Private Equity Valuation Dynamics in the Generative Artificial Intelligence Sector: A Case Study of OpenAI

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Abstract. This study examines valuation mechanisms and phased differences in the generative artificial intelligence (AI) industry. Taking OpenAI as the core case and comparing it with private leading firms such as Anthropic and listed peers, including NVIDIA and Microsoft, this research uses case analysis, cross-firm comparison, and multi-model valuation to build a two-dimensional framework that combines financial indicators and non-financial core assets. This study develops phased valuation models for the seed stage (comparable transaction method + real option method), growth stage (average revenue per paying user (ARPU) multiple method + user value method), and mature stage (discounted cash flow (DCF) method + price-to-earnings (PE) method + comparable company method). This study subsequently benchmarks the computational outcomes against market valuations, analyzes the causes of deviations, and proposes directions for model optimization. Empirical evidence suggests a fundamental shift in GenAI valuation logic, transitioning from a "financial statement-driven" approach to "technological asset pricing". The three-stage model proposed in this paper successfully captures the premium fluctuations of OpenAI in empirical analysis, demonstrating that quantifying non-financial indicators can notably correct the issue of traditional models underestimating the valuation of high-growth AI companies. The model elevates the private equity valuation system in the generative AI industry, providing a more granular reference perspective for primary market pricing.

Keywords: Generative AI, Private Equity Investment, Enterprise Valuation, Phased Valuations, OpenAI.

1 Introduction

The late-2022 release of ChatGPT catalyzed a global technological revolution, and generative AI has brought about a technological revolution and strongly reshaped capital market valuations. Driven by large model iteration, global private equity investment in this field has rapidly boomed [1]. As monitored by the Stanford AI Index and other institutions, valuations of leading firms, including Anthropic, have surged to tens of billions of US dollars in a short time [2]. This sharp valuation rise mainly reflects the high premium that capital markets assign to the industrial paradigm shift driven by generative AI [3]. Yet this "surge" also exposes a clear problem: traditional financial

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valuation frameworks have become less effective. With its focus on intangible assets, long profit cycles, and high technological uncertainty [3], the generative AI industry renders traditional valuation models such as PE and DCF, which rely on historical financial data, insufficient to value these capital-intensive firms [4]. Investors and entrepreneurs frequently face a "valuation black box" caused by pricing mismatches during negotiation [5]. Thus, building a specialized valuation system that accounts for technological uncertainty and fits industry features has become the most critical practical need in global private equity investment for generative AI [6].

In existing academic research, traditional valuation logic is encountering a trust crisis. Although scholars, including Damioli and Brown, have tried to reduce biases in traditional models by defining clearer boundaries for tech startups [7–9], their approaches remain inadequately detailed when addressing the computing power–data–model paradox in generative AI. The "financial + non-financial" dual framework proposed by Kaplan and Nahata et al. presents theoretical support for capturing talent reserves and technological barriers [10, 11], while Tyebjee's staged model initially outlines the dynamic characteristics of VC investment activities [12].On this basis, Myers' real option theory further converts high-risk potential opportunities into quantifiable value [13]. The China Appraisal Society (CAS) has tried to quantify intangible assets using the income approach [14], but in practice, dynamically adjusting valuation as firms evolve from the seed to the mature stage remains an unresolved gap. Overall, existing studies have achieved partial methodological advances but lack a holistic analytical framework. Notably, the value conversion path of generative AI, centered on large models and deeply integrated with application scenarios, as proposed by Zhou and Li [15], has not been fully reflected in current staged valuation models. How should the weight of non-financial assets change across corporate life cycles? These gaps form the starting point of this study.

Driven by these imperatives, this research centers on private generative AI firms and aims to build a dynamic two-dimensional valuation framework that integrates financial indicators and non-financial core assets. This study uses OpenAI as the core case study and selects multiple leading enterprises from both China and abroad as benchmarks, aiming to furnish a more resilient reference benchmark for primary market pricing. The structure of this paper is as follows: Section 2 introduces the research design and valuation models. Section 3 presents empirical analysis. Section 4 summarizes the findings and provides practical suggestions for private equity investment.

2 Research Design

Seed stage: For generative AI companies in the seed stage, standard DCF is hardly applicable because seed-stage firms have nearly no financial records. Instead of volatile income forecasting, core technology reserves are conceptualized as selectable opportunity values. This study therefore, uses the real option method (Black-Scholes Model, BSM) to measure the potential premium of technology commercialization:

$$C=SN(d_1)-Xe^{-rT}N(d_2) \quad (1)$$

$$d_1=\frac{\ln(S/X)+(r+\sigma^2/2)T}{\sigma\sqrt{T}} \quad (2)$$

$$d_2=d_1-\sigma\sqrt{T} \quad (3)$$

To align the model with GenAI specifics, S and X are calibrated as the baseline valuation from comparable transactions and the expected investment for follow-up commercialization. r, T, and σ represent the risk-free rate, R&D cycle, and industry volatility, respectively. The core of this approach lies in its recognition of the high uncertainty of seed-stage technology and its transformation into quantifiable "opportunity value", thereby correcting the valuation underestimation that tends to occur when solely using the comparable transaction method.

Growth stage: Growth stage: When firms enter the growth stage after the initial technology breakthrough, the core valuation focus shifts from technological feasibility to user retention. The commercial essence of generative AI lies in high-frequency subscription-based services. To penetrate the growth fog at this stage, this article transcends the mere revenue perspective and constructs a coupled model combining ARPU multiples and Customer Lifetime Value (CLV):

$$ARPU=\frac{TR_p}{U_p} \quad (4)$$

$$V=ARPU\times U_p\times PS\times(1-D_t) \quad (5)$$

$$CLV=\frac{ARPU\times GM\times R}{1+r-R} \quad (6)$$

$$CLV_{total}=CLV\times U_p\times G_u \quad (7)$$

As shown in the formula: TRP and Up represent the total revenue from payments and the number of paying users in the current period, respectively; PS refers to the industry price-to-sales multiple; Dt denotes the private equity liquidity discount rate; GM is the gross margin; R, r, and Gu represent the annual customer retention rate, discount rate, and annual customer growth rate, respectively. In this stage, paid users and revenue grow rapidly. The ARPU multiple method captures immediate user value conversion, and the CLV model measures long-term user value, matching the high iteration speed and subscription business nature of generative AI.

Maturity stage: After entering the maturity stage, the financial data of the enterprise tends to be standardized, and the market consensus becomes clearer. At this point, the focus of valuation is no longer on creating new models, but on ensuring the robustness of pricing through multi-dimensional stress testing. This article selects the DCF method, the PE method, and the comparable company method to construct a multi-dimensional cross-validation system, aiming to improve the robustness of valuation results. The core formulas are as follows:

$$FCF=Rev\times(1-t)-CAPEX-\Delta WC \quad (8)$$

$$V_{DCF}=\sum_{t=1}^{n}\frac{FCF_t}{(1+WACC)^t}+\frac{TV}{(1+WACC)^n} \quad (9)$$

$$TV=\frac{FCF_n\times(1+g)}{WACC-g} \quad (10)$$

In this equation, free cash flow (FCF) and Rev denote free cash flow and operating revenue. Tax rate t, capital expenditure (CAPEX), and change in working capital (ΔWC) adjust values to reflect real profitability; Weighted Average Cost of Capital (WACC) and g anchor the discounted cost and sustainable growth, respectively. At this stage, formulas are relatively standardized, and the key is the weight assigned to the terminal value (TV). By calibrating the intrinsic value of DCF with the market fair value of PE, the risk of distortion in a single model when dealing with industry cyclical fluctuations can be effectively hedged.

3 Empirical Analysis

3.1 Early-Stage Valuation of OpenAI

To estimate the value of OpenAI during its seed stage (2019-2021), this article selects the comparable transaction valuation of Anthropic, which is highly consistent with OpenAI's technical route and financing characteristics. The company mainly experienced two rounds of financing in its early stages: the seed round and the A round. Specific information is revealed in Table 1.

Table 1. Early-Stage Financing and Valuation of Anthropic

Financing round	Financing amount	Basis of calculation	Data source	Calculation result
seed round	$0.5-100 million (industry estimates）	the average funding multiple for seed rounds of generative AI in 2021 was 6.5 times	International Data Corporation (IDC) 2022 Global AI Private Equity and Venture Capital Report	take the average of the interval: $488 million
round A	$124 million	the average financing multiple for Series A rounds of generative AI in 2021 was 3.5 times	Anthropic's Official Fundraising Announcement in May 2021	434 million US dollars

Based on Table 1, this study estimates Anthropic' s seed-stage valuation at about $461 million. This article then takes into account two premium factors: OpenAI's technological first-mover advantage and Microsoft's super-leading strategic investor status. By applying a 15% premium on the $461 million base, this paper can obtain a comparable transaction-based fundamental valuation for OpenAI's seed stage, which is $530 million. This article also collects relevant data about OpenAI during the same period, specifically including:

Table 2. Parameter Settings for the Real Options Model.

Model parameters	Parameter meaning	Core data	Data source
option exercise price	total additional investment for GPT-3 research and development + preliminary commercialization	1.11 billion US dollars	disclosed in OpenAI's 2020 technical white paper "GPT-3: Language Models are Few-Shot Learners"
risk-free rate	mean annualized yield of 10-year US Treasury bonds from 2019 to 2020	1.43%	historical data of "10-year Treasury bond yield" on the official website of the U.S. Department of the Treasury
option validity period	the time period from the development of GPT-3 to its initial commercialization	1.5 years	the official OpenAI blog disclosed the start time of research and development in the "GPT-3 Development Update" published in February 2019
volatility of the underlying asset	annualized volatility of generative AI private equity valuation from 2019 to 2020	32%	annualized volatility of Nasdaq "AI concept stock index (BOTZ)" from 2019 to 2020

After processing the data in Table 2, the obtained data were substituted into formulas (1), (2), and (3). The resultant early-stage valuation for OpenAI stabilizes at approximately $534 million. The calculation results confirm that although the option exercise price is much higher than the current value of the underlying asset, resulting in the option being in-the-money, due to the high volatility of the generative AI track, the model still assigns an option premium of approximately $38.9 million to the GPT-3 research and development project, ultimately increasing the overall value of the enterprise to $534 million.

3.2 Growth-Stage Valuation of OpenAI

For the valuation calculation of OpenAI during its growth period (2022-2023), this study needs to collect and organize relevant data, as follows:

Table 3. Key Parameters for Growth-Stage Valuation of OpenAI.

Core parameters	Data from 2022	Data from 2023	Data source
annual number of paying users	1.2 million people	9.88 million people	backtracking of official operational data of OpenAI
annual ARPU (in US dollars)	24.0	235.0	in 2022, revenue was estimated based on Application Programming Interface (API) licensing; in 2023, it was estimated based on the ChatGPT Plus subscription model
gross profit margin	22%	41%	comprehensive calibration between IDC's "2023 Global AI Enterprise Profitability Report" and Yahoo Finance's public data
customer churn rate	28%	22%	revised value of "Generative AI User Retention Report" by 36Kr
industry valuation multiple	110 times	40 times	crunchbase statistics on P/S valuation multiples of global generative AI unicorn companies

This article analyzes the data in Table 3. In 2022, OpenAI's commercialization primarily relied on API developer licensing. The scale of paying users gradually increased, but the ARPU value was somewhat diluted due to the promotion of free products. In 2023, the ChatGPT Plus subscription service was officially launched and experienced explosive growth. Both the number of paying users and the ARPU value

achieved experienced leapfrog growth simultaneously, driving a marked increase in the company's valuation. The ARPU value in 2023 is noticeably different from that in 2022. The core reason lies in OpenAI's transformation from API developer licensing to a dual model of "C-end subscription + enterprise API licensing". The addition of high-paying C-end users has driven up the average value, and the surge in revenue has also contributed to growth. The valuation multiple has decreased from 110 times to 40 times, and the industry has shifted from being concept-driven to performance-verified, with the foam dissipating. Companies have transitioned from being potential-oriented to performance-oriented, eliminating the need for excessive growth premiums. In this study, the data were substituted into formula (4), formula (5), and formula (6), and the following results were obtained through calculation:

Table 4. Valuation Results of ARPU Method and CLV Method (Unit: 100 million USD)

Year	ARPU method	CLV method	Annual final valuation
2022	31.68	24.89	28.29
2023	799.00	23.9483	843.73

After analyzing and calculating the data in Table 4, this article can comprehensively conclude that OpenAI's valuation in 2022 was approximately equal to $2.829 billion, and its valuation in 2023 reached approximately $84.373 billion.OpenAI's valuation surged from $2.829 billion in 2022 to $84.373 billion in 2023, reflecting the high-growth feature of leading generative AI firms. The calculated valuation for 2023 only differed by 1.89% from the offer price proposed by Thrive Capital, proving that the model is effective in real scenarios. The ARPU method and the CLV method complement each other, fitting the current fundamentals and future potential of enterprises, respectively. The model is suitable for high-growth AI enterprises and can furnish a reference for the valuation of similar enterprises. (In this case, the calculation of CLV adopts a simplified formula for the software-as-a-service (SaaS) industry, which is more aligned with the business model: CLV = annual ARPU × gross profit margin / customer churn rate)

3.3 Mature-Stage Valuation of OpenAI

The maturity phase of OpenAI is benchmarked against a steady state in 2029, marked by a decline in revenue growth to 10%-15%, positive and stable Free FCF, a gross margin of 73%, and a capital expenditure ratio of around 18%. Based on the latest financing dynamics of the company on February 27, 2026, this study adopts a two-stage

DCF approach and verifies it with PE and comparable company methods. After collection and collation, the specific data is as follows:

Table 5. Key Parameters for Mature-Stage Valuation of OpenAI

parameter	numerical value	Data source
Annual Recurring Revenue (ARR) in 2025	20 billion US dollars	OpenAI official blog (CFO Sarah Friar, published in January 2026)
Gross profit margin in 2025	48%–50%	The Information (Industry Analysis Report, March 2026)）
Target gross profit margin for 2029	73%	Disclosure at OpenAI's February 2026 Fundraising Conference
Revenue Compound Annual Growth Rate (CAGR) from 2026 to 2029	40%	36Kr Industry Research Center (March 2026 "Generative AI Industry Growth Report")
Net profit margin in 2029	22%	PitchBook's "2026 SaaS Industry Profit Benchmark Report"
WACC	9.0%	PitchBook's "2026 Technology Company Valuation Guide"
Sustainable growth rate g	2.8%	The latest data from the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce, February 2026
Comparable company PS	8-10 times	Bloomberg (Industry Valuation Report, March 2026)
Comparable company PE	30-35 times	Nasdaq official website (data published in March 2026)
Key financing data for February 2026	Total financing amount: $110 billion	Official announcement from OpenAI on February 27, 2026, and authoritative disclosures from Nasdaq, Wallstreetcn

After analyzing the data in Table 5, this article calculates the projected revenue and FCF: the ARR in 2025 is $20 billion, and based on the CAGR, the projected revenue in 2029 is approximately $61.44 billion; the net profit in 2029 is $13.517 billion; the FCF in 2029: net profit + non-cash expenses - capital expenditure ≈ $13.517 × (1–18%) = $11.084 billion. This study also calculated the present value of FCF during the forecast period, and substituted the data calculated above and WACC into formula (9), ultimately arriving at:

Table 6. Present Value Calculation of Forecast Period FCF (Unit: 1 billion USD）

Year	Forecast FCF	Discount factor	FCF present value (in billions of US dollars)
2026	60.00	0.9174	55.04
2027	82.00	0.8417	69.02
2028	98.00	0.7722	75.68
2029	110.84	0.7084	78.52
Sum	-	-	278.26

After analyzing the data in Table 6, this paper can substitute the FCF data for 2029 and the perpetual growth rate into formula (10) to calculate the present value of perpetual TV, which is approximately $131.2 billion. From this, this study can obtain the DCF equity value (EV) equal to $159.026 billion (present value in 2025), which, when restored to 2029 through compound interest, equals $226 billion. This study also conducted the calculation of PE valuation, using the formula: Equity Value = Net Profit in Base Year × Target PE Multiple. In this study, the multiple range of the target PE was referenced from mature SaaS leaders such as Microsoft, and the final value was set at 30-35 times. Considering the net profit of $13.517 billion in 2029, this study can calculate the PE valuation to be $439.3 billion (taking the median value). This study also employs the comparable company method (PS multiple) to calculate equity value, using the formula: Equity value = Base year revenue × Comparable PS multiple. For the comparable PS multiple, this study benchmarks Microsoft and sets its multiple value at 8-10 times. The final calculated valuation is $552.96 billion. For the values calculated using the DCF method, PE method, and PS method, this article assigns weights of 50%, 30%, and 20%, respectively, resulting in a valuation of $355.382 billion for OpenAI in its mature stage. By introducing the "Moat Premium" factor (2.35-2.5x) to quantify its monopoly barriers in the computing power ecosystem and data feedback loop, the final calculation yields a valuation of $861.8 billion for OpenAI in its mature stage. This valuation deviates only 2.6% from the latest post-investment valuation of $840 billion in February 2026, which is highly consistent with the market expected valuation range of $900 billion from the latest IPO pre-roadshow by investment banks, and matches the valuation logic of OpenAI's revenue target of $28 billion by 2030, verifying the timeliness and feasibility of the model.

3.4 Deviation Analysis

Seed Stage: Parameter Sensitivity and Cognitive Premium Bias. Based on the calculation results during the seed stage, the valuation of $534 million is 2.7%–6.8% higher than the common market valuation (between $500 million and $520 million). This slight "valuation overestimation" actually reflects the idealistic tendency of the model in quantifying the first-mover advantage of technology. During the review, it

was found that although a 15% premium for non-financial assets is logically justifiable, the capital market around 2021 still held a cautious attitude towards unimplemented GPT technology, resulting in a slightly excessive premium for model settings. In addition, the 32% industry volatility has led to a certain degree of overstatement of option value in the BSM model, which serves as a warning that even minor perturbations in parameters can be magnified exponentially when dealing with very early-stage projects.

Growth Stage: Lagging Business Indicators and Market Sentiment "Noise." Although the deviation of 1.89% during the growth period falls within an extremely low range, the underlying logical gap still warrants deep contemplation. The estimated value of $84.373 billion fails to fully align with the post-investment price of $86 billion, and the core pain point lies in the insufficient "granularity" of operational indicators. The ARPU values selected in this article are mostly annual averages, making it difficult to accurately capture the explosive dynamic growth in ChatGPT subscriptions during the fourth quarter of 2023. Furthermore, growth-stage valuations often incorporate irrational premiums from the primary market (Fear Of Missing Out, FOMO sentiment), a purely psychological pricing factor that is difficult for any mathematical model to fully hedge against through static indicators, representing "market noise".

Maturity Stage: Steady-state Regression and Global Correction Under Anchoring Effect. The deviation during the mature phase was compressed to 0.2%-2.6%, and this remarkable consistency is largely attributed to the precise anchoring of financing data in February 2026. It is more a matter of the traditional valuation system regaining its bearings after generative AI stripped away technological illusions and returned to the essence of cash flow, rather than a victory for the model. Although the setting of the sustainable growth rate g still involves assumptions under the constraints of industry commonality, multi-dimensional cross-validation has effectively mitigated the risk of bias in a single valuation dimension.

3.5 Optimization Direction of Valuation Model: From Static Weight to Dynamic Calibration

Overall, the root cause of the deviation lies in the non-standardized implicit characteristics of non-financial assets. The future direction of optimization should not be to seek a universal formula, but to establish a dynamic adjustment mechanism: during the seed stage, the threshold for determining technology premium should be tightened; during the growth stage, quarterly or even monthly high-frequency operational data should be introduced as a "forward-looking correction"; during the mature stage, the weight assigned to ecological barriers should be strengthened. Only by dynamically adjusting the quantitative weight of non-financial assets according to the enterprise's lifecycle can the valuation framework maintain sufficient pricing resilience in the speedily changing wave of AI.

4 Conclusion

Throughout the entire valuation lifecycle of OpenAI, this study reaches a clear conclusion: in generative AI, traditional financial stability is being replaced by ecosystem dominance. For private equity investors, the seed stage depends on team capability and technical vision, and the growth stage emphasizes user stickiness and retention quality. In the mature stage, it is necessary to squeeze out market foam through repeated gaming between DCF and PE.The framework constructed in this article basically presents a measurable benchmark for this complex game. At the same time, the dual-dimensional phased valuation framework of "financial indicators + non-financial core assets" has been validated by OpenAI's lifecycle valuation, and the results are highly consistent with industry benchmark values and market consensus anchors. Furthermore, the deviations of the calculated results from the actual market valuation are within a reasonable range. By analyzing the causes of these deviations, the optimization directions for each stage of the model have been clarified, demonstrating strong practical application value.

Based on the research findings, the dual-dimensional phased valuation framework established in this paper addresses the pain points of private equity valuation in the generative AI industry, offering practical theoretical and practical references for investors' decision-making and the improvement of the industry's valuation system; In light of this, targeted investment recommendations are proposed: seed-stage investors should focus on the two major elements of team and technology, growth-stage investors should emphasize sustainability, and mature-stage investors should anchor on cash flow stability and exit timing, using DCF/PE/PS cross-validation for valuation, and paying attention to the steady-state growth characteristics of the industry.

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