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Backsolve Valuation Method

Executive Summary

The main idea behind the Backsolve method is to use recent transaction price for one of the classes of shares, Black-Scholes option pricing model and other additional information that can be derived from company's capital structure to determine estimated fair value (FV) of equity.

Application of the Backsolve method is performed using the following steps:

Step 1 - Identify pricing terms of the recent equity transaction;
Step 2 - Identify relevant dividend/distribution rights and related "breakpoints";
Step 3 - Prepare FV equity equation;
Step 4 - Estimate required inputs for option pricing model: risk-free rate, expected terms, volatility;
Step 5 - Calculate estimated FV of equity using "trial and error" approach;

FV equation in Step 3 represents a formula with two unknowns, being estimated FV of equity and estimated FV of a call option. Standard Black-Scholes equation also shows the above two variables and three other inputs, i.e., risk-free rate, expected volatility end option term. The three inputs can be determined using market information and management estimates.

The two equations, i.e., Black-Scholes formula and equity equation with two unknowns, being FV of stock and call option can be resolved to determine unknow values.

The practice approach used to determine the two unknowns is "trial and error" where a specialist considers multiple equity values (or option values) to make sure the two equations are appropriately resolved.

When company's equity has two classes, i.e., Series A and common stock, equity formula is as follows:

Estimated Equity FV **=** Estimated FV of Series A **+** FV of Call Option on Common at break 1 **-** Share of Series A in Distribution after break 2 **x** Call Option on Series A at break 2

Estimated FV of Series A is derived from recent equity transaction. Share of Series A in distribution after break 2 is a known number reflecting company's distribution terms.

General equity formula for N classes of stock and N breakpoints is as follows:

Estimated Equity FV **=** Estimated FV of Series A **+** FV of Call Option on Series B Stock at break 1 **–** Series A Share in Distributions After Break N **x** Call Option on Series A Stock at break N.

The above equity formula equity can be used as part of application of Backsolve method for any amount of equity classes. The application of the formula still depends on company's specific equity structure and terms of distribution.

Verbal interpretation of the above formula is that estimated FV of company's equity depends on the following specific inputs:

a) known dollar value for Series A stock;
b) FV of Call Option on Series B stock at break 1;
c) share Series A in distribution after break N;
d) FV of Call Option on Series A stock at break N;

Series A and Series B as used in the above formula and the list of inputs, simply refer to first and second classes of equity in the order of distribution priority. If a company only has two classes of equity, e.g., Series A preferred and common stock, Series B means common stock.

Other factors, including terms of company's debt may impact application of the Backsolve method. Generally, debt holders may be entitled to distributions prior to any equity holders, thus impacting the order of distribution used in the application of the Backsolve method. Valuation specialists should carefully review and understand company's capital structure and distribution terms. The above and other relevant factors will impact reasonableness and accuracy of valuation results.

Introduction

In the realm of privately held companies, where access to relevant market data can be limited, a valuation task takes on an added layer of complexity. As modern investment strategies continue to evolve and so does the demand for accurate and insightful valuations. Investors are no longer content with broad approximations; they seek precision and accuracy in valuation results used to make informed investment decisions.

One valuation approach applied to estimate fair value of a privately held company is the Backsolve method. According to AICPA's Valuation of Privately-Held-Company Equity Securities Issued as Compensation:

> *The backsolve method requires considering the rights and preferences of each class of equity and solving for the total equity value that is consistent with a recent transaction in the company's own securities, considering the rights and preferences of each class of equity*[1].

[1] AICPA, Valuation of Privately-Held-Company Equity Securities Issued as Compensation (New York, NY, 2013), p. 28

The starting point in application of Backsolve is that a knowledgeable investor has recently purchased stock of the subject company and this price approximates fair value of the stock in question. Besides the price, the method involves the use of the Black-Scholes formula as well as distribution terms as they relate to each class of equity interest.

According to the AICPA's guide:

> *The backsolve method is the most reliable indicator of the value of the enterprise at stage 1 if relevant and reliable transactions have occurred in the enterprise's equity securities. If transactions have occurred but are not arm's length or not concurrent with the valuation date, these transactions should still be considered, making adjustments as needed, considering the nature of the transaction and any changes in value that have occurred since the transaction (or that are expected to occur prior to the transaction).*[2]

The AICPA guide defines Stage 1 as the period of time when "*the enterprise has no product revenue and little or no expense history, it is typically unable to make reliable cash flow forecasts; therefore, the income approach would generally not provide a reliable estimate.*" [3]

Let's take a closer look at the intricacies of the Backsolve method.

Backsolve Method- Basic Application

The main idea behind the Backsolve method is to use recent transaction price for one of the classes of shares, Black-Scholes-Merton option pricing models and additional information that can be derived from company's capital structure to determine estimated fair value of equity.

Option pricing models are mathematical models used to estimate the fair value of option to buy or sell stock. Stock options are financial instruments that give the holder the right, but not the obligation, to buy (call option) or sell (put option) an underlying asset (such as stocks, bonds, commodities) at a predetermined price (the strike price) within a specified time frame in the future.

Option pricing models help investors and traders determine the theoretical value of the option, aiding in decision-making related to trading, hedging, and risk management. These models are based on assumptions about how the underlying stock price will change over time, considering such factors as volatility, interest rates, and time to expiration.

One of the most well-known option pricing models is the Black-Scholes Model.

Black-Scholes Model

The Black-Scholes model emerged at a time when options trading was gaining popularity, but there was no widely accepted method for valuing these instruments. The model provided a groundbreaking formula that allowed estimating option fair value.

[2] Ibid p. 98
[3] Ibid p. 98

The Black-Scholes model is based on several key assumptions well documented in professional literature[4]. The key assumptions include:

1. **Geometric Brownian Motion:** The model assumes that the price movement of the underlying asset follows a geometric Brownian motion, meaning that the logarithm of the asset's price follows a random walk with normally distributed increments. This assumption captures the characteristic of price volatility.
2. **No Arbitrage Opportunity:** The model assumes that it is not possible to earn risk-free profits by engaging in simultaneous buying and selling of the underlying asset and the option. This principle prevents arbitrage opportunities from arising.
3. **Continuous Trading:** The model assumes continuous trading and that options can only be exercised at expiration (European-style options). This simplification allows for the use of continuous-time mathematics.
4. **Constant Volatility:** The standard formula assumes that volatility (a measure of price fluctuations) is constant over the life of the option. This assumption is a simplification but allows for the derivation of a closed-form solution.
5. **Risk-Free Rate:** The risk-free interest rate is constant and known. It is used to discount the future value of the option's payoff to its present value.

The Black-Scholes formula for a European call takes into account these assumptions and calculates the option's fair value based on the following inputs: a) current price of the underlying stock, b) option's strike price, c) expected term, d) volatility, and e) the risk-free rate.

However, when considering the Backsolve method, there is a substantial amount of information that we do not have. The two more notably “unknowns” are current share price (which we are attempting to determine) and the option's strike price. We also do not know the expected term and volatility.

Let us focus on expected term and volatility first. What period of time should be used as the term of the option? Understandably, we are talking about a hypothetical option here. G. Trugman uses the median time to liquidity via initial public offering for U.S.-based companies, which ranged from 5-10 years[5]. In theory, the estimated term should be market specific, not entity specific, consistent with the definition of fair value concept per ASC 820. However, in certain cases, management estimates the expected time to exit as it applies to the company in question[6].

With regards to expected volatility, it is common to use appropriate peer group, i.e., a group of publicly traded companies which are similar to the subject company in terms of size, industry,

[4] Robert W. Kolb, James A. Ovedahl Futures, Options, and SWAPs. Fifth Edition. P. 449-455
[5] Understanding Business Valuation Gary R. Trugman 6th Edition, P. 1035
[6] AICPA Valuation of Privately- Held-Company Equity Securities Issued as Compensation. par. I.14, Table I-1. Specifically, see how “Time to liquidity” was determined in the example provided in the AICPA guide.

region, etc. Historical volatility of comparable companies can be used as a basis for estimated volatility of the subject company.

Another important input in the valuation exercise is based on the equity structure and equity holder distribution rights. Let us show how these inputs are determined below.

Equity Structure, Dividend Rights

The Backsolve method assumes that FV of equity can be estimated using combination of call (purchase) options, with an exercise price set to certain nominal values determined using equity holder distribution rights.

What do options have to do with company's "normal" equity shares, a reasonable reader can ask? The answer is twofold. First, generally speaking, owning shares is similar to owning an option in the sense that the ownership will become more beneficial provided company's value increases over time and less beneficial if it does not. If the company value increases, equity holders can benefit from the increase by selling their equity interest at a price above the initial purchase price, pledge high value equity interest as a collateral, etc. Same considerations apply to stock options when share price exceeds option's exercise price. From this perspective, financial prospects of owning a stock dependent on future uncertain events can be analogized to owning a call option. If so, FV of a stock can be quantified using the option pricing model[7].

Secondly, Backsolve method applies to capital structures where certain investors have dividend or other distribution preference. If the subject company pays dividends, preferred equity holders will likely to be paid prior to common equity holders. Specific dividend rights clarify the amount of preferred or priority payments made to one class of investors before other investors can be paid. The amount of payment preference enjoyed by preferred investors is used as an exercise price for a hypothetical call option held by common investors. Let us illustrate the above point with the example below.

> **Example:** On 12/31/20X3 the company issues preferred shares to investors in exchange for aggregate consideration of $ 1,000,000. Terms of issuance are that in the event of company's sale or that the company pays dividends, preferred shareholders should first be paid the amount of initial investment, i.e., $ 1,000,000 plus $ 200,000, constituting 20% return. Besides the above preferred shares, the company has a number of common shares. Common shareholders can only enjoy the payout provided preferred shareholders were paid first, as described above.
>
> Using terms of the example, interest held by common shareholders can be analogized to a call option on company's shares with a total exercise price of $ 1,200,000 or $ 1,000,000 + $ 200,000. This is because common shareholders can only benefit from their equity interests if

[7] Robert Kolb and James Ovedahl provide a good illustration of how owning stock can be analogized to a call option in a capital structure consisting of a bond and one class of shares. Bond holder will be paid prior to any distributions to equity holders. Therefore, "the stock is a call option on the firm with an exercise price equal to the debt obligation". Robert W. Kolb, James A. Ovedahl Futures, Options, and SWAPs. Fifth Edition P. 567

and when the company pays $ 1,200,000 to preferred shareholders. Preferred shares can be analogized to a call option for shares worth $ 1,200,000 with zero exercise price. From this perspective, company's fair value (FV) of total equity at 12/31/20X3 can be approximated as follows:

Equity FV = $ 1,000,000 + FV of Call Option with 1,200,000 exercise price

The above formula assumes that, after making $ 1,200,000 distributions to preferred shareholders, all subsequent dividend payments, if any, will be due to common shareholders. We will modify this assumption in other examples below.

As illustrated in the above example, using company's specific equity structure and distribution rights allows a valuation specialist to come up with the equation involving fair value of equity and stock option. In essence, Black-Scholes formula is an equation of these two variables as well. Two equations with two unknowns, i.e., stock fair value and option fair value can be resolved to determine the amount of the unknown variables.

The method used to determine the two unknowns is a "trial and error" approach where a specialist considers multiple equity values (or option value) to make sure both equations are appropriately resolved.

Dividend or other distribution thresholds resulting in the change in distribution rights are referred to as "breakpoints". Effectively, the breakpoints serve to determine option exercise price.

Overall, application of the Backsolve method is performed using the following steps:

Step 1 - Identify pricing terms of the recent equity transaction;
Step 2 - Identify relevant dividend/distribution rights and related "breakpoints";
Step 3 - Prepare FV equity equation;
Step 4 - Estimate required inputs for option pricing model: risk-free rate, expected terms, volatility;
Step 5 - Calculate estimated FV of equity using "trial and error" approach;

Let us illustrate application of the above approach using the example with two classes of equity shares- see section Example- Two Equity Classes.

Backsolve Method- Advanced Application

Example considered in the above section deals with two classes of shares and two corresponding break points. The question is whether the same or modified approach can be applied to three or more classes of equity. For this, we will have to modify equity FV equation. For N classes of stock, FV equation will be as follows:

Equity FV = FV of Class 1 +….+ FV of Cass N

In simple application of the Backsolve method, FV of one class shares was known while FV of the other class was determined using combination of the Black-Scholes formula and equity FV equation reflecting specific distribution preferences. As part of the approach, unknown FV of equity interest was analogized to the FV of a call option on the equity interest in question.

Same approach can apply to estimated fair value of equity for the company with more than 2 classes of equity interests.

Let us illustrate application of the Backsolve method to three classes of equity interest in section Example- Three Equity Classes.

Equity formula in the example with three equity classes is a summation of FV for each class. Summation of each class results in estimated FV of common stock being eliminated in the final equity formula. Similarly, the equity formula also does not contain the residual 10% interest attributable to Series B. As shown in the example, final equity formula is as follows:

> Equity FV at 12/31/20X3 = 1,000,000 + FV of Call Option on Series B Stock at break 1 - 10% of Call Option on Series A Stock at break 3.

Where 10% represents share of Series A in company's distribution after breakpoint 3.

Equity formula for any other amount of equity interests participating in company's distributions on terms similar to those considered above, would contain the same general components as in the formula with three classes. Specifically, the following elements will be included in estimated fair value of equity with N classes of equity interests:

e) known dollar value for Series A stock;
f) FV of Call Option on Series B stock at break 1;
g) share of Series A in distribution after break N;
h) FV of Call Option on Series A stock at break N;

FV of all other preferred and common stock, i.e., stock other than Series A and B will be eliminated in the final equity formula.

General equity formula for N classes of stock is as follows:

> Estimated Equity FV **=** Estimated FV of Series A **+** FV of Call Option on Series B Stock at break 1 **–** Series A Share in Distributions After Break N **x** Call Option on Series A Stock at break N

In the above formula, Series A and Series B simply refer to first and second classes of equity in the order of distribution priority. N reflects the amount of equity classes including preferred and common interests. In the first example above, N equals 2. N equals 3 in the second example.

The above equity formula can be used as part of application of Backsolve method for any amount of equity classes. The application of the formula still depends on company's specific equity structure and terms of distribution.

Verbal interpretation of formula with N classes of equity interests is that estimated FV of company's equity depends on specific inputs listed in items a) through d) above. Although the formula includes estimated FV of only two classes of equity interests, it also includes, as one of variables, the total amount of equity interests N.

Other things being equal, increase in N, results in higher exercise price for the call option on Series A at break N, which leads to lower estimated FV of a call option at the last breakpoint and higher overall FV of equity at the valuation date. Conversely, higher share of Series A in company's distribution at the final breakpoint results in lower overall fair value.

The two variables, i.e., N and Series A share in distributions at the last breakpoint, impact total estimated FV of equity in the same way as they impact total estimated FV of stock paid last given order of preference. In other words, higher (lower) N results in higher (lower) estimated FV of Series N stock. Reversely, higher Series A share at breakpoint N results in lower estimated FV of Series N stock.

Other factors not considered in this publication, including terms of company's debt may impact application of the Backsolve method. Generally, debt holders may be entitled to distributions prior to any equity holders, thus impacting the order of distribution used in the application of the Backsolve method. Valuation specialists should carefully review and understand company's capital structure and distribution terms. The above and other relevant factors will impact reasonableness and accuracy of valuation results.

Examples

Two Equity Classes- Example

Fact Pattern

Company A issued Series A Preferred shares to investors on or around December 31, 20X3 in exchange for $ 1,000,000. Besides preferred shares, Company A has commons shares issued and outstanding prior to December 31, 20X3.

Holders of Series A Preferred have a distribution preference so that in the event of a liquidity event (e.g., IPO, sale of the company or dividend payment), Series A holders will be entitled to distribution of $ 1,000,000 invested capital plus $ 200,000 prior to distribution to common shareholders. After Series A Preferred holders receive their $ 1.2 M, other distribution, if any, will be due to commons shareholders not to exceed $ 1,200,000. Subsequent distribution, if any, will be split between common and preferred shareholders so that preferred holders receive 10% of proceeds while common shareholders will receive 90%.

The task is to determine Company's estimated fair value of equity at or around December 31, 20X3.

Analysis

Step 1 - Identify pricing terms of recent equity transaction.

Company A issued Series A Preferred shares on or around December 31, 20X3 in exchange for $ 1,000,000.

Step 2 - Identify relevant dividend/distribution rights and relevant "breakpoints"

Distribution preference is as follows:

First $ 1,200,000 of distribution is due to Series A Preferred holders;
Next $ 1,200,000 is due to Common shareholders;
Subsequent distributions are split 90/10 between common and preferred shareholders;

Distribution of first $ 1,200,000 to Series A preferred constitutes breakpoint 1. Distribution of next $ 1,200,000 to common is considered a breakpoint 2.

Step 3 - Prepare Equity FV Equation

Estimated FV of equity at 12/31/20X3 is determined using the following equation:

Equity FV at 12/31/20X3 = FV of Series A Preferred+ FV of Common

FV of Series A equals to $ 1,000,000. FV of common shares is analogized to owing a call option on common shares. If Company A generates distributions in excess of $ 1,200,000, i.e., breakpoint 1, the excess will be distributed to common shareholders. If Company A does not

generate distributions in excess of $ 1,200,000, commons shares will be worthless. From this perspective FV of common shares is similar to FV of a call option on common stock at break 1. However, if Company A generates distributions in excess of $ 2,400,000, i.e., breakpoint 2, 10% of subsequent distributions will be due to preferred shareholders. Therefore, FV of common shares at 12/31/20X3 can be calculated as follows:

FV of Common at 12/31/20X3 = Call Option on Common at break 1 - 10% of Call Option on Preferred at break 2

Estimated FV of equity at 12/31/20X3 can be presented as follows:

Equity FV at 12/31/20X3 = $ 1,000,000 + FV of Call Option on Common at break 1 - 10% of Call Option on Series A at break 2

Step 4 - Estimate required inputs for option pricing model: risk-free rate, expected terms, volatility

Let's assume that estimated time to a liquidation event amounts to 6 years. The above estimate can be developed using third-party studies of average liquidation term from inception or management internal estimates. If third-party studies are used, overall estimated liquidation term should be reduced by the amount of time passed from company's inception through the valuation date. If management internal estimates are used, the estimates should be consistent with the market-participant perspective.

Estimated risk free rate was determined to be 4%, volatility – 80%, dividend rate – 0%.

Additional procedures performed to determine the above inputs are outside the scope of our example.

Step 5 - Calculate equity value of the business using trial and error method

Estimated FV of equity is determined as such that when used together with estimated fair value of call options, the two amounts, i.e., estimated FV of equity and call option satisfy two equations. One equation is a Black-Scholes formula establishing relations between FV of equity and a call option for given amounts of risk-free rate, volatility and dividend rate. Another equation is FV Equity Formula determined above. Mathematically, the exercise boils down to resolving the two equations with two unknowns, i.e., FV of equity and FV of a call option.

Practically, the above "trial and error" approach involves trying multiple values for equity FV in the Black-Scholes formula that will produce such FV of the call option which, together with equity FV, will also resolve FV equity equation.

Using Black-Scholes formula, FV of equity of $ 5,022,875 produces FV of a call option at breakpoint 1 of $ 4,430,673, and FV of a call option at breakpoint 2 of $ 4,077,981. The above is illustrated in Schedule 1- Black-Scholes Calculations.

Schedule 1- Black-Scholes Calculations

Inputs:	Breakpoint 1	Breakpoint 2
Equity Value	$5,022,875	$5,022,875
Exercise Price	$1,200,000	$2,400,000
Term- years	6	6
Volatility	80.00%	80.00%
Dividend Rate	0%	0%
Risk Free Rate	4.00%	4.00%
Call Option- FV	$4,430,673	$4,077,981

The above FV of equity and FV of two call options also resolve equity FV equation as illustrated below:

Equity FV at 12/31/20X3 = FV of Series A + FV of Call Option on Common at break 1 - 10% of Call Option on Common at break 2

$ 5,022,875 = $ 1,000,000 + $ 4,430,673 - 0.1 * 4,077,981

Overall, estimated FV of equity at 12/31/20X3 is $ 5,022,875.

Three Equity Classes- Example

Fact Pattern

Company A issued Series A Preferred shares to investors on or around December 31, 20X3 in exchange for $ 1,000,000. Besides preferred shares, Company A has commons shares and Series B Preferred issued and outstanding prior to December 31, 20X3[8].

Company A has distribution preference related to three classes of shares described below:

First $ 1,200,000 of distribution is due to Series A Preferred holders;
Next $ 1,200,000 is due to Series B
Next $ 1,200,000 is due to common shareholders;
Subsequent distributions are split 80/10/10 between common, Series A and Series B, respectively;

The task is to determine Company's estimated fair value of equity at or around December 31, 20X3.

Analysis

Step 1 - Identify pricing terms of recent equity transaction

Company A issued Series A Preferred shares on or around December 31, 20X3 in exchange for $ 1,000,000.

[8] In the example Series A Preferred was issued after Series B Preferred. Although this sequence may be inconsistent, it does not have any impact on the result of the fair value exercise.

Step 2 - Identify relevant dividend/distribution rights and relevant "breakpoints"

Distribution preference is as follows:

First $ 1,200,000 of distribution is due to Series A Preferred holders;
Next $ 1,200,000 is due to Series B Preferred shareholders;
Next $ 1,200,000 is due to common shareholders;
Subsequent distributions are split 80/10/10 between common, Series A and Series B shareholders, respectively;

Distribution of first $ 1,200,000 to Series A preferred constitutes breakpoint 1. Distribution of next $ 1,200,000 to Series B is considered a breakpoint 2. Distribution of $ 1,200,000 to commons shareholders is a breakpoint 3.

Step 3 - Prepare Equity FV Equation

Estimated FV of equity at 12/31/20X3 is determined using the following equation:

Equity FV at 12/31/20X3 = FV of Series A Preferred+ FV of Series B Preferred + FV of Common

FV of Series A equals to $ 1,000,000. FV of Series B is calculated as follows:

FV of Series B at 12/31/20X3 = FV of Call Option on Series B Stock at break 1 - FV of Call Option on Common Stock at break 2 + 10% of Call Option at break 3

10% in the above formula represents share of Series B distribution after distributing $ 1,200,000 to common shareholders.

FV of common is calculated as follows:

FV of Common at 12/31/20X3 = FV of Call Option on Common Stock at break 2 - 20% of Call Option at break 3.

20% in the above formula represents share of Series A and B distributions after distributing $ 1,200,000 to common shareholders.

Therefore, FV of equity at 12/31/20X3 can be presented as follows:

Equity FV at 12/31/20X3 = $ 1,000,000 + FV of Call Option on Series B Stock at break 1 - 10% of Call Option on Series A at break 3.

As the above equation shows, FV of call option at break 2 does not impact estimated FV of equity at 12/31/20X3.

Step 4 - Estimate required inputs for option pricing model: risk-free rate, expected terms, volatility

Estimated option term is 6 years, risk free rate- 4%, volatility – 80%, dividend rate – 0%.

Additional procedures performed to determine the above inputs are outside the scope of our example.

Step 5 - Calculate equity value of the business using trial and error method

Trial and error method was applied to determine such equity FV at 12/31/20X3 which, when used together with estimated fair value of call options, will satisfy both Black-Scholes and equity FV equation.

Using Black-Scholes formula, FV of equity of $ 5,266,203 produces FV of a call option at breakpoint 1 of $ 4,666,088, breakpoint 2- $ 4,304,776, breakpoint 3- $ 3,998,852. The above is illustrated in Schedule 2- Black-Scholes Calculations.

Schedule 2- Black-Scholes Calculations

Inputs:	Breakpoint 1	Breakpoint 2	Breakpoint 3
Equity Value	$5,266,203	$5,266,203	$5,266,203
Exercise Price	$1,200,000	$2,400,000	$3,600,000
Term- years	6	6	6
Volatility	80.00%	80.00%	80.00%
Dividend Rate	0%	0%	0%
Risk Free Rate	4.00%	4.00%	4.00%
Call Option- FV	$4,666,088	$4,304,776	$3,998,852

The above FV of equity and FV of two call options also resolve equity FV equation as illustrated below.

Equity FV at 12/31/20X3 = 1,000,000 + FV of Call Option on Series B Stock at break 1 - 10% of Call Option Stock at break 3.

$ 5,266,203 = $ 1,000,000 + $ 4,666,088 - 0.1 * 3,998,852

Overall, estimated FV of equity at 12/31/20X3 is $ 5,266,203.

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