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A Layperson's Guide to the Option Pricing Model

Everything You Wanted to Know, But Were Afraid to Ask

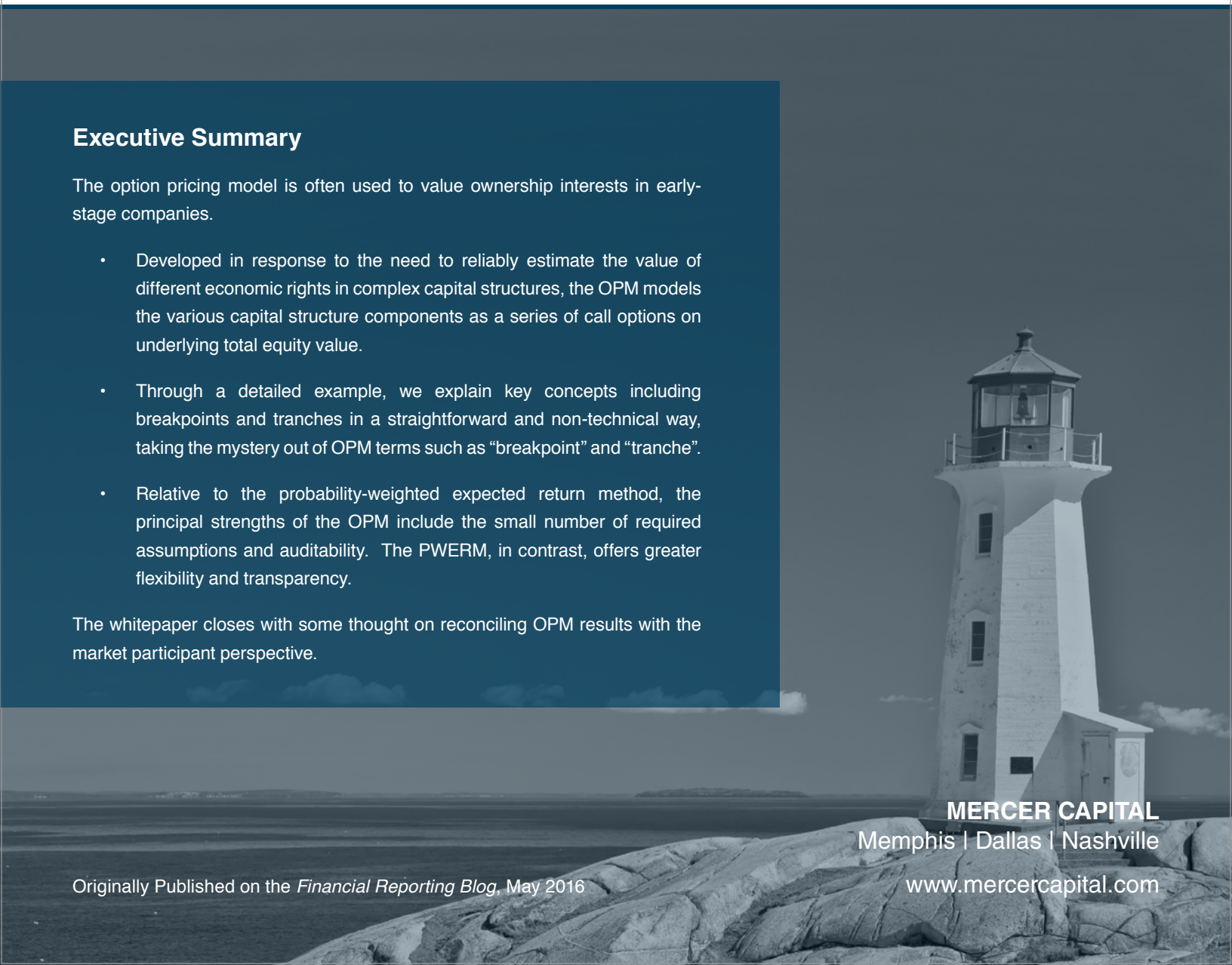
by Travis W. Harms, CFA, CPA/ABV

Executive Summary

The option pricing model is often used to value ownership interests in early-stage companies.

- Developed in response to the need to reliably estimate the value of different economic rights in complex capital structures, the OPM models the various capital structure components as a series of call options on underlying total equity value.
- Through a detailed example, we explain key concepts including breakpoints and tranches in a straightforward and non-technical way, taking the mystery out of OPM terms such as "breakpoint" and "tranche".
- Relative to the probability-weighted expected return method, the principal strengths of the OPM include the small number of required assumptions and auditability. The PWERM, in contrast, offers greater flexibility and transparency.

The whitepaper closes with some thought on reconciling OPM results with the market participant perspective.



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The option pricing model, or OPM, is one of the shiniest new tools in the valuation specialist's toolkit. While specialists have grown accustomed to working with the tool and have faith in the results of its use, many non-specialists remain wary, as the model – and its typical presentation – has all the trappings of a proverbial black box. The purpose of this whitepaper is to clarify the fundamental insights underlying the model and illustrate its application so that non-specialist users of valuation reports can gain greater comfort with the model. We will also address some qualitative concerns regarding use of the method in practice.

What is the Option Pricing Model Used For?

First, a bit of ground-clearing. What does the OPM not do? The OPM is not a method for determining the value of a business enterprise. The method does not consider the value of the subject business enterprise's assets and liabilities, evaluate the present value of projected cash flows, or concern itself with a comparison of the subject business enterprise to similar businesses with observable market values.

The OPM becomes useful only after the value of the business enterprise has been determined through application of valuation methods under the asset-based, income and market approaches. The OPM is a tool for allocating the total equity value to individual ownership classes in a complex capital structure. For enterprises with a simple capital structure (i.e., a single class of common equity), the OPM is not necessary and should not be used. However, when the subject business enterprise features multiple classes of preferred and/or common equity with differing economic rights, the OPM can be a most effective tool for differentiating the value of the various ownership classes. Such complex capital structures are most frequently encountered in early-stage enterprises, which are commonly valued for equity compensation and portfolio fair value reporting.

What Is the Fundamental Insight Underlying the OPM?

The "Eureka!" moment behind the OPM is the recognition that the payoffs to complex securities with arcane features can be mimicked through an appropriately constructed portfolio of component securities (most commonly fractional call options or digital options with varying strike prices). As a result, what may seem on the surface to be an impossible valuation task can be mastered if the economic payoffs for a complex security are untangled and re-cast as a bundle of simple securities that can be more readily valued. The method holds out the promise of replacing subjective judgment with replicable analysis, which helps to explain why auditors favor the method.

Consider a simple example. SimpleCo is capitalized with a single class of preferred shares and a single class of common shares. Upon liquidation or sale of SimpleCo, the preferred shareholders are entitled to receive $500, with the residual accruing to the common shareholders. The economic terms of the capital structure are summarized in Exhibit 1.

Exhibit 1: Payoff Table – SimpleCo

Total Equity	Preferred Shareholders	Common Shareholders
$0	$0	$0
$100	$100	$0
$200	$200	$0
$300	$300	$0
$400	$400	$0
$500	$500	$0
$600	$500	$100
$700	$500	$200
$800	$500	$300
$900	$500	$400
$1,000	$500	$500

Two observations can be made from a brief study of Exhibit 1.

1. **Financial engineering does not create value.** In every possible state of the world, the sum of the payoffs to the preferred and common shareholders is equal to the equity value. Creative pie-slicing does not make the pie any bigger.

2. **The payoffs to the common shareholders have the same basic shape as a call option.** The holder of a call option receives no payoff when the stock price is less than or equal to the strike price. However, the call option holder participates dollar-for-dollar in appreciation above the strike price.

Exhibit 2: Component Securities – SimpleCo

Enterprise Value	=	Preferred Shareholders	+	Common Shareholders
EV	=	*(EV - $500 Call)*	+	*$500 Call*

In light of these observations, we can express the value of the preferred and common share as shown in Exhibit 2 above.

By recasting the preferred and common equity classes into the component securities, the subjective judgment associated with selecting the appropriate yield on the preferred shares has been eliminated, as the value of the preferred shares is simply the excess of equity value over the value of a call option with a strike price of $500.

What Is a "Breakpoint"?

Moving to a more complex example will allow us to explain and define additional vocabulary terms from the OPM. Exhibit 3 summarizes the capital structure for ComplexCo.

Exhibit 3: Capital Structure – ComplexCo

	Liquidation Preference	Liquidation Priority	Conversion/ Exercise Price	Fully-Diluted Shares	% of Total
Class A Preferred	$1,000	*Pari Passu*	$2.00	500	19.6%
Class B Preferred	1,500	*Pari Passu*	$5.00	300	11.8%
Common Shares	0	Residual	na	1,500	58.8%
Warrants	0	Residual	$10.00	250	9.8%
Total	**$2,500**			**2,550**	**100.0%**

While this capital structure is still quite tame relative to many real-world counterparts, it is sufficiently complex to illustrate the fundamental tools used in OPM applications.

One could construct a payoff table similar to that in Exhibit 1. While certainly possible, doing so can become a bit cumbersome as the complexity of the capital structure increases. As a shortcut, valuation specialists identify the relevant "breakpoints" in the capital structure. In the OPM, a breakpoint is an equity value beyond which the marginal allocation of incremental value to the various equity classes changes. SimpleCo had a single breakpoint, while ComplexCo will prove to have four. We often see cases in which a dozen or more can be identified.

Exhibit 4: Breakpoint #1 – Class A & Class B Liquidation Preference

	Shares	Gross Proceeds	Exercise Price	Net Proceeds	% of Total	Marginal Proceeds	% of Total
Preference Claims							
Class A Preferred		$1,000	na	$1,000	40.0%	$1,000	40.0%
Class B Preferred		1,500	na	1,500	60.0%	1,500	60.0%
As-If Converted Shares	**$0.00**						
Class A Preferred	0	0	na	0	0.0%	0	0.0%
Class B Preferred	0	0	na	0	0.0%	0	0.0%
Common Shares	1,500	0	na	0	0.0%	0	0.0%
Warrants	0	0	0	0	0.0%	0	0.0%
Total	1,500	$2,500	$0	$2,500	100.0%	$2,500	100.0%

Exhibit 5: Breakpoint #2 – Class A Converts to Common

	Shares	Gross Proceeds	Exercise Price	Net Proceeds	% of Total	Marginal Proceeds	% of Total
Preference Claims							
Class A Preferred		$0	na	$0	0.0%	($1,000)	-33.3%
Class B Preferred		1,500	na	1,500	27.3%	0	0.0%
As-If Converted Shares	**$2.00**						
Class A Preferred	500	1,000	na	1,000	18.2%	1,000	33.3%
Class B Preferred	0	0	na	0	0.0%	0	0.0%
Common Shares	1,500	3,000	na	3,000	54.5%	3,000	100.0%
Warrants	0	0	0	0	0.0%	0	0.0%
Total	2,000	$5,500	$0	$5,500	100.0%	$3,000	100.0%

Breakpoints are identified starting with an equity value of $0. For ComplexCo, the Class A and Class B preferred shares participate on a pari passu basis, so the first breakpoint is the aggregate liquidation preference, or $2,500 (the total "Net Proceeds" in Exhibit 4). Additional elements of Exhibit 4 will be explained as we proceed through the example.

For equity values from $0 to $2,500, the Class A preferred shareholders will receive 40% of value, and the Class B preferred shareholders will receive 60%. For equity values above $2,500, the marginal proceeds will be allocated differently, as shown in Exhibit 5. This change in allocation is what makes $2,500 a breakpoint in this example.

Exhibit 6: Breakpoint #3 – Class B Converts to Common

	Shares	Gross Proceeds	Exercise Price	Net Proceeds	% of Total	Marginal Proceeds	% of Total
Preference Claims							
Class A Preferred		$0	na	$0	0.0%	$0	0.0%
Class B Preferred		0	na	0	0.0%	(1,500)	-25.0%
As-If Converted Shares	**$5.00**						
Class A Preferred	500	2,500	na	2,500	21.7%	1,500	25.0%
Class B Preferred	300	1,500	na	1,500	13.0%	1,500	25.0%
Common Shares	1,500	7,500	na	7,500	65.2%	4,500	75.0%
Warrants	0	0	0	0	0.0%	0	0.0%
Total	2,300	$11,500	$0	$11,500	100.0%	$6,000	100.0%

The next change in the allocation of proceeds will occur when the Class A Preferred shares convert to common. At common share values greater than $2.00 per share, the Class A Preferred shareholders will elect to convert, as their net proceeds from conversion will exceed the liquidation preference. As a result, the number of as-if converted shares increases, but the liquidation preference attributable to the Class A shares is forfeited. The corresponding breakpoint equity value is $5,500.

Breakpoint #3 corresponds to the common share price that will induce the Class B Preferred shareholders to convert to common shares ($5.00). In other words, the Class B Preferred shareholders will elect to convert, and be treated as common shareholders when the total equity value exceeds $11,500 (Exhibit 6).

As shown in Exhibit 7 on page 7, Breakpoint #4 corresponds to the exercise of outstanding warrants. Note that while the warrants will be exercised at $10.00 per share, the warrant holders will pay $10.00 per share to do so, so the net proceeds to the warrants remains $0 at that point, and the equity value breakpoint is the aggregate "Net Proceeds."

Beyond the last breakpoint, marginal proceeds can be allocated according to an additional illustrative payoff schedule assuming some arbitrary share price in excess of the last breakpoint, as shown in Exhibit 8 on page 7.

What is a "Tranche"?

The next step in applying the OPM is to build a matrix that identifies the marginal allocation percentages between the various breakpoints. For purposes of the OPM, a "tranche" is the difference between two adjacent breakpoints. The marginal proceeds within a given tranche are allocated to the various equity classes in fixed proportions (Exhibit 9 on page 8).

Exhibit 7: Breakpoint #4 – Warrants Exercise

	Shares	Gross Proceeds	Exercise Price	Net Proceeds	% of Total	Marginal Proceeds	% of Total
Preference Claims							
Class A Preferred		$0	na	$0	0.0%	$0	0.0%
Class B Preferred		0	na	0	0.0%	0	0.0%
As-If Converted Shares	**$10.00**						
Class A Preferred	500	5,000	na	5,000	21.7%	2,500	21.7%
Class B Preferred	300	3,000	na	3,000	13.0%	1,500	13.0%
Common Shares	1,500	15,000	na	15,000	65.2%	7,500	65.2%
Warrants	250	2,500	(2,500)	0	0.0%	0	0.0%
Total	2,550	$25,500	($2,500)	$23,000	100.0%	$11,500	100.0%

Exhibit 8: Illustrative Upside

	Shares	Gross Proceeds	Exercise Price	Net Proceeds	% of Total	Marginal Proceeds	% of Total
Preference Claims							
Class A Preferred		$0	na	$0	0.0%	$0	0.0%
Class B Preferred		0	na	0	0.0%	0	0.0%
As-If Converted Shares	**$15.00**						
Class A Preferred	500	7,500	na	7,500	21.0%	2,500	19.6%
Class B Preferred	300	4,500	na	4,500	12.6%	1,500	11.8%
Common Shares	1,500	22,500	na	22,500	62.9%	7,500	58.8%
Warrants	250	3,750	(2,500)	1,250	3.5%	1,250	9.8%
Total	2,550	$38,250	($2,500)	$35,750	100.0%	$12,750	100.0%

The marginal tranche allocation matrix summarizes the relative allocation to the various equity classes within the respective tranches. The allocations were calculated in the corresponding breakpoint tables. The illustrative upside scenario (Exhibit 8) allows us to confirm marginal allocation percentages for values in excess of the final breakpoint. Note that the marginal allocation percentages for the final tranche are equal to the proportion of total fully-diluted shares outstanding from each equity class.

The next step is to determine the value of each tranche. In doing so, we will work from right to left. Recall from our SimpleCo example that the portion of equity value in excess of a given amount can be

Exhibit 9: Marginal Tranche Allocation Matrix

	Tranche A	Tranche B	Tranche C	Tranche D	Tranche E
Upper Breakpoint	$2,500	$5,500	$11,500	$23,000	$35,750
Lower Breakpoint	$0	$2,500	$5,500	$11,500	$23,000
Tranche Width	$2,500	$3,000	$6,000	$11,500	$12,750
Marginal Allocations					
Class A Preferred	40.0%	0.0%	25.0%	21.7%	19.6%
Class B Preferred	60.0%	0.0%	0.0%	13.0%	11.8%
Common Shares	0.0%	100.0%	75.0%	65.2%	58.8%
Warrants	0.0%	0.0%	0.0%	0.0%	9.8%

% of Marginal Proceeds from Breakpoint payoff tables

calculated with reference to a call option on the underlying equity value with a corresponding strike price. In the case of ComplexCo, the value of the upside in excess of the final breakpoint ($23,000) is equal to the value of a call option having a strike price equal to that breakpoint value.

What about the value of the next tranche down? Following the same approach, the value of all of the upside beyond $11,500 is equal to the value of a call option on the underlying equity value having that strike price. The value of this call option represents the combined value of Tranche D and Tranche E. Since the value of Tranche E is known, the value of Tranche D can readily be calculated by subtraction. As shown in Exhibit 10 on page 9, the value of lower tranches is measured following the same procedure. Note that – in keeping with first observation above – the sum of the individual tranche values is equal to the equity value. Financial engineering can create complexity, but does not create value.

Finally, the tranche values are apportioned to the individual equity classes in accordance with the percentages from the marginal tranche allocation matrix (Exhibit 9). As shown in Exhibit 11 on page 9, the value of a particular equity class is the sum of the values of that class's respective allocations for each tranche.

The aggregate values are converted to per share amounts in Exhibit 12 on page 10.

On a per share basis, the results conform to expectations regarding the relative value of the various classes. The higher liquidation preference of the Class B preferred shares causes those shares to be most valuable. The common shares, which do not have any liquidation preference, are worth less than either class of preferred shares. Finally, the strike price on the warrants reduces the value of those instruments relative to common shares.

Exhibit 10: Derivation of Tranche Values

	Tranche A	Tranche B	Tranche C	Tranche D	Tranche E
Stock price (S)	**$17,500**	$17,500	$17,500	$17,500	$17,500
Exercise price (K)	$0	$2,500	$5,500	$11,500	$23,000
Time to expiration (T)	**4.0**	4.0	4.0	4.0	4.0
Volatility (σ)	**35.0%**	35.0%	35.0%	35.0%	35.0%
Risk-free rate (r)	**1.500%**	1.500%	1.500%	1.500%	1.500%
Value of call options	**$17,500**	**$15,148**	**$12,426**	**$8,033**	**$3,514**
Tranche Values	**$2,352**	**$2,722**	**$4,393**	**$4,519**	**$3,514**

Calculated by subtraction

Exhibit 11: Calculation of Equity Class Values

		Tranche A	Tranche B	Tranche C	Tranche D	Tranche E	Tranche E
Tranche Values	**A**	$2,352	$2,722	$4,393	$4,519	$3,514	$17,500
Marginal Allocations							
Class A Preferred	**B**	40.0%	0.0%	25.0%	21.7%	19.6%	
Class B Preferred		60.0%	0.0%	0.0%	13.0%	11.8%	
Common Shares		0.0%	100.0%	75.0%	65.2%	58.8%	
Warrants		0.0%	0.0%	0.0%	0.0%	9.8%	
Marginal Values							
Class A Preferred	**A x B**	941	0	1,098	982	689	3,710
Class B Preferred		1,411	0	0	589	413	2,414
Common Shares		0	2,722	3,295	2,947	2,067	11,031
Warrants		0	0	0	0	344	344
Total		$2,352	$2,722	$4,393	$4,519	$3,514	$17,500

Calculated by addition

Exhibit 12: Calculation of Per Share Values

	Total Value	Fully-Diluted Shares	Value per Share
Class A Preferred	$3,710	500	$7.42
Class B Preferred	$2,414	300	$8.05
Common Shares	$11,031	1,500	$7.35
Warrants	$344	250	$1.38

Other Economic Features That Can Be Modeled in Option Pricing Models

The ComplexCo example included the most common economic rights (liquidation preferences, conversion features, exercise prices) found in equity instruments. The OPM can also accommodate dividends, to the extent they accumulate and affect liquidation preferences and/or conversion. Participation rights for preferred shares allow preferred shareholders to receive – in addition to their base liquidation preference – additional proceeds at liquidation on an as-if-converted basis, often up to some cap, expressed as a multiple of the liquidation preference. The mechanics of participation rights can vary modestly, but in any event can be directly modeled within the OPM framework.

More exotic, and less common, features of preferred shares include price or return hurdles that influence the allocation of proceeds to the equity holders. The OPM can also be accommodated to these features. So long, as the feature can be reduced to a function of total equity value (i.e., for a given total equity value, there is one and only one possible allocation of proceeds to the various classes), the feature can be valued within the OPM framework.

Not all features can be reduced to a function of total equity value, however. The OPM cannot be adapted to directly value differential voting rights, price protection or ratchet provisions, drag-along and tag-along rights, pre-emptive rights. Some notable recent late-stage rounds have featured complex anti-dilution provisions, including guaranteed minimum returns in the event of an IPO that go beyond the protections offered by traditional price ratchets. When such features are present, valuation specialists need to consider whether a discrete adjustment to the results of the OPM analysis should be made in measuring fair value.

The OPM allocates the value of the existing capital structure, with the volatility parameter determining the potential changes in the value of the existing equity classes. Future issuances of additional equity are assumed to pull their own economic weight (i.e., neither contribute to, nor detract from, the value of the existing equity classes). As a result, there is no need to make assumptions in the OPM for the amount, timing, or pricing of future equity raises.

Assessing Reasonableness: Inputs

Beyond the formal elements of the capital structure that define breakpoints and tranche allocations, the required inputs to the OPM are the traditional Black-Scholes parameters. Exhibit 10 (reproduced on page 11) displayed the inputs used to allocate the value of ComplexCo.

Exhibit 10: Derivation of Tranche Values

	Tranche A	Tranche B	Tranche C	Tranche D	Tranche E
Stock price (S)	**$17,500**	$17,500	$17,500	$17,500	$17,500
Exercise price (K)	$0	$2,500	$5,500	$11,500	$23,000
Time to expiration (T)	**4.0**	4.0	4.0	4.0	4.0
Volatility (σ)	**35.0%**	35.0%	35.0%	35.0%	35.0%
Risk-free rate (r)	**1.500%**	1.500%	1.500%	1.500%	1.500%
Value of call options	**$17,500**	**$15,148**	**$12,426**	**$8,033**	**$3,514**
Tranche Values	**$2,352**	**$2,722**	**$4,393**	**$4,519**	**$3,514**

Calculated by subtraction

The OPM inputs can be developed, and tested for reasonableness, in the same manner as in other applications of the Black-Scholes model.

- **Stock Price.** The stock price in the OPM is the total equity value of the subject business. The total equity value is derived through application of traditional valuation methods under the asset-based, income and market approaches. As will be discussed in a subsequent section, a known value for a particular component of the capital structure can be used to find the implied total equity value (the "back-solve" method).
- **Exercise Price.** The exercise prices in the OPM correspond to the equity value breakpoints identified in the formal analysis of the capital structure.
- **Time to Expiration.** In applying the OPM, one must assume a single point estimate for when liquidity will be achieved, either through dissolution, strategic sale, or IPO. While the actual time to expiration cannot be known with certainty, reasonable estimates can generally be made by reference to the subject company's life cycle stage, funding needs, and strategic outlook.
- **Volatility.** As with time to expiration, volatility cannot be directly observed. The most common starting point for volatility analysis is an examination of historical return volatility for a group of peer public companies. If reliable data is available, implied volatility from publicly traded options on the shares of such companies may also be consulted. Analysts adjust the observed peer volatility measures to take into account life cycle stage, remaining milestones, and other qualitative factors pertaining to the subject company.
- **Risk-free Rate.** The risk-free rate corresponds to the assumed time to expiration.

The most challenging assumptions to establish and support in application of the OPM are the time to expiration and volatility. As discussed in the following section, testing the sensitivity of the OPM output to variation in these inputs is a critical element of assessing reasonableness.

Assessing Reasonableness: Output

Report reviewers can quickly confirm the most basic mechanical integrity of an OPM through three easy preliminary checks: (1) the sum of the aggregate equity class allocations equals the total equity value of the subject company, (2) the sum of the fully-diluted shares used to calculate value per share equals that in the capitalization table, and (3) the rank order of the per share value conclusions is consistent with the liquidity preferences, conversion rights, and exercise prices pertinent to the various equity classes. These simple checks will not uncover all potential modeling errors, but they do eliminate a good portion of the most egregious potential pitfalls.

Beyond mere mechanical integrity, an additional step in assessing the reasonableness of the OPM output is to consider the sensitivity of the resulting allocation to changes in key inputs, principally time to expiration and volatility. Exhibit 13 below provides such sensitivity analysis for ComplexCo.

We can make a few general observations from the sensitivity analysis in Exhibit 13.

1. Since the OPM is an allocation model, the total value of the equity classes is unaffected by changes in inputs. The only impact such changes can have is on the relative allocation to various classes. This is purely a zero-sum game; for one class to increase in value, one or more other classes must decrease in value.

Exhibit 13: Sensitivity to OPM Inputs

	Volatility = 35%			Time to Expiration = 4 yrs		
	Changes in Time to Expiration			Changes in Volatility		
	2 yrs	4 yrs	6 yrs	20%	35%	50%
Total Value						
Class A Preferred	$3,744	$3,710	$3,696	$3,764	$3,710	$3,698
Class B Preferred	2,345	2,414	2,458	2,304	2,414	2,526
Common Shares	11,221	11,031	10,878	11,290	11,031	10,729
Warrants	189	344	467	142	344	546
Total	$17,500	$17,500	$17,500	$17,500	$17,500	$17,500
Per Share Value						
Class A Preferred	$7.49	$7.42	$7.39	$7.53	$7.42	$7.40
Class B Preferred	$7.82	$8.05	$8.19	$7.68	$8.05	$8.42
Common Shares	$7.48	$7.35	$7.25	$7.53	$7.35	$7.15
Warrants	$0.76	$1.38	$1.87	$0.57	$1.38	$2.19
Difference between Class B & Common	*$0.34*	*$0.69*	*$0.94*	*$0.15*	*$0.69*	*$1.27*

2. The sensitivity results are easiest to interpret for the warrants. As the junior-most security in the capital structure, the sensitivity to changes in OPM inputs is unambiguous. Increases in time to expiration cause the allocation to warrants to increase, as do increases in volatility. Furthermore, because the warrants are at the bottom of the capital stack, the sensitivity of value to changes in inputs is magnified relative to other equity classes.

3. The Class B preferred shares benefit from downside protection, as the proximity of the conversion price ($5.00) to the current common share price increases the likelihood that the liquidation preference will preserve returns to the Class B preferred shareholders. The payoff to the Class B preferred shareholders is asymmetric since the upside is unlimited through the conversion feature, while the downside is constrained by the liquidation preference. As a result, assumptions that increase the dispersion of potential future outcomes (longer time to expiration and higher volatility) cause the value of the Class B preferred shares to increase.

4. The junior preferred shares (Class A) are directionally aligned with the common shares, although the fixed liquidation preference dampens volatility relative to the common shares. In cases of short times to expiration and low volatility, the per share value for Class A approaches that of the common as the likelihood that the current share price ($7.35) will fall below the Class A conversion price ($2.00) diminishes to a trivial level.

5. The sensitivity of the common shares, which are situated between the preferred classes and the warrants, is less predictable. In this case, the warrants have a parasitic relationship to the common shares, such that increases in the value of the warrants are accompanied by decreases in common share value. This relationship does not always obtain, however; the relative proportions of the instruments in the capital structure and the "moneyness" of the various capital structure components will determine the sensitivity of the common.

With reference to seniority, the equity classes at the "edges" of the capital structure are those that experience the greatest relative benefit from a skewed outcome. The most senior class benefits (on a relative basis) from the liquidation preference in a downside scenario, while the most junior class experiences the greatest marginal benefit from an upside scenario. Since the classes at the "edges" gain the most from skewed outcomes, they exhibit the greatest sensitivity to volatility and time factors, with the "interior" classes are less sensitive (Exhibit 14).

Exhibit 14: Seniority and Sensitivity to Volatility

Equity Classes Ranked by Seniority	
Class B Preferred	Most Senior
Class A Preferred	Muted Sensitivity
Common	
Warrants	Most Junior

Strengths and Weaknesses Relative to PWERM

The primary analytical alternative to the OPM is the probability-weighted expected return method, or PWERM as it is affectionately known. Whereas the OPM is a continuous model, with potential future outcomes assumed to occur pursuant to a lognormal distribution, the PWERM is a discrete model which considers a finite number of analyst-selected potential outcomes and associated probabilities. In contrast to the OPM, the PWERM pulls double duty as both a valuation method and a means of simultaneously allocating the resulting value to the various equity classes.

Exhibit 15 on page 15 summarizes a comparison of the two models along a variety of axes.

Reliability of Backsolve Application of OPM

The OPM is not a valuation method. However, if the value of any component of the capital structure is known – through either a contemporaneous primary issuance or secondary trade – the enterprise value corresponding to that value can be determined. Using the OPM to work backward from output to an indication of implied total equity value is known as the "backsolve" method.

As an example, consider the case of ComplexCo at the time the Class B preferred shares were issued at a price of $5.00 per share (one year prior to the valuation date in our Part 1 example). What was the implied total equity value of the company at that time? By starting with the known value of $5.00 per Class B preferred share, we can work backward, developing estimates for all the other assumptions, to determine the implied total equity value. In this case, we conclude that all assumptions are unchanged from Exhibit 10, with the exception of time to expiration, which is five years, instead of four. As shown in Exhibit 16, the resulting total equity value is $7,242 at the issuance date, compared to $17,500 at the later valuation date from our prior example.

Exhibit 16: Backsolve Method Using the OPM

	Total Value	Fully-Diluted Shares	Value per Share
Class A Preferred	$1,618	500	$3.24
Class B Preferred	$1,500	300	**$5.00**
Common Shares	$4,089	1,500	$2.73
Warrants	$35	250	$0.14
Total	$7,242		

This procedure is reasonable and appropriate in many circumstances. In our experience, however, it is important to keep in mind how the limitations of the OPM (primarily the lognormal distribution of outcomes) can distort the results of the analysis. When reading "backwards" from the value of a single equity class to the value of all equity, the effect of such distortions can be magnified. In our experience, the potential magnitude of such distortion is greatest when the known value is for the most senior

Exhibit 15: Comparison of OPM and PWERM

	OPM	PWERM
Required Assumptions	In addition to the breakpoints and tranche allocations dictated by the capital structure terms, requires only five inputs.	Requires more assumptions than the OPM. Analyst must specify amount, timing and probability of future liquidity events as well as dilution from future financing rounds and class-specific discount rates.
Sensitivity to Assumptions	As shown in Exhibit 13, sensitivity for many classes is somewhat muted. Since the OPM is only an allocation method, the impact of changes in inputs on allocation is generally tame compared to that in typical valuation methods.	Since the PWERM is both a valuation and allocation method, sensitivity to changes in inputs is potentially greater than with OPM.
Flexibility / Adaptability	Small number of required assumptions limits the flexibility and adaptability of the model. Cannot accomodate some common features of preferred shares such as mandatory conversion at IPO, IPO price guarantees and the like. The assumed lognormal distribution of outcomes may not be representative for many development-stage entities.	Can be readily adapted to unique features, such as price protection or ratchets. Offers the flexability to consider a range of potential future outcomes that more closely represent the market participant perspective than a lognormal distribution. Allows the analyst to consider outcomes at different times, and to model dilution from future funding rounds (even down rounds).
Transparency	Host of intermediate calculations and lack of familiarity with breakpoint analysis on the part of many report users contribute to perception that method is a "black box".	Generally intuitive, allocation of proceeds for each discrete scenario is readily checked for conformity to governing documents.
Auditability	While not necessarily intuitive for non-specialists, small number of assumptions and translation of governing documents to formal structure of model is highly auditable.	While the required inputs correlate to assumptions that market participants actually make, convincing and documentable support for these estimates may prove elusive.

security in the capital structure. In many cases, the lognormal assumption causes total loss scenarios to be under-represented in the probability distribution of potential future outcomes relative to market participant expectations. When combined with the use of the risk-free rate in a risk neutral framework, the OPM may assign greater value to the liquidation preference than market participants do. This can cause the difference between the most senior preferred class and other components of the capital structure to be exaggerated, resulting in an understated total equity value.

In our view, these distortions can be further aggravated when the equity class used to calibrate the total equity value accounts for only a small portion of the subject company's capital structure. In our practice, we temper the effect of this issue by also giving weight to the total equity value which is the product of the known per share price and the fully-diluted share count.

Reconciling the OPM with Market Participant Perspectives

There is an irony at the heart of fair value measurement. Fair value is, by definition, a market participant concept. In other words, a "correct" fair value measurement will reflect the exit price for the subject asset among a group of relevant market participants. However, some techniques for measuring fair value are rarely, if ever, used by actual market participants.

In our experience working with market participants in early-stage companies, new financing rounds are generally priced through a two-step process: (1) negotiate the pre-money total equity value of the company, and (2) divide that figure by the fully-diluted share count. These market participants clearly understand that the economic rights associated with senior preferred shares are valuable. However, they do not develop or express a discrete estimate of that value. We suspect that there are at least two potential explanations for this. First, the economic rights that benefit the senior preferred shares may be the required "sweetener" to arrive at the headline total equity value. Second, in many early-stage companies, the actual benefit of a liquidation preference may be perceived as limited. Certainly, the scenario that would trigger payout of a liquidation preference, in lieu of participating as common shareholder following conversion, is sub-optimal. If the most likely outcomes are smashing success (in which case everyone converts and is treated equally) or abysmal failure (in which case being first in line to get nothing is not helpful), market participants may be less impressed by the economic rights accruing to the senior securities than the OPM would seem to be.

Assuming we are right, this perfectly rational behavior on the part of market participants can put those with the responsibility to measure fair value in a difficult spot. Consider a company that recently closed a $20 million Class B round, with customary liquidation preferences and conversion rights. The term sheet states that the pre-money equity value is $100 million. There are 10 million Class A preferred and common shares outstanding, and the issuance price for the Class B round is $10 per share.

As shown in Exhibit 17, there are three logical possibilities in this case. The only case that is inconsistent with the OPM is the one that reflects the actual, stated terms of the transaction.

There is no simple solution to this conundrum. However, to our mind it does underscore the appropriate posture toward analytical tools like the OPM. The fair value measurement tool should serve the market

Exhibit 17: Reconciliation to Market Participant Perspective

TEV = $100 million Class B > $10.00	TEV = $100 million Class B = $10.00 per Term Sheet	TEV < $100 million Class B = $10.00
Consistent with OPM	Not Consistent **with OPM**	Consistent with OPM

participant perspective; the market participant perspective should not be subordinated to the fair value measurement tool, no matter how insightful and "correct" it may be. As we have noted on our *Financial Reporting Blog*, Fidelity reports identical per share values for different equity classes of a given investee company. In doing so, one is effectively disregarding the differential economic rights of the various classes. Strictly speaking, such a conclusion is economically untenable. Yet, it likely mirrors how Fidelity, and other market participants, actually view value.

Conclusion

Use of the OPM in fair value measurement is growing. The model has many attractive attributes, including its precision, small number of assumptions, muted sensitivities, and auditability. However, the model is not necessarily appropriate in all circumstances. The underlying assumption of lognormality may not be appropriate for some companies, and may limit the usefulness of the backsolve technique for determining implied total equity values. In our view, the model is best used in conjunction with the PWERM. Finally, as with all fair value measurement models, valuation specialists should carefully evaluate the degree to which the results of the model cohere with the market participant perspective.

About the Author

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