Venture Capital Valuations and Contracts

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Abstract

We investigate the impact of Venture Capital (VC) contracts on valuation heterogeneity (AVD) observed in mark-to-market valuations of appraisers relative to post-money valuations (PoMV) utilized by market participants. A retrospective option pricing analysis of 100 of the largest US VC-backed companies that went public between 2000-2024 suggests that holding period and equity volatility are first-order factors for the observed AVD, regardless of deal or contracting properties. Proper risk-adjusting leads to increased risk-neutral implied yields by more than 750 basis points, decreases over-concentration of value to downside protection by half, and harmonizes implied conversion probability spread among classes to 22% while reducing AVD to a median 25%. Appraisers' proper endogenous model and parameter selection for security specific volatility and illiquidity discount affects stock-based compensation fair value on average by 19.2%. Our results are robust and scalable to the broader VC universe.

Keywords: Venture capital, Contracts, Capital structure, Value of firm, Asset pricing

JEL codes: G12, G23, G32

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1. Introduction

The valuation of venture capital (VC)-backed companies has always posed several challenges to valuation appraisers, VC funds (VCs), audit teams, and other market participants, due to their illiquid nature, governing contractual economic rights, and privileges of investors tied to asymmetric and skewed pay-off characteristics of underlying economic classes, perceived idiosyncratic risk profile, lack of or limited information rights, and valuation implications that new financing rounds have in the value evolution journey of portfolio companies. Mark-to-market valuations performed by appraisers by relying on financing rounds and using quantitative option pricing methods (OPM) might generate substantial consolidated value (RNV) differential relative to fully diluted (FD) post-money valuations (PoMV), depending on the composition of contracting cash flows rights and model specifications. We are the first to provide comprehensive evidence that OPM fails to embed key elements of VC assets' risk attributes and unsystematic risk-adjusted returns of market participants if risk-adjusted assumptions are not leveraged, with significant financial reporting, tax and deal implications. We quantify the endogenous parameters of this valuation noise pertaining to OPM structural limitations and provide a valuation framework that aims to minimize asset pricing heterogeneity by analyzing (i) risk-neutral implied yield associated with liquidation preference (LP) or bond component of preferred stock classes, (ii) relative ratio of downside LP protection versus as converted upside feature of convertible or participating preferred stock and, (iii) risk-neutral conversion probability for preferred stock classes and variation relative to in-the-moneyness likelihood for subordinated common stock. We assess how properties of idiosyncratic risk reflected on contracting characteristics, positively contributing to this valuation noise, can be controlled by risk-adjusting non observable assumptions dealing with model imperfect distribution characteristics and addressing the non-diversifiable portion of the mispricing observations that is tied to model specifications which do not capture proper probabilistic distribution of expected liquidity outcomes. Risk-adjusted assumptions contingent on contracting provisions are first-order factors for VC valuation robustness and have massive implications for stock-based compensation (SBC) plans, deal multiples and pricing characteristics, taxable income and respective capital gains, optimal investment strategies, pricing and, liquidity dynamics in secondary markets.

An important contributing factor to this potential mispricing observation is the endogenous risk sharing behavior tied to VC investment strategies and the organic resolution of agency problems via proper contracting design with asymmetric risk exposure characteristics. Implementation of standard VC contracting structures for alignment between management teams and investors' diverging economic interests Townsend (1979), Grossman and Hart (1986), Baker (1992) and Berglöf (1994), first organically, and then by consciously accepting dilution in anticipation of strategic synergistic added value and abnormal returns, aims to maximize internal rate of return (IRR) or return on equity (ROE) leading to normalized optimal allocation of assets upon a qualifying liquidity event Cornelli and Yosha (2003), Inderst and Müller (2004) and Hall and Woodward (2010). The deterministic role of VCs is profound, since they add value to portfolio companies by developing a finite number of value enhancement activities that cover broader organizational efficiency aspects, financial health and ultimate liquidity plans Chemmanur et al. (2011), proper risk sharing equity incentive programs Hellmann and Puri (2002), and strategic executive human capital management Ewens and Marx (2017), Lerner (2022), among primary organic and add-on acquisition growth expectations. VCs develop adaptive sophisticated strategies and corporate monitoring mechanisms depending on both broader systematic risk factors but also technological developments Ewens et al. (2018) or broader social and macroeconomic variables Ewens and Farre-Mensa (2022) as well as idiosyncratic investment and company specific considerations Sahlman (1990), Tian (2011) and Broughman and Fried (2012) that have repeatedly tied to performance persistence Hochberg et al. (2013), Buchner et al. (2016) and Harris et al. (2023). Preferential reduced acquisition costs Hsu (2004) and risk-taking contracting orientation Litov et al. (2024) tied to VC reputation, consistent focus on influential managerial decision-taking access via Board of Directors (BoD) presence Amornsiripanitch et al. (2019), continuous emphasis on broader corporate governance and business monitoring mechanisms Barry et al. (1990) that also drive adaptive add-on funding strategies Hogrebe and Lutz (2024), heavy weight concentration on quality attributes of founding teams Bernstein et al. (2017), and strategic allocation of powerful control rights which represent significant reflection of the target liquidity plans Cumming (2008), shape investment performance characteristics for the contemplated illiquid VC assets. Top VC-backed companies have been systematically tied to the generation of excess returns for underlying shareholders and management teams, overcompensating investors for the increased idiosyncratic risk and the illiquid nature of the investment Gompers and Lerner (1997),Chen et al. (2012) and Brown and Kaplan (2019). The evolution and importance of VC investment momentum, reflected in consolidated deal size and respective activity over the past 24 years, is clearly illustrated in Figure 1.

[Insert Figure 1 here]

While investors deal with the valuation complications of this illiquid asset nature, followed by limited or no information rights, by harmonizing valuation benchmarks for private companies and treating them as comparable to public companies' equivalent value indications, valuation appraisers usually have a fundamentally different perspective depending on the stage of business, idiosyncratic risk profile, equity concentration, corporate governance characteristics, and engagement scope. They are bound by specific accounting reporting requirements and asset pricing guidelines introduced by the Accounting Standard Codification Topic 718 (ASC 718)[1], Accounting Standard Codification Topic 820 (ASC 820)[2], the 2019 American Institute of Certified Public Accountants Guide for the valuation of illiquid private investments (2019 AICPA Guide) [3], the Internal Revenue Code Section 409(a) and associated Treasury regulations (IRC 409(a)) [4]. Valuation professionals utilize a portfolio of different methods applicable in determining the total enterprise value (TEV) or business equity value (BEV) of a VC-backed company, including traditional income approaches, market, and asset methods. While these methods are computationally robust and are widely deployed as standard acceptable corporate valuation frameworks, they are still subject to high subjectivity and endogeneity issues due to potentially high input selection bias, structural limitations, and default standard error sensitivity, fundamental concerns about the probability distribution of projected outcomes, persistent difficulty in validating assumed or implied risk-adjusted growth assumptions, potential misalignment between market participant assumptions versus management driven key variables time series, and lack of sufficient, regularly-paced, verifiable, comprehensive historical data that could widen the confidence interval in the probabilistic assessment and forecast behavior of the utilized model.

Thus, appraisers and VCs strongly prefer to rely on pricing information of financing events that could be considered arms-length transactions and are deemed acceptable fair value (FV) or fair market value (FMV) indications to infer a TEV or BEV for portfolio companies [5] for financial reporting and tax purposes, respectively. Typically, for VC-backed companies, those indications are tied to the successful consummation of new financing rounds

[1]Refer to FASB ASC 718 – Compensation – Stock Compensation.

[2]Refer to FASB ASC 820 – Fair Value Measurement.

[3]The 2019 AICPA Guide for the *Valuation of Portfolio Company Investments of Venture Capital and Private Equity Funds and Other Investment Companies* provides comprehensive guidelines and best practices for the valuation of equity securities in privately held companies, which pose several challenges to valuation appraisers and audit teams due to (i) the lack of marketability of private equity securities, (ii) the complex capital structures and (iii) the absence of market value indications that would serve as reliable model calibration inputs.

[4]Refer to IRS Section 409(a).

[5]For financial reporting purposes, an equity valuation analysis aims to derive an estimate of FV, which, under ASC 820-10-20, is defined as the price that would be received to sell an asset or paid to transfer a liability in an orderly transaction between market participants at the measurement date. Conversely, for tax

or large-scale secondary transaction offerings [6]. For the valuation of traditional VC-backed companies with multi-share capital structures, lack of concrete exit pricing information, and absence of any imminent liquidity plans, the most prevalent and widely accepted approach for financial reporting and tax purposes is the OPM, which is based on the foundations of option pricing theory and the contingent claim analysis introduced by Black and Scholes (1973) and Merton (1974). The OPM treats the different equity classes as derivative instruments on the total assets of the company (either TEV or BEV) with strike prices that reflect the appropriate participation threshold of each security depending on the contractual economic rights and privileges and the specific capital structure details. Each equity security represents a derivative instrument on the total assets that is subject to unique economic payoff characteristics and different levels of risk governed by the attached structural economic features, current growth status of the consolidated assets of the company, and expectations on a going concern basis until the consummation of a strategic exit event.

The valuation community has now developed a better understanding that this valuation approach tends to overemphasize the value of downside protection (DP) or LP, under a combination of specific option pricing assumptions, due to the formed tails of the log-normal distribution payoff characteristics that lead to significant deviation between the FV indications implied within the risk-neutral framework relative to the FD PoMV indications relied upon by VCs or other market participants. Upon a downside scenario, if the value of the company after the consummation of a financing event decreases significantly, and the company considers a potential dissolution, the protection rights of the underlying economic classes will kick-in and distort the economic payoff to the various classes depending on applicable seniority, balance of the preferred stock classes, and total available assets. To illustrate the importance of contracting details on the valuation of VC assets, consider a company with 100 million common stock units, 20 million Series A units at $1.00 each, and 12 million Series B units at $2.00 each. Series A and B are pari passu but senior to common

reporting purposes, an equity valuation analysis aims to derive an estimate of FMV, which, under Treasury Regulation Rev. Rul. 59-60, 1959-1 B. 237, is defined as the price at which property would change hands between a willing buyer and a willing seller, when the former is not under any compulsion to buy and the latter is not under any compulsion to sell, both parties having reasonable knowledge of the facts. The OPM applies to the valuation of equity interests for both financial and tax reporting purposes. FV and FMV might lead to different valuation conclusions depending on the underlying capital structure, equity concentration, and illiquidity properties, but frequently they are deemed to be synonymous, which is how they are being treated for the purpose of this paper, given that any structural differences are out of the investigated research scope of this paper.

[6] Participation of new institutional investors and a substantial volume size are deemed essential to qualify for an arms-length transaction.

stock, and they reflect standard convertible preferred instruments with 1.0x LP multiple, 1.0x conversion ratio, and no attached dividend yield right. Recently, the company raised \$35 million in Series C Preferred at \$3.50 per share, with a pre-money valuation of \$462 million, resulting in a PoMV of \$497 million. Assuming that Series C resembles the rights of Series A and B but is senior to those classes, if the company is sold at its PoMV, all classes shall receive \$3.50 per unit. However, if the company's value decreases by 20% (\$397.6 million), Series C Units receive \$3.50 per unit, but Series A, Series B, and common stock receive \$2.75 per unit. In a distressed scenario with a 15% recovery rate (\$74.55 million), the payout of classes is skewed even more: \$3.50 per Series C Unit, \$1.80 per Series B Unit, \$0.90 per Series A Unit, and no residual distribution to common stock given that the value of recovered assets is less than the consolidated LP of the preferred stock classes. This rather simplified example highlights the significant pricing implications of contracting details and complexity of capital structures in the valuation of multi-share VC-backed assets, which can lead to substantial deviations from market expectations formed based on a PoMV basis.

Our paper contributes to several strands of the literature. First, we introduce a seminal contribution to the developing literature of asset pricing techniques in the VC space. Our paper resonates closely with Gornall and Strebulaev (2020), who applied a contingent model approach Black and Scholes (1973), Merton (1974) to 135 unicorns to determine valuation deviation relative to PoMV after accounting for contracting details as of the last financing round, and Agarwal et al. (2023) who applied a similar model, initially introduced by Metrick and Yasuda (2010), to marks of private companies included in mutual funds and concluded on an average delta between RNV and PoMV of 43% when accounting for contracting information. Our paper expands further, investigates valuation implied risk-adjusted return characteristics, highlights structural limitations of those models, and suggests an evaluation framework based on contracting information and risk-adjusted assumptions that aims to minimize pricing dispersion. Korteweg and Nagel (2016) suggested a novel stochastic discount factor model for the determination of the economic payoffs of VC assets with asymmetric payoff characteristics. Sorensen et al. (2014) developed an asset pricing model that incorporates capital allocation and leverage assumptions, transferability and illiquidity constraints, and active general portfolio management and compensation mechanisms to derive risk-adjusted private equity valuations. Gornall and Strebulaev (2021) developed a dynamic asset pricing model that incorporates future dilution of subsequent capital raised based on default deal assumptions. Opp (2019) introduced an intermediation asset pricing model for VC that addressed the irregularities and macroeconomic importance of VC re-sources whose impact might be higher than the realized exit values. Korteweg and Sorensen (2010) proposed an asset pricing model that accounts for irregularities in the frequency of reported valuations, diverse payoff functions, and adjustments for proper risk-adjusted performance evaluations. Berger et al. (1996) introduced a dynamic real option asset valuation framework that accounts for dynamic investor decisions with direct implications in optimal exit investment horizons and VC strategies.

Second, our paper contributes to the existing literature on the risk and return characteristics of VC contracts. Our paper validates certain empirical findings of Cochrane (2005), who concluded that VC investments in subsequent rounds are subject to a lower risk profile, which is reflected in risk-adjusted return metrics but not necessarily in the implied asset specific volatility. Ljungqvist (2003) analyzed private equity returns based on fund investment behavior and documented superior returns between 5% - 8% relative to public market indexes attributable to higher risk and illiquidity considerations. Yimfor and Garfinkel (2023) concluded that successful exit events are key explanatory factors of VC funds return performance for later stage companies and that for early stage companies, a number of other qualitative variables related to the number of capital raises completed, patent recognition, employee development characteristics etc., have a more direct correlation with the return characteristics of VC funds. Crain (2018) analysed quality data obtained from a large asset manager covering 207 VC funds in the period of 1981 to 2008 and concluded that there is a concave relationship between follow-on investments and underlying fund performance and that VCs with initial superior performance have higher incentives to consider future riskier portfolio assets when considering optimal trade-off between carried interest and fundraising incentives. Gompers et al. (2008) investigated investment strategies differentiation depending on market signals and VC expertise, Nguyen and Vo (2021) analysed the relationship between market liquidity and VC asset performance, Nanda and Rhodes-Kropf (2013) addressed the impact of market signals and timing of initial capital raise in risk-adjusted performance characteristics of VC assets, and Lerner (1994) investigated the impact of market timing into VC decisions about exit events and implied return metrics. Finally, Moskowitz and Vissing-Jørgensen (2002) investigated the behavioral reasons that drive investment decisions depending on risk assessment of illiquid private equity assets, Puri and Zarutskie (2012) evaluated the risk profile evolution during the expected life of the VC asset, Kaplan and Schoar (2005) examined the net return characteristics depending on fund strategy and confirmed performance persistence, and Barber and Yasuda (2017) linked the performance persistence to the importance of the contemplated VC asset management strategies, exit characteristics, and insights from interim asset valuation disclosures.

Finally, our paper contributes to the extensive literature on VC contracts and broader contracting and agency theory. Our paper closely relates to the research of Kaplan and Strömberg (2003), Bengtsson and Bernhardt (2014), and Fu et al. (2023) on contracting details evolution round over round and the existence of default contract in VC deal design and Ewens et al. (2022) who addressed the impact of VC contracts in the firm value and relative value allocation between external and internal parties by focusing on VC-backed first financing rounds. Kalay and Zender (1997), Biais and Casamatta (1999), Bascha and Walz (2001), and Schmidt (2003) addressed why VC deals rely heavily on hybrid equity securities to properly align insiders and outsiders and achieve optimal asset value growth and allocation pay-off characteristics. Using a dataset of 1266 companies, Bengtsson and Sensoy (2011) found a negative correlation between VC experience and skills relative to the negotiation power over securing strong downside cash flows protection rights; instead, skilled VC investors are more likely to negotiate board representation which leads to better VC monitoring mechanisms. Kaplan and Stromberg (2004) investigated structural contracting considerations depending on VC focus on monitoring and corporate governance mechanisms, and Bengtsson and Sensoy (2015) analysed the evolution of VC rights across financing rounds observing a negative correlation between financial performance and investors friendly cash flows rights. Broughman and Fried (2010) analysed implications of common stock ownership in eventual exit payoff characteristics and potential alteration of initial governing rights, Bengtsson and Ravid (2009) investigated the impact that the location of portfolio companies has in contracting details and relative bifurcation of economic rights and Geczy et al. (2021) studied how adaptive contracts utilized in PE or VC space are to social impact factors by focusing on different aspects of the contracts, concluding that rights associated with financial outcomes tend to be unchanged, but broader control and governance rights have a better alignment with impact-related objectives and criteria.

The remainder of this paper is organized as follows: Section 2 describes the mathematical framework for the valuation of VC-backed assets, along with a base case illustrative example. Section 3 provides an overview of the sample construction, valuation procedures performed, and a description of specific underlying assumptions. Section 4 includes the consolidated results of our analysis along with the robustness evaluation. Section 5 discusses the significant implications for the valuation of VC assets, while Section 6 concludes.

2. Option pricing model for the valuation of VC assets

In this section, we present the mathematical foundation for the valuation of VC-backed assets, derivation of analyzed risk and return implied metrics, and illustration of applicable valuation calculations on a hypothetical VC asset. Section 2.1 provides the OPM mathematical derivation, while Section 2.2 includes the description and formulaic expression of the analyzed valuation risk and return metrics. Section 2.3 features the illustration of the numerical example based on a hypothetical VC portfolio company, while Section 2.4 includes the robustness and sensitivity analysis of both contracting and modeling inputs on the hypothetical VC asset.

2.1. Mathematical framework

Let us consider a VC-backed company that has undergone N financing rounds. Each financing round date is denoted with t_n, $n = 1, \ldots, N$, and the company has issued j_n different preferred equity securities. It is worth noting that a company might issue multiple equity securities during any given financing round with flat pricing characteristics due to corporate governance reasons or potential conversion of convertible notes per applicable contracting requirements, etc. The mathematical framework presented herein is agnostic with respect to the number of newly issued securities and can capture the capital structure of any VC-backed company, regardless of its complexity.

The proposed pricing framework relies on valuing equity securities as a combination of call options written on the BEV, denoted with E_t, under the assumption that the company would pursue an exit event at a predetermined date. The so-called exit event date or liquidity date is denoted by T, and for each financing round, the expected time until a liquidity event is equal to $\Delta t_n = T - t_n$. The appropriateness of the initial liquidity date T might be reassessed periodically, depending on the market pricing of new financing rounds, controlling characteristics of consolidated VC equity concentration, broader market considerations, and other systematic or idiosyncratic factors. We recognize that the selection of this parameter is an endogenous decision that results from the optimization of the controlling or consolidated shareholders' equity net worth position. For the purposes of this paper, we treat the liquidity date as an exogenous parameter (the sensitivity of this input is addressed in Section 4.4 and Appendix B), and we rely on standard industry valuation practices that suggest a calibration based on a static assumed investment horizon, which is typically a management or VC input.

As previously discussed, we model each security as a combination of call options on the BEV of the company E_t, assuming that the latter follows a geometric Brownian motion process with the following specification:

$$dE_t = rE_t dt + \sigma E_t dW_t, \quad E_0 = E > 0 \tag{1}$$

where r denotes the risk-free rate of return, σ is the equity volatility, and dW_t denotes the increments of a standard Brownian motion process. It is important to note that we explicitly ignore dividends in the above stochastic process, since typically VC-backed assets are not tied to periodic dividend distribution amounts, and any declared dividend is properly accounted in the eventual payoff amount or respective required BEV threshold of each applicable security as of the liquidity date.

We define the FV of each security as the expected payoff as of the liquidity date, discounted at the risk-free rate of return that corresponds to the assumed investment term. The payoff function of each security is a non-linear function of the underlying asset price, and in particular, a piecewise linear function of the terminal equity value, reflecting various contracting details that govern seniority, LP, upside participation, conversion ratio, and other contractual protection rights as well as relative capitalization structure dynamics. Therefore, the payoff of the j-th equity security as a function of the company's BEV is mathematically expressed as:

$$\pi_j\left(E_T\right) = \int_0^{E_T} \omega_j(x)\, dx, \quad j = 1, \ldots, j_n \tag{2}$$

where $\pi_j(\cdot)$ denotes the payoff function and $\omega_j(\cdot)$ represents the participation ratio of the j-th equity security respectively. The participation ratio function is a piecewise linear function of the terminal equity value and behaves as a step function that is shifted upwards or downwards the first time the allocation rule among the various securities changes or a specified participation threshold is reached. In the industry parlance, these equity value thresholds or equilibrium value thresholds that trigger participation ratio adjustments are referred to as breakpoints. For example, a conversion breakpoint reflects the consolidated level of BEV at which it is economically optimal for a preferred shareholder to exercise the conversion option and elect to convert their original preferred stock into common stock equivalent shares (CSE Shares) to realize a better ultimate return.

To illustrate the properties of the participation ratio $\omega_j(\cdot)$ and dynamic adjustment per incremental threshold, we analyze the following hypothetical example. Consider a VC-backed company with a capital structure consisting of two classes of convertible preferred stock (Series A and B) and a class of common stock. Series B is senior to Series A, which is senior to common stock, and both classes are convertible into CSE shares based on a 1.0x conversion ratio. Based on their relative economic rights, the first positive breakpoint relates to the satisfaction of the preferential LP claims of the Series B. Subsequently, Series A is entitled to their unreturned LP. Once the total preferential claims of Series A and B have been satisfied, then the common stock is entitled to any distribution amounts participating with an effective 100% participation ratio until the level of BEV at which it is economically beneficial for the preferred stock with the lower conversion price (CP), which usually mirrors the original issue price (OIP) adjusted for LP properties or downround anti-dilution adjustments, to convert into CSE shares. Assuming a normal financing round value evolution such that $OIP_B > OIP_A$, the next BEV threshold will reflect the Series A conversion breakpoint that is going to trigger an adjustment to the participation ratio of common stock to account for the dilutive impact of the as converted Series A feature. Similarly, the last BEV threshold is the Series B conversion threshold that introduces a step down adjustment to the effective participation ratios or both Series A and common stock for any incremental distribution amount. The aforementioned dynamic adjustment of effective payoff rights is illustrated graphically in Figure 2.

[Insert Figure 2 here]

To generalize this example, we can leverage the set of breakpoints, denoted by B_i ($i = 1, \ldots, i_n$ and i_n is the total number of breakpoints), to separate the integrals into subintervals within which the weight is constant and equal to ω_i. Thus, the payoff function can be expressed as:

$$\pi_j\left(E_T\right) = \int_0^{\min(B_2,E_T)} \omega_j(x)\, dx + \sum_{i=2}^{i_n-1} \int_{\min(B_i,E_T)}^{\min(B_{i+1},E_T)} \omega_j(x)\, dx + \int_{\min(B_{i_n},E_T)}^{E_T} \omega_j(x)\, dx, \qquad (3)$$

where the first breakpoint $B_1 \equiv 0$ and the 'min' ensures that the formula is correct $\forall E_T > 0$. Within each integral, the weights of all equity securities are constant, as x lies between two consecutive breakpoints. If ω_{ji} is the weight of the j-th security between breakpoints i and $i+1$ (and ω_{ji_n} is the weight of the j-th security above the final breakpoint), then the payoff can be simplified to:

$$\begin{aligned}\pi_j(E_T) = \omega_{j1} \min\left(B_2, E_T\right) + \sum_{i=2}^{i_n-1} \omega_{ji}\left(\min(B_{i+1}, E_T) - \min(B_i, E_T)\right) \\ + \omega_{ji_n}\left(E_T - \min(B_{i_n}, E_T)\right).\end{aligned} \qquad (4)$$

This result can be expressed in a matrix form:

$$\begin{pmatrix} \pi_1(E_T) \\ \vdots \\ \pi_{j_n}(E_T) \end{pmatrix} = \begin{pmatrix} \omega_{11} & \cdots & \omega_{1i_n} \\ \vdots & \ddots & \vdots \\ \omega_{j_n1} & \cdots & \omega_{j_ni_n} \end{pmatrix} \cdot \begin{pmatrix} \min(B_2, E_T) \\ \vdots \\ \min(B_{i+1}, E_T) - \min(B_i, E_T) \\ \vdots \\ E_T - \min(B_{i_n}, E_T) \end{pmatrix}, \tag{5}$$

or more compactly:

$$\mathbf{\Pi}\left(E_T\right) = \Omega_n \cdot \boldsymbol{\Delta B}\left(E_T\right) \tag{6}$$

Note that the weights of the different security classes are independent of the BEV and they only depend on the set of breakpoints. The $(j_n \times i_n)$ matrix of weights, Ω_n, is referred to as the allocation matrix. Clearly, the following relation must hold:

$$\sum_{j=1}^{j_n} \omega_{ji} = 1, \forall i \in \{1, \ldots, i_n\}, \tag{7}$$

or in matrix form,

$$\Omega_n \cdot \boldsymbol{e_i} = 1, \forall i \in \{1, \ldots, i_n\}, \tag{8}$$

where e_i is the i_n-dimensional unitary vector along the i direction, i.e., the vector with the i-th element equal to 1 and all the others equal to 0. The total value of the economic payoff is equal to the underlying asset price, which is the BEV. Since the primary motivation of the OPM is to bifurcate the consolidated asset price value to the various equity classes based on their respective economic claims, we replicate the payoff structure of the company's equity classes by utilizing a theoretical portfolio of European-style call options. Each call option value reflects the net upside beyond the applicable breakpoint or strike price. The positive incremental delta between two consecutive option calculations represents the net value associated with the risk-neutral probability that the ending BEV lies within the designated breakpoints. Each incremental call option value is allocated to the company's equity classes based on the proper participation ratios, as specified by the allocation matrix. Let us consider the last breakpoint, above which all securities participate on a pro-rata basis. The payoff above the i_n-th breakpoint is:

$$\pi^{(i_n)}(E_T) = \max(E_T - B_{(i_n)}, 0) \tag{9}$$

Here, we use the superscript to distinguish payoffs between breakpoints from payoffs of securities (where we use a subscript). Later, we will use the notation π_j^i to denote the allocation of the payoff between breakpoints i and $i+1$ to the j-th security. This payoff is equivalent to the payoff of a call option with strike price $B_{(i_n)}$. Its present value (as of a financing round date t_n) using risk-neutral valuation is:

$$\begin{aligned} e^{-r(T-t_n)}\pi^{(i_n)}(E_T) &= e^{-r\Delta t_n}\mathbb{E}\left[\max(E_T - B_{(i_n)}, 0)\right] \\ &= e^{-r\Delta t_n}\mathbb{E}\left[\begin{cases} E_T - B_{(i_n)}, & E_T \geq B_{(i_n)} \\ 0, & E_T < B_{(i_n)} \end{cases}\right] \\ &= e^{-r\Delta t_n}\int_{B_{(i_n)}}^{+\infty}(x - B_{(i_n)})f(x)\,dx, \end{aligned} \tag{10}$$

where $\mathbb{E}\left[\cdot\right]$ denotes expectation value and $f(x)$ is the probability distribution of the risk-neutral BEV.

$$f(x) = \frac{1}{x\sigma\sqrt{\Delta t_n}\sqrt{2\pi}}\exp\left\{-\frac{(\ln x - \ln E_{t_n} - (r - \frac{\sigma^2}{2})\Delta t_n)^2}{2\sigma^2\Delta t_n}\right\} \tag{11}$$

E_{t_n} is the equity value as of the financing round date t_n.

$$e^{-r\Delta t_n}\pi^i(E_T) = e^{-r\Delta t_n}\int_{B_{i_n}}^{+\infty}(x - B_{i_n})\frac{1}{x\sigma\sqrt{\Delta t_n}\sqrt{2\pi}}e^{-\frac{(\ln x - \ln E_{t_n} - (r-\sigma^2/2)\Delta t_n)^2}{2\sigma^2\Delta t_n}}\,dx$$

$$= e^{-r\Delta t_n}\int_{\frac{\ln(B_{i_n}/E_{t_n}) - (r-\sigma^2/2)\Delta t_n}{\sigma\sqrt{\Delta t_n}}}^{+\infty}\left(E_{t_n}e^{(r-\sigma^2/2)\Delta t_n + u\sigma\sqrt{\Delta t_n}} - B_{i_n}\right)\frac{1}{\sqrt{2\pi}}e^{-u^2/2}\,du$$

$$= E_0 N(d_1) - B_{i_n}e^{-r\Delta t_n}N(d_2) \equiv C(E_{t_n}, B_{i_n}, r, \sigma, \Delta t_n)$$

$N(\cdot)$ is the cumulative standard normal distribution, and its arguments, d_1 and d_2, emerge as integration limits when transforming to the standard normal distribution:

$$d_{1,2}(E_{t_n}, B_{i_n}, r, \sigma, \Delta t_n) \equiv \frac{\ln(E_{t_n}/B_{i_n}) + (r \pm \sigma^2/2)\Delta t_n}{\sigma\sqrt{\Delta t_n}} \tag{12}$$

The BEV can be expressed as the sum of the consecutive call option values that measure the net value attributable the interim payoff functions between consecutive breakpoints. The present value (as of t_n) of the expected payoff between breakpoints i and $i+1$ is equal to:

$$
\begin{aligned}
e^{-r\Delta t_n}\pi^i(E_T) &= e^{-r\Delta t_n}\begin{cases} 0, & E_T \leq B_i \\ E_T - B_i, & B_i < E_T \leq B_{i+1} \\ B_{i+1} - B_i, & B_{i+1} < E_T \end{cases} \\
&= e^{-r\Delta t_n}\int_{B_i}^{B_{i+1}} (x - B_i) f(x)\, dx + e^{-r\Delta t_n}\int_{B_{i+1}}^{+\infty} (B_{i+1} - B_i) f(x)\, dx \\
&= C(E_{t_n}, B_i, r, \sigma, \Delta t_n) - e^{-r\Delta t_n}\int_{B_{i+1}}^{+\infty} (x - B_{i+1}) f(x)\, dx \\
&= C(E_{t_n}, B_i, r, \sigma, \Delta t_n) - C(E_{t_n}, B_{i+1}, r, \sigma, \Delta t_n)
\end{aligned} \tag{13}
$$

We now have all the necessary components to calculate the present value of each equity security. The present value of the j-th security between breakpoints i and $i+1$ is:

$$
e^{-r\Delta t_n}\pi_j^i(E_T) = \omega_{ji}\left(C(E_{t_n}, B_i, r, \sigma, \Delta t_n) - C(E_{t_n}, B_{i+1}, r, \sigma, \Delta t_n)\right) \tag{14}
$$

and the overall present value of the j-th security is the sum over all i:

$$
\begin{aligned}
e^{-r\Delta t_n}\pi_j(E_T) &= e^{-r\Delta t_n}\sum_{i=1}^{i_n} \pi_j^i(E_T) \\
&= \sum_{i=1}^{i_n - 1} \left[\omega_{ji}\left(C(E_{t_n}, B_i, r, \sigma, \Delta t_n) - C(E_{t_n}, B_{i+1}, r, \sigma, \Delta t_n)\right)\right] \\
&+ \omega_{ji_n} C(E_{t_n}, B_{i_n}, r, \sigma, \Delta t_n)
\end{aligned} \tag{15}
$$

The present values of all the securities can be also written in a matrix form:

$$
e^{-r\Delta t_n}\begin{pmatrix} \pi_1(E_T) \\ \vdots \\ \pi_{j_n}(E_T) \end{pmatrix} = \begin{pmatrix} \omega_{11} & \cdots & \omega_{1i_n} \\ \vdots & \ddots & \vdots \\ \omega_{j_n 1} & \cdots & \omega_{j_n i_n} \end{pmatrix} \cdot \begin{pmatrix} E_{t_n} - C(E_{t_n}, B_2, r, \sigma, \Delta t_n) \\ \vdots \\ C(E_{t_n}, B_i, r, \sigma, \Delta t_n) - C(E_{t_n}, B_{i+1}, r, \sigma, \Delta t_n) \\ \vdots \\ C(E_{t_n}, B_{i_n}, r, \sigma, \Delta t_n) \end{pmatrix} \tag{16}
$$

Note that the first and last inputs of $\Delta C(E_T)$ are also differences between call options.

The first input has a strike price of 0 (denoting that there is no negative distribution amount) and the last input has a strike price of $+\infty$, with values E_{t_n} and 0, respectively. Following this notation, the present value of the j-th equity security is given by:

$$e^{-r\Delta t_n}\pi_j(E_T) = e_j^T \cdot \Omega_n \cdot \Delta C(E_{t_n}) \tag{17}$$

where the superscript T denotes the transpose of a matrix and e_j is the j_n-dimensional unitary vector along the j direction. Since we perform the analysis as of the latest financing round, we typically solve to determine the level of BEV that calibrates the FV of latest issued preferred stock class to be equal to its OIP. If the index N corresponds to the latest issued preferred stock, then its present value using the OPM is

$$e^{-r\Delta t_n}\pi_N(E_T) = e_N^T \cdot \Omega_n \cdot \Delta C(E_{t_n}) \tag{18}$$

2.2. Risk and return metrics

In this section, we introduce the valuation implied risk and return metrics that we analyze in order to determine the appropriateness of implied valuation indications and robustness of utilized modeling framework and parameters. These metrics include (i) the risk-neutral implied yield or IRR for the DP or discounted LP of preferred stock classes, (ii) the ratio of DP relative to the aggregate fair value of the preferred stock classes, (iii) the risk-neutral conversion probability (RNCP) of the various equity classes depending on contracting details, and (iv) the asset value delta (AVD) defined as the relative % difference between RNV and PoMV. Those risk-neutral observations should reconcile properties of VC investment strategies, idiosyncratic asset characteristics, and broader market participant considerations for illiquid private equity asset classes.

An important consideration for the stated risk and return metrics is that all the preferred instruments can be treated as the sum of two bifurcated instruments (i) junior or mezzanine debt component that covers the LP properties and mirrors return expectations of private credit instruments, plus (ii) an upside component in the form of an equity sweetener via options or warrants with adjusted strike price that reflects the type of preferred stock. More specifically, convertible preferred stock are subject to an adjusted strike price or breakpoint that reflects the conversion threshold, versus in the case of participating preferred stock the adjusted strike price reflects the aggregate level of LP for all preferred stock classes. For non-convertible, non-participating preferred stock instruments, there is no effective upside feature.

LP Internal Rate of Return (LP IRR): This underlying metric measures the risk-neutral implied IRR tied to the successful repayment of the unreturned capital contribution, adjusted for any other LP characteristics (i.e. dividends, multiple etc). It is calculated by treating the present value of the LPs implied by the OPM as the FV of the debt component, as of the measurement date, and the total LP amount as the expected repayment value at the liquidity date. The contemplated IRR needs to take into account the private nature of the contemplated VC asset and yield indications attributable to private credit instruments or companies with similar growth and risk characteristics. At time t_n (the present as of the n-th financing round), the value of the LP component is $e^{-r\Delta t_n}\pi_j^i(E_T)$. Assuming that at time T_n, the value will be equal to LP_j, we assign an implied IRR to the bond component of the equity security j as of the n-th financing round:

$$LP\ IRR_{jn} = \left(\frac{LP_j}{\omega_{ji}\left(C\left(E_{t_n}, B_i, r, \sigma, \Delta t_n\right) - C\left(E_{t_n}, B_{i+1}, r, \sigma, \Delta t_n\right)\right)}\right)^{\frac{1}{\Delta t_n}} - 1 \qquad (19)$$

This return metric is not intended to capture the consolidated ROE of preferred stock classes based on their applicable issuance date, but instead determine the implied IRR tied to the debt component as of the effective measurement date, as a relative yield benchmark between the latest issued preferred stock and remaining preferred stock classes and a measure of idiosyncratic risk-adjusted expectations for market participants entering the contemplated or similar transactions.

Downside Protection (DP): This specified risk-adjusted characteristic measures the relative bifurcation of value of preferred securities between the downside (mezzanine bond component) and the upside feature (conversion feature) and is calculated as the ratio between the present value of the LP and the all-in FV of the preferred security. Essentially, DP quantifies the portion of an investment mark-to-market valuation that is safeguarded by the LP. VCs aim to realize a target ROE and anticipate a high payoff via the generation of additional returns attributable to the conversion feature - they do not just aim to get their unreturned capital or LP back. Those return expectations should be bifurcated as of the initial calibration rate to reflect proper risk sharing attributes for the two aforementioned separate instruments. As companies raise additional successful financing rounds, the portion of the DP lowers because of the stock price appreciation and the higher in-the-moneyness characteristics of the common stock. A heavy concentration in the downside protection, unless it refers to abnormal LP characteristics (i.e. 2.0x multiple or 15% PIK rate), might indicate improper balancing of market participants expectations. If the equity security j

receives its liquidation preference, LP_j, between breakpoints i and $i+1$ after the n-th financing round, then the present value under the risk-neutral framework is essentially the difference of the call options multiplied by the security allocation % of the underlying equity security between these two breakpoints:

$$e^{-r\Delta t_n}\pi_j^i(E_T) = \omega_{ji}\left(C(E_{t_n}, B_i, r, \sigma, \Delta t_n) - C(E_{t_n}, B_{i+1}, r, \sigma, \Delta t_n)\right) \tag{20}$$

and DP is calculated as the portion of the fair value attributed to the bond value of the preferred equity instrument.

$$DP_j = \omega_{ji}\left(C(E_{t_n}, B_i, r, \sigma, \Delta t_n) - C(E_{t_n}, B_{i+1}, r, \sigma, \Delta t_n)\right) \Big/ FV_j \tag{21}$$

Risk-Neutral Conversion Probability (RNCP): In the context of the OPM, this metric denotes the probability that a particular class of preferred stock will convert into common stock. Essentially, this risk-neutral probability indicates the likelihood that the conversion feature of preferred stock classes will be triggered and shareholders will realize more than the contractual LP claims. This measure is particularly important, because the probabilistic assessment of high ROE eventual payoff characteristics might be understated under a risk-neutral framework relative to standard market participant assumptions based on the financing round track history of the portfolio company, target liquidity event, and remaining expected investment horizon. Additionally, a relative analysis of the differential conversion likelihood of the various preferred instruments provides meaningful insights about the robustness of the utilized approach when compared with standard VC strategies and typical investment payout characteristics. If the j-th preferred equity security is converted into CSE shares at breakpoint B_{i_j}, then the RNCP for this security is defined as the $N(d_2)$ applicable to the conversion breakpoint, i.e.

$$P(E_T > B_{i_j}) = \int_{B_i}^{+\infty} f(x)\,dx = N\left[d_2\left(B_{i_j}\right)\right] \tag{22}$$

where

$$d_2 = \frac{\ln\left(E_{t_n}/B_{i_j}\right) + (r + \sigma^2/2)\,\Delta t_n}{\sigma\sqrt{\Delta t_n}} \tag{23}$$

This metric can be also applied to common stock to infer the likelihood that common stock holders receive any residual asset value once the LP of all preferred stock classes has been satisfied. In those cases, the aforementioned formulas are modified to include the effective breakpoint that corresponds to the full repayment of the consolidated LP.

Asset Value Delta (AVD): The RNV implied by the OPM is typically lower than the PoMV, due to the bifurcation of the different contracting economic rights and privileges and their implications under a risk-neutral framework, unless there is a significantly lower than 1.0x conversion ratio for one or more preferred stock classes that might trigger significant excess value for the common stock until the required relative bifurcated value of the as conversion feature, which then accrues value with a much smaller slope relative to the common stock, is achieved. The level of valuation dispersion between the two valuation indications, tied to both specific contracting details as well as modeling assumptions, provides significant pricing information about the robustness of the utilized model and appropriateness of selected option pricing assumptions. In order to quantify this difference, we introduce the AVD metric, defined as:

$$AVD = \frac{RNV}{PoMV} - 1, \tag{24}$$

While material AVD differences might be explainable due to the existence of non-standard strong investor rights or increased idiosyncratic risk, they usually represent the first indicator or red flag of a potential misalignment in implied VC risk attributes of the contemplated assets, especially for established VC portfolio companies with a good success record and significant OIP evolution among financing rounds.

2.3. Base case numerical illustration

In this section, we illustrate how the OPM is applied to a real-world scenario. For the purpose of this analysis, we consider a hypothetical portfolio company with a typical VC capital structure, and we develop a model as of the latest financing round. The valuation analysis of all the assets described in Section 3.1 has been performed based on a similar process, adjusted to account for specific option pricing assumptions tailored to the idiosyncratic characteristics of each asset.

Let us assume a company that has launched six financing rounds between December 2008 and February 2017, issuing seven classes of preferred stock, from Seed to Series F, with an initial public offering (IPO) date of August 15, 2019. The preferred stock classes are standard convertible instruments with 1.0x LP, no dividend rights, same seniority and 1.0x conversion ratio[7]. Panel A of Table 1 provides a detailed breakdown of available information per equity class.

[Insert Table 1 here]

The first step entails the development of the breakpoint analysis that includes all the key BEV thresholds that refer to equilibrium level of assets that trigger adjustments to the participating classes or conversion decisions based on the contractual economic rights. The analysis is performed as of the latest financing round and reflects the first step that determines the applicable strike prices utilized in the OPM. Panel B of Table 1 includes all the appropriate BEV thresholds that capture LP seniority characteristics and applicable conversion thresholds per issued and outstanding class depending on the conversion mechanics and respective CP. Once the breakpoints have been established, the next step encompasses the derivation of the applicable call option value that corresponds to each breakpoint, by considering the following option pricing inputs:

- *Strike price*: Reflects the breakpoints presented in Panel B corresponding to key BEV thresholds that capture changes inferred by contracting rights.
- *Asset price*: Represents the RNV of the portfolio company as of the latest financing round, and is denoted with E_{t_N}. The BEV is determined through a back-solve calibration approach such that the FV of the latest issued preferred stock equals the stated OIP, under the explicit assumption of an arms-length transaction.
- *Expected term*: Corresponds to the assumed investment horizon until the potential IPO from the latest financing round date. For this example, the expected term is equal to 2.5 years (i.e., the year-fraction between the date of last round t_n and the IPO date T).
- *Volatility*: Refers to the re-levered equity volatility and is typically negatively correlated with asset growth, unless there are significant risk changes that shape different ROE expectations. For the purpose of this example, we consider a 60% equity volatility.

[7]The example presented within this section is based on random assumptions due to data confidentiality regarding our sample assets' unique contracting and deal characteristics.

- *Risk-free rate*: Represents the risk-neutral BEV growth rate, based on the U.S. treasury curve as of the applicable measurement date, that corresponds to the assumed investment horizon and is set at 1.41% for this example.

The calculation of European call option values and the allocation of the incremental option values across the participating equity securities is presented in Table 2. Panel A presents the allocation matrix Ω_n applicable for the assumed hypothetical portfolio company. The capital structure includes 8 different equity classes that imply 9 finite breakpoints based on the applicable contracting details. Therefore, the allocation table is a (8×9) dimensional matrix. The first row shows the participation ratio for the Series Seed, the second row shows the participation ratio for the Series A, and the last row shows the participation ratio for the common stock. Panel B presents the calculation of call options values with strike prices equal to the corresponding breakpoints. The equity value E_{t_N} is calculated by goal-seeking to determine the RNV that calibrates the FV of Series F to the applicable OIP of \$100.00. By multiplying the incremental option values with the allocation table, we are able to derive the FV of each class and observe the value differential based on the applicable economic rights.

[Insert Table 2 here]

With respect to the risk and return metrics, we notice that the LP IRR is equal to 2.96%. The LP IRR is the same across all preferred stock classes, since they participate pari passu on the distributions up to the first breakpoint, and the purpose of this metric is to capture the IRR tied to the debt component of preferred stock classes as of the effective measurement date (not the issuance date of prior preferred stock). The RNCP is equal to 88.00% and 84.87% for the Series Seed and Series A, respectively, whereas it decreases dramatically for the Series F (10.10%). Finally, DP is equal to 1.1% and 5.7% for the Series Seed and Series A , respectively, given the significant stock price appreciation relative to their OIP, while it increases to 93.0% for the Series F.

From this hypothetical example, we observe that the standard OPM calibrated retrospectively using the IPO date and a set of rules that appraisers would consider in practice generates risk and return metrics that deviate from standard market participants' assumptions. For example, the yielded LP IRR of 2.96% for all preferred securities implies a risk premium of 1.55%, which is noticeably low compared to yield of private credit or private equity instruments as well as relative to public equities as observed in average historical returns of S&P 500 and Russell 2000 indices. Additionally, we observe that the relative bifurcation of the value between the DP and the as conversion feature of Series F is heavily skewed in favor of the unreturned capital protection, yielding a RNCP of only 10.10% and a weight of only 7.0% for the value attributable to the potential upside of the stock (1-DP%). At the same time, the incremental RNCP between Series C and Series F is almost 60.0%, reflecting materially different prospects for a VC asset with homogenous risk attributes and organic expectations tied to either an extremely successful liquidity event or under-performance and recovery of less than par per applicable class. To a certain extent, those valuation observations are associated with the option pricing assumptions utilized in the context of the OPM and more specifically the assumed expected term and equity volatility. As illustrated in Figure 3, this modeling outcome bias is rooted in the implied risk-neutral distribution tails generated by the absence of risk-adjusted option pricing assumptions that fail to capture the organic characteristics and prospects of VC assets. Increasing the investment horizon or assumed equity volatility creates more extreme fat tails, both negative and positive, that have a material impact in the risk-adjusted metrics and the bifurcation of the relative economic features. A more in-depth analysis of the impact of those parameters based on specific contracting details is provided in Section 4.

[Insert Figure 3 here]

2.4. Sensitivity to contracting and modeling inputs

The base case numerical illustration was based on a VC-backed company with standard contracting details usually observed in late stage ventures. However, the nature of contracting details varies depending on both systematic and idiosyncratic reasons. In this section, we perform a sensitivity analysis on the contracting details and document their impact in the observed valuation, risk, and return metrics. Similar sensitivity is performed based on the expected term and equity volatility assumptions to examine the impact of model related parameters. Appendix A includes a list of performed sensitivities with respective descriptions. A detailed valuation output from this analysis is summarized in Appendix B.

Figure 4 presents the results of the sensitivity analysis for the major contracting and modeling inputs. Panel A indicates that the LP IRR of the Series F remains below 8% across all scenarios presented. In particular, we see that scenarios with (i) participating preferred feature, (ii) higher CR, (iii) lower last round OIP, and (iv) higher investment amounts lead to LP IRR values that are higher than the base case scenario but are still considerably lower than target double-digit return expectations. Panel B presents evidence that DP across all scenarios is above 80%, suggesting strong structural modeling concentration on left tail distributions with default option pricing inputs. Analysis of Panel C reveals that the analyzed contracting details do not materially change the RNCP, except for major changes in the type of preferred stock from convertible to participating, which has tangible valuation implications. Finally, the findings presented in Panel D suggest that the AVD remains significant and higher than 25% across all scenarios (higher than 40% in most of the sensitivities), confirming that pricing differential is not tied to specific contracting details. A more detailed output of the sensitivity analysis is presented in Appendix B, while Section 4 decomposes in depth contracting and modeling causality effects in all analyzed valuation risk and return metrics based on the actual sample analysis.

[Insert Figure 4 here]

3. Data

In this section, we outline the sample characteristics, data collection, and validation procedures, valuation processes, quality control, and model output review mechanisms, and a broader view of standard industry practices. We first discuss the criteria applied to form the final sample of VC-backed assets in Section 3.1, while in Section 3.2, we present the key sample characteristics. We then document in Section 3.3 the various data sources, depending on the nature of variables under consideration and challenges due to non disclosure of private information. Section 3.4 summarizes the thought process for the determination of option pricing assumptions under standard market participant expectations and available private equity data. Finally, in Section 3.5, we provide an empirical valuation guidance based on standard valuation principles and commonly accepted valuation assumptions depending on the company and asset under consideration and access to company specific information.

3.1. Sample selection

For our sample construction, we relied on Pitchbook [8] and selected the top 100 VC-backed companies that went public between January 1, 2000 and January 15, 2024 based on the latest reported PoMV in connection with the contemplated exit transaction. Our sample also includes companies that went private after the initial IPO; while the screening was performed based on the latest reported PoMV, for assets falling under the category of more than one exit events, the analysis has been performed as of the actual IPO date. After a review of the initial database and additional filtering conditions for broader private equity investments,

[8]Source: PitchBook Data, Inc.

we also added 65 companies that had VC-backed characteristics and were not reflected in the original screening. To ensure that a robust analysis in quantifying the impact of contracting details could be implemented and that we account for average VC investment horizons and deal characteristics, we introduced a minimum of 3 financing rounds as an additional criterion. Given limitations on available data on foreign companies, potentially different regulation requirements, implications in structural characteristics, return expectations, and investment windows, we only considered U.S. based companies or foreign companies that are publicly traded in the U.S. stock market.

In order to perform a robust asset pricing analysis, we need to have, at a bare minimum, available and verified capitalization structure information and a detailed description of the economic rights and privileges per outstanding equity class. Given that a calibration to the latest deal pricing is performed, forecasting or financial information other than the total interest bearing debt obligations of the company is not necessary. To ensure accuracy of utilized asset specific information, we cross-checked the data relative to publicly available corporate documents and public articles covering financing round disclosures to identify any material discrepancies.

Out of the 20,423 total companies of the consolidated screening, we thoroughly reviewed existing financial and capitalization structure information as well as available corporate documents for the top 361 companies based on deal size. We excluded 207 companies due to incomplete picture in terms of deal history, capitalization structure or governing cash flows rights, 17 companies due to irregularities in underlying waterfall economics that could not be verified, 8 companies that fell out of the scope of the researched exit transaction type (IPO), and 3 companies that were not publicly traded in the U.S. as of the report generation date. Finally, we removed from our sample 26 companies due to lack of supporting publicly filled pre-IPO documentation or other corporate filing support appropriate both for data validation and valuation analysis.

Ultimately, we rely only on IPO exits in order to add an additional layer of data validation through the required pre-IPO filing documentation, since the motivation of the current paper is to perform an analysis with real valuation processes, live valuation engagements rules, and minimize deviation of pricing characteristics attributable to the information source. However, it is important to note, as also concluded in Sections 4 and 5, that our empirical findings are applicable in the broader spectrum of VC-backed investments regardless of sample selection, given the standard use of hybrid equity securities with specific economic rights as default instruments in the deal making process (Bengtsson and Bernhardt, 2014; Fu et al., 2023), the standardization of cash flows and control rights, risk and return attribution characteristics and limitations of the existing option pricing models to both idiosyncratic characteristics, as well as standard default assumptions. Due to the significant time commitment for the successful completion of all required multi-step data validation and valuation procedures, the analysis is limited to only 100 assets but the research conclusions are applicable to the broader VC universe.

3.2. Sample characteristics

In this section, we present key characteristics of the final selected sample of VC-backed companies. In particular, Table 3 summarizes key details related to contracting rights, financing activity, investment and performance characteristics, as well as liquidity attributes. Panel A reflects a heavier concentration into the consummation of 4-6 completed financing rounds across the analyzed assets before a successful IPO exit. Secondary preferred stock transactions with flat pricing characteristics, close proximity of transactions, or issue of separate classes that mirror recent preferred equity stock with same pricing details (i.e. conversion of convertible notes) are grouped as a single round. Panels B and C validate findings of Bengtsson and Bernhardt (2014) and Fu et al. (2023), confirming the existence of default contracts, with convertible and pari passu properties presence as of the latest round, of 87% and 78%, respectively. Panel D confirms higher exit activity post 2015, which aligns with the VC activity evolution presented in Figure 1. Panel E suggests that 72% or our sample contemplated a successful IPO within 2 years from the latest financing round while only 5% are linked to a horizon longer than 4 years. The majority of assets falls under the spectrum of a PoMV, as of the latest financing round, between \$1 to \$4 billion (45%), immediately followed by 29% concentration of companies with a PoMV lower than \$1 billion, and 11% with a valuation higher than \$10 billion. Panel G suggests that new capital raised in connection with the latest financing round reflects a FD percentage lower than 5% for 32 out of the 100 companies, with a consolidated concentration of 49% between 5%-15%, while only 7% are related to an effective CSE percentage higher than 25%. Finally, the majority of the contemplated companies imply an OIP multiple of the last round relative to the prior one between 1x to 2x (55%), with only 2 out of 100 companies linked to an OIP multiple of less than 1x in the last round, consistent with natural market participant expectations for strong market performance and meaningful up-round investment return characteristics prior to an IPO contemplation.

[Insert Table 3 here]

3.3. Capitalization structure and contracting information

The most significant corporate filing documents for pre-IPO companies, in terms of contracting details, are the Certificate of Incorporation (COI) and the S-1 filing. The COI is a legal document that includes the formation governing principles of a new corporation and describes in detail the underlying economic rights and privileges of all equity classes that are either authorized for issuance or are already issued and outstanding. The COI has a very specific structure depending on the complexity and the deal history of the underlying corporate entity. In the first part of the document, a detailed description of the available equity classes and authorized number of shares is included, followed by an outline of the governing cash flows rights in terms of LP and seniority characteristics. Specific conversion and anti-dilution provisions upon triggering of certain material business events are incorporated later along with specification of other investor or founder economic rights (e.g. board representation, IPO veto, IPO Ratchet, redemption, right of first refusal (ROFR), drag-along and tag-along rights etc.). Typically companies issue an amended and updated COI once a new financing round is successfully completed and a new preferred security has been issued to existing and/or new investors. If no official revised COI is issued, then a brief amended version outlining underlying changes to existing sections or subsections is released and becomes immediately effective. While COIs include information for the primary economic classes (e.g. preferred stock, common stock), they do not include information for any convertible notes, simple agreements for future equity (SAFE), management equity plan (MEP) awards (i.e. options or incentive units with different vesting awards). The potentially dilutive effect of those instruments is reflected in the number of authorized number of common shares and underlying anti-dilution and conversion protection rights of existing equity classes.

The S-1 filing is a registration statement required by the Securities and Exchange Commission (SEC) for companies that intend to go public for the first time. Contrary to the COI, the S-1 is a comprehensive document that includes both business specific information in term of financial performance, organizational matters, risk characteristics, and detailed outlook assessment, investment plan description, specific strategic going concern characteristics, detailed capitalization structure information as well as broader systematic risk assessment, market timing, and return characteristics. Financial statements information is typically included in those documents along with relevant notes disclosure about material business events, deal history, and specific SBC information that provides a better understanding of applicable MEP pool sizes and total amounts attributable to MEP that have either been recognized or expected to be amortized over the remaining expected life of those awards, as well as specific information about strike prices, evolution of applicable terms, and other important option pricing assumptions. Detailed pricing information for MEP awards constitute significant valuation indications especially for the common stock, given that the strike prices are usually determined based on 409(a) valuation engagements and mirror the FMV of the common stock such that they effectively represent at-the-money derivative structures to avoid any moneyness issues that might trigger a tax liability for the MEP holders as of the initial grant date. S-1 filings also have significant information about material changes to the capital structure due to important changes in the leverage of the company, potential stock splits, reverse stock splits, re-capitalization changes due to dividend declaration or convertible stock issuance, indication of outstanding number of units per class (relative to the authorized number only indicated in the COIs), and confirmation of the latest applicable economic rights. When combined with the latest amended COIs, they provide an in depth overview of all the critical information needed to properly value the various economic cash flows rights and risk sharing characteristics.

We gather capital structure and specific contracting information from those two documents and emphasize any underlying changes applicable due to a potential stock split that might not be clearly stated but meaningfully affects upside equity participation claims. Given the time-lag between the latest COI and S-1 filing, minor capitalization structure changes primarily to the common stock or MEP pool might be applicable. Since for the purpose of the individual asset analysis we perform a calibration as of the deal date, we extract the implied common stock number from the PoMV of that round, given that there is typically limited variability in aggregate share count of preferred stock classes in the absence of material restructuring events. More specifically:

$$\text{Common stock} = \frac{\text{PoMV}_n}{\text{OIP}_n} - \sum_{\text{i}=1}^{\text{n}} \text{Original Shares}_i \times \text{Conversion Ratio}_i$$

Similar to how investors price deals and infer PoMV indications, the common stock pool is inclusive of any additional MEP options and potentially authorized but not issued yet shares and accounts for the dilution due to issuance of shares in connection with the preferential conversion of preferred stock classes or convertible notes. In cases of large discrepancies between the PoMV implied common stock and the indicated number in the S-1 filing within a short time period, which implies either fundamentally different deal pricing calculations or data imperfection, we rely on the information indicated in the official S-1 filing. Existence of short time periods between deal events and S-1 filing as well as the calibration procedure performed within the option pricing context eliminate the impact of noise attributable to common stock differential share-count metrics, as confirmed in the respective sensitivity of common stock pool in Sections 2.4 and 4.4. Also, any minor discrepancy in the actual latest deal closing date, depending on the source of information, has an immaterial impact in the valuation outcome given the calibration procedure to the latest preferred security OIP via an OPM that considers the effective investment horizon until the IPO.

Table 4 summarizes primary economic features attributable to preferred stock classes and the implications from an economic payoff perspective. Not all attached economic rights have a tangible and quantifiable value under the financial reporting or tax requirements; the focus of the current paper is on the primary attached embedded cash flow rights that have significant pricing implications and are typically included in standalone or portfolio valuation engagements.

[Insert Table 4 here]

3.4. Option pricing assumptions

Option pricing assumptions have significant importance in the derivation of risk-adjusted return metrics and mispricing characteristics relative to investors' and broader market participants' expectations. The standard inputs utilized in relevant valuations and the thought process for the justification of each assumption are described as follows:

Volatility: Given that the underlying asset price of the OPM is the implied BEV of the company, the volatility should reflect the re-levered equity volatility. Since there is no observable public trading history for private VC-backed assets, this assumption is typically based on the volatility analysis of a set of guideline public comparable companies (GPC). Implied un-levered asset volatility is derived by solving for an asset volatility and equity volatility that satisfy both equations of Merton (1974), given each company's leverage, and the same process is repeated for the determination of the re-levered volatility of the VC-backed asset by accounting for the company-specific leverage profile. Given that the GPC typically consists of more mature companies with potentially significant differences in risk and return characteristics, there is subjectivity in the selection of the assumed asset volatility metric, the quantification of any applicable size adjustment, and potentially an underestimation of the true idiosyncratic risk profile of the underlying variable. In those cases, a broader industry screening and volatility build-up process is performed to better quantify an applicable size premium; however, another robust alternative is considered that accounts for risk sharing structural considerations[9]. That approach utilizes standard return

[9]Refer to the fourth edition of the Contingent Consideration Guide (p. 60, lines 1783-1811).

expectations for VC investors depending on the business stage and growth characteristics, number of financing rounds contemplated, and broader exit strategy expectations, and derives an implied risk-adjusted volatility metric from the capital asset pricing model (CAPM) as follows (Sharpe, 1964):

$$\sigma = \frac{\sigma_m \times \beta_i}{\rho_i} \tag{25}$$

where σ_m denotes the long-term volatility of the market index (e.g. S&P 500), β_i denotes the indicated beta coefficient of the VC-backed company versus the broader market index, and ρ_i is the correlation coefficient (set to 1)[10]. In this paper, we rely on the CAPM approach to infer market participant expectations based on systematic and idiosyncratic risk characteristics for our sample, but we have also performed a sensitivity analysis to highlight the importance of the build-up method and respective assumptions in valuation mispricing indications. To infer a beta-specific ROE volatility, we rely on average ROE expectations per stage of growth of VC asset and number of contemplated financing rounds, based on the following classification:

Financing Round	Return on Equity
Series A - Series B	35.0%
Series C - Series D	30.0%
Series E or later	25.0%

Those ROE indications follow general patterns of risk-adjusted metrics utilized by valuation professionals in accordance with industry available private equity returns like the Pepperdine studies[11]. This implied volatility calculation should be considered the floor tied to the utilized ROE, given the maximum correlation coefficient assumption.

Investment Horizon: While there are general VC investment horizon targets in connection with certain return multiples or IRR thresholds, the actual investment window depends on the underlying strategy, fund, and asset specific risk and return characteristics as well as broader market and industry variables. We have performed a retrospective valuation approach relying on the actual timing between the latest financing round and the actual

[10] If the VC ROE is 25% and the risk-free rate of return is 2.5%, then the indicated risk premium for the company under consideration would be 22.5%. If the market risk premium is 6%, this would translate to a company-specific beta of 3.75. Multiplying the equity beta by the assumed long-term volatility (e.g., the historical volatility of the S&P 500 - 18% assumption for this example) yields an equity volatility of 67.5%.

[11] For the most recent Pepperdine private cost of capital survey, please refer to this link.

IPO date, under the assumption that (i) if that time window is short, management would be able to provide a target exit window indication with a high confidence interval assuming standard information access conditions for typical valuation engagements, and (ii) if the actual IPO preparation process took longer, then the implied holding period is more consistent with traditional default investment horizon assumptions for the given financing round and risk profile. Additionally, the fundamental motivation of this paper is to present the risk-adjusted return characteristics based on actual exit event metrics to clearly illustrate the gap between realized returns and pricing considerations relative to risk-neutral implied observations. That said, we have also performed sensitivity analyses using different holding periods and present the net impact of those in the resulted indications in Section 4.4.

Risk-free rate: Since we operate in a risk-neutral framework, the drift of the OPM is based on the treasury rates as of the applicable deal date that correspond to the assumed holding period, adjusted on a continuous compounding form in order to comply with the option pricing framework requirements[12]. A linear interpolation between applicable term structure rates is performed to infer the specific rate corresponding to the assumed expected term. The expected risk-neutral growth rate is adjusted automatically to changes in the holding period to reflect the appropriate term structure.

3.5. Generally accepted valuation principles

In this section, we discuss certain important valuation considerations that appraisers take into account when performing those valuations and specific details for model-related parameters utilized within the context of this paper.

Single Scenario OPM: Most appraisers rely on a single scenario OPM application when relying on financing rounds. With the exception of crossover rounds and a specific IPO expectation, typically, consummation of financing rounds is associated with limited information about the potential IPO exit runway and more importantly expected or target IPO pricing characteristics. Additionally, alternative monetization events might be considered by VC funds depending on market timing and performance characteristics, opportunity costs assessment, asset allocation dynamics, and overall portfolio strategy. The purpose of the single OPM is to capture this variability in terms of both expected value outcomes as well as potentially contemplated exit strategies without introducing noise until there is more specific, tangible information that could be incorporated within the context of a scenario based analysis or hybrid analysis, which incorporate explicit event cash flows characteristics,

[12] https://home.treasury.gov/

pricing assumptions, and governing allocation mechanisms. Typically, those methods are introduced when an S-1 filing is in place and preliminary investment bankers' indications are available. Given that as of the last deal date, this information is not available, our analysis is based on a single OPM scenario to comply with standard valuation procedures and avoid introducing qualitative parameters with lack of supporting evidence.

Static Exit Approach: Standard valuations performed for ASC 718/820 or 409(a) purposes rely on a single investment horizon assumption as a weighted average indication of all the potential contemplated strategies and respective holding periods unless (i) there are differences in the applicable economic rights of certain classes that are directly linked to the investment horizon (i.e. changes to LP characteristics over time or changes to performance or market-based conditions of MEP awards with step up thresholds depending on exit time etc.), that require non-linear adjustments or (ii) are related to specific sectors (i.e. pharmaceutical or biotech) where modeling of event outcomes is highly dependent on key milestones and approval processes and a probabilistic analysis of the various events contemplated, or (iii) there are various events contemplated with different potential investment horizon assumptions that require different valuation treatment due to the materiality of relative pricing characteristics. The fundamental limitation of this approach, as we highlight in this paper, is that it does not account for a dynamic investment management performance assessment and a determination of exit time-frame based on an optimal return analysis or other fund specific variables that drive those decisions in the real world. Dynamic multi-period simulation techniques, least squares Monte Carlo simulations, or real option analyses could be used as alternatives, but they are subject to other limitations, inputs selection bias, and are prone to error bias given the nature of available information for illiquid securities, the skewed and asymmetric payoff characteristics, and respective pricing implications within a risk-neutral framework. Thus, appraisers tend to rely on a static approach to deal with uncertainty in a way that minimizes the introduction of unknown variables.

Bifurcation of Economic Features: While investors might be entitled to a broad range of underlying economic rights, not all of them are analyzed for financial reporting or tax purposes. For example, voting rights are typically not given consideration under ASC 718 based on optimal market participant assumptions, while for tax purposes, a careful examination of minority and equity concentration is deemed necessary. Similarly, redemption rights are not typically incorporated separately in the valuation process, given the overlap with the LP claims. ROFRs might have important implications from an investor perspective, but they do not necessarily affect the total consideration, and it is challenging to quantify the impact of such right into the irregular risk profile of VC assets. Veto rights are also important both for insiders and outsiders, but their impact in the consolidated value consideration or allocation mechanisms is difficult to be measured due to the various different potential complications (e.g. delay in IPO process which might affect pricing mechanisms, change of exit strategy, renegotiation of primary cash flows rights, issuance of additional shares as a sweetener etc.). IPO Ratchet is also extremely important for investor return metrics, but it is typically given special consideration when a clear IPO path is contemplated with specific documentation and supportive scenario based analysis modeling characteristics.

MEP options: In accordance with standard contracting and agency theory, VCs grant a pool of management awards to employees in order to properly align economic interests and maximize the potential asset value with the constrained holding period. While summary information about SBC plans might be available in S-1s, detailed information about the timeline of grants, strike price and vesting conditions, number of issued and outstanding shares, and vested portion at a specific point estimate is sensitive information that is not typically provided to investors with no information rights. Valuation professionals use some default assumptions about the available pool and applicable economic terms based on broader industry trends and past engagement characteristics. When no specific breakdown of MEP option awards is available, typically those share-classes are treated as a combined class with the common stock. The impact of the SBC is partially hedged by the fact that per the 2019 AICPA Guide, market participants consider valuations on a net SBC basis assuming that it's a company's responsibility to satisfy those ongoing cash flow requirements. Thus, an introduction of intrinsic value exercise for the determination of value attributable to the primary economic classes, followed by a calibration of a forward-looking approach (typically an OPM) is deemed necessary, such that optionality attributable to non-exercised awards and potential in-the-moneyness in the future is incremental and non-dilutive [13]. Given that for the purpose of this analysis we rely on financing rounds' implied OIP, we do not need to perform an intrinsic value exercise but instead proceed directly with the OPM implementation; given that we calibrate our equity value such that the FV of the latest preferred stock class equals the stated OIP, the consolidated impact of changes in the individual strike price characteristics of the MEP option pool is not material. In this paper, we have combined all the potential MEP option awards with the common stock as a single equity class, assuming that the common stock implied from the PoMV accounts for the issued and reserved for

[13] Refer to Q&A 14.27 - Incorporating Stock-Based Compensation into the Valuation of the 2019 AICPA Guide for more information.

future issuance option pool. In Section 4.4, we have also performed sensitivities around the MEP option total ownership percentage and respective adjustments on the applicable strike prices, to confirm the minimum impact in the reported risk-adjusted valuation metrics.

Discount for lack of marketability (DLOM): Minority equity positions in VC-backed companies represent derivative instruments on the company's BEV, which is nonmarketable since it is not freely traded on established public markets. Thus, those equity interests are subject to certain illiquidity and transferability limitations with specific value implications for financial reporting or tax purposes. Typically, the valuation community does not apply any DLOM to preferred stock classes due to structural protection and seniority rights, consolidated aggregate preferred stock class equity concentration, and influential corporate governance and monitoring mechanisms [14]; thus, their FV is reported on a marketable, public-equivalent basis similar to reported transaction pricing indications. However, the FV or FMV of minority common stock or MEP option awards is typically subject to DLOM, due to fundamental differentiation of applicable economic rights and illiquidity or transferability considerations. Those considerations are typically incorporated in 409(a) or ASC 718/820 valuations, such that the concluded value of junior equity interests, like common stock and options, respectively, is on a non marketable, non-controlling basis. While there are a variety of qualitative and quantitative DLOM approaches, some of the most commonly utilized quantitative put option or similar approaches are those introduced by Chaffe (1993), Ghaidarov (2009), Finnerty (2012), Longstaff (2015) and Longstaff (2018). The relative comparison of DLOM applications is out of the scope of this paper, since we aim to isolate the impact of contracting and option pricing assumptions based on the same value determination basis. However, we take into consideration standard DLOM procedures in Section 4.5, where we isolate the impact of contracting information and valuation inputs in the implied SBC for VC-backed portfolio companies.

4. Empirical evidence

In this section, we present the empirical results of our study. Section 4.1 summarizes the valuation output based on the OPM calibration and retrospective IPO investment horizon. Section 4.2 analyzes the impact of contracting inputs on valuation metrics and risk-adjusted characteristics, while Section 4.3 investigates sensitivity of valuations to option

[14] To a certain extent, any illiquidity considerations have been already reflected in the pricing characteristics of successfully completed financing rounds (i.e. OIP, ROE etc.) and the PoMV/BEV calculated in connection with those transactions.

pricing assumptions per analyzed contracting group. Section 4.4 examines the sensitivity of our conclusions to contracting, capital structure and modeling parameter changes. Section 4.5 addresses the effect of both contracting and option pricing assumptions on the SBC figures of VC-backed companies.

4.1. Valuation output

This section includes the valuation output based on the OPM analysis of each sample VC-backed company by relying on the retrospective IPO investment horizon. Table 5 includes a detailed description of the implied valuation risk and return characteristics per company. The median observed AVD is 48.8%, which is directionally consistent with empirical findings of Gornall and Strebulaev (2020) and Agarwal et al. (2023). Deviation of investor friendly protection rights, relative security pricing characteristics and deal size, assumed investment horizon, and implied volatility inferred from the perceived ROE, contribute to a pricing deviation range between 16.6% to 95.1%, with the highest deviation observed in a participating preferred structure with an effective IPO window less than 1 year, reflecting both strong contracting and sensitivity modeling assumptions. Out of the 100 assets, 25 are linked to a value differential higher than 58.2%. In terms of the risk and return characteristics of the latest preferred security, the median LP IRR is 5.79% with an effective risk premium of 4.34%, which represents a significantly low implied IRR metric for an illiquid private investment with VC risk attributes. According to the 2019 AICPA Guide[15], typical ROE expectations for investments in portfolio companies vary between 15% to 25%, depending on the various business specific characteristics and reflecting a sizeable premium relative to public indexes, while general VC IRR expectations are tied to even higher premiums, which are more consistent with the private equity studies mentioned in Section 3.4. Out of the 100 assets, 73 are tied to a realized LP IRR less than 10%, while only 8 assets yield IRR expectations higher than 20%, which confirms a structural valuation limitation. The assets observed in the top percentiles of the perceived IRR are associated with strong contracting characteristics, related primarily to LP protection or participating feature. This observation is important because it verifies that the distribution tails of the OPM, based on the standard valuation assumptions, might generate abnormal return characteristics that do not reconcile market participants organic expectations.

[Insert Table 5 here]

[15]Refer to paragraph B.04.03 of the 2019 AICPA Guide Appendix for more details.

This finding is also verified by an analysis of the DP ratio implied by the relative bifurcation of the downside versus upside coverage. Our analysis suggests that 77% of the companies have an implied DP for the latest security higher than 80%, while the effective sample ratio decreases only by 13% for DP ratios higher than 90%. Only 7 out of the 100 assets have an implied ratio lower than 70%, which suggests a heavily skewed distribution of eventual payoff characteristics in the favor of exit outcomes not properly aligned with the traditional recovery rates of VC investments and portion of portfolio companies that yield either negative returns or no returns at all [16]. Lower DP ratios are typically observed for standard VC contracts with higher investment horizon and volatility assumptions that contribute to the development of wider risk-neutral distribution fat tails, which resonate more effectively with VC investment specifications. On the other hand, an analysis of relative DP coverage of the prior preferred stock classes corroborates organic expectations of market participants due to the increase in the underlying asset value relative to the implied bifurcated weights as of the original transaction calibration date. As the BEV increases round over round, the FV of prior preferred stock classes is increased primarily due to the higher potential upside (no cap) and to a smaller extent due to the capped incremental risk-neutral probability of capital or LP repayment. The median DP of the preferred stock issued immediately prior to the latest financing transaction has a median observation lower by an absolute 18.3%; the number of observations with an LP coverage lower than 70% is higher by a multiple of 5.6x while the lowest observation is 14.2%. The statistical difference between analyzed classes becomes larger and more meaningful in the relative comparison of the Series A preferred stock relative to the latest one; the median observation for that class drops by 85.1%, and 90% of the sample has an effective DP coverage lower than 50%, validating the significant stock appreciation between the respective rounds regardless of utilized method (RNV or PoMV). Key descriptive statistics of risk and return characteristics of preferred stock classes along with certain other deal characteristics or underlying assumptions are presented in Table 6. A more detailed full sample valuation output that includes the relative risk and return characteristics for equity classes other than the latest preferred stock is presented in Appendix C.

[Insert Table 6 here]

The heavier concentration of risk-neutral distributions in distressed or low-medium performing scenarios is also validated by the RNCP observed across the various equity classes.

[16] Refer to Paragraph 8.31 of the 2019 AIPCA Guide and Metrick and Yasuda (2010) for more details about those actual statistics.

The median conversion probability associated with an observed ultimate exit price higher than the conversion price of the latest preferred stock class is only 10.75%, with 81% of our sample yielding a risk-neutral likelihood less than 20%. Only 3 companies out of the sample are linked to a probability of an upside conversion higher than 50%, and those assets are primarily tied to participating features with either longer IPO term or low deal size relative to PoMV that contributes positively to pricing differential characteristics across all analyzed metrics. The preferred stock issued immediately prior to the latest financing round has a median observed conversion probability higher than 17%, while this incremental delta becomes significantly larger in the comparison of the Series A preferred stock versus the latest preferred stock with an incremental likelihood of 59.5%. Out of the 100 assets, 75 assets have a Series A RNCP higher than 50%. The median incremental difference between the likelihood that common stock is in-the-money relative to the conversion triggering of Series A is only 2.30%, given the considerably lower OIP and CP of Series A relative to the latest financing round. In reality, the incremental difference between the implied RNCP of the various preferred stock classes is not materially different given the typical binary outcome of VC strategies; (i) significant over-performance and high exit ROE or (ii) distressed situation and recovery of a small portion of capital. Low or medium performing scenarios that might lead to longer investment horizons, fund-to-fund transfers, secondary transactions, or major recapitalization events, do not constitute the principal investment strategy and do not reflect structural pricing considerations of deal makers as they negotiate deal characteristics.

Overall, the analysis of the consolidated sample results validates valuation patterns typically observed in standalone or mark-to-market valuations performed by appraisers and highlights the significant underlying valuation issue. The significant value differential for those successful companies measured by the AVD, followed by the non-proportional risk attribution confirmed by the low LP IRR, high DP protection, and substantial relative RNCP difference between classes, confirms the primary motivation of the current paper about structural limitations of utilized option pricing models that might generate significant mispricing observations depending on the synthesis of contracting details and set of option pricing assumptions. Section 4.2 expands further into the impact of specific contracting characteristics into valuation observations and sensitivity to key modeling assumptions.

4.2. Contracting details, deal characteristics, and pricing impact

Our results so far focus on the entire panel of VC-backed companies, and we have not yet considered the impact of contracting considerations in valuation metrics or their sensitivity to option pricing assumptions and other deal characteristics. In this section, primary focus is given to 2 different contracting groups depending on applicable economic rights and privileges: the first group is convertible versus participating preferred stock, and the second is senior versus pari passu prefered stock ranking. Additional contracting and modeling parameters are also analyzed to quantify the impact of different investor protection rights in valuation observations. Table 7 provides an output summarizing this relative evaluation analysis.

[Insert Table 7 here]

Panel A verifies standard expectations that the LP IRR attributable to a participating preferred stock instrument is higher relative to the respective yield of a convertible preferred instrument, all else equal. Given that the majority of standard VC contracts entail the issuance of convertible preferred stock instruments, the consideration of a participating preferred stock by market participants is a potential indication of a higher perceived risk that is tied to the requirement of a more valuable consideration in compensation for the increased unsystematic exposure. Unless there are strategic reasons that could justify deviation from average contracting structures (e.g. strategic focus on a key lead investor with significant value enhancing activities), a participating feature is positively correlated with higher conversion upside, given the direct participation with CSE shares immediately after satisfaction of LP claims versus a call option with a strike price equal to the conversion price (in the case of convertible preferred structures). Since the FV of the last preferred stock class is bifurcated between the downside coverage and upside participation, a higher upside claim through direct common stock participation is translated into higher LP IRR, lower DP, and higher RNCP, all else equal, relative to a convertible preferred stock class. Based on the observed median valuation observations, the LP IRR of the last preferred stock class is higher by a premium of 9.8% and DP is lower by an absolute 16.5%, while the RNCP is 4.27 times higher relative to median valuation output of convertible structures from our sample. The relative delta between the FV of the last preferred stock and the second to last preferred stock is lower in the case of participating preferred by about 1/3, given same RNCP and upside value for all preferred stock classes relative to materially different risk and return characteristics in convertible preferred structures. While we typically expect a lower RNV for participating structures which leads to a higher AVD that's not the case with the median observation of our sample, which is lower by an absolute 7.1%. This can be explained by sample properties and the materially smaller numbers of participating preferred structures, which are also tied to specific deal characteristics (e.g. deal size relative to PoMV), investment term assumptions (effective horizon, term, and equity volatility) and security specific characteristics (cap metrics). Sample-adjusting for those parameters and performing a sensitivity analysis based on the same properties across our full sample validates our original expectation, as presented in Table 9 of Section 4.4, which indicates that the valuation delta is 1.44x higher in participating structures relative to convertible ones (-68.5% versus - 47.6%). Finally, given the significant dilution of the common stock on the upside by the immediate participation of the preferred stock classes post LP recovery, the ratio of the FV of the last preferred stock class relative to the FV of the common stock is significantly higher for participating preferred structures (313% versus 126%); while the ratio of the upside value of the preferred stock on an as converted basis (1-DP) is higher relative to convertible structures, the absolute FV of the common stock is considerably lower due to the incremental dilution of the as converted participating structures that do not allow common stock holders to catch-up until the respective CP of the contemplated preferred stock classes is met.

Moving into the next contracting group, Panel B confirms that the existence of a senior investor friendly protection right is linked to higher value differential between RNV and PoMV, as well as higher FV multiple for the last preferred stock relative to the second to last preferred stock or common stock FV, respectively. A high seniority feature is linked to a higher probability of downside coverage, before residual claims of other preferred stock classes are covered, which eliminates dilution from other preferred securities in low BEV distribution tails and pushes more direct value to the contemplated senior instrument, requiring a lower asset price, from an option pricing perspective, that calibrates the FV to the stated OIP. This valuation outcome has a dilutive impact in all the remaining capital structure with a double dilutive effect for preferred stock instruments, in terms of both riskier downside coverage and lower common stock value upside as well as a higher impact in the more junior classes (common stock or options). DP of last preferred stock is higher by 135 basis points (bps), while the RNCP of the last preferred class is only 64.8% of the RNCP implied for convertible preferred stock classes. The impact in the common stock is observed both in terms of probability of in-the-moneyness (absolute delta of 39.4%) as well as realized ultimate payoff functions (last preferred stock class multiple over common stock is 1.03 times higher) relative to respective metrics for the convertible sample. From an option pricing perspective, the higher DP coverage should be associated with a lower implied LP IRR, which is not confirmed by the median statistic, indicating specific sample properties related to the analyzed deal characteristics and option pricing assumptions that create this valuation inconsistency. Risk-adjusting for this sample selection observation and performing a sensitivity for the full sample based on same contracting characteristics validates our organic expectation that senior LP IRR should be meaningfully lower (3.7% versus 7.5%), as presented in Table 9. Similar directional valuation patterns are observed in Panel C as we break down valuation observations by consolidated number of seniority characteristics for all contemplated financing rounds. A relative comparison of all pari passu cases versus all senior structures clearly demonstrates a significantly lower IRR for the senior structures (almost 1/4), significantly lower RNV relative to PoMV (1.39x higher multiple of AVD discount), 3.92 times higher likelihood of conversion for senior stock classes, and a substantial decrease in the probability of a positive distribution to common stock as the seniority of preferred stock decreases (64% relative to 82%).

The pricing characteristics of VC-backed companies is affected not only by the level of contracting details but the level of sensitivity of those rights relative to the synthesis of deal characteristics and option pricing assumptions utilized. Panels A-C of Table 8 summarize the impact of certain important deal parameters to the observed risk and return characteristics. Substantial increase to the OIP round-over-round is directly linked to higher deviation between RNV and PoMV indications due to different properties of value inflation incorporation in a risk-neutral versus risky world. In such cases, given that the absolute upside value of the as conversion feature of the latest preferred stock becomes larger, the common stock is also more valuable and is associated with a higher in-the-moneyness probability, which is also the case for the earlier preferred stock classes with a lower OIP. Deal size characteristics also affect the bifurcation of value, depending also on contracting details. A smaller deal size is associated with a meaningful increase in the PoMV, leads to materially higher discounts of RNV relative to PoMV, higher value concentration in low and medium performing scenarios, lower value attribution to junior instruments, and lower likelihood of extreme positive distribution events. Smaller deal size accompanied with strong protection rights (e.g. seniority, high LP multiple or CR) can yield completely unrealistic risk and return characteristics, with over-concentration of value allocation dynamics to the left side of the probability density function mapping. A relative comparison of risk characteristics of upround versus downround financing considerations, for the latest contemplated round, illustrates the reflection of increased idiosyncratic exposure in downrounds within the risk-neutral framework for junior classes and significant impairment for common stock, which leads to substantial FV premium for the latest preferred stock class, and a marginal differentiation in applicable DP coverage for the newly issued security. Depending on the issuance of senior or pari passu preferred stock in low-performing BEV situations, the implied AVD might be more explainable due to the existence of sizable non-diversifiable risk.

While we monitor different valuation effects derived from various contracting details, a common observation for most of the analyzed metrics, across all contracting rights, is the deviation from standard risk and return characteristics attributable to illiquid VC instruments. The LP IRR indications imply risk premiums materially lower than double-digit returns in most cases, suggesting that the likelihood of preferred stock conversion for the last preferred stock is significantly low and with a considerate delta relative to other preferred stock classes. In the next section, we investigate how we can mitigate the risk of increased valuation noise by analyzing the sensitivity of valuation implied risk and return metrics, per contracting group, to the key option pricing assumptions.

[Insert Table 8 here]

4.3. Risk-adjusting valuations

The impact of certain of the aforementioned deal characteristics or contracting implications is, to a great extent, a function of the option pricing assumptions related to the investment horizon or equity volatility utilized. As presented in Panel D and E of Table 8, an increased assumed term until an IPO facilitates major discrepancies in the relative bifurcation of value between the downside recovery and upside gains, leading to higher observed LP IRR, lower DP coverage, smaller discount of RNV relative to the PoMV, as well as similar directional value patterns between the various preferred stock classes and a more harmonized differential between the implied conversion probability of the various preferred stock classes and common stock moneyness likelihood. Figure 5 expands on the yielded observations and illustrates the results of the sensitivity analysis performed across various levels of equity volatility and assumed investment horizon, all else equal, addressing the impact of the utilized option pricing options on the implied risk and return metrics, per contracting group.

[Insert Figure 5 here]

Comparing the low (0.5 years) and high end (12 years) of assumed expected terms, the median observed LP IRR for the latest preferred stock class of convertible structures increases by a multiple of 3.4x, increasing to 8.9% (closer to market participant expectations), while the DP decreases from 99% to 36%. The RNCP of the last preferred stock doubles, while the marginal difference relative to the probability of a positive distribution to the common stock reduces to almost 1/5 of the implied low term delta. The delta between the FV of those 2 classes reduces from 66.6% to 28.4%, while a similar directional value pattern is observed in the AVD, with the high term delta being only 36% of the low term valuation differential. An evaluation of all the sensitized risk and return metrics indicates that utilization of an investment horizon higher than 7 years yields more natural expectations for VC-backed assets, with a more proper risk attribution between 9-12 years. Interesting observations are documented in the case of the equity volatility, with a derived concave relationship (64% of the sample of convertible assets) relative to AVD and a negative correlation relative to DP. Increased volatility is translated into increased fat distribution tail scenarios that push value to both ends of the risk-neutral distribution with asymmetric upside dynamics (no cap in the upside, capped in the downside). A positive correlation with the FV of the equity classes other than the calibrated one is observed, given the higher upside feature that affects all classes including the common stock, despite the lower yielded RNCP for most of the classes except for the latest one (implied probability of common stock drops from 98.6% to 55.1%, with almost identical observations for the Series A preferred stock, while the latest preferred stock conversion probability increases from 7.7% to 11.8%). The equilibrium volatility threshold that alters the concave relationship dynamics to a positive correlation between RNV and volatility is the 80.0% sensitivity input, but the level of risk-adjustment for the consolidated value in high volatility scenarios is not as meaningful as the impact of the expected term, within the specific range of volatility considered. For Equity volatility ranges between 100% - 120%, the inferred LP IRR for the last preferred stock ranges between 12.3% - 20.0%, bridging the gap relative to standard investor expectations. The DP ratio supports the adjustment in the lower end of the distribution, with DP decreasing to 81.2% (relative to 98.6%) between the low and high volatility scenarios.

An analysis of the sensitivities performed on the participating preferred structure of our sample also produces compelling results: LP IRR relationship follows an opposite statistical relationship reflecting a negative correlation with assumed investment horizon. The fundamental reason is that the preferred stock holders hold both a preferred stock and a common stock (or a ratio of CSE shares), so effectively there is an almost linear exposure to equity claims, with different slopes, depending on key inflation BEV thresholds that trigger dilutive adjustments. That said, the impact of the time value component prevails relative to changes in the upside feature related to changes in the asset price, while in the case of conversion structures where the upside is captured, typically, by an at- or out-of-the-money option from a risk-neutral perspective, the % change in FV of the option is higher relative to the asset price (such that the weighted average change in all classes matches the net change in the asset price) and optionality prevails relative to the IRR component. This observation is also accompanied by the already sufficiently high double digit return implied in the participating structures that has a more profound compounding sensitivity to changes in the assumed horizon (23.5% versus 13.2% in low and high end scenarios). On the other hand, equity volatility is positively correlated with the LP IRR, leading to more material adjustments to the yielded left side extreme distressed tails of the RNV probability density function, producing more natural market participant observations for a volatility higher than 60%, in the range of 10.7% to 31.3%. Correction of AVD by increasing the assumed investment horizon is more sensitive relative to convertible structures (-60.8% to -12.7%), while the RNCP of in-the-moneyness of the CSE shares for all classes is not as sensitive compared to convertible structures.

Moving into the second group of contracting details, we observe that senior versus pari passu preferred stock instruments have a more similar statistical relationship with both expected term and equity volatility. An increase in the assumed expected term between the low and high of the term range could bring down the observed median AVD in senior (pari passu) structures to 30.8% (35.2%) of the highest observed metric, lower the value differential between the last preferred stock class and common stock from 85.6% to 31.2% (64.0% to 25.0%), increase the implied LP IRR for the last preferred stock by 674 bps (633 bps), and decrease the overallocation of value to the DP from 99.3% to 37.5% (98.6% to 34.2%). A concave relationship between the RNCP and expected term is observed, with a peak of 12.4% (15.5%) in 3 years for senior (pari passu) instruments. Additionally, a concave relationship between AVD and equity volatility is also observed in both structures (acknowledging the endogenous effect of convertible contracting details) with yielded peak indication at 60% (60%) for senior (pari passu) structures and an effective sample size that follows those statistical relationship properties of 59% (56%). Changes to the assumed equity volatility do not bear a very material adjustment to the asset price of the OPM if they are not followed by an adjustment of the expected term that produces more substantial risk-adjusted distribution mechanics. However, they can trigger a significant impact in the relative bifurcation of value between the downside and upside participation, with an incremental premium for senior (pari passu) instruments of 1409 bps (1970 bps), a correction in the risk-neutral implied LP DP from 99.4% to 78.2% (97.9% to 77.3%), an improvement of the RNCP of the last preferred stock class by 648 bps (339 bps), and a tangible impact in the yielded likelihood of a common stock participation in distribution proceeds to almost 59% (57%) of the highest RNCP observed in a low volatility environment. The relative analysis of the risk-adjusted return metrics of all contemplated sensitivities for senior structures, all else equal, suggest that an investment horizon higher than 7 years (preferably higher than 9 years) brings IRR and risk premium expectations closer to inherent deal expectations for VC assets with a higher room of potential correction improvement for abnormally high assumptions relative to the LP IRR metrics observed in pari passu instruments where the marginal improvement post the 7-year mark is relatively trivial. Reliance on at least a 7 year horizon brings down the DP coverage for senior (pari passu) preferred stock classes to 59% (55%), decreases the conversion probability differential between the last and second-to-last preferred stock class to 5.6% (6.8%), and helps the valuation reconciliation between market participants and appraisers by reducing the AVD to -35% (-28%). Similarly, an analysis of the valuation output based on the equity volatility sensitivity suggests that a volatility of 100% generates more proper risk-adjusted LP IRR expectations for senior (pari passu) preferred stock, concluding on 10.6% (14.1%), while simultaneously improving probabilistic distributions of values, leading to an effective DP weight reasonably lower than 90%.

In conclusion, a thorough analysis of the sensitivity of contracting inputs to key option pricing assumptions suggests that an incorporation of risk-adjusted investment horizon and equity volatility assumptions, typically in combination, could significantly improve the standard error of valuation marks across all analyzed contracting details, with different levels of valuation mispricing delta and asset idiosyncratic exposure, and could, if not completely, partially mitigate valuation noise attributable to modeling properties, calibrating more organically valuation output with broader market participant expectations.

4.4. Robustness

Considering that our sample consists of the largest 100 VC-backed companies that pursued an IPO during the period 2000-2024, a natural expectation is that this sample might not fully reflect attribution of VC investment properties in security issuances or deal characteristics, which by extension might have valuation implications. Even though our paper validates empirical findings about default VC contracts with standard economic rights, which are reflected in the population of assets per contracting category, we need to ensure that our valuation conclusions are robust and not prone to a sample selection, analysis, or grouping bias. Additionally, given the small number of assets in certain categories that might be tied to different deal and option pricing characteristics, a supplemental motivation is to validate our prior conclusions with extensive robustness checks that clearly demonstrate contracting versus modeling causality valuation effects.

Therefore, we introduce a number of sensitivity analyses that cover a spectrum of contracting details, deal characteristics, and option pricing assumptions that are applicable to the full sample. The sensitized parameter is modified once at a time, all else equal, such that the effect of that specific parameter to the full sample could be properly illustrated regardless of investment properties or asset specifications. Starting from the base case scenario, we systematically adjust our OPM for the new introduced parameter and re-backsolve to determine the level of RNV that yields a FV indication for the last preferred stock, equal to the stated OIP, considering the newly introduced assumption. The results of these robustness checks, as described by the median observation of the full sample and respective metric, are presented in Table 9.

[Insert Table 9 here]

For the purpose of the base case analysis of our sample, we relied on the PoMV to derive an implied number of common shares, which was also cross-checked relative to corporate filings to ensure appropriateness. The first sensitivity is around the assumed number of common stock, to reflect any potential errors on the assumed common stock pool or differences between how investors track value indications relative to appraisers who typically consider only issued and outstanding shares, as well as to further illustrate the common stock dilutive and pricing impact in risk-neutral metrics. While the AVD discount increases (decreases) by 5.1% (4.1%) when we increase (decrease) the number of common stock, following the higher (lower) weight concentration of common stock into the consolidated derived RNV, the key risk and return characteristics related to downside versus upside coverage are not materially different, which indicates that valuation mispricing could not be properly controlled only by capital structure characteristics. The next sensitivity is around the OIP increase between the last 2 rounds, where we analyze two scenarios involving a half or double OIP, respectively, relative to the base case assumption. As expected, a lower OIP decreases the effective gap of RNV relative to PoMV, due to absolute FV difference between the last preferred stock and all the other equity classes, and improves slightly the implied LP IRR for all preferred stock classes. However, the absolute observed DP coverage and relative differences between the upside conversion probabilities of the various equity classes clearly indicate that valuation output is still prone to improper VC properties incorporation. Finally, we performed a sensitivity incorporating the impact of a specific portion of the common stock pool (10%-15%) issued in the form of MEP options, instead of grouping them with the common stock as CSE shares. For this purpose, we use a weighted average strike price that reflects expectations for the FMV of common stock at the time of issuance, in accordance with 409(a) engagement practices that rely on forward looking OPM analyses and issuance of options at-the-money as of each grant date. We rely on the average OIP of all issued preferred stock classes, and we apply a haircut of 50.0% to get to marketable proxy for the common stock, which is then discounted further by a rounded 32.0% DLOM, in accordance with the Finnerty model maximum discount for subordinated interests with risky profile and long investment windows in order to get to a nonmarketable FV for the common stock that reflects the appropriate participation thresholds for the grouped tranche of options. More information about DLOM modeling applications and related output, as well impact on SBC expenses of VC portfolio companies, is presented in Section 4.5 and Appendix D. Our sensitivity validates our expectation that incorporation of stock options does not bear any material adjustment on any analyzed risk and return metric, so there is no structural modeling concern related to incorporation of exogenous predetermined option pool parameters, even if those pools are tied to dynamic endogenous FV indications.

The next set of sensitivities includes incorporation of investor friendly rights related to different target key economic characteristics. More specifically, we analyze separately the impact of dividend rights (6.0%-8.0% paid in cash), LP multiples (1.25x-1.5x), and high CR (2.0x-5.0x). As expected, stronger investor friendly rights drive a more substantial difference between RNV and PoMV, leading the AVD to an average discount of -74.4% and -88.3% in the case of LP multiple and CR sensitivities, respectively. Introduction of less founder friendly protection rights yields higher LP IRR expectations, which relates to endogenous parameters primarily driven by the higher downside protection or relative bifurcation of value between upside and downside protection and not necessarily to structural or modeling assumptions. Incorporation of additional protection rights that deviate from standard VC contracts is typically perceived as a signal of increased unsystematic exposure, which generates sizable premiums to standard VC ROE expectations applicable in typical VC investment risk profiles. That said, even though from a relative analysis, the LP IRRs are improved, the applicable risk premiums might still fail to properly incorporate proper risk attribution characteristics. The same conclusion applies to the derived DP % that are heavily skewed in the favor of low performing BEV scenarios and are associated with the lack of significant volume of extreme liquidity events in both directions. Relative margins of conversion probabilities of preferred stock classes and moneyness likelihood of common stock are improved due to the dilutive impact of the last preferred stock rights, both in terms of value and probabilistic assessment of high exit value events, but they are still subject to more organic harmonization and proper risk balance across all classes.

The subsequent set of sensitivities validates our prior contracting findings and is important for the establishment of an increased confidence interval and a navigation guide for proper risk and return characteristics evaluation. We amend the sample properties such that preferred stock classes across all sample companies are either (i) all convertible, (ii) all participating, (iii) all senior to the prior issued preferred stock, or (iv) all pari passu. That way, any observed changes are directly linked to VC contracting characteristics rather than deal or modeling specifications, eliminating potential sample selection or subsample analysis concerns. A relative analysis of all convertible versus all participating sensitivities indicates a materially higher AVD and LP IRR for the last preferred stock for participating structures due to the increased asset specific risk, while the dispersity of the median DP coverage is not substantial. A more material correction is acknowledged for the conversion probabilities of the larger OIP preferred stock classes due to fundamental differences of the structural consideration of the value upside embedded instrument and effective call option value attributable to common stock versus options with a CP equal to OIP. A relative analysis of senior versus pari passu preferred stock classes suggests that less founder friendly investor rights are tied to higher delta between RNV and PoMV indications, with direct implications on the delta between the most senior classes and all the other subordinated classes, lower LP IRR attributable to higher DP coverage for senior classes and a considerable spread adjustment for junior equity classes, and lower probability of remote positive conversion events across all classes. On the other hand, the relative RNCP delta of senior versus pari passu structures across all classes compared to the spread implied in the convertible versus participating structures is materially lower, suggesting a different idiosyncratic assessment of upside scenarios with different value sensitivity within each contracting group.

Figure 6 provides compelling evidence about the monotonic relationship of contracting rights regardless of asset properties and deal specifications. This figures presents the spreads between the analyzed risk and return valuation metrics for the full sample based on the sensitivity analysis assuming that all assets have same contracting characteristics in terms of type of preferred stock (convertible, participating) or seniority (senior pari passu). Strong one direction uniform relationship is observed in the relative spreads of AVD, LP IRR and DP across both type of preferred and seniority groupings. Similarly, statistically significant relationship is observed for the RNCP in terms of the seniority ranking with a little higher standard deviation for the relative spread between convertible versus participating structures given the opposite correlation of those contracting types with both holding period and volatility. Participating (senior) structures are consistently tied to higher AVD, higher (lower) LP IRR and RNCP and lower (higher) DP relative to convertible (pari passu) structures. Relative evolution of all contemplated metrics reveals a higher impact of contracting amendment in the type of preferred stock relative to the seniority characteristics.

[Insert Figure 6 here]

In the last panel, we perform a sensitivity across our full sample, adjusting the effective investment horizon (0.5-12 years), derived equity volatility (40%-120%), and utilized risk-free rate of return (1%-3%-5%). As already concluded in Section 4.3, an increase in the assumed horizon positively contributes to the minimization of valuation differential between appraisers and deal participants by substantially altering the weights between DP and upside participation, leading to lower DP coverage, higher RNCP for the last preferred stock class (for the bigger part of the term structure), lower RNCP for earlier OIP or junior equity classes, but with higher absolute attributable value upside due the existence of more extreme positive liquidity outcomes, and risk premiums that more properly incorporate VC attributes. Similar directional impact observations are noted in the case of volatility increase, with a more tangible adjustment in the LP IRR of the latest preferred stock round, which is also directly reflected in the lower DP coverage and lower impact in the implied RNCP across all classes. A downward concave relationship for 57% of the sample assets is observed in the AVD assessment, with the assumed investment horizon being an endogenous parameter that affects the slope of this concave relationship along with deal specifications, while the same relationship is also reflected in the value differential between the latest preferred stock class and common stock claims. Lastly, an increase in the risk-neutral growth rate is positively related to reduction of yielded AVD, increase of observed LP IRR, and decrease of DP coverage for the last preferred stock, as well as higher RNCP for most of the equity classes due to the higher asset price appreciation, but the level of correction in all the analyzed metrics does not bridge the gap relative to typical market expectations, confirming that risk-free rate is not a mispricing valuation driver and can not be relied upon for mitigation of structural limitations.

4.5. Contracting and stock-based compensation

Up to Section 4.4, we have focused on the impact of contracting details, deal characteristics, and modeling parameters to consolidated valuation metrics and relative risk and return characteristics attributable to investors and entrepreneurs. However, valuation metrics affect significantly the SBC attributable to MEP option awards that are issued in connection with key hire or growth plans and aim to properly align employees with shareholders and maximize firm asset value over the assumed investment horizon. Even though we have monitored the impact of all the aforementioned parameters to the common stock, MEP option awards constitute derivative instruments, with a common stock underlying asset price and a specified contractual strike price or participation threshold, and by construction, they are subject to a higher risk profile. Adding to this structural properties differentiation other contractual disparities related to vesting, exercisability, or transferability, widens the relative risk assessment of option awards compared to equity classes with more senior claims or standard VC protection rights.

In this section, we isolate the impact of contracting details and option pricing assumptions to implied FV metrics of MEP options that are typically used for expense purposes in accordance with ASC 718 requirements. For this purpose, we assume that VC-backed companies issue those awards at-the-money to avoid any tax related issues for their MEP award holders. We ignore any potential market vesting conditions which are more typically observed in private equity fund transactions and assume that all those awards have a standard 5 year vesting horizon as of the grant date, which matches the latest financing transaction date for the purpose of this analysis (in alignment with valuation standards), given that employee stock option pool dilution and adjustment of the total effective CSE shares pool is considered by deal participants in the determination of the PoMV and respective OIP as of each financing round. From a valuation perspective, the FV of those awards can be estimated within the same OPM applied when determining the FV of all the other equity classes for financial (tax) reporting purposes, but it is typically calculated separately under IPO forward looking scenarios, given that options might not be subject to vesting acceleration upon a qualified IPO and might have a longer expected life and vesting horizons that affect the potential exercisability horizon, derived service period, and applicable FV. In such cases, instead of using the RNV for allocation purposes, a separate option pricing calculation is applied exclusively for the granted options, with an asset price and strike price reflecting the FV indication (on a marketable basis) of the common stock implied by the OPM (under the IPO investment horizon assumption), an assumed horizon that considers the expected life of the those awards (taking into account vesting schedule and expiration dates and relying on a weighted average calculation), a risk-free rate that corresponds to this new effective term, and a volatility that reflects the specific security volatility of the common stock [17]. Reliance on consolidated equity volatility is not appropriate, due the endogenous inconsistency between the risk properties of the underlying asset price versus the exogenous parameters of the consolidated company volatility, but it might be used from certain appraisers as a proxy or floor for SBC expense purposes. This important modeling parameter selection has also significant implications for valuation and deal purposes with tangible consequences for all related parties.

Once we calculate the call option value (C_{ATM}) according to the aforementioned option pricing assumptions, the next step is to quantify the discount related to the illiquid nature of the underlying awards and factor in specific transferability and illiquidity constraints. As has been discussed in Sections 3.5 and 4.4, respectively, one of the most widely accepted quantitative put options models applicable in multi-tranche capital structures under a risk-neutral framework is the Finnerty (2012) model. The model entails the calculation of an at-the-money average strike put option written on the underlying asset price and can be derived with a closed form solution within a standard risk-neutral option pricing framework. Appendix D includes a detailed description of model specifications and applications. Once a DLOM has been established for the underlying MEP options, the FV of this option class on a nonmarketable, noncontrolling basis is calculated based on the following formula:

$$FV = C_{ATM} * (1 - DLOM). \tag{26}$$

Typically, the FV of MEP option awards (ignoring DLOM applications) is impacted from contracting details similarly to common stock, since they represent a derivative instrument on that class with a higher effective implied leverage (from a claims perspective) or risk profile, but the asset price and strike price are dynamically equivalently adjusted to reflect derived common stock valuation properties. Figure 7 presents the impact of contracting details and modeling parameters to the SBC issued in connection with the last financing round. As expected, strong contracting details (i.e. participating, senior) have a more significant impact on the derived FV of options across all scenarios, with the delta being a variable component related to the level of option pricing assumptions utilized. Panel A

[17] The equity volatility of a company represents the weighted average implied volatility of the various equity classes depending on the relative risk profile, economic rights, and capitalization table characteristics. Derivation of specific security volatility estimates for all underlying classes leads to lower observed volatility for senior preferred equity classes with entitled VC protection rights and higher observed volatility for junior equity classes (subordinated preferred stock, common stock, or options) that represent call options with increased strike prices, no linear consolidated payoff characteristics, and ultimately higher perceived risk. Details about the derivation of class specific volatility within an OPM risk-neutral framework are provided in Appendix D.

suggests that convertible structures have a considerable larger delta in changes to the option pricing assumptions, acknowledging the lower dilution from preferred stock classes on the upside relative to participating structures (median FV relative to last preferred stock class OIP increases by more than 1.8x between the low and high end volatility ranges relative to participating structures). Additionally, the spread between the aforementioned contracting group becomes smaller in low vesting horizon assumptions. A relative analysis of contracting impact of senior versus pari passu preferred stock classes, presented in Panel B, indicates that there is a higher positive correlation and delta relative to modeling assumptions. While pari passu preferred structures seem to be more sensitive to changes in the underlying effective term, senior classes are linked to a higher observed dispersity in sample valuation observations when relying on the longer vesting horizon, due to the more material impact of risk-adjusted option pricing assumptions to the implied risk-neutral distribution tails of the underlying asset. Another important observation derived from Panels C and D is that the FV of awards typically granted in structures with investor friendly economic rights (participating, senior etc.), is heavily discounted, both due to the subordination claim profile and due to the incremental DLOM that is attributable to the endogenous higher class-specific common volatility, which has a sizable premium relative to indications observed for more standard convertible or pari passu structures. In particular, the DLOM of convertible structures is approximately 30% lower than the DLOM of participating structures, while the DLOM of senior structures is 20% higher than the DLOM of pari passu structures.

[Insert Figure 7 here]

Overall, it is evident that the SBC issued in connection with transactions is subject to a high level of endogenous parameters selection, with significant financing reporting and tax implications. An appraiser's decision to rely on a short liquidity term and avoid embedded vesting restrictions might significantly understate the value of the contemplated MEP awards. Additionally, an appraiser's assessment that the consolidated equity volatility of the VC-backed company is an appropriate proxy for the risk profile of the underlying asset might also lead to significant mispricing characteristics that do not properly reflect the true FV dynamics of the contemplated equity class. A combination of those parameters with strong contracting details will lead to substantial pricing dispersity with tangible financial impact for the broader financial ecosystem. Figure 8 illustrates the impact of those modeling related assumptions in the consolidated sample assuming a 2.0% pool of options granted as of the last financing round, inferring that an adjustment to the assumed exercisability or vesting term might increase the consolidated SBC expense between 70.5% ($734m) to 57.3% ($864m) for the low and high end of the sensitized volatility range, while an appraiser's decision to rely on higher volatility, either due to utilized method or introduction of class volatility properties, might trigger an increase between 57% to 78% (based on the low and high end of the range), which is translated to a total value differential between $663m to $866m. Finally, Panel C shows the FV impact that a choice of the volatility approximation has on the consolidated value of SBC. In particular, an appraisers decision to rely on the pricing of options using the total equity volatility, without capturing the incremental risk profile of common stock, leads to an underestimation of SBC by approximately 19.2% ($180m). This value differential is only as of the latest financing round and according to a stated % grant assumption; however,the implications for the total MEP option pool grants during the expected life of the VC-backed asset are considerably higher with significant financial reporting, tax and deal implications.

[Insert Figure 8 here]

5. Implications for practice

Our empirical analysis and robustness procedures have confirmed that the valuation of VC-backed companies by appraisers, by relying on pricing information of financing rounds and development of OPM analyses based on standard engagement valuation assumptions and industry practices, might be subject to significant mispricing characteristics if the utilized models are not properly adjusted for both idiosyncratic VC characteristics as well as structural modeling properties. Contracting rights have significant valuation implications across all the analyzed valuation implied risk and return metrics, with different underlying delta related to specific deal characteristics, relative capitalization structure details, and range of considered option pricing assumptions.

The assumed effective investment horizon and equity volatility are prevailing modeling parameters that lead to significant deviation of risk-neutral observations relative to standard market participant assumptions, regardless of contracting rights synthesis. Low assumed expected term until a liquidity event or volatility of assets leads to higher concentration of potential business outcomes in low or medium performing BEV scenarios, within a risk-neutral OPM model, attributes an increased value allocation to the DP coverage of preferred stock classes, underestimates the implied LP IRR attributable to those classes given the endogenous derived RNV probability density function, leading to risk premiums that are low even for public equity investments, and results to RNCP differentials between various preferred stock classes or relative to common stock that do not reconcile VC properties, optimal investment policies, and historical VC liquidity activity. At the same time, SBC issued to employees might be significantly underestimated due to both exogenous modeling selection or assumptions characteristics as well as endogenous derived metrics related to the perceived risk profile of contemplated award class and derived illiquidity discount. Existence of stronger non-default investor friendly VC contracts are positively correlated with larger AVD, DP allocation, and RNCP spreads among the various equity classes, while the relatively higher implied LP IRR is typically justified due to signals to market participants for increased idiosyncratic exposure that required higher investor protection, unless the negotiated rights were determined for other strategic reasons.

Table 10 presents a regression analysis with respect to the determinants of LP IRR and RNCP deviations. Statistically significant results are observed across the presented valuation implied risk and return metrics for the majority of analyzed equity classes. The coefficients of the linear and logistic regression models are significant for the majority of the analyzed equity classes, clearly demonstrating that the selected option pricing assumptions have prevailing explanatory power for the underestimation of LP IRR and RNCP. In particular, higher equity volatility and expected term parameters translate to a higher LP IRR as well as a higher RNCP for the latest preferred stock class, and a smaller RNCP delta relative to prior preferred stock classes.

[Insert Table 10 here]

Risk-adjusting valuation assumptions to reflect VC risk properties could lead to more robust valuation indications with huge financial, tax, and deal implications. The level of risk-adjustment is a variable dynamic function of contracting structures, deal characteristics, and live information provided by VCs and portfolio companies. Appraisers should seek to optimize all the derived risk and return metrics and properly balance downside and upside value attributes across the full capitalization table. Standalone evaluation of a single derived metric or equity class might fail to properly align relative risk-sharing properties. Figure 9 aims to provide valuable information about optimal combinations of liquidity horizon and equity volatility assumptions for the analyzed sample properties. Investment term risk-adjustment could optimize risk properties across all key risk and return metrics, and volatility could ensure establishment of more optimal relative value allocation attributable to the implied risk-neutral fat distribution tails. Incremental benefits beyond abnormally high levels of standard deviation or term adjustments are non-meaningful and should trigger re-evaluation of all sample assumptions, deal characteristics, and model selection.

In reality, the deviation between pricing indications of appraisers relative to market participants might be higher, due to default preference of appraisers to rely on GPC methods for purposes of estimating the implied volatility of the subject interest VC-portfolio company. This method is typically linked to underestimation of proper risk properties, given that the utilized set of comparable companies typically includes companies larger in size and more mature, and there is a great room for subjectivity in the applicable descriptive statistic selection process. Quantifying a size risk premium for idiosyncratic risk based on primarily public data for illiquid investments is a challenging task open to significant noise. The utilized beta volatility method in this paper should be used as a credible benchmark that reflects market participant expectations across all industries, assets, and business stages, and should be given proper weight concentration or considered as a floor depending on the confidence interval of the utilized ROE.

Presence of sizable secondary transactions on older or junior preferred stock classes or common stock, providing credible pricing information should be also considered in the optimization of key option pricing assumptions, and infer specific risk and return metrics. If double FV alignment (between the latest preferred stock and the secondary transacted equity class) could not be appropriately achieved through a single OPM application and risk-adjusted terms and volatility, consideration of alternative scenario based analysis or hybrid method is deemed necessary to avoid any significant mispricing behavior. Additionally, consideration of dynamic jump-diffusion models with variable volatility components tied to the achievement of key inflation thresholds for portfolio companies (i.e. consummation of additional successful financing rounds) might also establish more proper reconciliation of relative risk-sharing properties among investors, entrepreneurs and employees. We leave those valuation considerations for future research.

[Insert Figure 9 here]

6. Conclusion

Our paper investigates the impact of VC contracts on substantial valuation heterogeneity typically observed in mark-to-market valuations performed by appraisers relative to PoMV indications used by VCs. Based on a retrospective option pricing analysis of 100 of the largest US VC-backed companies that went public between 2000-2024, we document that assumed investment horizon and equity volatility are first-order factors for this valuation differential across all contracting groups, regardless of deal characteristics, leading to substantial mispricing and disproportionate bifurcation of value between embedded contracting features. Proper selection of risk-adjusted holding period and equity volatility improves risk and return metrics for the latest issued preferred stock classes by increasing LP IRR by more than 750 bps, decreases value over-concentration to DP by half, reduces consolidated AVD differential closer to 25%, and harmonizes RNCP spread among equity classes to a median delta of 22%. Pricing differential of earlier preferred stock classes or subordinated common stock is reduced almost to half with proportional adjustments into at-the-money options or MEP awards, while appraisers' proper endogenous model and parameter selection for security specific volatility and illiquidity discount has a net average impact on the FV of contemplated SBC awards of 19.2%. Our results are robust regardless of sample or subsample selection and the determination of risk-adjusted option pricing parameters is a dynamic optimization process considering contracting rights, deal characteristics, market participants organic expectations, and modeling properties. Our suggested implied risk and return risk-neutral metrics are scalable to the broader VC universe with significant financial reporting, tax and deal implications.

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Figure 1: VC deals history

This figure shows the evolution of Venture Capital (VC) deals, both in terms of deal-count and size, in the US from 2000 to 2024. The left axis represents the total value of VC deals in billion U.S. dollars, while the right axis indicates the number of VC deals completed for a given year. The sample includes full transactions and completed deals across all VC stages, sourced from PitchBook Data, Inc.

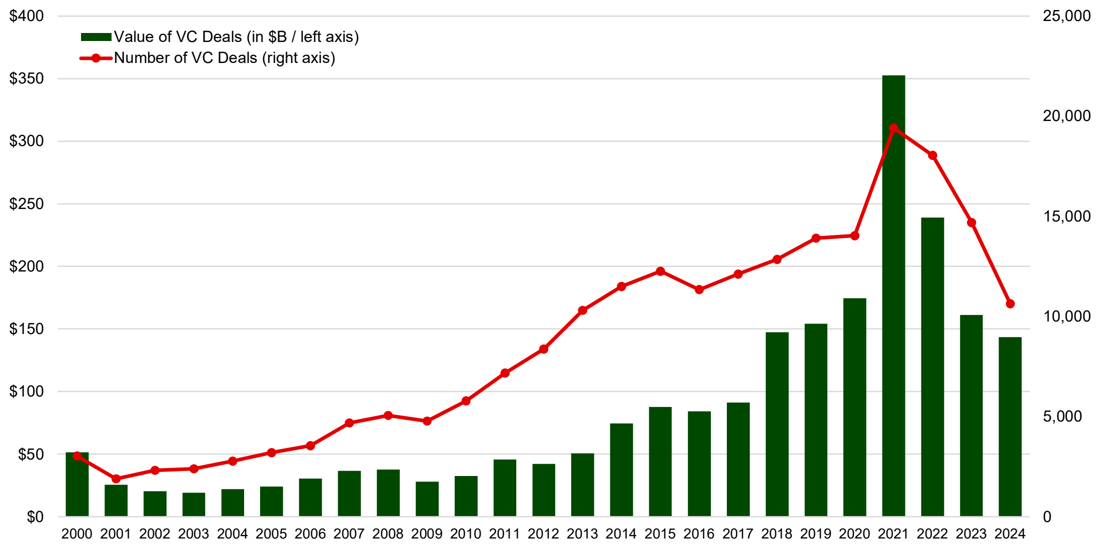


Figure 2: Graphical illustration of participation ratio functions

This figure shows the participation ratio function of the common stock, Series A, and Series B preferred Stock considered in our simplified hypothetical example. The term B_i indicates the breakpoint equity value threshold at which at least one allocation ratio changes, whereas ω_{ji} denotes the allocation ratio of the j-th security applicable at the i-th breakpoint. For this example, we assume that the number of Series A, Series B and common stock is equal, and further, we assume that the Series B OIP is twice the Series A OIP.

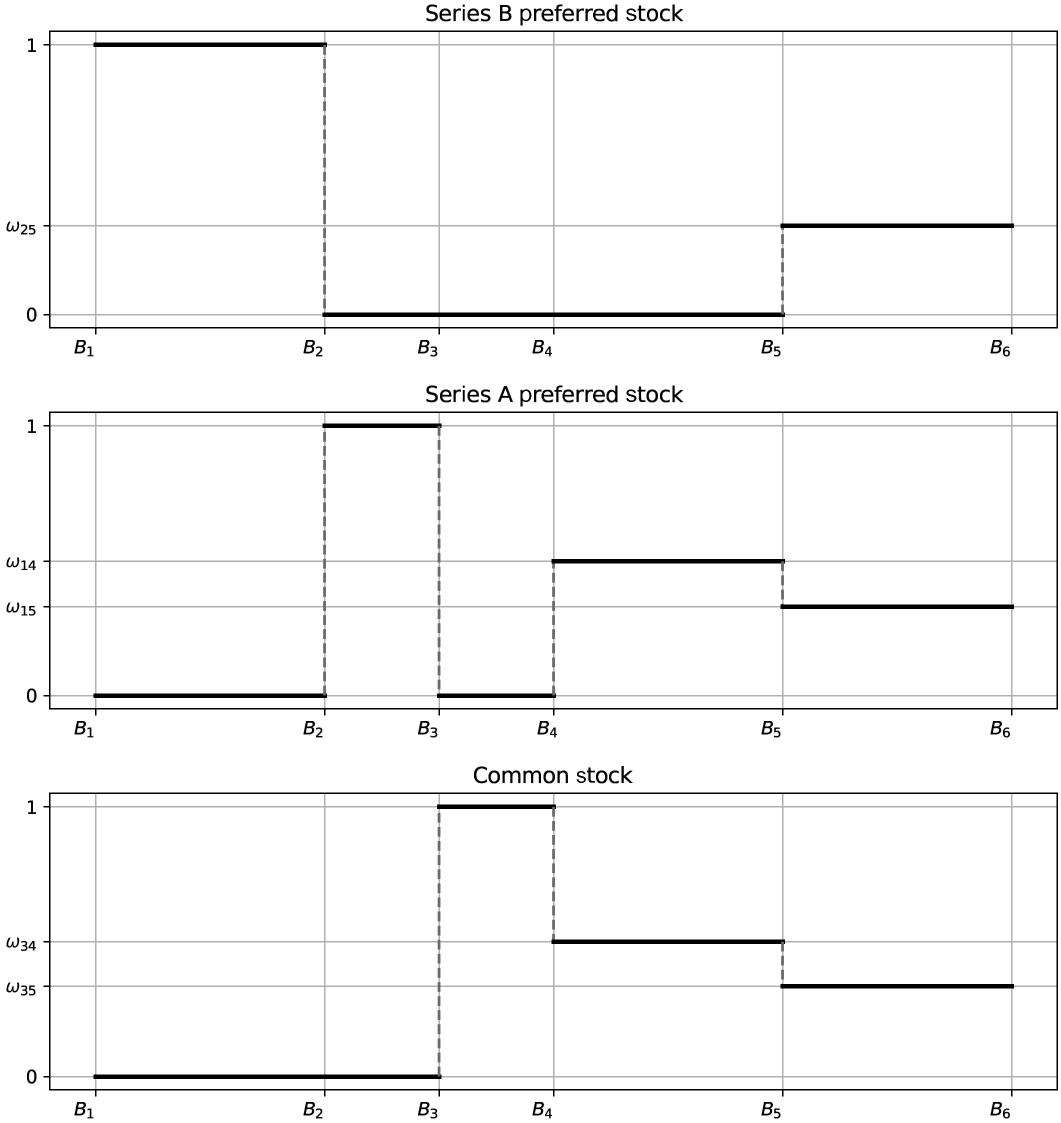


Figure 3: Risk-neutral equity value distribution for the hypothetical portfolio company

This figure shows the probability density function (PDF) of the risk-neutral equity value (RNV) distribution for the hypothetical portfolio company as of the expected initial public offering (IPO) date. The shaded areas show the breakpoints based on specific capital structure and conversion thresholds of each preferred security. For each of these areas, we also provide the applicable risk-neutral conversion probability (RNCP) under the base case scenario. The solid line shows the distribution of expected business equity value (BEV) outcomes under the base case parameters. The dashed line shows the distribution of future BEV outcomes based on the base case contracting assumptions after adjusting the expected term to 5 years. Finally, the dash-dotted line illustrates the impact that an increased volatility of 100% has, all else equal, to the yielded RNV PDF.

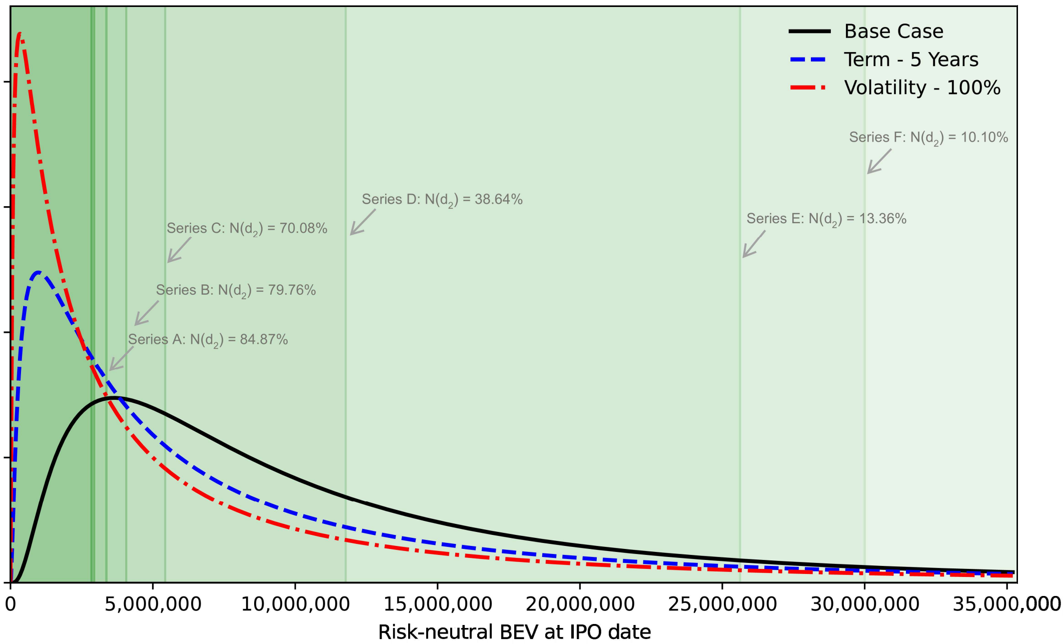
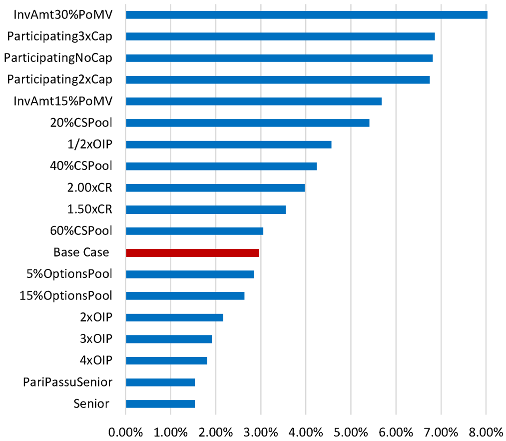


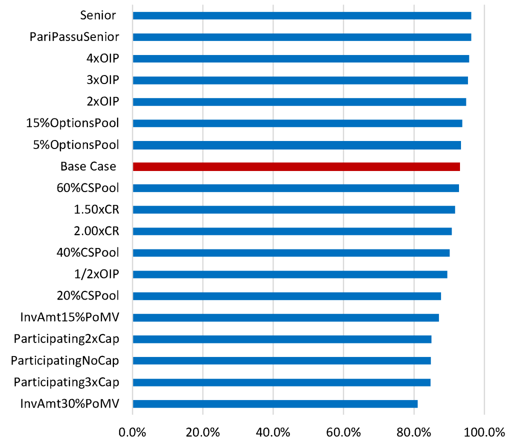
Figure 4: Robustness of results of hypothetical VC portfolio company based on various contracting and modeling inputs

This figure shows the key valuation metrics of the hypothetical Venture Capital (VC)-backed company related to the various sensitivity analyses of different contracting or modeling assumptions performed. *Senior* assumes that each new preferred stock class is senior to the prior class, while *PariPassuSenior* assumes that only the last preferred stock class is senior and all other classes are pari passu. For original issue price (OIP) scenarios, changes in the OIP of the latest round by -50%, 100%, 200%, and 300% are labeled as *1/2xOIP*, *2xOIP*, *3xOIP*, and *4xOIP*, respectively. We also sensitize the common stock pool (CSPool), such as *60%CSPool* describes a common stock ownership of 60% on a fully diluted (FD) basis, while *40%CSPool* and *20%CSPool* represent an ownership of 40% and 20%, respectively. Additionally, we introduce option pools with a weighted average stike price equal to the average OIP of all classes, multiplied by a discount of 50% and an additional discount of 32% (proxy of discount for lack of marketability (DLOM) based on the Finnerty model). Scenarios *15%OptionsPool* and *5%OptionsPool* assume the number of options is 15% and 5%, on a FD basis, respectively. *InvAmt15%PoMV* assumes that the new capital raised in the latest financing round is 15% of the post-money valuation (PoMV), and *InvAmt30%PoMV* assumes an effective deal size of 30%. *1.50xCR* assumes an effective conversion ratio (CR) of 1.50x for all preferred stock classes, while *2.00xCR* assumes a 2.00x CR. Finally, *Participating2xCap* and *Participating3xCap* assume that all preferred stock classes are participating with a 2x and 3x participation cap, respectively, while *ParticipatingNoCap* describes participating preferred stock class with no cap.

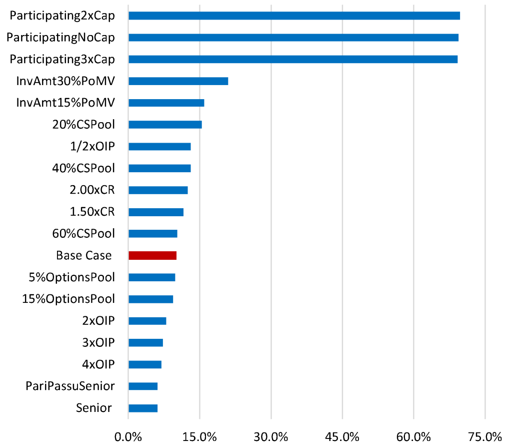
Panel A: LP IRR of Series F



Panel B: DP of Series F



Panel C: RNCP of Series F



Panel D: AVD of Series F

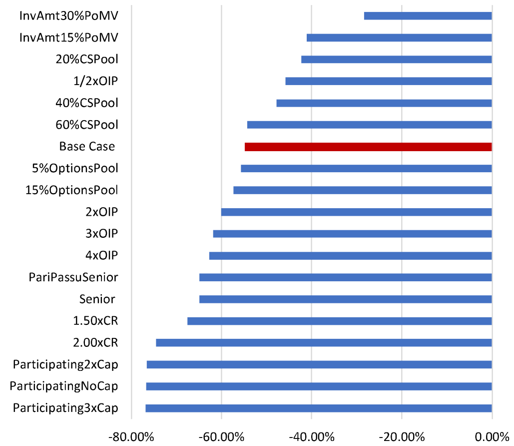


Figure 5: Contracting details, modeling assumptions and impact on risk and return metrics

This figure shows the sensitivity of median implied valuation risk and return characteristics, for the 100 Venture Capital (VC)-backed companies, to changes in assumed investment horizon (T) and equity volatility (σ), for two groups of contracting structures (convertible versus participating and senior versus pari passu). Subscript N denotes the last preferred stock class for the analyzed companies. LP IRR: liquidation preference internal rate of return, AVD: asset value delta (discount) of the implied risk-neutral equity value (RNV) relative to the post-money valuation (PoMV) related to the last issued preferred stock class, DP: downside protection coverage relative to the calibrated fair value (FV), RNCP: risk-neutral conversion probability.

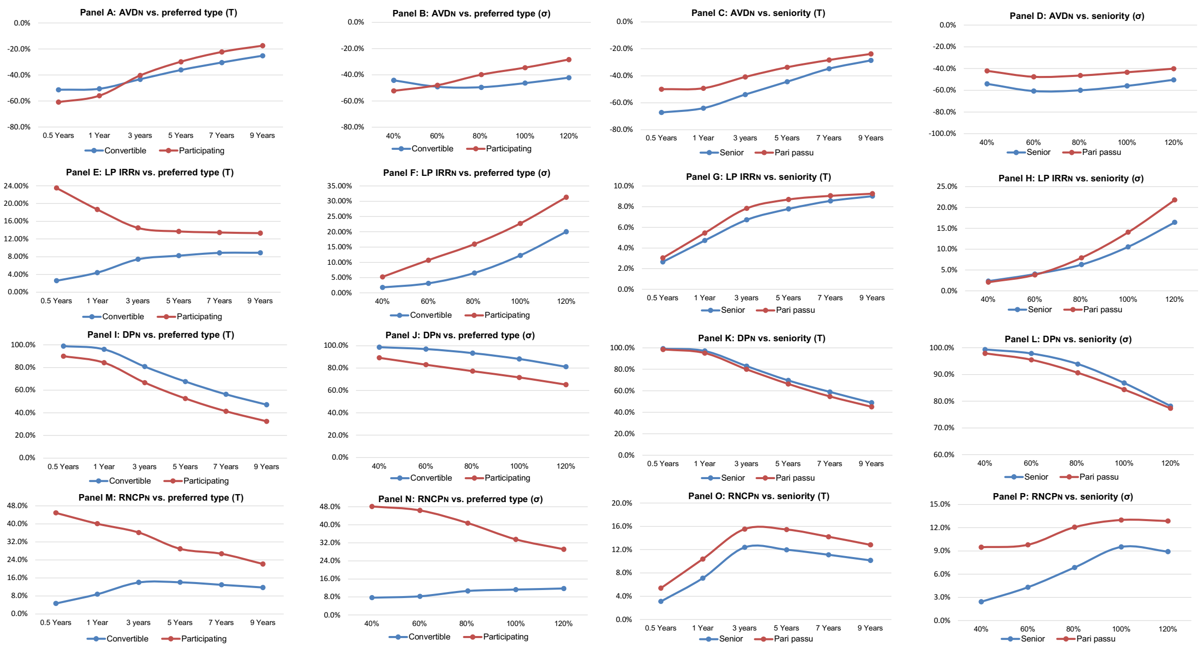


Figure 6: Valuation metric spreads and contracting rights

This figure compares the key valuation metrics for each one of the 100 companies, considering four sensitivities on the type of preferred (convertible or participating) and seniority (senior or pari passu). Panel A plots the difference in asset value delta (AVD) for the last issued preferred security, while Panel B displays differences in LP internal of return (LP IRR). Panel C provides the difference in downside protection (DP) for the last issued preferred security, while Panel D shows the difference in risk-neutral conversion probability (RNCP). Subscript N denotes the last preferred stock class, *Spread(C-P)* denotes the difference in the valuation metric under scope for a company with all convertible shares versus all participating ones, and *Spread(S-PP)* denotes the difference in the valuation metric under scope for a company with all senior shares versus all pari passu ones. For presentation purposes, any outliers that extend beyond the y-axis limits have been removed from the illustrated graphs.

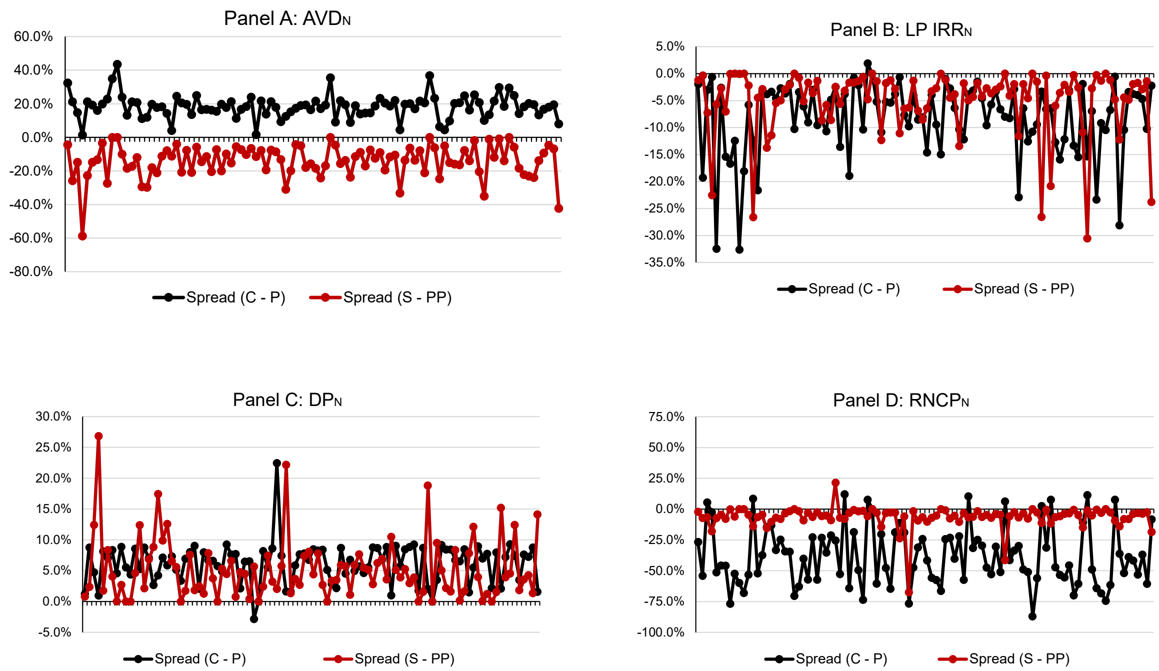
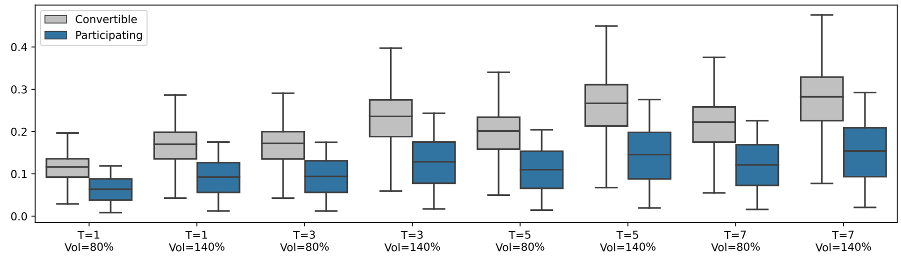


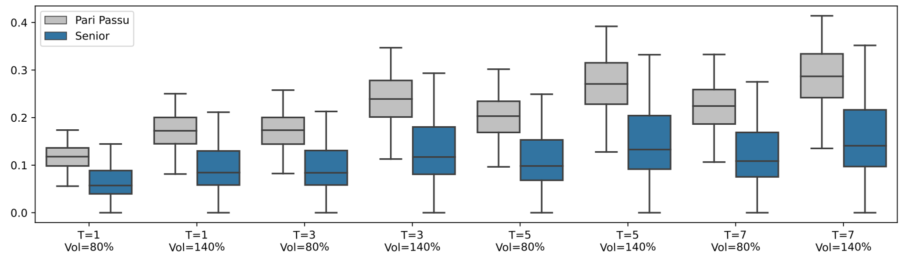
Figure 7: Impact of volatility and expected life of awards on stock-based compensation

This figure shows the fair value (FV) of hypothetical at-the-money management equity plan (MEP) awards granted by venture capital (VC)-backed companies for the sample of 100 VC-backed companies. The FV is based on the option pricing call option formula for the stated expected life term, adjusted for the applicable discount for lack of marketability (DLOM), which is calculated based on either the liquidity term or an assumed 5 year term that accounts for potential incremental exercisability or vesting restrictions. Panels A and B show the distribution of FV of MEP awards, for different contracting groups, as a percentage of the last preferred stock original issue price (OIP) relative to different levels of volatility for each assumed expected life term. Panel C shows the distribution of DLOM across the different contracting groups (using as input the concluded equity volatility for each company and the stated term), whereas Panel D shows distribution of volatility per contracting input considering the following indications: (i) equity volatility, and (ii) common stock class-specific volatility.

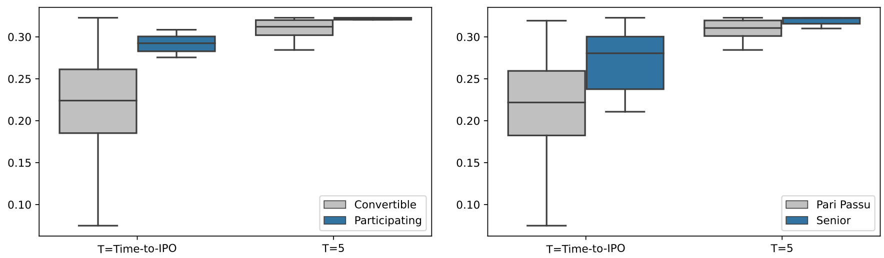
Panel A: FV / OIP versus volatility (Preferred type)



Panel B: FV / OIP versus volatility (Seniority)



Panel C: DLOM (Preferred type and seniority)



Panel D: Volatility (Preferred type and seniority)

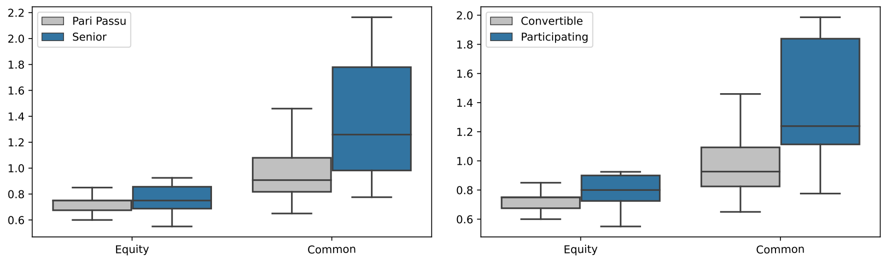
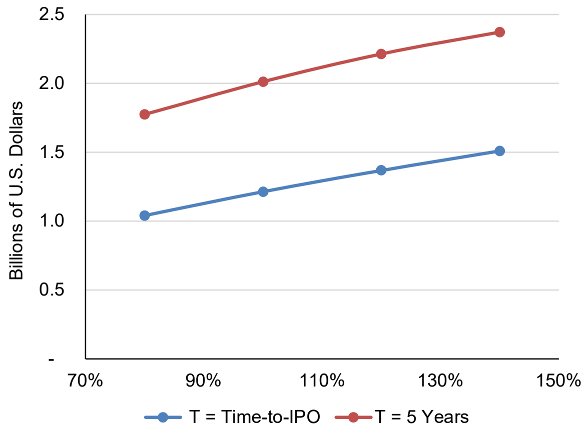


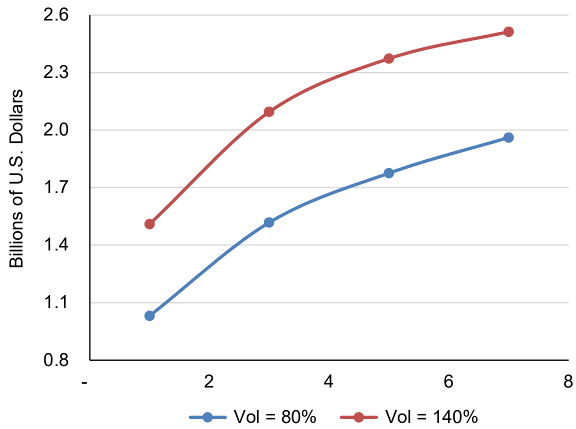
Figure 8: Impact of volatility and vesting term on consolidated stock-based compensation

This figure shows the fair value (FV) and related risk metrics of the stock options issued by each company in the sample of 100 VC-backed companies, assuming that the options represent 2% of the FD shares. The FV is based on the at-the-money call option formula for a given vesting term, multiplied by the respective discount for lack of marketability (DLOM). Panel A provides the total FV of all options assumed for the sample of companies as a function of volatility, while Panel B provides the total FV of all options assumed for the sample of companies as a function of option term. The volatility takes values from 80% to 140%, while the term is set to the time to IPO or a 5 year term. Panel C provides the consolidated FV of all options, considering a valuation using either the equity volatility or the common stock class-specific volatility, and a vesting term equal to the time-to-IPO.

Panel A: Total consolidated FV versus volatility



Panel B: Total consolidated FV versus term



Panel C: Total consolidated FV versus selected volatility

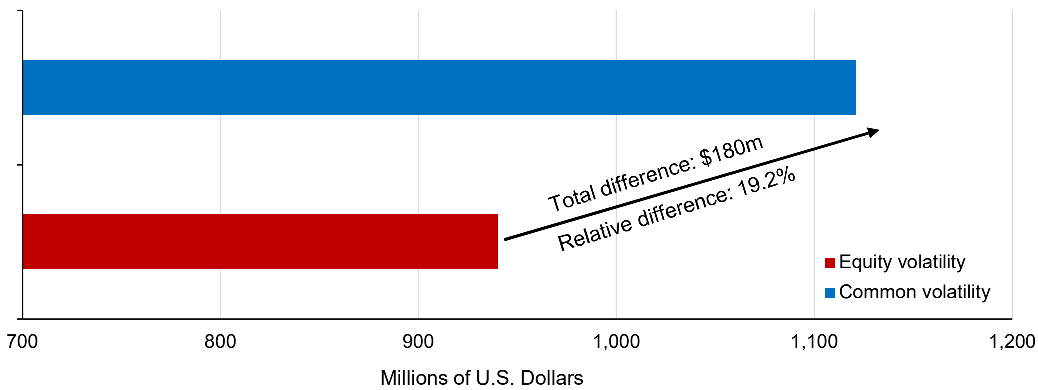


Figure 9: Impact of term, volatility, and contracting rights on valuation metrics

The figure shows the volatility and term parameters that generate a double digit LP internal rate of return (LP IRR), an asset value delta (AVD) higher than -30%, and a downside protection (DP) lower than 85% for the last issued preferred security (Series N), as well as a risk-neutral conversion probability (RNCP) for the last issued preferred security compared to common higher than -25%. Panels A to D display the region with double digit LP IRR for the assets in which the last preferred is convertible, participating, senior, or pari passu, respectively. Panels E to F display the region with AVD higher than -30% for the assets in which the last preferred is convertible, participating, senior, or pari passu, respectively. Panels I to L display the region with DP lower than 85% for the assets in which the last preferred is convertible, participating, senior, or pari passu, respectively. Finally, Panels M to P display the region with RNCP delta lower than -25% for the assets in which the last preferred is convertible, participating, senior, or pari passu, respectively. The blue area indicates the range of parameters in which the stated directional relation is true, where the expected valuation metric was calculated from a linear regression with (i) dependent variable being the LP IRR / AVD / DP or RNCP difference, and (ii) independent variables being the term and volatility.

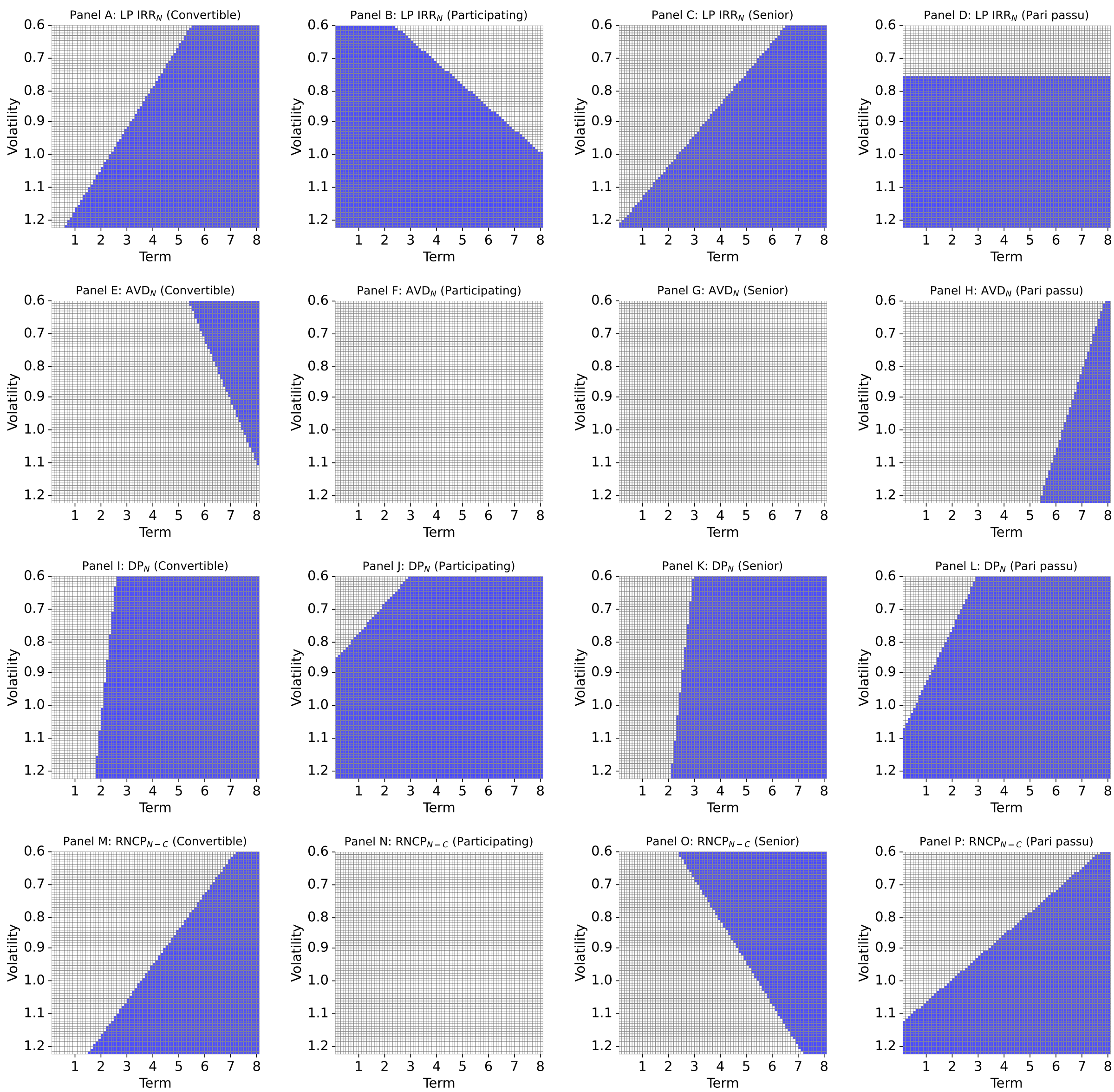


Table 1: Capitalization table and breakpoint analysis of hypothetical VC portfolio company

This table provides the capitalization table details of the different security classes issued by the Venture Capital (VC)-backed portfolio company as well as the breakpoint analysis that captures the various key business equity value thresholds (BEV). Panel A shows the capitalization table, including date of issuance (Date), number of shares outstanding (Shares), original issue price (OIP), liquidation preference (LP), and conversion ratio (CR). The table also includes the post-money valuation (PoMV) at the time of each funding round, formed by investors under a fully diluted (FD) approach (assuming that the common stock is constant for this example). Series Seed capital represents a type of preferred equity instrument, and similar to the Series A to Series F stock, is subject to similar economic rights and privileges. Panel B shows the breakpoint analysis performed for the hypothetical portfolio company as of the last financing round date. Breakpoint 1 is the starting point with a BEV of $0 illustrating that there is no negative equity value distribution. Breakpoint 2 denotes the BEV threshold at which all preferred stock classes receive their LP, given that all securities are subject to the same seniority, leading to a breakpoint value of $2.85 billion. Breakpoints 3 to 9 represent the BEV thresholds at which each class of preferred stock (Series Seed, Series A, Series B, Series C, Series D, Series E, and Series F) converts into common stock equivalent (CSE) shares. The BEV thresholds are calculated based on the incremental price per share differential between consecutive thresholds multiplied by the respective number of participating classes between those consecutive thresholds and is added to the immediately prior achieved level of BEV. Number of shares and BEV thresholds are presented in thousands of shares and U.S. Dollars, respectively.

Panel A: Capitalization table

Class	Date	Shares	OIP	LP	CR	PoMV
Series Seed	12/31/2008	30,000	$0.50	$0.50	1.00x	$107,450
Series A	11/10/2010	17,000	$2.50	$2.50	1.00x	$579,750
Series B	12/15/2011	17,100	$5.50	$5.50	1.00x	$1,369,500
Series C	2/25/2013	15,000	$11.00	$11.00	1.00x	$2,904,000
Series D	9/30/2014	13,000	$35.00	$35.00	1.00x	$9,695,000
Series E	3/31/2016	15,000	$85.00	$85.00	1.00x	$24,820,000
Series F	2/15/2017	8,000	$100.00	$100.00	1.00x	$30,000,000
Common	n/a	184,900	n/a	n/a	n/a	n/a

Panel B: Breakpoint analysis

Breakpoint	Description	BEV threshold
B_1	Starting point of analysis	$0
B_2	Preferred stock receive LP	$2,846,550
B_3	Series Seed converts into CSE shares	$2,939,000
B_4	Series A converts into CSE shares	$3,368,800
B_5	Series B converts into CSE shares	$4,064,500
B_6	Series C converts into CSE shares	$5,434,000
B_7	Series D converts into CSE shares	$11,770,000
B_8	Series E converts into CSE shares	$25,620,000
B_9	Series F converts into CSE shares	$30,000,000

Table 2: OPM analysis for the hypothetical VC portfolio company

This table shows the allocation of value analysis performed for the hypothetical Venture Capital (VC)-backed portfolio company, based on an option pricing method (OPM) as of the latest financing round date. Panel A shows the allocation table incorporating the applicable participation ratio per equity class within two consecutive breakpoints. Panel B provides the call option calculation per breakpoint and the call option differences that are allocated among the participating classes based on their respective participation ratios. The sum of all interim allocated values between the various incremental call option values yields the total FV attributable to each equity class. Panel C shows the derived Fair Value (FV) per class, including the various risk and returns metrics. B_i denotes the breakpoint, E_{t_N} the risk-neutral equity value (RNV) as of the valuation date, Δ_{t_N} the expected term, σ the equity volatility, r the risk-free rate of return, $C(\cdot)$ the call option value, and $\Delta C(\cdot)$ the call option difference between two consecutive breakpoints. The absolute values are expressed in thousand of U.S. dollars or thousands of number of shares.

Panel A: Allocation table (Ω_n)

$\omega_{j,i}$	$i=1$	$i=2$	$i=3$	$i=4$	$i=5$	$i=6$	$i=7$	$i=8$	$i=9$
$j=1$	0.5%	0.0%	14.0%	12.9%	12.0%	11.4%	10.8%	10.3%	10.0%
$j=2$	1.5%	0.0%	0.0%	7.3%	6.8%	6.4%	6.1%	5.8%	5.7%
$j=3$	3.3%	0.0%	0.0%	0.0%	6.9%	6.5%	6.2%	5.9%	5.7%
$j=4$	5.8%	0.0%	0.0%	0.0%	0.0%	5.7%	5.4%	5.1%	5.0%
$j=5$	16.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.7%	4.5%	4.3%
$j=6$	44.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.1%	5.0%
$j=7$	28.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%
$j=8$	0.0%	100.0%	86.0%	79.7%	74.3%	70.0%	66.8%	63.3%	61.6%

Panel B: Calculation of incremental call option values (ΔC)

i	B_i	E_{t_N}	Δt_N	σ	r	$C(E_{t_N}, B_i, r, \sigma, \Delta t_N)$	$\Delta C(\cdot)$
1	0	13,543,504	2.50	60.0%	1.41%	13,543,504	2,646,755
2	2,846,550	13,543,504	2.50	60.0%	1.41%	10,896,749	78,840
3	2,939,000	13,543,504	2.50	60.0%	1.41%	10,817,909	358,689
4	3,368,800	13,543,504	2.50	60.0%	1.41%	10,459,220	552,860
5	4,064,500	13,543,504	2.50	60.0%	1.41%	9,906,360	989,630
6	5,434,000	13,543,504	2.50	60.0%	1.41%	8,916,730	3,216,085
7	11,770,000	13,543,504	2.50	60.0%	1.41%	5,700,645	3,102,977
8	25,620,000	13,543,504	2.50	60.0%	1.41%	2,597,668	492,016
9	30,000,000	13,543,504	2.50	60.0%	1.41%	2,105,652	2,105,652

Panel C: Calculation of fair values ($\Omega_n \times \Delta C$) and risk and return metrics

Series	j	Total fair value ($\Omega_n \times \Delta C$)	Shares (M)	Fair value per share ($\Omega_n \times \Delta C$ / M)	Internal rate of return $LP\ IRR_j$	Conversion probability $RNCP_j$	Downside protection DP_j
Series Seed	1	1,217,415	30,000	40.58	2.96%	88.00%	1.1%
Series A	2	693,108	17,000	40.77	2.96%	84.87%	5.7%
Series B	3	704,117	17,100	41.18	2.96%	79.76%	12.4%
Series C	4	634,740	15,000	42.32	2.96%	70.08%	24.2%
Series D	5	681,841	13,000	52.45	2.96%	38.64%	62.0%
Series E	6	1,316,067	15,000	87.74	2.96%	13.36%	90.1%
Series F	7	800,000	8,000	100.00	2.96%	10.10%	93.0%
Common	8	7,496,216	184,900	40.54	n/a	88.66%	n/a

Table 3: VC sample characteristics

This table presents the characteristics of the Venture Capital (VC)-backed companies included in our sample. Panel A summarizes the breakdown of companies based on the total number of financing rounds pursued prior to the consummation of an initial public offering (IPO) (including any seed rounds). Panel B shows the breakdown of the sample based on the seniority characteristics, while Panel C describes the allocation of companies according to the convertible or participating feature. Panel D presents the distribution of IPO dates, while Panel E shows the actual split of the companies under consideration based on the effective investment horizon until an IPO from the latest financing round. Panel F illustrates the sample properties in terms of realized post-money valuation (PoMV), Panel G outlines the sample characteristics depending on the latest reported investment amount relative to the PoMV, and Panel H displays the unit-count allocation based on the OIP multiple of the latest financing round relative to the prior one.

Panel A: Number of financing rounds		
3 financing rounds		8
4 financing rounds		19
5 financing rounds		20
6 financing rounds		20
7 financing rounds		15
8 financing rounds		8
9 financing rounds		5
10 financing rounds		5

Panel B: Seniority	
Last financing round	
Pari passu	78
Senior	22
Prior financing rounds	
Pari Passu	58
Senior $\leq$ 50%	26
Senior > 50%	10
All senior	6

Panel C: Last preferred type		
Convertible		87
Participating		13
Participating with Cap	10	
Participating without Cap	3	
Non-Convertible		0

Panel D: IPO date	
From 2000 to 2004	5
From 2005 to 2009	5
From 2010 to 2014	12
From 2015 to 2019	27
From 2020 to 2024	51

Panel E: IPO investment horizon	
Less than 1 year	45
Between 1 and 2 years	27
Between 2 and 3 years	14
Between 3 and 4 years	9
More than 4 years	5

Panel F: PoMV of last round	
Less than \$1 billion	29
Between \$1 billion and \$4 billion	45
Between \$4 billion and \$7 billion	10
Between \$7 billion and \$10 billion	5
More than \$10 billion	11

Panel G: Deal size versus last round PoMV	
Less than 5%	32
Between 5% and 10%	24
Between 10% and 15%	25
Between 15% and 25%	12
Higher than 25%	7

Panel H: OIP multiple	
Less than 1x	2
Between 1x and 2x	55
Between 2x and 3x	25
Between 3x and 4x	10
More than 4x	8

Table 4: Economic rights and privileges of preferred stock classes

This table provides an overview of the key terms of preferred stock classes typically observed in capital structures of Venture Capital (VC)-backed companies. Those terms are usually explicitly described in the Certificate of Incorporation (COI) or other corporate documents of the company, such as the S-1 form. Certain terms may have a significant economic impact in the potential ascribed value of preferred securities, while other terms may primarily affect control and corporate governance properties with not easily quantifiable added value. DP: downside protection, CP: conversion price, CR: conversion ratio, CSE: common stock equivalent, LP: liquidation preference, OIP: original issue price, IPO: initial public offering, IRR: internal rate of return, MOIC: multiple on invested capital, ROFR: right of first refusal

Preferred stock rights	**Description of economic characteristics**
Convertible	Includes both DP and a conversion feature. Effectively, it represents a subordinated debt claim plus a call option with a strike price equal to the CP, adjusted to account for the applicable CR.
Non-convertible	Includes only DP and effectively represents a subordinated debt claim with no further upside.
Participating	Includes both DP and upside through common stock participation. Effectively, it is a subordinated debt claim plus a specific number of CSE shares depending on applicable CR.
Participating with cap	Preferred stock accrues value based on DP plus common stock upside, based on applicable CR, until the cap threshold is reached. After the common stock shares catch-up on the cap-threshold value, they share the same upside characteristics with participating preferred stock classes.
LP multiple	Specifies the multiple applicable to the OIP and any potential dividend rate, if applicable, in connection with the DP.
Senior	Reflects the order of economic claims once any interest-bearing debt obligations are repaid. Senior instruments are eligible for priority economic claims based on the contractual order specified in the COI.
Pari passu	Reflects the same seniority order for applicable preferred stock classes but allocation relative to the weights of respective LP claims.
IPO ratchet	IPO protection right that entitles holders to a minimum IRR or MOIC, if the stock price as of the IPO date falls below a specific level.
IPO veto	Hold-up right that could potentially affect liquidity plans, transaction closing or overall allocation mechanisms.
Weighted average anti-dilution	Consolidated ownership interest protection right for preferred shareholders that allows them to minimize dilution upon issuance of new preferred stock at a lower OIP.
Full ratchet anti-dilution	Consolidated ownership interest protection right for preferred shareholders that allows them to convert at the lowest OIP of subsequently issued preferred stock classes.
Cash dividend	Dividend right that entitles holders to incremental LP claims and indirectly increases the effective conversion price at which a preferred stockholder would elect to convert their holdings into common stock to account for higher intrinsic LP value.
PIK dividend	Dividend right that entitles holders to incremental LP claims and an adjustment of the conversion upside by assuming that accrued and unpaid dividend return amount can be converted into common stock shares at the same conversion price as the preferred capital contribution balance.
CR	Determines the ratio of conversion of each preferred stock into CSE shares based on the contractual CP, adjusted to account for any down-rounds, other major capitalization structure changes, or other structural protection characteristics.
Redemption	Entitles holders to the put right to redeem their shares at a specific value, which usually mirrors the LP or intrinsic capital contribution amount.
ROFR	Allows existing shareholders early access in potential purchase or sale of equity interests before initiating offering procedures with potential external willing buyers.
Tag-along / Co-sale	Entitles minority shareholders to a participating right in contemplated liquidity transactions by controlling shareholders, based on the same set of underlying conditions and pricing characteristics.
Drag-along	Entitles majority or controlling shareholders to require minority shareholders to participate in a contemplated transaction and sell their interests based on the specified pricing characteristics.

Table 5: Detailed sample valuation characteristics

This table presents the detailed characteristics of the VC-backed companies included in our sample. More specifically, key information included is the number of financing rounds successfully closed prior to the initial public offering (IPO), latest preferred stock class issued, concluded equity volatility (Vol), effective liquidity horizon from the latest deal date in years (IPO Term), and asset value delta (AVD) between the risk-neutral implied equity value (RNV) and post-money valuation (PoMV) as of the latest financing round date. The right panel provides the terms of the last preferred stock class. *Type* denotes the type of preferred stock, with *C* indicating a convertible preferred, *P* indicating a participating preferred, and *PC* indicating a participating preferred with a cap. *SR* denotes the seniority ranking, with *S* indicating a senior preferred and *PP* indicating a pari passu preferred. *LPM* denotes the liquidation preference (LP) multiple while *CR* denotes the contractual conversion ratio. Finally, *LP IRR* denotes the LP internal rate of return, *DP* denotes the downside protection, *RNCP* denotes the conversion probability, and *RP* denotes the risk premium, calculated as the difference between the LP IRR and the risk-free rate of return corresponding to the IPO term. The names of the companies have been removed for data confidentiality reasons.

	Number	Last		IPO		Last round terms							
ID	of rounds	round	Vol	term	AVD	Type	SR	LPM	CR	LP IRR	DP	RNCP	RP
1	6	D-1	65.0%	0.7	-50.7%	C	PP	1x	1x	2.6%	98.3%	6.0%	0.0%
2	4	D	90.0%	3.1	-39.8%	PC	PP	1x	1x	19.1%	58.4%	37.2%	18.8%
3	7	F	77.5%	1.7	-66.2%	C	S	1x	1x	10.1%	96.8%	3.9%	9.8%
4	8	E-1	75.0%	0.6	-47.5%	C	PP	1x	1x	4.6%	97.5%	7.7%	4.5%
5	7	G	75.0%	0.3	-39.9%	C	PP	1x	1x	6.0%	98.1%	8.0%	5.9%
6	7	F	70.0%	3.8	-46.6%	C	PP	1x	1x	5.9%	80.6%	13.8%	4.1%
7	6	F	75.0%	0.7	-47.0%	C	PP	1x	1x	5.6%	96.5%	9.4%	5.5%
8	6	F	75.0%	0.3	-67.2%	C	PP	1x	1x	0.1%	100.0%	0.2%	0.1%
9	6	F	67.5%	0.9	-45.6%	C	PP	1x	1x	5.0%	95.9%	10.4%	3.4%
10	3	C	65.0%	0.2	-33.6%	C	PP	1x	1x	5.0%	99.0%	6.9%	0.2%
11	4	D	67.5%	0.3	-37.5%	C	PP	1x	1x	5.0%	98.6%	7.4%	0.1%
12	5	E	65.0%	1.8	-47.2%	C	PP	1x	1x	5.2%	91.1%	13.4%	2.5%
13	4	C	92.5%	0.8	-31.1%	PC	PP	1x	1x	47.6%	73.8%	42.0%	47.5%
14	9	G	75.0%	0.5	-44.7%	C	PP	1x	1x	5.4%	97.4%	8.4%	5.3%
15	5	E	65.0%	3.1	-36.2%	C	PP	1x	1x	8.0%	78.7%	18.7%	5.1%
16	5	E	75.0%	0.8	-57.2%	C	S	1x	1x	2.5%	98.1%	5.2%	2.4%
17	6	F	75.0%	2.2	-18.0%	C	PP	1x	1x	17.6%	69.8%	23.2%	17.4%
18	4	D	72.5%	2.4	-33.6%	C	PP	1x	1x	10.9%	78.2%	19.5%	7.9%
19	5	E	60.0%	3.5	-25.1%	C	PP	1x	1x	9.7%	72.6%	23.2%	7.0%
20	7	F-1	75.0%	2.9	-39.2%	C	PP	1x	1x	8.7%	78.3%	15.6%	7.9%
21	4	D	87.5%	4.0	-50.1%	C	S	1x	1x	7.3%	75.7%	10.7%	6.1%
22	5	E	65.0%	2.5	-53.3%	C	PP	1x	1x	4.0%	90.8%	11.7%	1.2%
23	7	G	67.5%	1.7	-43.7%	C	PP	1x	1x	6.5%	90.0%	14.5%	4.6%
24	5	E	75.0%	1.2	-56.1%	C	PP	1x	1x	3.7%	95.8%	7.9%	3.5%
25	5	E	47.5%	0.4	-80.6%	C	PP	1x	1x	9.0%	100.0%	0.0%	2.9%
26	6	F	75.0%	0.7	-72.0%	C	S	1x	1x	0.4%	99.7%	1.0%	0.2%
27	6	E/E-1	65.0%	1.0	-49.2%	C	PP	1x	1x	3.7%	96.5%	9.0%	1.4%
28	3	C-1	90.0%	1.3	-26.9%	C	PP	1x	1x	21.1%	78.2%	20.7%	20.9%
29	4	D	90.0%	0.7	-53.6%	C	S	1x	1x	6.1%	95.7%	8.4%	6.0%
30	3	C	70.0%	1.9	-21.5%	C	PP	1x	1x	16.5%	74.9%	25.6%	12.6%
31	5	D	87.5%	3.7	-30.8%	C	PP	1x	1x	13.3%	63.1%	15.1%	12.0%
32	4	C	90.0%	0.9	-52.6%	C	PP	1x	1x	6.8%	94.5%	9.5%	6.7%
33	7	F	72.5%	2.9	-54.2%	PC	PP	1x	1x	10.4%	75.4%	56.2%	9.3%
34	8	H	75.0%	0.5	-55.4%	C	PP	1x	1x	1.8%	99.1%	3.4%	1.6%
35	3	C	85.0%	7.2	-21.1%	C	PP	1x	1x	12.9%	42.0%	12.1%	10.6%
36	4	C	77.5%	4.1	-52.8%	C	PP	1x	1x	5.4%	80.4%	10.9%	4.2%
37	8	H	75.0%	0.7	-67.7%	C	PP	1x	1x	0.7%	99.5%	1.7%	0.6%
38	5	D	90.0%	1.8	-66.5%	PC	S	1x	1x	14.2%	78.3%	43.7%	13.9%
39	7	F	75.0%	0.2	-95.1%	C	S	1x	1x	6.0%	100.0%	0.0%	6.0%
40	8	H	67.5%	1.9	-55.9%	C	PP	1x	1x	3.5%	93.9%	9.4%	1.8%
41	5	E	60.0%	0.7	-16.6%	C	PP	1x	1x	18.9%	87.9%	28.4%	16.2%
42	5	E	67.5%	2.1	-46.8%	C	PP	1x	1x	5.7%	89.1%	13.6%	4.0%
43	6	E	72.5%	1.7	-64.1%	C	PP	1x	1x	2.3%	96.1%	6.1%	2.0%
44	4	D	77.5%	2.7	-53.7%	C	S	>1x	1x	18.4%	90.2%	6.6%	16.3%
45	5	E	60.0%	2.8	-67.4%	P	S	1x	1x	3.7%	90.3%	21.5%	1.3%
46	3	C	90.0%	0.2	-62.0%	C	S	1x	1x	0.4%	99.9%	0.6%	0.3%
47	6	F	77.5%	0.7	-88.2%	P	PP	1x	1x	10.2%	93.8%	77.7%	10.2%
48	4	D	80.0%	2.6	-49.5%	C	PP	1x	1x	7.0%	84.1%	12.7%	5.3%
49	5	E	67.5%	1.3	-29.8%	C	PP	1x	1x	11.9%	86.5%	20.9%	9.8%
50	4	C	85.0%	1.3	-30.9%	C	PP	1x	1x	16.7%	82.0%	19.5%	16.2%
51	10	I	65.0%	0.8	-34.7%	C	PP	1x	1x	8.6%	94.0%	15.7%	6.4%
52	9	I	75.0%	2.6	-59.6%	C	PP	1x	1x	3.8%	91.0%	8.8%	3.5%
53	6	E-1	75.0%	1.0	-58.3%	C	PP	1x	1x	2.9%	97.1%	6.3%	2.8%
54	6	F	65.0%	0.4	-45.1%	C	PP	1x	1x	2.5%	99.0%	4.9%	0.0%
55	4	D	70.0%	5.1	-28.7%	C	PP	1x	1x	13.0%	64.6%	15.8%	9.3%
56	7	G	67.5%	0.8	-57.1%	C	S	1x	1x	2.0%	98.4%	5.0%	0.2%
57	7	G	75.0%	1.8	-43.4%	C	PP	1x	1x	7.9%	87.0%	14.5%	7.4%

Continued on next page

Table 5: Detailed sample valuation characteristics (Continued)

	Number	Last		IPO		Last round terms							
ID	of rounds	round	Vol	term	AVD	Type	SR	LPM	CR	LP IRR	DP	RNCP	RP
58	3	B	92.5%	0.5	-60.0%	C	S	1x	1x	11.1%	98.6%	3.9%	11.0%
59	6	F	77.5%	0.6	-61.1%	C	PP	1x	1x	1.6%	99.0%	3.2%	1.5%
60	5	E	75.0%	2.1	-60.7%	C	S	1x	1x	3.4%	93.2%	8.2%	2.9%
61	4	D-1	62.5%	1.8	-42.2%	PC	S	1x	1x	13.2%	80.2%	40.6%	11.1%
62	5	D	72.5%	5.2	-37.7%	C	S	1x	1x	7.6%	68.5%	14.3%	6.1%
63	9	I	65.0%	1.4	-46.2%	C	S	1x	1x	5.2%	92.9%	12.7%	2.8%
64	6	F	65.0%	1.1	-41.6%	C	PP	1x	1x	6.4%	93.1%	14.0%	3.9%
65	10	H	72.5%	1.9	-52.4%	C	PP	1x	1x	5.0%	91.3%	11.1%	3.7%
66	6	D	67.5%	3.2	-32.8%	C	PP	1x	1x	9.1%	75.8%	18.8%	7.3%
67	10	I	67.5%	1.7	-48.4%	C	PP	1x	1x	5.1%	92.1%	12.2%	3.5%
68	5	D-2	75.0%	0.2	-28.4%	PC	PP	1x	1x	24.1%	96.7%	19.6%	24.0%
69	6	F	75.0%	1.4	-43.2%	C	PP	1x	1x	7.9%	89.6%	14.1%	7.7%
70	3	C	67.5%	2.8	-39.2%	C	S	1x	1x	8.1%	80.4%	18.4%	3.8%
71	4	D	92.5%	0.6	-28.3%	C	PP	1x	1x	24.6%	87.6%	20.7%	24.5%
72	5	E	67.5%	1.7	-47.0%	C	PP	1x	1x	5.5%	91.2%	13.0%	3.9%
73	7	G	75.0%	0.9	-48.8%	C	PP	1x	1x	5.4%	95.4%	9.8%	5.2%
74	9	H	75.0%	0.2	-58.1%	C	PP	1x	1x	0.1%	100.0%	0.2%	0.0%
75	5	E	67.5%	1.1	-49.5%	C	PP	1x	1x	4.3%	95.5%	9.9%	2.5%
76	4	D	90.0%	1.4	-21.6%	PC	PP	1x	1x	45.8%	59.9%	30.1%	45.6%
77	6	F	75.0%	1.6	-72.2%	C	PP	>1x	1x	25.7%	99.1%	1.4%	25.6%
78	4	D	80.0%	0.8	-37.2%	PC	S	1x	1x	23.2%	85.4%	30.6%	22.2%
79	5	D	90.0%	1.0	-47.7%	C	PP	1x	1x	9.3%	91.8%	12.1%	8.5%
80	7	F	75.0%	0.6	-50.4%	C	PP	1x	1x	3.9%	97.6%	7.0%	3.8%
81	8	H	65.0%	0.8	-45.5%	C	PP	1x	1x	4.5%	96.4%	9.9%	2.1%
82	4	C	90.0%	3.1	-51.6%	C	PP	1x	1x	7.6%	79.9%	10.8%	6.8%
83	8	G	70.0%	0.5	-56.9%	C	PP	1x	1x	1.4%	99.2%	3.1%	0.3%
84	10	G-2	75.0%	0.6	-54.6%	C	PP	1x	1x	2.8%	98.3%	5.4%	2.7%
85	10	J	75.0%	0.8	-69.8%	C	S	1x	1x	0.7%	99.5%	1.7%	0.6%
86	3	C	80.0%	0.6	-30.8%	PC	PP	1x	1x	46.2%	79.5%	46.3%	44.1%
87	6	F	67.5%	1.6	-47.0%	C	PP	1x	1x	5.4%	91.9%	12.7%	4.0%
88	9	G2	65.0%	0.4	-43.3%	C	PP	1x	1x	2.8%	99.0%	5.1%	0.3%
89	7	F	75.0%	0.9	-64.7%	C	PP	1x	1x	1.5%	98.6%	3.6%	1.4%
90	7	F	75.0%	0.2	-63.1%	C	PP	1x	1x	0.1%	100.0%	0.1%	0.0%
91	6	E	65.0%	1.4	-52.4%	C	PP	1x	1x	3.6%	95.3%	9.5%	1.2%
92	6	F	55.0%	5.5	-49.6%	PC	S	1x	1x	6.5%	70.8%	38.4%	2.0%
93	8	H	67.5%	0.4	-26.4%	C	PP	1x	1x	13.7%	95.5%	17.1%	12.2%
94	8	G	75.0%	1.1	-50.9%	C	PP	1x	1x	5.0%	94.8%	9.7%	4.9%
95	7	G	70.0%	3.1	-40.9%	C	PP	1x	1x	7.4%	79.9%	15.9%	5.7%
96	6	F	77.5%	1.0	-75.1%	C	S	1x	1x	0.5%	99.5%	1.4%	0.4%
97	7	G	75.0%	2.3	-62.0%	C	PP	1x	1x	3.2%	93.1%	7.9%	2.8%
98	4	D	87.5%	2.3	-60.9%	P	PP	1x	1x	15.2%	72.3%	51.3%	13.9%
99	5	D	77.5%	1.0	-58.5%	C	PP	1x	1x	3.1%	97.0%	6.4%	3.0%
100	4	D	92.5%	0.7	-68.7%	C	S	1x	1x	1.8%	98.7%	3.2%	1.7%

Table 6: Summary valuation statistics

This table presents a summary of descriptive statistics for key valuation assumptions and respective output of the option pricing method (OPM) analysis for the full sample. Panel A provides the model parameters that feed as inputs to the OPM, including return on equity (ROE) depending on business growth stage and number of successfully closed financing rounds, equity volatility (σ), and risk-free rate of return (r) corresponding to the remaining investment horizon until the initial public offering (IPO) date. Panel B shows the original issue price (OIP) per round for the last, second-to-last, and Series A preferred stock class, respectively. Panel C summarizes the business equity valuation metrics, including post-money valuation (PoMV), risk-neutral value (RNV), and the asset value delta (AVD) between the aforementioned metrics. Panel D summarizes the distribution of the downside protection (DP) ratio relative to the implied fair value (FV) for key preferred stock classes. Panel E shows the liquidation preference internal rate of return (LP IRR), while Panel F reports the risk-neutral conversion probability (RNCP) of the analyzed preferred stock classes, as implied by the OPM. Subscript *N* denotes the last preferred stock class, *N-1* refers to the second the last preferred stock class, *A* denotes the Series A preferred stock.

Panel A: Model inputs							
	Mean	Std. Dev.	10%	25%	Median	75%	90%
ROE	26.5%	2.3%	25.0%	25.0%	25.0%	30.0%	30.0%
σ	74.2%	9.1%	65.0%	67.5%	75.0%	77.5%	90.0%
r	1.3%	1.3%	0.1%	0.1%	1.0%	2.1%	2.8%
Panel B: OIP							
	Mean	Std. Dev.	10%	25%	Median	75%	90%
OIP_N	20.39	24.46	3.22	7.46	13.00	20.70	46.05
OIP_{N-1}	11.23	13.01	1.56	3.27	7.10	12.52	23.07
OIP_A	1.09	2.55	0.09	0.22	0.50	1.00	1.98
Panel C: Equity valuation							
	Mean	Std. Dev.	10%	25%	Median	75%	90%
$POMV$	4,696,745	9,338,387	180,384	631,074	1,800,000	4,150,000	10,120,000
RNV	2,243,540	4,769,602	102,847	364,600	775,298	1,803,647	4,910,265
AVD	-48.8%	15.0%	-67.2%	-58.2%	-49.0%	-39.2%	-28.6%
Panel D: DP							
	Mean	Std. Dev.	10%	25%	Median	75%	90%
DP_N	89.1%	11.5%	73.6%	80.4%	93.2%	98.1%	99.3%
DP_{N-1}	72.1%	20.6%	42.1%	58.4%	74.9%	89.7%	96.3%
DP_A	16.7%	20.8%	1.4%	3.4%	8.0%	21.2%	49.4%
Panel E: LP IRR							
	Mean*	Std. Dev.*	10%	25%	Median	75%	90%
$LP\ IRR_N$	8.6%	8.9%	1.6%	3.5%	5.8%	10.3%	18.4%
$LP\ IRR_{N-1}$	16.9%	29.7%	2.6%	4.5%	7.5%	16.3%	45.6%
$LP\ IRR_A$	22.8%	36.9%	2.8%	5.1%	10.4%	26.3%	87.1%
Panel F: RNCP							
	Mean	Std. Dev.	10%	25%	Median	75%	90%
$RNCP_N$	14.2%	13.2%	1.7%	6.3%	10.8%	17.4%	30.2%
$RNCP_{N-1}$	30.8%	20.0%	9.8%	15.8%	27.8%	40.9%	51.9%
$RNCP_A$	65.4%	25.2%	26.7%	50.5%	70.2%	87.0%	94.1%

*The mean and standard deviation does not include any observations with LP IRR higher than 300%.

Table 7: Impact of contracting details on valuation metrics

This table presents the median descriptive statistic observations of key valuation metrics of our sample, based on a classification according to their respective contracting details. Panel A shows the breakdown by type of preferred stock class, i.e., either convertible or participating (with or without a participation cap), whereas Panel B and Panel C provide the breakdown by seniority in terms of the latest round or all consummated rounds, respectively. Subscript N denotes the last preferred stock class, *N-1* refers to the second-to-last preferred stock class, A denotes the Series A preferred stock, and C describes the common stock. AVD: asset value delta representing the discount of the risk-neutral value (RNV) relative to the post-money valuation (PoMV), LP IRR: liquidation preference internal rate of return, DP: downside protection coverage relative to Fair Value (FV), RNCP: risk-neutral conversion probability.

	AVD	$\frac{FV_N}{FV_{N-1}}-1$	$\frac{FV_N}{FV_C}-1$	IRR_N	DP_N	$RNCP_N$	$RNCP_{N-1}$	$RNCP_A$	$RNCP_C$
Panel A: Preferred type									
Participating	-42.17%*	30.68%	313.27%	15.20%	78.31%	40.59%	38.41%	40.59%	40.59%
Convertible	-49.25%	46.46%	125.88%	5.37%	94.81%	9.50%	27.15%	73.20%	78.60%
Panel B: Last round seniority									
Senior	-58.59%	66.77%	350.65%	6.04%	94.44%	7.40%	21.69%	40.92%	42.14%
Pari passu	-47.01%	41.10%	121.85%	5.62%	93.09%	11.42%	30.44%	78.93%	81.53%
Panel C: Number of senior rounds									
Pari passu	-47.10%	38.64%	120.85%	5.47%	91.85%	11.91%	30.44%	80.56%	81.97%
Senior $\leq$ 50%	-49.84%	57.42%	169.83%	6.49%	93.02%	10.28%	26.88%	60.48%	61.83%
Senior $>$ 50%	-58.54%	59.46%	320.42%	7.85%	94.89%	11.11%	20.45%	31.36%	42.40%
All Senior	-65.35%	96.77%	425.14%	1.25%	99.07%	2.42%	15.39%	57.10%	63.68%

*The AVD presented also includes instruments with participation cap. The relevant AVD based solely on participating instruments (with no cap) is -67.43%.

Table 8: Impact of deal characteristics and modeling inputs on valuation metrics

This table presents the median descriptive statistic valuation observations depending on certain analyzed deal characteristics and modeling assumptions. Panel A shows the breakdown of the valuation output based on a classification related to the multiple of original issue price between the last and secon-to-last round, while Panel B provides the breakdown based on deal size versus PoMV of last round. Panel C distinguishes the valuation output between upround versus downround financing transaction consideration related to the last preferred stock. Panel D provides relevant valuation metrics depending on the actual investment window from the last preferred stock date to the initial public offering (IPO) date, while Panel E summarizes risk and return characteristics per level of equity volatility derived for each analyzed company. Subscript N denotes the last preferred stock class, *N-1* refers to the second-to-last preferred stock class, A denotes the Series A preferred stock and C describes the common stock. AVD: asset value delta representing the discount of the risk-neutral value (RNV) relative to the post-money valuation (PoMV), LP IRR: liquidation preference internal rate of return, DP: downside protection coverage relative to Fair Value (FV), RNCP: risk-neutral conversion probability, OIP: original issue price.

	AVD	$\frac{FV_N}{FV_{N-1}} - 1$	$\frac{FV_N}{FV_C} - 1$	$LP\ IRR_N$	DP_N	$RNCP_N$	$RNCP_{N-1}$	$RNCP_A$	$RNCP_C$
Panel A: OIP multiple									
Less than 1x	-39.69%	13.24%	446.75%	18.19%	82.82%	35.61%	35.61%	33.04%	35.61%
Between 1x and 2x	-47.18%	28.23%	131.85%	5.44%	95.29%	9.88%	18.51%	69.54%	71.63%
Between 2x and 3x	-49.25%	68.88%	119.79%	5.66%	91.84%	10.87%	33.20%	72.45%	72.97%
Between 3x and 4x	-49.52%	88.72%	118.08%	6.24%	90.67%	10.27%	43.29%	75.35%	77.48%
More than 4x	-63.73%	153.20%	299.38%	9.63%	92.30%	13.77%	66.58%	71.63%	78.27%
Panel B: Deal size versus last round PoMV									
Less than 5%	-53.96%	50.74%	147.22%	3.65%	96.01%	7.76%	22.23%	87.49%	88.65%
Between 5% and 10%	-49.82%	43.56%	130.93%	4.79%	94.28%	9.85%	21.69%	71.73%	76.17%
Between 10% and 15%	-44.70%	57.15%	117.40%	7.61%	91.15%	12.96%	36.08%	56.25%	57.57%
Between 15% and 20%	-29.24%	38.68%	78.37%	15.12%	84.24%	18.96%	32.92%	51.13%	55.65%
More than 25%	-30.77%	22.14%	253.16%	24.13%	85.44%	30.15%	37.70%	42.00%	42.00%
Panel C: Downround									
Upround / Flat	-48.25%	46.81%	126.32%	5.55%	93.54%	9.87%	27.63%	70.31%	73.20%
Downround	-51.91%	29.77%	446.75%	9.63%	91.22%	26.05%	34.52%	48.42%	48.42%
Panel D: Time-to-IPO									
Less than 1 year	-50.68%	45.58%	157.20%	4.57%	98.25%	6.94%	23.87%	80.82%	83.96%
Between 1 and 3 years	-49.50%	46.46%	129.35%	6.40%	90.76%	12.96%	27.91%	69.54%	72.97%
More than 3 years	-38.80%	41.19%	83.95%	7.80%	74.12%	15.48%	30.09%	53.11%	55.25%
Panel E: Equity volatility									
Less than 65%	-45.87%	29.09%	259.73%	9.38%	84.05%	25.78%	39.50%	47.61%	49.08%
Between 65% and 85%	-48.56%	44.41%	130.18%	5.23%	95.05%	9.77%	27.63%	78.93%	79.46%
More than 85%	-50.87%	58.61%	136.09%	12.21%	79.10%	13.63%	25.54%	48.86%	52.10%

Table 9: Robustness to different contacting and capital structure assumptions

The table shows the key valuation metrics for the various sensitivity analyses considered in the empirical estimation of the OPMs for the sample of 100 VC-backed companies, changing only one parameter at a time. *All Pref Yield - 6% Cash* assumes that all preferred securities are entitled to a 6% cash dividend, whereas *All Pref Yield - 8% Cash* assumes that all preferred securities are entitled to a 8% cash dividend. *1/2 Number of Common* considers a scenario in which the number of common is reduced by half, whereas *2x Number of Common* considers a scenario in which the number of common is twice the share count of the base case scenario. *1/2 OIP - Last Round* considers a scenario in which the OIP of the last round is reduced by half, while *2x OIP - Last Round* considers a scenario in which the OIP of the last round is twice the OIP of the base case scenario. *All Convertible* denotes a scenario in which all preferred shares are convertible, *All Participating* denotes a scenario in which all preferred shares are participating, *All Senior* denotes a scenario in which all preferred shares are senior, while *All Pari Passu* denotes a scenario in which all preferred shares are pari passu. *All LP 1.25x* denotes a scenario in which the LP multiple is 1.25x for all preferred shares, while *All LP 1.5x* denotes a scenario in which the LP multiple is 1.5x for all preferred shares. *2x Conv. Ratio* denotes a scenario in which all preferred shares have a conversion ratio of 2x, whereas *5x Conv. Ratio* denotes a scenario in which all preferred shares have a conversion ratio of 5x. Further, we introduce option pools with an average strike price equal to the average OIP of all classes, multiplied by a discount of 50% and an additional discount of 32% (proxy of discount for lack of marketability (DLOM) based on the Finnerty model) in scenarios *Options - 10%* and *Options - 15%* assuming that the number of options is 10% and 15%, on a fully diluted basis, respectively. Changes in the expected term are reflected in scenarios *Time - 0.5 Years*, *Time - 1 Year*, *Time - 3 Years*, *Time - 5 Years*, *Time - 7 Years* and *Time - 9 Years*. Finally, changes in equity volatility are provided in scenarios *Vol - 40%*, *Vol - 60%*, *Vol - 80%*, *Vol - 100%* and *Vol - 120%*, while changes in risk-free rates are reflected in scenarios *Rf - 1%*, *Rf - 3%* and *Rf - 5%*.

Scenarios	AVD	$\frac{FV_{N-1}}{FV_N}-1$	$\frac{FV_A}{FV_N}-1$	$\frac{FV_C}{FV_N}-1$	$LP\ IRR_N$	$LP\ IRR_{N-1}$	$LP\ IRR_A$	DP_N	DP_{N-1}	DP_A	$RNCP_N$	$RNCP_{N-1}$	$RNCP_A$	$RNCP_C$
Base Case	-49.0%	-30.7%	-56.0%	-56.8%	5.8%	7.5%	10.4%	93.2%	74.9%	8.0%	10.8%	27.6%	70.2%	72.5%
Panel A: Deal characteristics														
1/2 Number of Common	-44.9%	-28.6%	-52.9%	-54.9%	7.3%	9.0%	12.2%	91.9%	72.7%	7.1%	12.8%	28.7%	65.5%	68.2%
2x Number of Common	-54.1%	-32.9%	-59.2%	-60.3%	4.5%	5.6%	8.4%	94.7%	78.9%	9.4%	8.8%	23.7%	74.3%	79.4%
1/2 OIP - Last Round	-40.0%	4.9%	-51.6%	-53.5%	8.4%	11.5%	15.4%	90.1%	90.2%	14.3%	13.4%	13.2%	58.3%	61.9%
2x OIP - Last Round	-53.9%	-50.2%	-58.9%	-59.9%	4.8%	5.9%	7.6%	94.5%	54.8%	4.3%	8.9%	46.6%	79.6%	82.8%
Options - 10%	-51.0%	-30.9%	-56.0%	-57.3%	5.3%	7.2%	10.0%	93.9%	76.8%	8.7%	10.6%	26.8%	71.8%	75.6%
Options - 15%	-51.5%	-31.1%	-56.2%	-57.8%	5.0%	6.9%	9.9%	94.0%	76.9%	9.0%	10.4%	26.7%	73.4%	76.9%
Panel B: Investor rights														
All Pref Yield - 6% Cash	-59.5%	-36.5%	-67.9%	-71.0%	8.8%	11.3%	15.0%	96.6%	86.9%	12.0%	5.9%	16.0%	57.1%	61.1%
All Pref Yield - 8% Cash	-61.4%	-37.8%	-71.0%	-73.8%	10.3%	12.6%	16.7%	97.3%	88.8%	13.1%	4.7%	14.1%	52.4%	57.4%
All LP 1.25x	-69.2%	-39.5%	-83.4%	-84.7%	23.9%	28.7%	37.4%	99.1%	95.2%	17.2%	1.8%	6.2%	38.4%	41.4%
All LP-1.5X	-74.4%	-44.3%	-89.6%	-91.6%	43.0%	51.5%	64.5%	99.8%	98.1%	27.1%	0.4%	2.0%	23.8%	25.5%
2x Conv. Ratio	-72.1%	-28.6%	-52.3%	-76.9%	7.3%	9.0%	11.3%	91.9%	72.6%	7.2%	12.6%	28.6%	65.0%	68.2%
5x Conv. Ratio	-88.3%	-27.8%	-50.0%	-90.3%	8.6%	10.7%	13.7%	90.5%	70.1%	6.3%	14.2%	29.1%	61.4%	65.3%
Panel C: Contracting inputs														
All Convertible	-47.6%	-30.2%	-54.4%	-55.1%	5.6%	7.2%	10.1%	93.2%	77.6%	7.5%	10.3%	27.7%	70.3%	72.8%
All Participating	-68.5%	-37.5%	-82.4%	-85.6%	13.7%	17.4%	23.2%	85.4%	77.2%	15.8%	55.4%	55.4%	55.4%	55.4%
All Senior	-57.8%	-41.4%	-67.9%	-69.9%	3.7%	12.5%	31.7%	96.2%	81.0%	8.3%	7.0%	20.1%	56.5%	61.7%
All Pari Passu	-44.2%	-28.1%	-52.3%	-54.1%	7.5%	7.5%	7.5%	91.4%	73.5%	7.9%	12.7%	30.7%	74.3%	78.7%
Panel D: Option pricing assumptions														
Time - 0.5 Years	-51.4%	-36.9%	-59.8%	-62.4%	3.0%	4.1%	6.3%	98.7%	86.4%	12.6%	5.2%	26.5%	89.2%	91.7%
Time - 1 Year	-51.0%	-34.0%	-57.9%	-61.1%	5.3%	7.3%	9.6%	95.6%	78.9%	10.6%	9.2%	28.2%	76.4%	80.6%
Time - 3 years	-43.0%	-27.5%	-49.1%	-51.1%	7.7%	9.5%	11.9%	80.5%	57.3%	5.6%	15.2%	26.8%	57.1%	59.8%
Time - 5 Years	-35.9%	-22.2%	-41.6%	-42.6%	8.4%	9.8%	11.8%	67.3%	44.0%	3.5%	14.6%	23.2%	46.6%	48.4%
Time - 7 Years	-30.3%	-18.1%	-34.2%	-35.6%	9.0%	10.0%	11.7%	55.1%	34.6%	2.5%	14.0%	20.3%	39.0%	40.3%
Time - 9 Years	-25.0%	-14.7%	-28.6%	-29.3%	9.3%	10.1%	11.7%	46.4%	27.3%	1.8%	12.5%	17.7%	33.2%	34.4%
Vol 40%	-45.0%	-31.8%	-50.3%	-52.9%	2.1%	2.3%	2.5%	98.0%	85.7%	9.8%	8.8%	38.0%	95.0%	97.2%
Vol 60%	-49.0%	-34.0%	-55.7%	-59.0%	3.9%	4.6%	6.4%	95.9%	80.2%	10.6%	9.2%	28.0%	79.9%	83.4%
Vol 80%	-48.9%	-30.2%	-55.8%	-57.7%	7.8%	9.3%	12.8%	91.1%	72.4%	7.6%	11.3%	26.8%	66.7%	70.6%
Vol 100%	-45.1%	-26.9%	-52.0%	-54.2%	13.3%	16.3%	20.6%	84.6%	64.2%	5.5%	12.8%	24.3%	57.7%	61.1%
Vol 120%	-41.5%	-22.8%	-48.3%	-49.9%	21.3%	24.6%	30.5%	77.3%	58.5%	4.1%	12.6%	20.4%	49.0%	52.3%
Rf - 1%	-49.6%	-30.8%	-56.5%	-57.3%	5.5%	7.4%	10.2%	93.7%	75.3%	7.9%	10.6%	26.4%	69.6%	74.5%
Rf - 3%	-45.7%	-28.1%	-52.0%	-52.7%	6.7%	8.2%	10.0%	91.5%	70.8%	7.0%	12.5%	30.0%	74.9%	78.3%
Rf - 5%	-42.2%	-26.3%	-47.5%	-48.9%	8.2%	9.4%	11.4%	89.6%	66.4%	6.4%	14.7%	33.3%	77.4%	81.5%
Median	-49.0%	-30.7%	-55.7%	-57.3%	7.5%	9.3%	11.7%	93.2%	75.3%	7.9%	10.8%	26.8%	65.5%	68.2%

Table 10: Option pricing assumptions and mispricing of VC-backed assets

This table presents the results of ordinary least squares (OLS) and logistic (Logit) regressions examining the factors that drive the valuation mispricing of VC-backed assets when relying on option pricing method (OPM) analysis. We examine the impact of equity volatility and liquidity term across the last, second-to-last, and first issued preferred stock class. For the Logit regression in Panel A, the dependent variable is an indicator variable equal to one if the liquidation preference (LP) internal rate of return (LP IRR) of the subject security is lower than the median LP IRR across all securities at the same round. For the Logit regression in Panel B, the dependent variable is an indicator variable equal to one if the risk-neutral conversion probability (RNCP) of the subject security is lower than the median RNCP across all securities at the same round. Subscript N denotes the last preferred stock class, *N-1* refers to the second-to-last preferred stock class and A denotes the Series A preferred stock. T denotes the time-to-IPO, whereas σ denotes the return on equity (ROE) implied equity volatility and C is the constant. Standard errors are shown in parentheses. * and ** denote statistical significance at the 10% and 5% level, respectively.

Panel A: LP IRR

	OLS			Logit		
	$LP\ IRR_N$	$LP\ IRR_{N-1}$	$LP\ IRR_A$	$LP\ IRR_N$	$LP\ IRR_{N-1}$	$LP\ IRR_A$
C	-0.174**	-0.662**	-0.928	6.785**	6.781**	4.445**
	(0.071)	(0.329)	(0.600)	(2.181)	(2.129)	(1.850)
σ	0.339**	1.254**	2.049**	-7.455**	-7.851**	-5.633**
	(0.093)	(0.434)	(0.791)	(2.772)	(2.729)	(2.428)
T	0.005	-0.044	-0.124**	-0.833**	-0.627**	-0.169
	(0.006)	(0.030)	(0.055)	(0.237)	(0.211)	(0.166)
Observations	100	100	100	100	100	100
R-Squared	12.51%	10.01%	11.11%	16.75%	13.59%	4.87%

Panel B: RNCP

	OLS			Logit		
	$RNCP_N$	$RNCP_{N-1}$	$RNCP_A$	$RNCP_N$	$RNCP_{N-1}$	$RNCP_A$
C	-0.017	0.677**	1.497**	2.236	-2.483	-9.210**
	(0.108)	(0.165)	(0.184)	(2.074)	(1.732)	(2.430)
σ	0.160	-0.476**	-0.983**	-0.532	3.423	10.669**
	(0.142)	(0.218)	(0.243)	(2.684)	(2.290)	(3.087)
T	0.025**	-0.010	-0.071**	-1.280**	-0.035	0.867**
	(0.010)	(0.015)	(0.017)	(0.296)	(0.156)	(0.245)
Observations	100	100	100	100	100	100
R-Squared	7.12%	5.01%	25.53%	22.89%	1.72%	20.87%

Appendix

Appendix A. Description of sensitivities

Table A.1: Definition of sensitivity Scenarios

Listed sensitivity	Sensitivity description*
2Years	An expected investment horizon from the latest financing round of 2 years and a risk-free rate that corresponds to that term is assumed.
5Years	An expected investment horizon from the latest financing round of 5 years and a risk-free rate that corresponds to that term is assumed.
7Years	An expected investment horizon from the latest financing round of 7 years and a risk-free rate that corresponds to that term is assumed.
9Years	An expected investment horizon from the latest financing round of 9 years and a risk-free rate that corresponds to that term is assumed.
12Years	An expected investment horizon from the latest financing round of 12 years and a risk-free rate that corresponds to that term is assumed.
Vol70%	An equity volatility of 70% is assumed.
Vol80%	An equity volatility of 80% is assumed.
Vol90%	An equity volatility of 90% is assumed.
Vol100%	An equity volatility of 100% is assumed.
Vol120%	An equity volatility of 120% is assumed.
InvAmt5%PoMV	The invested amount of the latest round is 5% of the PoMV, which implies a different PoMV.
InvAmt15%PoMV	The invested amount of the latest round is 15% of the PoMV, which implies a different PoMV.
InvAmt30%PoMV	The invested amount of the latest round is 30% of the PoMV, which implies a different PoMV.
20%CSPool	The number of common stock is 20% of the FD shares, which implies a different PoMV.
40%CSPool	The number of common stock is 40% of the FD shares, which implies a different PoMV.
60%CSPool	The number of common stock is 60% of the FD shares, which implies a different PoMV.
5%OptionsPool	The number of options is 5% of the total shares on a FD basis. An average strike price of 50% of the average OIP of all classes, adjusted for a discount for lack of marketability of 32% is used.
15%OptionsPool	The number of options is 15% of the total shares on a FD basis. An average strike price of 50% of the average OIP of all classes, adjusted for a discount for lack of marketability of 32% is used.
1/2xOIP	The OIP of the latest preferred stock class decreased by 50%.
2xOIP	The OIP of the latest preferred stock class increases by 100%.
3xOIP	The OIP of the latest preferred stock class increases by 200%.
4xOIP	The OIP of the latest preferred stock class increased by 300%.
CnCDivCash8%	A 8.0% cumulative, non-compounding dividend is assumed, paid in cash from issuance date to liquidity date for each preferred stock class.
CnCDivCash12%	A 12.0% cumulative, non-compounding dividend is assumed, paid in cash from issuance date to liquidity date for each preferred stock class.
CnCDivPIK8%	A 8.0% cumulative, non-compounding dividend is assumed, paid in kind from issuance date to liquidity date for each preferred stock class.
CnCDivPIK12%	A 12.0% cumulative, non-compounding dividend is assumed, paid in kind from issuance date to liquidity date for each preferred stock class.
CCDivCash8%	A 8.0% cumulative, annually-compounding dividend is assumed, paid in cash from issuance date to liquidity date for each preferred stock class.

* PoMV: post-money valuation, OIP: original issue price

Table A.1 – continued from previous page

Listed sensitivity	Sensitivity description
CCDivCash12%	A 12.0% cumulative, annually-compounding dividend is assumed, paid in cash from issuance date to liquidity date for each preferred stock class.
CCDivPIK8%	A 8.0% cumulative, annually-compounding dividend is assumed, paid in kind from issuance date to liquidity date for each preferred stock class.
CCDivPIK12%	A12.0% cumulative, annually-compounding dividend is assumed, paid in kind from issuance date to liquidity date for each preferred stock class.
1.25xOIP	A 1.25x liquidation preference multiple applicable to the OIP of each preferred stock class is assumed.
1.25x(OIP+CCDivCash8%)	A 1.25x liquidation preference multiple applicable to both (i) OIP, and (ii) 8.0% cumulative annually compounding dividend paid in cash, for each preferred stock, is assumed.
1.50xOIP	A 1.50x liquidation preference multiple applicable to the OIP of each preferred stock class is assumed.
1.50x(OIP+CCDivCash8%)	A 1.50x liquidation preference multiple applicable to both (i) OIP, and (ii) an 8.0% cumulative annually-compounding dividend paid in cash for each preferred stock class, is assumed.
1.75xOIP	A 1.75x liquidation preference multiple applicable to the OIP of each preferred stock class is assumed.
1.75x(OIP+CCDivCash8%)	A 1.75x liquidation preference multiple applicable to both (i) OIP, and (ii) 8.0% cumulative annually compounding dividend paid in cash, for each preferred stock, is assumed.
2.00xOIP	A 2.00x liquidation preference multiple applicable to the OIP of each preferred stock class, is assumed.
2.00x(OIP+CCDivCash8%)	A 2.00x liquidation preference multiple applicable to both (i) OIP, and (ii) an 8.0% cumulative annually-compounding dividend paid in cash for each preferred stock class, is assumed.
1.50xCR	A 1.50x conversion ratio for each preferred stock class is assumed.
2.00xCR	A 2.00x conversion ratio for each preferred stock class is assumed.
ParticipatingNoCap	All preferred stock classes are participating without any cap.
Participating2xCap	All preferred stock classes are participating with 2.0x cap.
Participating3xCap	All preferred stock classes are participating with 3.0x cap.
Senior	Each new preferred stock class is senior to the immediately prior class issued.
PariPassuSenior	Only the last preferred stock class is senior and all the prior classes are pari passu.

* PoMV: post-money valuation, OIP: original issue price

Appendix B. Valuation output of numerical sensitivities

Table B.1 presents the results of the sensitivity analysis that addresses the impact of modeling related assumptions to the implied RNCP of preferred stock classes and common stock. From Panel B, we observe that the expected term is negatively correlated with the RNCP of most classes, except for the latest one that reflects different statistical relationship until the peak realized at the 7-year investment horizon. Similar negative correlation is observed for the equity volatility, due to the same underlying structural impact in the implied risk-neutral distribution tails. Both OPM assumptions have a material impact in the analyzed metrics. Panel D suggests that an increasing ratio of deal size in the latest round relative to the PoMV has a positive impact in the conversion likelihood for junior preferred stock and early preferred stock classes with low OIP, while the opposite relationship is noted for the higher OIP preferred stock classes. Similar statistical observations are documented in Panel E regarding the impact of the effective common stock pool on a FD basis, with an increased effective ownership increasing the upside likelihood of low OIP preferred stock classes and subordinated common class. Panel F demonstrates that an increased option pool has minor positive impact to the RNCP of common stock through Series D, while a minor negative relationship is identified for the last two preferred stock classes. Finally, Panel G infers that increased deal consideration attributable to higher OIP positively contributes to the value of all other equity classes, due to the higher bifurcated value of both downside and upside value that affects all sharing classes, with a minor opposite impact on the Series F. Overall, this table provides evidence that the RNCP of all classes is sensitive to changes in utilized expected term or volatility across all securities and that actual deal characteristics might have mixed signals in the value impact across the various equity classes.

Table B.2 presents the impact of modeling related assumptions to the implied DP of preferred stock classes. We document a significant negative correlation between both expected term/volatility versus the yielded DP for all classes, with higher expected terms yielding lower ratios by almost -70% for lower OIP preferred classes and higher volatility inferring differences close to -45% for the same classes with a closer alignment across the various securities. Increased risk-adjusted option pricing assumptions push more value to extreme negative or positive outcomes and alter materially the balance between the downside protection versus the upside feature. Extreme observations tied to abnormal positive returns skew the upside claims with a zero-sum game effect on the DP realized. The impact of the remaining analyzed factors is not as material; investment amount, common stock pool, and options pool have the same statistical relationship across all classes (negative for the investment amount and positive for the rest), while mixed signals between the latest preferred stock class relative to the prior ones and common is observed in the OIP sensitivity. Ultimately, this table confirms the importance of the risk-adjusted option pricing assumptions in generating material discrepancies in observed risk-neutral DP characteristics across all classes, and that in most cases, a change to a sensitized parameter has more homogenous impact in the contemplated risk-adjusted metric for the underlying classes.

Table B.3 summarizes the results of contracting details in the risk-adjusted valuation output associated with the RNCP of analyzed classes. A quick review of all presented tables indicates that stronger investor rights ascribe more value to DP and have a negative effect on the likelihood of potential conversion associated with the upside feature. The impact of the LP multiple is the most material across all sensitivities, with an observed homogenous negative correlation varying between -79% to -98% between the low/high LP multiple ranges, with the higher absolute delta reflected in the subordinated common stock or lower preferred stock class OIP claims. CR changes are not sensitive relative to the base case implied metrics, while change of the type of preferred stock from convertible to participating has a material impact across all classes, with the larger delta observed in the higher OIP preferred stock classes. Since all preferred stock classes participate immediately once LP claims have been satisfied, there is no differentiation between the yielded RNCP per equity class. Changes in the type of participating preferred cap conditions do not affect the RNCP for the immediate participation post LP recovery, but instead only affect the likelihood of a higher ROE beyond the specified cap thresholds, which is not intended to be captured by the current metric. Introducing investor friendly seniority rights affects negatively the yielded RNCP across all classes, while the underlying seniority characteristics for prior classes relative to the latest one do not imply any valuation changes given that the effective conversion thresholds and participation dynamics in the LP spectrum and post Series F conversion upside are unchanged. In conclusion, stronger investor rights have a material impact on the observed likelihood of conversion across all equity classes and widen the gap between LP coverage and upside participation feature, suggesting that extreme positive events are associated with more remote probabilities and higher idiosyncratic risk assessment.

Table B.4 highlights the impact of contracting characteristics to the DP of preferred stock classes. Similar to Table B.3, stronger protection rights assign more value to the bifurcated DP right of preferred stock classes, with a materially higher delta observed in the lower OIP preferred stock classes. LP multiple changes are still dominant for the early preferred stock classes, with trivial differentials for the last three preferred stock classes due to the already considerably high implied DP. Seniority and participating features yield similar statistical relationship and relative differentiation for early versus late preferred stock classes, while CR changes do not bear any material adjustments to the analyzed valuation metric. This table confirms earlier findings that stronger contracting details reallocate the consolidated value, attributing more value to the LP DP coverage due to the greater concentration of weight in low- or medium-performing BEV scenarios.

Finally, Table B.5 completes the puzzle of the impact of both contracting and modeling related assumptions to the AVD and LP IRR of underlying preferred stock classes. Stronger investor protection rights increase the yielded AVD and observed LP IRR due to heavier concentration in the low-middle performing scenarios and the limited relative upside in extreme scenarios. AVD differentials vary between -65% to -87%, reflecting materially different valuation conclusions that might be utilized by appraisers relative to market participants. Implied LP IRR is positively correlated with the existence of those rights due to the more meaningful discount required within the risk-neutral framework in connection with the bifurcation of the DP and the upside feature, but still in many cases (seniority, participating feature, CR and partial dividend scenarios), the implied LP reflects low-mid single digits IRR expectations that are not consistent with standard VC risk characteristics. It is evident from the table that contracting details that yield a higher IRR also contribute to a significant delta in the RNV relative to the PoMV, that might create pricing anomalies for market participants and might fail to organically capture VC properties. On the other side, Panel B suggests that risk-adjusting option pricing assumptions and using higher expected term or volatility can lower the observed AVD and increase the inferred LP IRR, reconciling in a more harmonious way investor expectations, but still generate unrealistic risk-adjusted characteristics that require further adjustment or additional consideration of multiple variables. Deal assumptions that relate to common stock FD ownership, option pool dilution, and OIP appreciation relative to last round, seem to contribute to mispricing characteristics, increasing the observed net value differential and implying abnormally low returns. Higher deal size in the latest rounds facilitates the reduction of the pricing differential and better alignment with organic IRR expectations, despite the still low absolute % characteristics. Ultimately, investor friendly rights, while increasing implied LP IRR metrics increase the observed AVD differential, signaling either increased idiosyncratic risk or structural modeling limitations. Incorporation of risk-adjusted option pricing assumptions seems necessary to mitigate mispricing effects, but the robustness of the utilized approach might still need further evaluation in the absence of not properly supported risk and return characteristics.

Table B.1: Sensitivity of conversion probabilities to changes in modeling inputs

This table presents the sensitivity analysis of the risk-neutral conversion probability $N(d_2)$ (RNCP) under various modeling assumptions. The scenarios include (i) different expected term (2, 5, 7, 9 and 12 years), (ii) varying levels of equity volatility (70%, 80%, 90%, 100% and 120%), (iii) different investment amount percentages in the latest round relative to the post-money valuation (PoMV) (5%, 15% and 30%), (iv) sensitivity around the company's common stock pool (CSPool) size (20%, 40%, 60%), and (iv) options pool size (5%, 15%), as well as (v) different original issue price (OIP) assumptions for the latest preferred stock class relative to the base case (1/2xOIP, 2xOIP, 3xOIP, 4xOIP).

Scenario	Common	Series A	Series B	Series C	Series D	Series E	Series F
Panel A: Base case							
Base Case	88.66%	84.87%	79.76%	70.08%	38.64%	13.36%	10.10%
Panel B: Expected term							
2Years	91.89%	88.48%	83.60%	73.76%	39.17%	11.67%	8.42%
5Years	75.66%	71.56%	66.63%	58.45%	35.84%	17.30%	14.46%
7Years	67.97%	64.08%	59.57%	52.37%	33.45%	17.94%	15.46%
9Years	61.27%	57.65%	53.53%	47.10%	30.78%	17.51%	15.34%
12Years	52.98%	49.75%	46.16%	40.66%	27.16%	16.30%	14.50%
Panel C: Equity volatility							
Vol70%	81.89%	77.61%	72.22%	62.81%	35.49%	14.11%	11.16%
Vol80%	75.24%	70.85%	65.55%	56.77%	32.96%	14.54%	11.88%
Vol90%	68.85%	64.54%	59.52%	51.47%	30.62%	14.60%	12.20%
Vol100%	62.75%	58.65%	53.97%	46.65%	28.32%	14.33%	12.19%
Vol120%	51.45%	47.91%	43.98%	38.03%	23.81%	13.08%	11.39%
Panel D: Investment amount							
InvAmt5%PoMV	85.54%	82.03%	77.38%	68.67%	39.80%	14.80%	11.37%
InvAmt15%PoMV	74.30%	71.86%	68.71%	62.88%	42.16%	19.71%	15.96%
InvAmt30%PoMV	61.96%	60.54%	58.70%	55.25%	42.08%	24.55%	21.02%
Panel E: Common stock pool							
20%CSPool	75.55%	74.03%	71.45%	65.93%	44.16%	19.60%	15.45%
40%CSPool	81.34%	78.84%	75.23%	68.05%	42.17%	16.89%	13.08%
60%CSPool	88.06%	84.38%	79.39%	69.94%	38.97%	13.65%	10.34%
Panel F: Options pool							
5%OptionsPool	89.32%	85.68%	80.73%	71.29%	38.74%	13.12%	9.88%
15%OptionsPool	90.68%	87.37%	82.79%	73.87%	38.92%	12.60%	9.41%
Panel G: OIP change							
1/2xOIP	79.67%	73.43%	65.68%	52.74%	21.45%	5.02%	13.15%
2xOIP	93.93%	92.04%	89.34%	83.72%	59.61%	29.45%	7.99%
3xOIP	95.72%	94.54%	92.83%	89.16%	71.13%	42.36%	7.29%
4xOIP	96.59%	95.76%	94.55%	91.93%	78.08%	52.22%	6.96%

Table B.2: Sensitivity of downside protection to changes in modeling inputs

This table presents the sensitivity analysis of the risk-neutral downside protection (DP) under various modeling scenarios. The scenarios include (i) different expected term (2, 5, 7, 9 and 12 years), (ii) varying levels of equity volatility (70%, 80%, 90%, 100% and 120%), (iii) different investment amount percentages in the latest round relative to the post-money valuation (PoMV) (5%, 15% and 30%), (iv) sensitivity around the company's common stock pool (CSPool) size (20%, 40%, 60%), and (iv) options pool size (5%, 15%), as well as (v) different original issue price (OIP) assumptions for the latest preferred stock class relative to the base case (1/2xOIP, 2xOIP, 3xOIP, 4xOIP).

Scenario	Series A	Series B	Series C	Series D	Series E	Series F
Panel A: Base case						
Base Case	5.70%	12.42%	24.17%	62.05%	90.08%	92.98%
Panel B: Expected term						
2Years	6.12%	13.34%	26.01%	66.21%	92.88%	95.25%
5Years	4.01%	8.74%	17.03%	45.91%	75.73%	80.28%
7Years	3.12%	6.79%	13.30%	36.97%	65.38%	70.43%
9Years	2.50%	5.46%	10.72%	30.49%	56.71%	61.85%
12Years	1.85%	4.04%	7.97%	23.25%	45.83%	50.73%
Panel C: Equity volatility						
Vol70%	5.35%	11.62%	22.52%	57.73%	86.30%	89.71%
Vol80%	4.87%	10.56%	20.45%	52.93%	81.88%	85.77%
Vol90%	4.36%	9.46%	18.32%	48.07%	77.04%	81.33%
Vol100%	3.86%	8.38%	16.26%	43.34%	71.94%	76.54%
Vol120%	2.96%	6.45%	12.56%	34.60%	61.39%	66.31%
Panel D: Investment amount						
InvAmt5%PoMV	5.38%	11.71%	22.79%	59.36%	88.57%	91.81%
InvAmt15%PoMV	4.42%	9.62%	18.75%	50.80%	82.72%	87.11%
InvAmt30%PoMV	3.63%	7.89%	15.39%	42.86%	75.61%	81.07%
Panel E: Common stock pool						
20%CSPool	4.41%	9.59%	18.75%	51.21%	83.38%	87.67%
40%CSPool	4.91%	10.70%	20.87%	55.69%	86.45%	90.14%
60%CSPool	5.63%	12.26%	23.87%	61.50%	89.80%	92.76%
Panel F: Options pool						
5%OptionsPool	5.73%	12.50%	24.34%	62.53%	90.38%	93.22%
15%OptionsPool	5.80%	12.65%	24.70%	63.53%	91.00%	93.70%
Panel G: OIP change						
1/2xOIP	9.71%	20.77%	38.62%	80.22%	96.84%	89.45%
2xOIP	3.18%	6.98%	13.84%	40.66%	74.23%	94.80%
3xOIP	2.21%	4.86%	9.69%	29.63%	60.67%	95.37%
4xOIP	1.70%	3.73%	7.44%	23.15%	50.38%	95.63%

Table B.3: Sensitivity of conversion probabilities to changes in economic rights

This table presents the sensitivity analysis of the risk-neutral conversion probability $N(d_2)$ (RNCP) of the various equity classes under different contracting assumptions. The scenarios include (i) different dividend assumptions (compounding or not, 8% or 12% dividend yield), (ii) various liquidation preference multiples adjustments (1.25x-1.75x with adjustments for potential accruing dividends), (iii) different conversion ratio (CR) assumptions (1.50x and 2.00x), (iv) participating preferred stock classes with various valuation cap adjustments (no cap, 2xcap or 3x cap), and (v) different seniority features (new preferred stock class is senior to the prior class, only the last preferred stock class is senior and all other classes are pari passu). CnC: cumulative non-compounding, PIK: paid in kind, CC: compounding and cumulative, OIP: original issue price.

Scenario	Common	Series A	Series B	Series C	Series D	Series E	Series F
Panel A: Base case							
Base Case	88.66%	84.87%	79.76%	70.08%	38.64%	13.36%	10.10%
Panel B: Compounding non-cumulative dividends							
CnCDivCash8%	64.35%	55.65%	46.86%	34.82%	11.97%	2.74%	2.13%
CnCDivCash12%	53.66%	44.04%	35.27%	24.48%	7.10%	1.44%	1.15%
CnCDivPIK8%	64.44%	58.66%	51.47%	39.88%	14.47%	3.02%	2.04%
CnCDivPIK12%	53.72%	48.05%	41.09%	30.37%	9.48%	1.66%	1.08%
Panel C: Compounding cumulative dividends							
CCDivCash8%	62.83%	53.14%	44.14%	32.48%	11.04%	2.58%	2.05%
CCDivCash12%	51.04%	39.65%	30.86%	21.11%	6.10%	1.32%	1.12%
CCDivPIK8%	63.15%	57.27%	49.87%	38.09%	13.18%	2.61%	1.75%
CCDivPIK12%	51.32%	45.50%	38.20%	27.27%	7.64%	1.20%	0.76%
Panel D: Liquidation preference multiple							
1.25xOIP	58.99%	51.97%	44.09%	32.46%	10.20%	1.83%	1.20%
1.25x(OIP+CCDivCash8%)	37.61%	28.63%	21.46%	13.62%	3.09%	0.48%	0.36%
1.50xOIP	38.54%	31.95%	25.24%	16.52%	3.68%	0.45%	0.28%
1.50x(OIP+CCDivCash8%)	24.50%	17.39%	12.20%	7.05%	1.25%	0.15%	0.11%
1.75xOIP	26.81%	21.30%	16.00%	9.67%	1.72%	0.17%	0.10%
1.75x(OIP+CCDivCash8%)	16.96%	11.43%	7.63%	4.12%	0.61%	0.06%	0.04%
2.00xOIP	19.52%	15.00%	10.85%	6.17%	0.92%	0.07%	0.04%
2.00x(OIP+CCDivCash8%)	12.27%	7.93%	5.09%	2.60%	0.33%	0.03%	0.02%
Panel E: Conversion ratio							
1.50xCR	85.15%	81.98%	77.61%	69.20%	40.48%	15.06%	11.53%
2.00xCR	82.78%	80.03%	76.13%	68.50%	41.57%	16.20%	12.50%
Panel F: Participating feature							
ParticipatingNoCap	69.41%	69.41%	69.41%	69.41%	69.41%	69.41%	69.41%
Participating2xCap	69.67%	69.67%	69.67%	69.67%	69.67%	69.67%	69.67%
Participating3xCap	69.23%	69.23%	69.23%	69.23%	69.23%	69.23%	69.23%
Panel G: Seniority							
Senior	82.65%	77.71%	71.38%	60.19%	28.87%	8.41%	6.13%
PariPassuSenior	82.65%	77.71%	71.38%	60.19%	28.87%	8.41%	6.13%

Table B.4: Sensitivity of downside protection to changes in economic rights

This table presents the sensitivity analysis of the risk-neutral downside protection (DP) under different contracting assumptions. The scenarios include (i) different dividend assumptions (compounding or not, 8% or 12% dividend yield), (ii) various liquidation preference multiples adjustments (1.25x-1.75x with adjustments for potential accruing dividends), (iii) different conversion ratio (CR) assumptions (1.50x and 2.00x), (iv) participating preferred stock classes with various valuation cap adjustments (no cap, 2xcap or 3x cap), and (v) different seniority features (new preferred stock class is senior to the prior class, only the last preferred stock class is senior and all other classes are pari passu). CnC:compounding non-cumulative, PIK: paid in kind, CC: compounding and cumulative, OIP: original issue price.

Scenario	Series A	Series B	Series C	Series D	Series E	Series F
Panel A: Base case						
Base Case	5.70%	12.42%	24.17%	62.05%	90.08%	92.98%
Panel B: Compounding non-cumulative dividends						
CnCDivCash8%	17.31%	33.58%	54.68%	88.98%	98.30%	98.75%
CnCDivCash12%	24.30%	44.32%	66.31%	93.64%	99.13%	99.33%
CnCDivPIK8%	12.52%	26.15%	46.60%	85.97%	98.10%	98.80%
CnCDivPIK12%	16.18%	32.80%	55.52%	90.81%	98.98%	99.38%
Panel C: Compounding cumulative dividends						
CCDivCash8%	19.88%	37.00%	57.79%	89.94%	98.40%	98.79%
CCDivCash12%	30.65%	51.41%	71.42%	94.63%	99.20%	99.34%
CCDivPIK8%	13.32%	27.67%	48.80%	87.39%	98.38%	98.99%
CCDivPIK12%	18.26%	36.46%	60.13%	92.84%	99.28%	99.57%
Panel D: Liquidation preference multiple						
1.25xOIP	15.68%	31.97%	54.54%	90.37%	98.90%	99.33%
1.25x(OIP+CCDivCash8%)	36.32%	59.41%	79.30%	97.21%	99.71%	99.79%
1.50xOIP	26.40%	48.97%	72.86%	96.52%	99.73%	99.85%
1.50x(OIP+CCDivCash8%)	49.27%	72.48%	88.17%	98.82%	99.90%	99.93%
1.75xOIP	35.95%	60.99%	82.37%	98.32%	99.90%	99.94%
1.75x(OIP+CCDivCash8%)	59.27%	80.45%	92.51%	99.39%	99.96%	99.97%
2.00xOIP	44.30%	69.60%	87.80%	99.05%	99.95%	99.97%
2.00x(OIP+CCDivCash8%)	66.99%	85.59%	94.92%	99.64%	99.98%	99.99%
Panel E: Conversion ratio						
1.50xCR	5.30%	11.54%	22.49%	58.90%	88.38%	91.66%
2.00xCR	5.05%	11.00%	21.46%	56.88%	87.18%	90.73%
Panel F: Participating feature						
ParticipatingNoCap	12.26%	23.51%	38.08%	66.17%	82.61%	84.82%
Participating2xCap	12.72%	25.66%	42.43%	69.25%	82.98%	84.95%
Participating3xCap	12.95%	25.47%	40.88%	67.19%	82.58%	84.74%
Panel G: Seniority						
Senior	6.69%	14.70%	28.80%	70.34%	94.23%	96.27%
PariPassuSenior	7.34%	15.88%	30.40%	71.23%	94.04%	96.27%

Table B.5: Risk-neutral equity value and internal rate of return sensitivity to changes in modeling / contracting Inputs

This table presents the impact of certain modeling and contracting assumptions to the discount (AVD) of the risk-neutral implied equity value (RNV) relative to the post-money valuation (PoMV), as well as the risk-neutral liquidation preference internal rate of return (LP IRR) of the latest preferred stock class. The modeling assumptions sensitivities include the following: (i) different expected term (2, 5, 7, 9 and 12 years), (ii) varying levels of equity volatility (70%, 80%, 90%, 100% and 120%), (iii) different investment amount percentages in the latest round relative to the PoMV (5%, 15% and 30%), (iv) sensitivity around the company's common stock pool (CSPool) size (20%, 40%, 60%), and (v) options pool size (5%, 15%), as well as (vi) different original issue price (OIP) assumptions for the latest preferred stock class relative to the base case (1/2xOIP, 2xOIP, 3xOIP, 4xOIP). The contracting assumptions sensitivities include the following: (i) different dividend assumptions (compounding or not, 8% or 12% dividend yield), (ii) various liquidation preference multiples adjustments (1.25x-1.75x with adjustments for potential accruing dividends), (iii) different conversion ratio (CR) assumptions (1.50x and 2.00x), (iv) participating preferred stock classes with various valuation cap adjustments (no cap, 2xcap or 3x cap), and (v) different seniority features (new preferred stock class is senior to the prior class, only the last preferred stock class is senior and all other classes are pari passu). CnC:compounding non-cumulative, PIK: paid in kind, CC: compounding and cumulative.

Panel A: Contracting inputs

Scenario	AVD	$LP\ IRR_F$
Base Case	-54.85%	2.96%
CnCDivCash8%	-73.46%	8.11%
CnCDivCash12%	-77.18%	11.37%
CnCDivPIK8%	-78.21%	8.09%
CnCDivPIK12%	-82.84%	11.34%
CCDivCash8%	-73.57%	8.53%
CCDivCash12%	-76.98%	12.30%
CCDivPIK8%	-79.49%	8.44%
CCDivPIK12%	-84.82%	12.19%
1.25xOIP	-77.74%	9.65%
1.25x(OIP+CCDivCash8%)	-82.04%	18.20%
1.50xOIP	-83.66%	17.71%
1.50x(OIP+CCDivCash8%)	-84.89%	27.08%
1.75xOIP	-86.02%	25.16%
1.75x(OIP+CCDivCash8%)	-86.29%	35.16%
2.00xOIP	-87.28%	32.02%
2.00x(OIP+CCDivCash8%)	-87.11%	42.58%
1.50xCR	-67.63%	3.55%
2.00xCR	-74.58%	3.98%
ParticipatingNoCap	-76.78%	6.82%
Participating2xCap	-76.61%	6.75%
Participating3xCap	-76.89%	6.86%
Senior	-65.00%	1.53%
PariPassuSenior	-65.00%	1.53%

Panel B: Modeling inputs

Scenario	AVD	$LP\ IRR_F$
Base Case	-54.85%	2.96%
2Years	-56.57%	2.46%
5Years	-46.29%	4.49%
7Years	-40.30%	5.14%
9Years	-35.41%	5.48%
12Years	-29.15%	5.82%
Vol70%	-53.74%	4.45%
Vol80%	-51.78%	6.34%
Vol90%	-49.37%	8.63%
Vol100%	-46.67%	11.31%
Vol120%	-40.80%	17.89%
InvAmt5%PoMV	-51.82%	3.48%
InvAmt15%PoMV	-41.14%	5.69%
InvAmt30%PoMV	-28.38%	8.77%
20%CSPool	-42.32%	5.41%
40%CSPool	-47.79%	4.25%
60%CSPool	-54.27%	3.06%
5%OptionsPool	-55.66%	2.85%
15%OptionsPool	-57.29%	2.64%
1/2xOIP	-45.80%	4.57%
2xOIP	-60.08%	2.16%
3xOIP	-61.88%	1.92%
4xOIP	-62.75%	1.81%

Appendix C. Supplemental valuation output

Table C.1: Supplemental sample valuation characteristics

This table presents additional derived valuation metrics for our sample. More specifically, key information included is the fair value (FV) discount of prior preferred stock classes or the common stock relative to the last one and the key risk and return implied metrics. The names of the companies have been removed due to data confidentiality reasons. Subscript N denotes the last preferred stock class, *N-1* refers to the second the last preferred stock class, A denotes the Series A preferred stock and C describes the common stock. LP IRR: liquidation preference internal rate of return, DP: downside protection coverage relative to FV, RNCP: risk-neutral conversion probability.

ID	$\frac{FV_{N-1}}{FV_N}-1$	$\frac{FV_A}{FV_N}-1$	$\frac{FV_C}{FV_N}-1$	$LP\ IRR_{N-1}$	$LP\ IRR_A$	DP_{N-1}	DP_A	$RNCP_{N-1}$	$RNCP_A$	$RNCP_C$
1	-22.0%	-55.5%	-55.7%	2.6%	10.4%	94.8%	18.0%	14.9%	90.0%	93.9%
2	-32.1%	-47.2%	-53.9%	19.1%	19.1%	39.1%	18.8%	37.2%	37.2%	37.2%
3	21.7%	-88.6%	-90.2%	41.4%	305.5%	99.1%	51.1%	1.0%	5.9%	6.9%
4	-5.9%	-56.7%	-56.9%	4.6%	4.6%	96.8%	5.2%	9.5%	88.3%	88.9%
5	-27.7%	-51.7%	-51.9%	6.0%	6.0%	89.8%	3.6%	28.4%	88.9%	89.5%
6	-7.6%	-51.3%	-51.4%	5.9%	5.9%	77.3%	0.7%	15.8%	71.0%	71.6%
7	-36.4%	-57.8%	-57.9%	5.6%	62.1%	80.5%	23.6%	33.6%	70.5%	72.1%
8	-64.5%	-70.7%	-70.7%	0.1%	0.1%	84.1%	6.6%	42.0%	99.7%	99.9%
9	-6.9%	-54.2%	-54.8%	5.0%	5.0%	94.6%	10.7%	12.9%	85.1%	88.4%
10	-36.4%	-38.0%	-38.1%	5.0%	5.0%	64.9%	26.6%	83.3%	99.3%	99.8%
11	-38.9%	-39.4%	-39.5%	5.0%	5.0%	52.7%	16.6%	92.0%	99.9%	100.0%
12	-26.3%	-52.1%	-52.8%	5.2%	5.2%	78.9%	11.8%	26.8%	79.4%	87.4%
13	-19.3%	-45.8%	-71.7%	47.6%	47.6%	68.1%	54.1%	42.0%	42.0%	42.0%
14	-37.1%	-53.5%	-53.8%	5.4%	5.4%	81.5%	6.0%	36.1%	86.9%	88.0%
15	-25.1%	-42.2%	-43.2%	8.0%	8.0%	57.8%	7.8%	33.3%	66.3%	69.0%
16	-42.4%	-93.1%	-79.3%	52.1%	202.6%	93.3%	79.2%	10.9%	16.1%	34.9%
17	-16.4%	-34.4%	-34.8%	17.6%	46.9%	50.3%	14.8%	35.5%	40.6%	41.8%
18	-28.9%	-34.8%	-41.5%	10.9%	10.9%	48.5%	32.8%	41.5%	51.2%	64.9%
19	-21.2%	-32.2%	-35.1%	9.7%	9.7%	48.2%	14.5%	40.6%	54.6%	57.6%
20	-30.2%	-46.5%	-46.8%	8.7%	8.7%	52.8%	1.8%	30.4%	60.1%	60.7%
21	-47.3%	-54.0%	-54.1%	16.0%	16.0%	34.2%	0.8%	25.2%	52.2%	52.9%
22	-51.1%	-56.1%	-56.1%	4.0%	4.0%	42.3%	1.1%	55.5%	91.1%	91.7%
23	-16.8%	-52.1%	-52.4%	6.5%	19.5%	83.2%	10.0%	21.9%	69.3%	73.8%
24	-26.2%	-62.9%	-63.1%	3.7%	3.7%	89.5%	3.5%	15.8%	84.9%	86.6%
25	-69.6%	-67.8%	-92.3%	9.0%	35.1%	74.5%	37.9%	90.7%	73.2%	90.7%
26	-31.3%	-82.6%	-82.9%	5.7%	85.9%	98.8%	21.0%	3.5%	54.7%	63.2%
27	-42.7%	-54.2%	-54.5%	3.7%	6.6%	72.8%	12.5%	43.7%	90.1%	93.1%
28	-29.5%	-34.3%	-41.3%	21.1%	21.1%	43.4%	29.8%	42.2%	46.4%	53.9%
29	-55.8%	-65.3%	-65.5%	38.0%	69.9%	63.1%	10.8%	36.2%	63.3%	66.0%
30	-18.9%	-25.0%	-35.1%	16.5%	16.5%	53.0%	38.7%	42.0%	48.5%	56.3%
31	-26.8%	-36.6%	-37.7%	13.3%	13.3%	33.2%	5.5%	28.1%	43.9%	46.5%
32	-19.3%	-55.1%	-59.9%	6.8%	6.8%	89.6%	41.1%	15.7%	57.8%	83.0%
33	-23.5%	-63.4%	-64.6%	10.4%	10.4%	67.7%	8.4%	56.2%	56.2%	56.2%
34	-16.3%	-61.1%	-61.1%	1.8%	1.8%	97.9%	4.0%	7.2%	95.0%	95.5%
35	-20.5%	-22.7%	-25.4%	12.9%	12.9%	14.2%	8.8%	23.6%	27.1%	33.2%
36	-34.7%	-55.9%	-55.9%	5.4%	5.4%	58.3%	0.2%	21.6%	70.4%	70.5%
37	-29.6%	-70.4%	-70.5%	0.7%	0.7%	97.8%	4.8%	6.2%	97.0%	97.9%
38	-73.6%	-76.9%	-77.1%	45.6%	45.6%	42.9%	6.1%	25.9%	41.3%	43.7%
39	-83.2%	-100.0%	-100.0%	>300%	>300%	100.0%	68.7%	0.0%	0.0%	0.1%
40	-42.2%	-59.7%	-59.7%	3.5%	3.5%	73.4%	0.9%	30.5%	89.3%	89.6%
41	-10.3%	-29.2%	-39.8%	18.9%	18.9%	79.9%	44.0%	37.8%	55.7%	62.5%
42	-36.2%	-53.6%	-53.8%	5.7%	5.7%	65.7%	3.7%	33.2%	77.4%	79.1%
43	-51.0%	-67.3%	-67.4%	2.3%	2.3%	75.1%	4.4%	27.6%	87.6%	89.7%
44	-63.3%	-62.8%	-64.4%	40.7%	40.7%	42.4%	14.3%	20.0%	31.8%	31.8%
45	-64.1%	-33.8%	-90.3%	11.6%	71.2%	73.1%	82.6%	21.5%	21.5%	21.5%
46	-61.2%	-78.0%	-78.5%	71.7%	>300%	89.5%	24.4%	24.6%	59.5%	64.1%
47	-77.7%	-90.9%	-93.8%	10.2%	10.2%	72.4%	27.0%	77.7%	77.7%	77.7%
48	-46.4%	-53.9%	-54.2%	7.0%	7.0%	40.2%	5.1%	40.8%	70.3%	73.4%
49	-26.2%	-40.0%	-42.7%	11.9%	11.9%	63.0%	17.8%	43.1%	64.6%	68.1%
50	-23.3%	-40.4%	-44.8%	16.7%	16.7%	63.0%	21.9%	32.7%	53.7%	55.0%
51	-12.0%	-46.4%	-46.7%	8.6%	8.6%	89.6%	2.8%	23.9%	80.8%	81.5%
52	-39.9%	-62.1%	-62.1%	3.8%	3.8%	72.7%	0.5%	22.8%	79.6%	79.8%
53	-44.2%	-63.7%	-63.8%	2.9%	12.3%	81.2%	1.7%	27.9%	87.4%	87.8%
54	-23.0%	-49.0%	-49.0%	2.5%	2.7%	95.5%	6.5%	17.2%	99.8%	99.9%
55	-32.3%	-91.8%	-39.0%	13.0%	22.7%	22.7%	59.0%	32.1%	14.0%	41.8%
56	-14.7%	-71.0%	-71.0%	6.2%	52.4%	97.2%	2.3%	7.4%	70.2%	70.8%
57	-28.0%	-51.1%	-51.4%	7.9%	7.9%	70.3%	3.6%	27.6%	69.5%	70.3%
58	-59.7%	-67.1%	-79.8%	177.5%	177.5%	88.5%	76.9%	12.8%	21.1%	39.2%
59	-36.6%	-68.7%	-68.8%	1.6%	11.7%	93.9%	5.2%	13.7%	89.5%	91.1%
60	-31.7%	-69.6%	-69.8%	16.1%	28.1%	87.5%	8.3%	11.1%	52.5%	56.4%

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Table C.1: Supplemental sample valuation characteristics (Continued)

ID	$\frac{FV_{N-1}}{FV_N}-1$	$\frac{FV_A}{FV_N}-1$	$\frac{FV_C}{FV_N}-1$	$LP\ IRR_{N-1}$	$LP\ IRR_A$	DP_{N-1}	DP_A	$RNCP_{N-1}$	$RNCP_A$	$RNCP_C$
61	-23.7%	-62.2%	-75.8%	52.7%	52.7%	73.1%	49.2%	40.6%	40.6%	40.6%
62	-37.5%	455.1%	-44.7%	14.6%	18.1%	33.1%	6.3%	26.1%	41.3%	45.6%
63	-37.0%	-59.2%	-59.7%	24.7%	24.7%	81.1%	7.2%	21.9%	62.6%	63.7%
64	-40.8%	-50.6%	-50.6%	6.4%	18.5%	59.0%	2.9%	51.7%	83.9%	84.6%
65	0.0%	-57.7%	-57.8%	5.0%	5.0%	91.3%	1.7%	11.1%	81.1%	82.1%
66	-33.3%	-40.6%	-41.5%	9.1%	9.1%	35.5%	5.7%	44.5%	58.3%	59.9%
67	-22.4%	-55.1%	-55.1%	5.1%	5.1%	83.8%	0.5%	21.2%	83.4%	83.6%
68	-8.5%	-81.0%	-96.7%	24.1%	>300%	96.4%	82.8%	19.6%	19.6%	19.6%
69	-37.0%	-52.2%	-52.4%	7.9%	7.9%	62.7%	2.5%	37.7%	72.5%	73.0%
70	-37.1%	-47.5%	-48.0%	17.7%	17.7%	51.9%	9.3%	33.2%	60.0%	65.7%
71	-2.1%	-44.1%	-46.8%	24.6%	24.6%	86.7%	16.6%	21.7%	60.6%	64.2%
72	-46.7%	-53.8%	-54.0%	5.5%	5.5%	47.7%	2.7%	51.9%	80.4%	81.5%
73	-16.0%	-58.5%	-58.7%	5.4%	5.4%	91.6%	2.9%	15.6%	83.0%	84.0%
74	-59.4%	-59.4%	-59.4%	0.1%	0.1%	34.7%	0.1%	99.8%	100.0%	100.0%
75	-48.8%	-56.3%	-56.4%	4.3%	4.3%	58.4%	3.8%	52.1%	89.0%	89.9%
76	-18.1%	-27.8%	-55.2%	45.8%	45.8%	73.2%	63.9%	16.4%	19.7%	30.1%
77	-41.7%	-84.3%	-85.3%	25.7%	25.7%	95.7%	14.7%	4.5%	36.3%	39.5%
78	4.8%	-84.0%	-85.3%	201.5%	201.5%	80.3%	21.7%	30.6%	25.5%	30.6%
79	-41.2%	-53.7%	-54.4%	9.3%	9.3%	63.4%	9.4%	39.8%	75.9%	78.5%
80	-46.4%	-58.1%	-58.2%	3.9%	22.4%	73.3%	13.5%	43.7%	83.8%	87.7%
81	-18.1%	-53.6%	-53.7%	4.5%	4.5%	92.1%	1.7%	21.2%	91.9%	92.2%
82	-28.2%	-53.8%	-55.1%	7.6%	7.6%	63.8%	10.6%	18.5%	54.0%	66.3%
83	-51.5%	-60.2%	-60.2%	1.4%	1.4%	79.0%	2.2%	44.1%	98.8%	99.0%
84	-16.5%	-62.6%	-62.7%	2.8%	2.8%	96.3%	4.8%	9.8%	90.4%	92.3%
85	-10.7%	-88.6%	-88.7%	16.2%	>300%	99.4%	13.0%	1.7%	26.8%	29.2%
86	-20.1%	-31.4%	-78.8%	46.2%	46.2%	74.7%	70.9%	46.3%	46.3%	46.3%
87	-29.3%	-54.6%	-54.7%	5.4%	5.4%	78.1%	1.8%	27.2%	80.9%	81.8%
88	-17.0%	-39.5%	-52.3%	2.8%	2.8%	97.0%	0.3%	12.0%	99.2%	99.2%
89	-32.6%	-68.0%	-68.1%	1.5%	1.5%	94.4%	2.6%	11.3%	94.0%	94.5%
90	-61.9%	-64.5%	-64.5%	0.1%	0.1%	78.3%	1.4%	61.3%	100.0%	100.0%
91	-35.4%	-56.6%	-56.7%	3.6%	3.6%	81.0%	3.3%	29.1%	92.2%	93.6%
92	-21.3%	-61.2%	-67.3%	11.2%	23.1%	63.0%	22.3%	38.4%	38.4%	38.4%
93	-22.6%	-42.8%	-43.0%	13.7%	97.8%	81.5%	16.3%	44.7%	75.1%	78.6%
94	-16.9%	-58.1%	-58.4%	5.0%	5.0%	90.7%	5.8%	15.4%	80.7%	83.4%
95	-30.1%	-46.1%	-46.6%	7.4%	7.4%	55.2%	3.9%	33.2%	65.6%	67.1%
96	-61.6%	-80.9%	-81.3%	5.3%	18.0%	61.6%	16.8%	78.8%	70.1%	78.8%
97	-42.1%	-66.3%	-66.3%	3.2%	11.7%	76.2%	0.0%	21.3%	78.5%	78.5%
98	-55.5%	-70.3%	-72.3%	15.2%	34.6%	37.9%	6.8%	51.3%	51.3%	51.3%
99	-21.4%	-65.3%	-65.4%	3.1%	3.1%	93.4%	4.9%	11.6%	87.5%	89.5%
100	-51.7%	-87.1%	-87.8%	98.6%	>300%	95.0%	37.1%	6.2%	16.0%	20.3%

Appendix D. Finnerty put option model

Discount for lack of marketability (DLOM) is a well-established concept in business valuation, particularly for non-listed private companies. The securities of a privately held company are subject to illiquidity and transferability restrictions, if they are not associated with any strong put option redemption rights than can mitigate liquidity risks; thus, their FV or FMV typically reflects a discount relative to marketable value indications of publicly traded equity classes. DLOM is also viewed as an incremental premium on the ROE expectations of market participants, due to the illiquid nature of the contemplated asset, which has a negative effect on the concluded value. In the context of our paper, we determine the appropriate DLOM for the FV of SBC awards granted as of the last financing round utilizing a put option pricing model. Put option pricing models introduce the concept that, in order to hedge the lack of marketability risk, the investor could theoretically use a long-put option strategy. This strategy allows the investors to sell their interest at a predetermined price, essentially protecting against downward price movements. In this case, we employ the Finnerty (2012) model, which considers the average price of the asset during the holding period to derive the strike price for the put option. By using an average-strike put option, Finnerty assumes that the investor is equally likely to sell the shares at any point in time during the marketability restriction period. Under this framework, the lack of marketability translates to a lost opportunity to sell the asset at a higher price before the end of the period, ultimately reflecting the increased risk and reduced liquidity associated with the investment.

Before applying the Finnerty model, an important input that needs to be calculated is the class-specific equity volatility σ_j, which is the volatility of the underlying asset. The 2019 AICPA suggests a formula for calculating the this volatility parameter, which based on our mathematical notation, is defined as follows[18]:

$$\sigma_j = \frac{\sigma E_{t_n}}{e^{-r\Delta t_n}\pi_j} \sum_{i=1}^{i_n} \omega_{ji} \left[N\left(d_1(E_{t_n}, B_i, r, \sigma, \Delta t_n)\right) - N\left(d_1(E_{t_n}, B_{i+1}, r, \sigma, \Delta t_n)\right)\right]. \tag{D.1}$$

Note that the class-specific volatility σ_j is higher than the equity volatility σ of a company with multi-shares capital structure, especially for securities with asymmetric payoff characteristics and higher idiosyncratic risk, such as stock options. The equity volatility of a

[18] Refer to Paragraph B.08.07 of the 2019 AICPA Guide Appendix for more details. According to the 2019 AICPA Guide, the class-specific volatility formula derivation is based on Beaton et al. (2009).

VC-backed company is typically the weighted average volatility of all the contemplated securities, such that a deviation of relative risk profiles between equity classes with strong investor rights (preferred stock classes) and equity classes with subordinated riskier economic claims (common stock, MEP options) and specific deal characteristics have been already incorporated in the consolidated assets' standard deviation. As a result, the valuation of options on a nonmarketable basis is typically performed using the class-specific equity volatility σ_j that matches the risk profile of the underlying security. According to Finnerty (2012), the DLOM can be calculated as follows:

$$DLOM = e^{-\delta \Delta t_n} \left[N\left(\frac{\nu\sqrt{\Delta t_n}}{2}\right) - N\left(-\frac{\nu\sqrt{\Delta t_n}}{2}\right)\right] \tag{D.2}$$

where δ is the dividend yield of the equity security and

$$\nu\sqrt{\Delta t_n} = \sqrt{\sigma_j^2 \Delta t_n + \ln\left(e^{\sigma_j^2 \Delta t_n} - \sigma_j^2 \Delta t_n - 1\right) - 2 \cdot \ln\left(e^{\sigma_j^2 \Delta t_n} - 1\right)} \tag{D.3}$$

An important takeaway from the above formula is that (i) a higher class-specific volatility or (ii) a longer holding period, lead to a higher DLOM, all else equal. Finally, it should be noted that for longer effective investment periods or higher derived volatility metrics, the Finnerty model indicates that DLOM increases at a progressively slower rate, eventually reaching a maximum value of roughly 32.3%.