_s and θ_d are, respectively, the payouts per unit of time by the firm to equity-holders and debt-holders, σ is the volatility of the value of the firm per unit of time, and dW_t is a standard wiener process. Note that to keep the model tractable the volatility σ is assumed constant over time.

We now let H=B(X, t) where B(X, t) is the market value of the debt and a function of the value of the firm and time. Since H is assumed to be affected by a single factor, X, the dynamics of H can be given by

$$dH_t = (\mu_H H_t - \theta_d)dt + \sigma_H H dW_{tH} \tag{16}$$

where the drift μ_H is the instantaneous expected rate of return on H, σ_H is the instantaneous standard deviation of H, and dW_{tH} is a standard wiener process. From equation (15) and (16), using the valuation technique of Merton (1974), we obtain the following partial differential equation:

$$\frac{1}{2} B_{XX} \sigma^2 X^2 + B_X (rX - \theta_S - \theta_d) + B_t + \theta_d - r\, B = 0 \tag{17}$$

where r is a risk-free rate.

This partial differential equation must be satisfied by the market value function of the debt B(X, t). Now, suppose that F is the promised payment to the debt-holders at the maturity. As long as the market value of the firm, X, is larger than F, the firm will pay F to the debt-holders at maturity. If X is smaller than F, however, the firm will go bankrupt and the debt-holders will receive X only. This can be summarized by:

$$If\ \ X>F, \qquad B=F$$
$$If\ \ X<F, \qquad B=X$$

From these conditions, the boundary condition B(X, T) = Min[X, F] can be set for the maturity date T. The other boundary condition is immediately obtained from the non-negativity of the debt. At any time t, B(0, t) = 0. By using these two conditions and under the assumption that θ_s and θ_d are sufficiently small relative to X, if we let $\Delta = (\theta_s + \theta_d)/X$, we obtain the following closed form[7]:

$$B(X,t) = Fe^{-r(T-t)} - [Fe^{-r(T-t)}\Phi(d_2) - Xe^{-\Delta(T-t)}\Phi(d_1)] + (1-e^{-r(T-t)})\,\frac{\theta_d}{r} \qquad (18)$$

$$d_1 = \frac{-\ln(\frac{X}{F}) - (r-\Delta+\frac{1}{2}\sigma^2)(T-t)}{\sigma\sqrt{T-t}}$$

$$d_2 = d_1 + \sigma\sqrt{T-t}$$

where $\Phi(\cdot)$ is the standard cumulative normal distribution function. Since the firm value is closely related to the stock value, we use the standard deviation of stock returns as an estimate for σ. In equation (18), the fundamental debt value consists of three components. On the right hand side, the first term is the present value of a zero-coupon bond, the next bracketed term is the value of a put option, and the last term is associated with the present value of a coupon stream related to the remaining maturity. In other words, if the value of the firm X goes below the face value of the debt, stockholders will turn over all of the assets to the debt-holders. The last term on the right hand side collapses to the present value of a perpetuity when coupons are paid indefinitely. However, as maturity approaches zero, the last term converges to zero. Since we have assumed that all cash flows are held as retained earnings until the firm is liquidated, the payout to the stockholders θ_s is zero. The fundamental debt value therefore depends on θ_d: for example, if θ_d is equal to zero, B(X, t) will be the fundamental debt value for a zero-coupon bond and if θ_d is not equal to zero, B(X, t) will be the fundamental value for a coupon-bond.

We can now obtain the fundamental value of the equity by subtracting the fundamental debt value from equation (18) from the fundamental firm value. That is,:

$$E(X,t) = X - B(X,t) \tag{19}$$

where E(X,t) is the fundamental value of equity at time t given the fundamental firm value X.

Risk premium on risky debt

Our focus in this section is on the risk premium of the risky debt. Since firm retains all its earnings until liquidation, θ_s must be zero. We are thus left with θ_d as the only form of payout by the firm. Assuming continuous compounding and denoting respectively the yield-to-maturity on the risky bond and the discount function of the coupons by R and K(R), the value of the debt can be expressed as:

$$B(X,t) = F\ e^{-R(T-t)} + \theta_d K(R) \tag{20}$$

Rearranging equation (20) in terms of the risk premium yields

$$(R-r\ ) = -\frac{1}{T-t}\ln[\frac{Be^{r(T-t)} - \theta_d e^{r(T-t)}K(R)}{F}] \tag{21}$$

Note that in the case of a zero-coupon bond, θ_d is equal to zero and the risk premium can be directly obtained from equation (20). When coupons are present, however, solving for the risk premium entails defining a function

$$G(R) = (R-r) + \frac{1}{T-t}\ln[\frac{Be^{r(T-t)} - \theta_d e^{r(T-t)}K(R)}{F}] \tag{22}$$

and solving for the yield-to-maturity R numerically by finding its roots.

3 - The Data

We obtain a list of top 20 IT companies ranked by revenue level from the Washington Post. We begin by eliminating 8 firms because not all accounting data needed for the application of our valuation procedure were available for these companies. In addition, since our model is exclusively intended to be applied to those growing firms that have not reached the stable stage yet, we eliminate those seasoned companies that have reached a steady state. In our study, we detect that, on the average, it takes about 13 years for the firm in the IT sector to reach the stage of steady growth. Thus for our purpose we select only those firms that are in existence for ten years or less. This results in the selection of six companies in this study. They are, namely, BearingPoint Inc, EPlus Inc, Costar Group Inc, Online Resources Corp, SteelCloud Inc, and InteliData Technologies Corp.

All data needed are obtained from COMPUSTAT and 10-Q quarterly reports. Table 1 shows the range of data available from COMPUSTAT for each firm. Data for BearingPoint Inc are available from 1998 to 2003, for EPlus Inc from 1995 to 2003, for CoStar Group Inc from 1996 to 2003, for Online Resources Corp from 1997 to 2003, for SteelCloud Inc from 1996 to 2003 and the data for InteliData Technologies Corp from 1994 to 2003. We use quarterly data for valuation and a future long-term horizon of 25 years[8]. As mentioned earlier in this paper, we face some limitations when estimating the fundamental value of the debt. Since the debt characteristics are not always being described in detail in the 10-Q quarterly reports, we assume that all cash flows are the face values of risky bonds[9].

4 - Valuation

Fundamental firm value

In order to simulate the fundamental firm value, we need to have parameters and starting values estimated and collected. Under the assumption that the past is a reasonable predictor of the future, we use statistical measures such as mean, variance, and covariance from the past data. In addition, for the practical justification of our model, we use the estimates of the long-run variables obtained from using the data of a stable firm in the IT sector. As shown in Figure 2, since Computer Sciences Corp has the longest history in this sector, it is assumed to display the most stable profile for the revenue growth pattern. We thus select this firm as a stable firm. From Figure 2, it is observed that it took about 13 years (about 52 quarters) to reach the stable stage since the firm's inception. Table 2 and Table 3 report parameter description and estimated parameters respectively for the six firms. The values of R_0, CF_0, and LC_0 are directly observable from the 2003 10-Q quarterly reports. The starting growth rate g_0 is estimated as an average of the revenue growth over the most recent four quarters. Similarly g^M is estimated as an average of the revenue growth for the stable firm[10]. We calculate $\log V_0$ and $\log V^M$ respectively as the log variance of the revenue growth over recent four quarters for the firm under consideration and the log variance of the revenue growth for the stable firm. The interest expense[11] Dp,, and risk-free rates are estimated as averages calculated from the past data. Tax rate is obtained from the tax table. Based on the past historical pretax income of our sample firms, 35% tax rate is approximately reasonable. The speed adjustment parameter κ is estimated from the half life to reach the stable growth[12]. The volatility of the volatility process φ_1 is the estimated standard deviation of changes in the log variance of the revenue growth for the stable firm, and φ_0 is the standard deviation of changes in the revenue growth for the stable firm. The long-run average ratio α^M is obtained from regressing the stable firm's revenue on the stable firm's total expense and each firm's α_0 is estimated from the regression with recent four quarters' total expense and revenue. The volatility of the ratio process φ_3 is estimated as the standard deviation of changes in the quarterly ratio based on the past data for the stable firm. Lastly, λ is estimated as the product of the correlation and the market risk premium divided by the standard deviation of the market portfolio[13]. With estimated values and starting values displayed in table 3, we simulate 10,000 paths and use equations (9) through (14) to estimate the fundamental values of the six firms. In Table 4 we report the results. Since all annual data were obtained as of the fiscal year of each company, the fundamental value approximates the true value of companies as of the most recent fiscal year.

Sensitivity test

To conduct the sensitivity analysis we check the change in the firm value over 10% - increase in the value of all the estimated parameters. Since, however, the same percentage increase in α^M makes the long-run average ratio larger than one, we instead change the value of α^M and α_0 by only 1%. Table 5 shows that overall; the fundamental firm values estimated by our model are not that sensitive to changes in the value of parameters. The directions of the change in the firm value are almost consistent across all the sample firms. In general, we observe that five parameters such as $\log V^M$, φ_1, α^M, Dp, and r seem to have more impact on the firm value than the other parameters. Since $\log V^M$ and φ_1 are the parameters in the stochastic volatility process, the stochastic volatility assumption turns out to play an important role in our model as postulated earlier..

Fundamental debt value

We now estimate the fundamental debt value for each company using the procedure outlined in Section 2.However, although the 10-Q quarterly reports provide the face value of the various obligations to be paid at different maturities, they do not provide a detailed description of the debt characteristics. Moreover, equation (18) is on the basis of risky bonds only with one single maturity date. We therefore assume that all obligations can be expressed in terms of risky bonds and we calculate a face value-weighted duration to obtain an average maturity for all different debts. Then, based on the face value-weighted duration and the total face value, we estimate the fundamental debt value for a given coupon amount. Results are reported in Table 6 for seven cases with coupon rates going from 0 to 6 percent. Note that the risk premium is independent of the coupon rate therefore, for computational ease we use the zero-coupon case to infer the premium. Table 6 also shows that for a given face value, a higher coupon rate implies a higher fundamental debt value. While Online Resources Corp has premium bonds as the coupon rate increases, the rest of them have discount bonds across all seven cases. If various market debt values were observable directly, comparisons with their respective fundamental values could have been made and used for financing and investment purposes. However, since debt values are not directly observable, the main conclusion we can draw is that with the assumption of a zero-coupon, being judged by the fundamental risk premium, EPlus and InteliData Technologies seem to have the riskiest debts whereas Online Resources and Steel Cloud have obligations whose characteristics are close to that of riskless bonds.

Fundamental equity value

Since the equity value is the difference between firm value and debt value, we can now estimate the fundamental equity value of each company from the previous results. Table 7 reports fundamental equity values and corresponding share prices across all levels of coupon rates. Note that the fundamental stock price decreases with an increase in the coupon rate. The market price of a share of Bearing Point, Inc. at the end of 4th quarter/2003 was \$10.09 and the number of its outstanding shares was about 191 million. For all cases, its fundamental stock price falls between \$12 and \$14, which implies that its share price was undervalued by about 25%. The stock of EPlus Inc. was traded for \$15.60 and about 9 million shares were outstanding. Since for all cases, the fundamental stock prices are between \$21 and \$23, the market price as of 3rd quarter/2003 was undervalued by about 30%. A possible explanation for this is that many IT stocks have been steadily decreasing during the past few years and that as a result some might have actually gone below fair levels. InteliData Technologies Corp, Online Resources Corp, and Steel Cloud Inc have the fundamental stock prices that almost do not change for all seven cases and their market prices turn to be overvalued. Costar Group Inc shows the most extreme difference between the market price and the fundamental price. Its market price seems to be overvalued by about 480%. After all, four out of six IT firms turn to have the overestimated market prices, indicating that their persistently high share price may still be overestimating the value of the firm's equity.

5 - Conclusion

The valuation of Information Technology firms has been the subject of intense discussion since the stock market “bubble” of the 1990s. Most start-ups in the field of information technology tend to share common features: their early earnings are often negative, and their expected growth high but also possibly highly erratic. These characteristics make using traditional valuation tools difficult. In this paper we attempt to show that by incorporating (real) options in the valuation of both the total value of the firm as well as the market value of its debt one can explain even seemingly very large firm prices observed in the market.

We show how to estimate the fundamental market value of a growing IT corporation on the basis of two option-based valuation techniques. The corporate debt valuation of Merton (1974) is used in conjunction with the rational pricing technique of Schwartz and Moon (2000) as a way to determine the fairness of the share prices. Merton (1974) proposes to use a Black and Scholes (1973) type of reasoning by building a zero-return portfolio in order to derive an estimate of the value of the firm’s debt. This approach avoids does not have to make assumptions about the corporate debt being convertible and converted into stocks as it is done in Schwartz and Moon (2000). The methodology by Schwartz and Moon (2000) on how to value internet companies is otherwise used to estimate the total value of the IT firms selected. We also extend Schwartz and Moon (2000) by allowing for stochastic volatility of percentage revenue changes, permitting the derivation of possibly even higher company terminal values. We finally retrieve fundamental equity values by computing the difference X-D. Six firms from the Information Technology sector are selected and used for the empirical implementation of the method. After obtaining their theoretical prices we compare whether these theoretical prices are at the level of the market-observed ones. We find that even though the observed market prices remain moderately higher than the theoretical ones in four out of the six cases studied, our methodology is nevertheless able to produce theoretical firm values at least as high as the observed market values in two of the cases.

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Table 1
Data
In this table we provide the companies that have been valued in this study

Sample Firms	Range of Accounting Data
BearingPoint Inc	1st Qtr/1998 – 4th Qtr/2003
EPlus Inc	1st Qtr/1995 – 3rd Qtr/2003
Costar Group Inc	1st Qtr/1996 – 4th Qtr/2003
Online Resources Corp	1st Qtr/1997 – 4th Qtr/2003
SteelCloud Inc	1st Qtr/1996 – 4th Qtr/2003
InteliData Technologies Corp	1st Qtr/1994 – 4th Qtr/2003

Table 2
Parameter description.

Parameter	Description
R_0	The starting value of the revenue
CF_0	The starting value of the cash flow
LC_0	The starting value of the loss carry-forward
r	The risk-free rate
Dp	The depreciation cost
Int	The interest expense
Tc	The corporate tax rate
κ	The speed adjustment
λ	The price of risk
φ_0	The volatility of changes in the revenue growth
φ_1	The volatility of changes in the log variance of the revenue growth
φ_3	The volatility of changes in the ratio of the total cost to the revenue
α^M	The long-run average ratio
α_0	The starting value of the ratio
$\log V^M$	The long-run average log variance
$\log V_0$	The starting value of the log variance
g^M	The long-run average growth rate
g_0	The starting value of the growth rate

Table 3

Estimated Value of Parameters and Starting Values for Simulation

This table provides the estimated values of various parameters as well as the starting values for simulation. All parameters except for R0, CF0, LC0, Int, α0, logV0, and g0, are displayed in equation (6) through equation (14). Int which stands for interest expense is used to calculate the EBITDA, and LC0, R0, logV0, g0, α0, and CF0 are starting values for equation (6), (9), (10), (11), (13), and (14), respectively.

Parameter	Bearing Point Inc	EPlus Inc	Costar Group Inc	Online Resources Corp	Steel Cloud Inc	InteliData Technologies Corp
R0 (million)	780.135	79.801	25.27	9.722	9.031	4.362
CF0 (million)	105.198	26.846	35.643	7.65	8.099	7.603
LC0 (million)	188.9	0	0	88	32.6	0
r	0.01	0.01	0.01	0.01	0.01	0.01
Dp (million)	18.064	1.583	0.898	0.52	0.265	0.635
Int (million)	4.445	1.74	0	0.223	0.042	0.016
Tc	0.35	0.35	0.35	0.35	0.35	0.35
κ	0.049	0.082	0.069	0.058	0.069	0.116
λ	0.161	0.079	0.118	0.109	0.07	0.051
φ0	0.002	0.002	0.002	0.002	0.002	0.002
φ1	2.326	2.326	2.326	2.326	2.326	2.326
φ3	0.024	0.024	0.024	0.024	0.024	0.024
αM	0.95	0.95	0.95	0.95	0.95	0.95
α0	0.948	0.946	0.999	0.91	0.989	1.087
logVM	-5.244	-5.244	-5.244	-5.244	-5.244	-5.244
logV0	-5.222	-4.968	-9.527	-3.811	-1.888	-4.219
gM	0.019	0.019	0.019	0.019	0.019	0.019
g0	0.043	0.024	0.039	-0.02	-0.012	-0.1

Table 4
Fundamental Firm Value

In this table we report the fundament values as computed by the Monte Carlo simulation for the six companies in our study.

IT Company	Fundamental Firm Value
Bearing Point Inc (as of 4th Qtr/2003)	3145.20 million
EPlus Inc (as of 3rd Qtr/2003)	294.49 million
Costar Group Inc (as of 4th Qtr/2003)	151.67 million
Online Resources Corp (as of 4th Qtr/2003)	57.94 million
Steel Cloud Inc (as of 4th Qtr/2003)	36.55 million
InteliData Technologies Corp (as of 4th Qtr/2003)	51.64 million

Table 5

Sensitivity Analysis

We tested the sensitivity of the firm value over 10% increase in all the parameters except for α^M and α_0. Since the same change in α^M and α_0 does not make sense, we changed the value of these two parameters by only 1%. The positive sign implies the increase in the firm value in Table 3 while the negative sign does the opposite. All parameters except for Int, α_0, $\log V_0$, and g_0, are displayed in equation (6) through equation (14). Int which stands for interest expense is used to calculate the EBITDA, and $\log V_0$, g_0, and α_0 are starting values for equation (10), (11), and (13), respectively.

Parameter	Percentage Change in Firm Value					
	Bearing Point	EPlus	Costar Group	Online Resources	Steel Cloud	InteliData Technologies
r	-4.14%	-3.96%	-3.58%	-3.45%	-3.23%	-3.87%
Dp	+3.63%	+3.45%	+3.67%	+5.92%	+4.71%	+8.17%
Int	+0.06%	+0.21%	0.00%	+0.14%	+0.03%	+0.02%
Tc	-2.52%	-2.44%	-1.72%	-0.16%	-0.74%	-0.17%
κ	-3.24%	+1.62%	-1.74%	+0.16%	+0.74%	+1.37%
λ	-2.24%	-1.79%	-1.25%	-0.67%	-1.12%	-0.17%
φ_0	+0.07%	+0.01%	+0.02%	0.00%	-0.03%	+0.02%
φ_1	-4.27%	-8.03%	-3.99%	-1.16%	+2.85%	-1.49%
φ_3	+2.01%	+1.50%	+1.42%	+0.26%	+0.90%	+0.08%
α^M	-5.08%	-5.77%	-4.85%	-2.05%	-3.39%	-1.03%
α_0	-2.13%	-1.54%	-1.29%	-1.19%	-1.48%	-0.33%
$\log V^M$	-4.34%	-7.62%	-4.13%	-1.07%	-0.03%	-1.36%
$\log V_0$	-3.35%	-3.04%	-1.33%	-0.88%	+0.77%	-0.29%
g^M	+3.23%	+3.37%	+2.85%	+0.83%	+1.37%	+0.45%
g_0	+4.02%	+1.37%	+2.06%	+0.54%	+0.38%	+0.41%

Table 6
Fundamental Debt Value and Risk Premium

In this table we provide the values of the debt and the obtained risk premium

	Company	Bearing Point	EPlus	CoStar Group	Online Resources	Steel Cloud	InteliData Technologies
	Face Value (million)	878.10	119.88	32.17	1.86	0.37	7.55
Case 1 (0% Coupon)	Fundamental Debt Value (million)	546.75	112.15	25.60	1.80	0.36	7.19
	Fundamental Risk Premium (%)	1.87%	0.27%	0.83%	0.00%	0.00%	0.10%
Case 2 (1% Coupon)	Fundamental Debt Value (million)	580.18	113.68	26.54	1.82	0.36	7.27
Case 3 (2% Coupon)	Fundamental Debt Value (million)	613.61	115.21	27.48	1.83	0.36	7.35
Case 4 (3% Coupon)	Fundamental Debt Value (million)	647.03	116.74	28.43	1.85	0.36	7.44
Case 5 (4% Coupon)	Fundamental Debt Value (million)	680.46	118.27	29.37	1.86	0.37	7.52
Case 6 (5% Coupon)	Fundamental Debt Value (million)	713.89	119.80	30.31	1.88	0.37	7.60
Case 7 (6% Coupon)	Fundamental Debt Value (million)	747.32	121.33	31.25	1.90	0.37	7.68

Table 7

Fundamental Equity Value and Stock Price

This table provides the fundamental equity value and fundamental stock price. These values are computed using the following equations:
Fundamental equity value = fundamental firm value – fundamental debt value.
Fundamental stock price = fundamental equity value / the number of shares.

	Company	Bearing Point (as of 4qtr/2003)	EPlus (as of 3qtr/2003)	CoStar Group (as of 4qtr/2004)	Online Resources (as of 4qtr/2003)	Steel Cloud (as of 4qtr/2003)	InteliData Technologies (as of 4qtr/2003)
Current Market	Stock Price (as of the end of qtr)	10.09	15.60	41.70	6.56	4.30	1.56
	Number of Outstanding Shares (million)	191.663	9.265	17.877	17.812	12.609	51.231
Case 1 (0% Coupon)	Fundamental Equity Value (million)	2598.45	182.34	126.07	56.14	36.19	44.45
	Fundamental Stock Price ($)	13.56	19.68	7.05	3.15	2.87	0.87
Case 2 (1% Coupon)	Fundamental Equity Value (million)	2565.02	180.81	125.13	56.12	36.19	44.37
	Fundamental Stock Price ($)	13.38	19.52	7.00	3.15	2.87	0.87
Case 3 (2% Coupon)	Fundamental Equity Value (million)	2531.59	179.28	124.19	56.11	36.19	44.29
	Fundamental Stock Price ($)	13.21	19.35	6.95	3.15	2.87	0.86
Case 4 (3% Coupon)	Fundamental Equity Value (million)	2498.17	177.75	123.24	56.09	36.19	44.20
	Fundamental Stock Price ($)	13.03	19.18	6.89	3.15	2.87	0.86
Case 5 (4% Coupon)	Fundamental Equity Value (million)	2464.74	176.22	122.30	56.08	36.18	44.12
	Fundamental Stock Price ($)	12.86	19.02	6.84	3.15	2.87	0.86
Case 6 (5% Coupon)	Fundamental Equity Value (million)	2431.31	174.69	121.36	56.06	36.18	44.04
	Fundamental Stock Price ($)	12.69	18.85	6.79	3.15	2.87	0.86
Case 7 (6% Coupon)	Fundamental Equity Value (million)	2397.88	173.16	120.42	56.04	36.18	43.96
	Fundamental Stock Price ($)	12.51	18.69	6.74	3.15	2.87	0.86

Figure 1

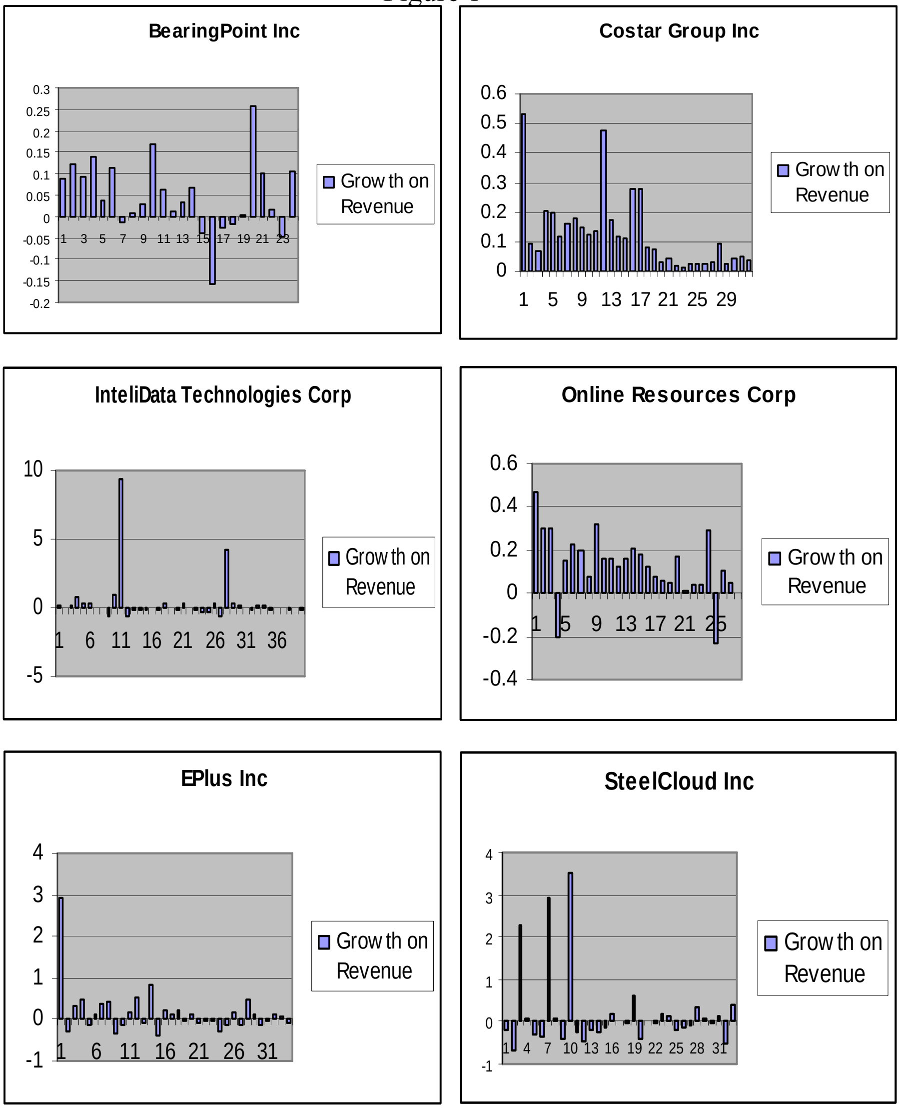
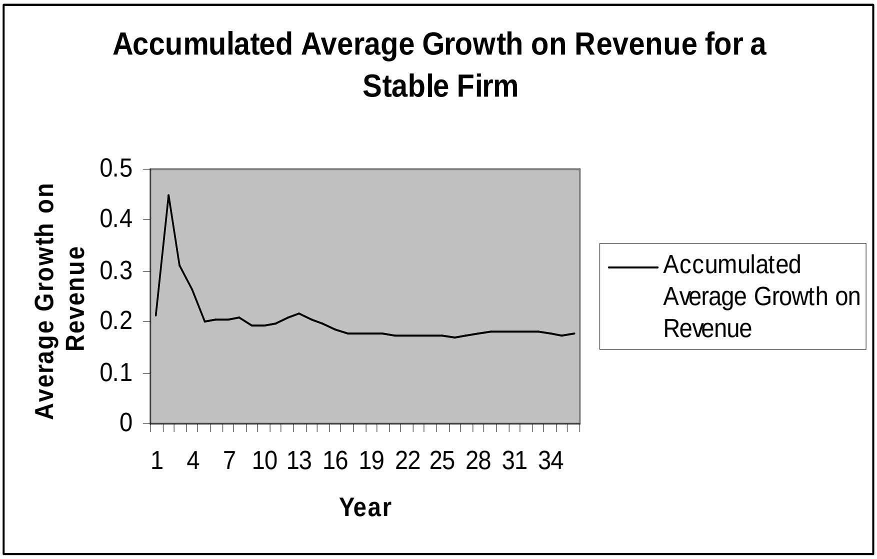

BearingPoint Inc
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
1 3 5 7 9 11 13 15 17 19 21 23
Growth on Revenue
Costar Group Inc
0.6
0.5
0.4
0.3
0.2
0.1
0
1 5 9 13 17 21 25 29
Growth on Revenue
InteliData Technologies Corp
10
5
0
-5
1 6 11 16 21 26 31 36
Growth on Revenue
Online Resources Corp
0.6
0.4
0.2
0
-0.2
-0.4
1 5 9 13 17 21 25
Growth on Revenue
EPlus Inc
4
3
2
1
0
-1
1 6 11 16 21 26 31
Growth on Revenue
SteelCloud Inc
4
3
2
1
0
-1
1 4 7 10 13 16 19 22 25 28 31
Growth on Revenue

Figure 2


Accumulated Average Growth on Revenue for a Stable Firm
Average Growth on Revenue
0.5
0.4
0.3
0.2
0.1
0
1 4 7 10 13 16 19 22 25 28 31 34
Year
Accumulated Average Growth on Revenue

Footnotes

1. Because there are several different liabilities in contractual obligations, some are tradable in the market but the others are not tradable.
2. For example, the Gordon model requires a steady growth over a firm's entire life.
3. This approach is often used by practitioners. (See Schwartz and Moon (2000))
4. The original process that is not risk-neutralized can be described as follows;

$$\frac{dR_t}{R_t} = g_t dt + \sqrt{V_t}\, dZ$$

where g_t is at the mercy of firm's risk preference.

5. Schwartz and Moon (2000) used analysts' projection due to this problem.
6. See Gourieroux and Jasiak (2001)
7. See Neftci (2000) and Klebaner (2001).
8. We adopt the same horizon as Schwartz and Moon (2000).
9. According to this assumption, seven cases with different coupons are suggested.
10. We restrict change in revenue between +10% and -10% per quarter to avoid statistical bias due to isolated large changes.
11. In our model, the interest expense is used to calculate EBITDA at the long-term horizon, T.
12. The speed adjustment is calculated as log 2 divided by the half life. For example, since the time period the stable firm took to reach steady growth is 52 quarters (13 years) and as of 4th Qtr/2004, Steel Cloud Inc's business history is 32 quarters (8 years), on average, it still needs about 20 more quarters to reach the stable stage. Therefore, the estimate of the speed adjustment for this firm is log 2/10 = 0.0693.
13. See Baxter and Rennie (1996).