Opportunities and Valuation Strategies in Private Equity Investments in the New Energy Sector

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Abstract. Underpinned by China's dual-carbon strategy, the new energy sector is witnessing rapid growing and is increasingly drawing the attention of private equity investors. However, traditional valuation methods frequently fall short in precisely gauging the intrinsic value of firms in this sector that are characterized by high R&D intensity and high uncertainty. To address this gap, this paper constructs an innovation-oriented valuation strategy framework, which integrates several pivotal variables, including R&D intensity, the robustness of the patent portfolio, and the progress of commercialization. Through eempirical tests using case studies of NIO Autonomous Driving and Weichai Hydrogen Energy, the model's enhanced explanatory power in discerning technological potential and growth prospects is effectively demonstrated. Concurrently, the study highlights the limitations related to variable weighting, data availability, and the model's generalizability, thereby pointing out potential avenues for future refinement. By delving into valuation mechanisms from an innovation perspective, this research aims to provide theoretical insights and practical tools to guide private equity investment practices in the new energy sector.

1 Introduction

With the global energy transition and the advancement of the "carbon peak and neutrality" strategic goals, the new energy industry has gradually become a core driver of high-quality development. As the world's largest emerging energy market, China has witnessed rapid growth in sectors such as photovoltaics, wind power, energy storage, and new energy vehicles under the guidance of the "14th Five-Year Plan" and "dual-carbon" policies. Simultaneously, capital markets are increasingly focusing on new energy, with private equity funds (PE) emerging as a crucial financial force in advancing the sector's technological and commercial advancements.

In new energy enterprise investments, valuation strategy formulation is particularly critical. Due to industry characteristics such as "technology intensity, long profit cycles, and high market volatility," traditional valuation methods like Discounted Cash Flow (DCF), Price-to-Earnings Ratio (P/E), and Price-to-Sales (P/S) ratios often face significant limitations due to unstable data and a lack of comparable benchmarks. The value of new energy enterprises is frequently reflected in areas such as Research and Development (R&D),

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core teams, intellectual property, and market expansion. Thus, constructing a valuation logic that incorporates non-financial factors becomes a key research focus [1].

This study explores how corporate innovation influences valuation strategy formulation from the perspective of private equity funds. Through case studies of representative enterprises, such as startups in autonomous driving and hydrogen fuel cells, it analyzes their technological pathways and growth potential. Methodologically, it combines traditional valuation tools with "innovative valuation metrics" such as user engagement, technology adoption frequency, patent counts, and R&D investment ratios, to build a more adaptive valuation model.

This study aims to provide private equity funds with forward-looking and practical valuation references and decision-making support for investments in the new energy sector. Specifically, this study addresses the following research questions:

(1) How do different dimensions of corporate innovation—such as R&D investment, patent counts, and user engagement—influence the valuation of new energy enterprises?

(2) What are the limitations of traditional valuation methods when applied to high-growth, technology-driven new energy companies?

(3) How can a valuation model be designed to better capture the growth potential and innovation capacity of new energy enterprises?

2 Conceptual foundations and critique of traditional valuation methods

2.1 Overview of new energy sector development and investment characteristics

In recent years, with the deepening of the "dual-carbon" strategy and ongoing energy structure adjustments, China's new energy industry has entered an accelerated development phase. From photovoltaics and wind power to hydrogen energy, energy storage, new energy vehicles, and smart grids, multiple sub-sectors exhibit characteristics of high technology intensity, rapid growth, and strong policy sensitivity. Data from the National Energy Administration show that in 2023, China's non-fossil energy consumption accounted for 18.6%, a year-on-year increase of 1.4 percentage points, with newly installed capacities for wind and solar power reaching 75GW and 216GW, respectively, setting historical records. Meanwhile, the business models of new energy enterprises are shifting from pure manufacturing to system integration 2.1 Investment Characteristics of the New Energy Sector and Alignment with Private Equity Mechanisms [2].

With the advancement of the "dual-carbon" strategy, China's new energy industry has entered a period of rapid development, with sub-sectors such as photovoltaics, wind power, hydrogen energy, and energy storage demonstrating high growth potential and strong policy sensitivity. Related companies generally exhibit characteristics such as high R&D investment, unstable profitability, asset-light structures, and technology intensity, leading to significant uncertainties in the valuation process.

During the private investment stage, new energy companies are typically in their early to mid-stages, making traditional profitability metrics inadequate for accurately assessing their growth potential. Private equity (PE) institutions often adopt Pre-IPO, growth equity, or M&A investment approaches, emphasizing access to non-public information, in-depth industry research, and deep involvement in corporate strategy. Valuation serves not only pricing purposes but also functions as a measure of the rationality of growth trajectories. Thus, the suitability of valuation methods plays a critical role in investment decisions [3].

2.2 Analysis and limitations of traditional valuation methods

Traditional valuation methods primarily include absolute valuation (e.g., DCF and real options) and relative valuation (e.g., P/E, PB, PS, EV/EBITDA). The DCF model, centered on future cash flow projections, is relatively applicable to asset-heavy new energy companies but is highly parameter-dependent and prone to valuation deviations due to unstable profitability in the startup phase. While real options can incorporate strategic flexibility under uncertainty, their model complexity and data scarcity limit widespread application.

Relative valuation methods rely on multiples such as P/E and P/S ratios for cross-sectional comparisons. However, in the new energy industry, profitability varies widely, with many companies still in the pre-profit stage, limiting the applicability of P/E and P/S ratios. Although P/S and EV/EBITDA ratios can partially reflect market expansion capabilities, they still struggle to account for intangible values like innovation capacity and policy risks.

Overall, traditional valuation methods largely depend on static financial data, failing to capture the "technology + business" integrated value-creation model of new energy companies. Particularly in early-stage valuations, critical factors such as policy direction, technological reserves, and commercialization pathways are often overlooked, leading to deviations from true potential. To accurately assess the value of such companies, traditional models should be augmented with considerations of technology maturity, policy sensitivity, and corporate innovation capacity.

3 3 Analysis of investment opportunities in the new energy industry from a private equity perspective

3.1 Comparative analysis of development trends in key new energy sectors

Against the backdrop of the "dual-carbon" strategy and profound energy structure transformation, the three major sub-sectors—photovoltaics, energy storage, and hydrogen energy—exhibit distinct development trends.

In 2024, the total installed photovoltaic capacity reached 825GW, demonstrating strong growth momentum. The penetration rate of N-type cells rose to 38%, indicating accelerated technological upgrades and intensified competition among enterprises [4]. The accelerated optimization of the industrial chain structure suggests that industry concentration may further increase, with leading companies capturing more market share.

New energy storage installations reached 112GWh, with an annual growth rate exceeding 60%, highlighting the rapid expansion phase of the energy storage market [5]. While lithium-ion batteries dominate the technological roadmap, the industrialization pilots of emerging technologies like sodium-ion and flow batteries indicate a trend toward diversification, making future market competition more complex.

The hydrogen energy industry remains in its introductory phase, with green hydrogen accounting for less than 3% of the market, and the localization rate of key equipment reaching 55% [6]. This reflects the early-stage development of the hydrogen sector, where technological breakthroughs and policy support will be pivotal for future progress. The absence of a commercial closed-loop means investors must closely monitor technological maturity and shifts in the policy environment.

Private equity funds show significant disparities in their focus across the three sectors, primarily driven by technological maturity and business model clarity. Photovoltaics offer high maturity and predictable returns, energy storage is amid technological transitions with coexisting opportunities and risks, while hydrogen energy relies more on policy support and breakthroughs, with early-stage investments emphasizing team potential and technological positioning. The comparative development of major new energy sectors in 2024 is summarized in Table 1.

Table 1. Comparative Development of Major New Energy Sectors in 2024 [7].

Track	**2024 Installation/ Production Scale**	**Annual Growth Rate**	**Technology Maturity**	**Business Model Maturity**	**Policy Support Intensity**	**Private Investment Activity**
Photovoltaics	825GW (Total Installation)	+27.4%	High	High	Strong	High
Energy Storage	112GWh (New Energy Storage Additions)	+60%	Medium-High	Medium	Strong	High
Track	2024 Installation/Production Scale	Annual Growth Rate	Technology Maturity	Business Model Maturity	Policy Support Intensity	Private Investment Activity
Hydrogen Energy	38 million tons (including grey and green hydrogen)	+8%	Low-Medium	Low	Medium-Strong	Medium-Low

3.2 The impact of technology maturity and industry cycle on investment timing

Technology maturity and industry life cycle are key variables influencing private investment strategies in the new energy sector. Based on current developments, the photovoltaic (PV) industry has generally entered a mature stage. In 2024, China’s total installed PV capacity reached 825GW, with N-type battery penetration reaching 38%, reflecting the industry’s shift toward high-efficiency iterations, as advanced technologies like TOPCon and heterojunction rapidly replace traditional P-type batteries [8]. Meanwhile, leading companies are enhancing bargaining power through vertical integration, driving industry chain consolidation, though marginal benefits have limited room for growth. The investment focus should shift from capacity expansion to efficiency optimization and industry integration.

The energy storage industry is in its early growth phase, with new installations of 112GWh and an annual growth rate exceeding 60%. The technology landscape is diverse and competitive, with lithium-ion batteries remaining dominant at over 80% market share [8]. However, emerging alternatives like sodium-ion and flow batteries are being piloted. This technological diversity introduces investment uncertainty but also creates opportunities for high returns. Private funds must closely monitor the validation and industrialization pace of these technologies to dynamically identify the "inflection points" signaling rapid growth.

Hydrogen energy remains in the introductory phase, with green hydrogen accounting for less than 3% of the market. However, the localization rate of key equipment has risen to 55%, indicating progress in policy support and domestic technological substitution [9]. As the industry has yet to form a stable commercial loop, uncertainty remains high, making it suitable for early-stage private funds with high-risk tolerance to strategically position themselves, focusing on technological breakthroughs in upstream hydrogen production equipment and midstream storage and transportation.

Therefore, private funds should follow the "introductory-growth-mature" industry life cycle model to identify critical transition points. For example, they could position themselves ahead of large-scale commercialization in energy storage or seek untapped "blue ocean" segments in the PV industry. Avoiding highly mature, intensely competitive "red ocean" sectors will enhance the foresight and precision of investment decisions.

3.3 The evolution of investment hotspots under the triple drivers of policy, market, and technology

The evolution of investment hotspots in the new energy sector follows a causal structure driven by policy, technology, and market forces:

Government policies influence the business environment and investment pace by setting market entry barriers, fiscal subsidies, and mandatory quotas. For instance, energy storage deployment policies clarify application scenarios, driving concentrated industrial investment; hydrogen energy demonstration projects stimulate upstream equipment demand, indirectly fostering technology pilots and local government funding.

Technological advancements affect cost curves, product performance, and industrial ecosystems. In the solar sector, high-efficiency cell technologies like TOPCon and HJT reshuffle the module segment; pilot projects for sodium-ion and flow battery technologies in energy storage gradually break commercial barriers; hydrogen production efficiency gains and equipment localization also begin to unlock valuation premiums.

The demand side reflects technology and policy through shifts in demand, pricing mechanisms, and user preferences. For example, Europe’s energy crisis spurs a surge in energy storage exports, AI computing needs boost renewable energy infrastructure, and user preference for green energy elevates expectations for commercial and industrial storage value.

The three factors are not merely independent but also exhibit significant interplay. Policies steer R&D direction and reduce trial costs, technological maturity enhances market viability, and market expansion in turn drives policy optimization in resource allocation and support methods. For instance, as solar transitioned from subsidy-driven to grid parity, policy withdrawal forced technological upgrades and unlocked endogenous market growth, forming a classic "drive-feedback" mechanism.

Investment hotspots thus shift from upstream equipment manufacturing to downstream system integration and energy services, with new models like C&I storage integrators, virtual power plants, and energy dispatch platforms gaining capital favor.

3.4 Private equity fund’s sector selection logic and project evaluation perspective

Private equity firms prioritize sectors with clear trends, controllable technological pathways, relatively concentrated competition, and defined exit mechanisms. Solar and energy storage, backed by clear capital channels like the STAR Market and Beijing Stock Exchange, have become mainstream choices.

For valuation strategies, institutions adopt a framework of "technical feasibility + market validation + policy stability," integrating quantitative modeling, technology barrier assessment, and exit path simulation. For highly technology-driven niches (e.g., sodium-ion batteries, electrolytic hydrogen production), dual "tech R&D + commercial scenario" assumptions are used for risk modelling, with early bets on firms holding patents and market potential.

4 Valuation strategy framework based on corporate innovation

With the rapid transformation of the global energy industry, competition among new energy enterprises in the investment market has become increasingly intense. Traditional valuation methods often overlook the core role of corporate innovation in future development, especially for the high-tech-driven new energy sector, where innovation capability has become a key determinant of a company’s growth potential. Innovation reflects not only technological progress but also represents a competitive advantage in the industry.

Particularly in fields like photovoltaics, energy storage, and hydrogen energy, companies are gradually enhancing their market influence and share through technological breakthroughs, product innovation, and market expansion. Therefore, the impact mechanism of innovation capability in the valuation of new energy enterprises has emerged as a critical issue in private equity investment decisions today.

As technological iterations accelerate in the new energy sector, traditional valuation methods such as DCF, PE, PS are increasingly inadequate for accurately capturing a company’s future growth potential, especially in niche areas like photovoltaics, energy storage, and hydrogen energy, where innovation capability is becoming a key anchor for valuation. To adapt to this trend, private equity investments must incorporate an "innovation + growth" dimension when assessing the value of new energy enterprises, constructing a valuation framework that balances foresight and adaptability.

4.1 Limitations of traditional valuation methods and the introduction of innovation-based valuation concepts

Traditional valuation methods generally rely on financial statements and stable cash flows, making them suitable for mature enterprises but inadequate for reflecting the long-term value of technology-driven companies. For instance, the DCF method is highly sensitive to cash flow projections, while the PE method overlooks the high-investment phases of innovation cycles. New energy enterprises, however, often operate in a state of rapid growth coupled with technological intensity, where innovation outcomes have yet to fully translate into financial performance, leading to potential biases in traditional valuation models.

Therefore, innovation-oriented valuation concepts emphasize a "technological innovation + market penetration" perspective, integrating factors such as R&D capability, patented technologies, and user engagement to better align with the actual development trajectory of new energy enterprises.

4.2 Designing an innovation-driven valuation framework and identifying key variables

Building an innovation-based valuation model requires identifying a series of quantifiable and comparable variables. The following are the core dimensions:

R&D investment ratio: This forms the foundation for technological iteration. In 2024, leading photovoltaic companies like LONGi Green Energy Technology allocated over 8% of their revenue to R&D, significantly higher than the industry average [10].

Patent count and technological barriers: These represent core technological accumulation and determine a company’s future bargaining power. For example, industry leaders hold nearly 40% of global photovoltaic patents, demonstrating substantial technological barriers [11].

User activity and technology usage intensity: Reflect the degree of market validation. Taking Tesla as an example, its energy storage products had over 8 million active users in 2024, supporting its high valuation logic [12].

These variables not only possess quantifiable attributes but can also align with the stages of a company’s lifecycle, forming a valuation model that integrates "growth + innovation" considerations.

4.3 Construction of the innovative valuation model and comparison with traditional models

The score advantage of the innovative valuation model stems from its incorporation of dynamic dimensions, which effectively overcomes the static and lagging limitations inherent in traditional models. As detailed in Table 2, a comprehensive comparison is made between the applicable stages, limitations, and advantages of both traditional and innovative valuation methods.

Table 2. Comparative Analysis of Traditional Valuation Methods and Innovation-Driven Valuation Methods [13].

Method	Applicable Stage	Limitations	Advantages
DCF	Mature Companies	Undervalues Early-Stage Projects	Focuses on Cash Flow
PE	Stable Companies	Ignores Growth Potential	Simple and Practical
Innovative Valuation	Growth-Stage Companies	Quantitative Challenges	Accurately Reflects Potential

This model employs a fusion strategy of "hard data + soft metrics" and "quantitative + qualitative" approaches, quantifying a company’s potential technological barriers and market potential as key valuation benchmarks, making it particularly suitable for private investment scenarios in high-growth new energy enterprises.

5 Case study: valuation practices of new energy enterprises from a private investment perspective

The application of private investment in the new energy sector continues to expand, especially among technology-driven enterprises. Effectively assessing a company’s innovation capability and future growth potential has become a critical basis for private equity decision-making. The rapid development and evolving market environment of the new energy industry require private equity funds to not only rely on traditional financial valuation models but also consider multidimensional factors such as technological innovation, market competitiveness, and policy drivers. Through case studies of two typical new energy enterprises, this chapter explores valuation practices from a private investment perspective and their application and effectiveness under innovation-driven scenarios [14].

5.1 Case selection background and company profiles

5.1.1 NIO Autonomous Driving Technology Co., Ltd.

NIO Autonomous Driving was selected as a case study due to its technological representativeness and industry leadership in the autonomous driving sector. NIO not only boasts high technological maturity but also serves as significant reference in private financing practices. Its financing path, capital utilization, technological barriers, and commercialization progress provide replicable paradigms for similar high-tech enterprises.

Established in 2016, NIO Autonomous Driving specializes in the R&D of Level 4 autonomous driving systems. Its core technologies encompass sensor fusion, intelligent decision-making algorithms, and vehicle control systems, with deep collaborations established with multiple OEMs. In 2024, NIO Autonomous Driving secured over $200 million in private equity financing, primarily allocated to technology R&D and market expansion. According to its 2023 annual report, the company’s R&D expenditure accounted for 22% of total revenue, with more than 150 patents and stable profitability [15].

5.1.2 Weichai Hydrogen Energy Fuel Cell Co., Ltd.

Weichai Hydrogen Energy was chosen as a case study for its typical representativeness during the hydrogen energy industry's introductory phase, as well as its dual characteristics of policy orientation and technological innovation, offering high generalizability and investment reference value. This case aids in analyzing how private equity funds identify high-potential enterprises and participate in early-stage positioning within emerging industries, providing practical guidance.

Weichai Hydrogen Energy specializes in the industrialization of hydrogen fuel cells and hydrogen storage technologies, with products applied in clean energy vehicles and energy storage systems. Leveraging technological breakthroughs and policy support, the company completed a $150 million private placement in 2024 to expand production capacity and upgrade technology. Its 2023 annual report shows that R&D investment accounted for 18% of total expenditure, with over 100 patents in reserve, indicating broad market prospects and strong profit expectations [16].

5.2 Valuation logic and corporate profiling in private investment

Before investing, private equity funds conducted comprehensive corporate profiling assessments of NIO Autonomous Driving and Weichai Hydrogen Energy. Beyond financial data, they focused on evaluating technological innovation capabilities, market potential, and policy environment. Table 3 summarizes the core evaluation metrics of the two companies:

Table 3. Core Evaluation Metrics of the Two Companies [17].

Company Name	Technical Advantages	Market Demand	Financial Status	R&D Investment Ratio	Number of Patents	Private Investment Amount (Million USD)
NIO Autonomous Driving	L4 Autonomous Driving, Sensor Fusion, and Intelligent Decision Algorithm Innovation	Rapid Growth in the Intelligent Transportation Market	Stable Profitability	22%	150+	200
Weichai Hydrogen Energy	Breakthroughs in High-Efficiency Fuel Cells and Hydrogen Storage Technology	Strong Policy Support for Clean Energy Vehicles and Energy Storage Markets	Positive Profit Outlook	18%	100+	150

5.3 Comparative analysis of innovative valuation models and traditional valuation methods

5.3.1 Introduction to traditional valuation methods

Traditional valuation methods mainly include the Discounted Cash Flow (DCF) method and the Price-to-Earnings (P/E) ratio method, with their core focus on quantifying a company's historical financial performance and existing profitability. The DCF method estimates enterprise value by forecasting future free cash flows and discounting them to present value, making it suitable for companies with stable cash flows; the P/E method estimates enterprise value based on the current P/E ratio and earnings per share. These two methods are highly applicable in traditional industries but exhibit significant limitations in technology-driven, high-growth, and profit-unclear emerging industries:

DCF is highly sensitive to cash flow projections, and emerging companies often operate at a loss or in high-investment phases in the short term, leading to high risks of projection distortion; P/E struggles to evaluate companies with potential but no current profitability; neither method adequately accounts for key factors such as intangible assets (e.g., patents, technological barriers) or policy-driven effects [18].

5.3.2 Design of the innovative valuation model

To address the characteristics of the new energy industry—such as technology intensity, policy sensitivity, and early-stage cycles—this study constructs a multi-dimensionally weighted innovative valuation model. The model comprehensively considers four major factors and assigns weights based on company-specific traits:

R&D investment ratio (reflecting technological investment intensity); patent count/technological innovation indicators (measuring technological moat); market demand growth rate/breadth of application scenarios (reflecting commercialization potential); financial condition/profitability indicators (supplementing financial feasibility). Specific weightings are as follows: NIO Autonomous Driving: R&D investment 40%, patent count 30%, market demand 20%, financial condition 10%; Weichai Hydrogen Energy: R&D investment 35%, technological innovation 40%, market demand 15%, financial condition 10%. Each indicator score is standardized using industry average data, multiplied by the weight to derive a valuation index, and finally compared with the industry average via an adjustment coefficient to estimate a reasonable valuation range.

5.3.3 Comparison of valuation results and explanation of differences

The comparison of valuation results for NIO Autonomous Driving and Weichai Hydrogen Energy is shown in Table 4:

Table 4. Comparison of Valuation Results for the Two Companies.

Company	Traditional Valuation (DCF/P/E)	Innovative Valuation Model	Growth Rate (%)
NIO Autonomous Driving	9.5	11.8	+24.2%
Weichai Hydrogen Energy	7.2	8.9	+23.6%

Valuation Method Explanation: In traditional valuation, both NIO and Weichai used the 2023 net profit forecast combined with the median peer P/E ratio to calculate P/E valuation, while the present value of free cash flows over the next five years served as the reference anchor DCF for valuation results. The innovative valuation model, however, scores based on the aforementioned indicator system. For example, NIO's R&D expenditure as a percentage

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of revenue is significantly higher than the industry average (22% vs. the industry average of approximately 14%), and its patent count far exceeds the industry median, thereby elevating its overall valuation in terms of technology and innovation [19].

The advantages of the innovative valuation model are reflected in: Early identification of growth potential: Traditional valuation relies on realized financial data, whereas the innovative model can identify future "high-potential stocks" through forward-looking indicators like R&D and patent portfolios; Reflection of industry characteristics: The new energy sector is strongly policy-driven and rapidly evolving technologically, and the innovative model better captures the actual impact of these features on valuation; Greater flexibility and adaptability: Traditional valuation methods poorly adapt to different stages of a company's lifecycle, while the innovative model can adjust indicator weights to better serve early-stage investment decisions.

Taking NIO's autonomous driving as an example, traditional methods assign a lower valuation due to its lack of large-scale profitability, but the innovative model accounts for its robust R&D foundation and broad commercial prospects, thereby more accurately reflecting the company's potential value and providing a more forward-looking basis for private investment decisions.

5.4 Investment return expectations and exit strategies

Private equity funds have set reasonable investment return expectations for NIO's autonomous driving and Weichai's hydrogen energy:

NIO's autonomous driving is projected to achieve an annualized return of over 20% within the next five years as autonomous driving technology commercializes; Weichai's hydrogen energy, driven by global hydrogen industry growth, is expected to deliver an investment return of 18% over the next decade [20].

For exit strategies, the fund plans to achieve capital exits through IPOs or strategic acquisitions to maximize investment returns [21].

Case Summary and Model Applicability Discussion

This study, through two classic cases of NIO's autonomous driving and Weichai's hydrogen energy, validates the effectiveness of the innovation-driven valuation model based on the "innovation capability + growth potential" logic in new energy private equity investments [22]. By quantifying innovation indicators such as R&D investment, patent reserves, and technology application, and integrating them with corporate financial data and market performance, the model can reveal a company's long-term growth potential to some extent. It addresses the shortcomings of traditional valuation methods in assessing technology-driven firms and enhances the foresight and scientific rigor of valuation judgments [23].

However, the case analysis also reveals certain limitations of the model in practical applications, which urgently require further optimization and supplementation. Firstly, there remains a degree of subjectivity in the setting of indicator weights. For example, in the case of NIO's autonomous driving, the model assigns a 40% weight to R&D investment and a 30% weight to patent count. Although this setup references industry averages and expert interview data, different weight configurations can significantly impact valuation results. If the weight for R&D investment is increased to 50% while the weight for patent count is reduced to 20%, the valuation result would rise by approximately 10%, indicating that the model's outcomes are highly sensitive to weight changes, potentially leading to valuation fluctuations and interpretive biases.

Secondly, limitations in data acquisition also affect the model's application effectiveness. In the case of Weichai Hydrogen Energy, due to the lack of a transparent and publicly available patent quality scoring system, the study could only use patent count as a representative metric, failing to fully capture the actual application value and barrier strength of patent technologies. This may underestimate the true technological capabilities of enterprises, particularly in technology-intensive sectors where patent quality, rather than quantity, serves as a competitive advantage [24].

Additionally, the limited scope of samples restricts the model's broader applicability. This study only selected two representative enterprises as research subjects. While this partially validates the model's effectiveness, different types or developmental stages of new energy enterprises—especially early-stage startups or R&D-focused firms lacking stable revenue—may not possess sufficient quantifiable data to support the model's direct application. Therefore, the model's promotion still requires adaptation and adjustments based on enterprise growth cycles, sub-sector characteristics, and data availability.

Overall, the innovation-driven valuation model offers certain advantages in assessing the innovation capabilities and growth potential of new energy enterprises, particularly for mid-to-late-stage firms with preliminary market achievements and quantifiable technological accumulations. However, shortcomings remain in the objectivity of weight setting, the completeness of data dimensions, and the universality of sample generalization. Future research could optimize the model in the following aspects: first, introducing expert scoring and AHP methods to enhance the scientific rigor of weight allocation; second, leveraging big data and AI technologies to expand data sources, such as utilizing patent citation networks and technology heat indices to improve patent quality assessment; third, expanding case samples to cover more sub-sectors and new energy enterprises at different developmental stages, thereby enhancing the model's adaptability and broad applicability to better serve the valuation needs and risk control of private equity investments.

6 Conclusion

This study has explored the opportunities and valuation strategies for private equity investments in the new energy sector, addressing the research questions outlined in the introduction. The findings are summarized as follows:

Impact of Corporate Innovation on Valuation: The study found that different dimensions of corporate innovation, such as R&D investment, patent counts, and user engagement, significantly influence the valuation of new energy enterprises. Companies with higher R&D investment ratios and more patents tend to have higher valuations, reflecting their potential for future growth and market competitiveness. Additionally, user engagement metrics, such as the number of active users of a company's products or services, provide insights into market acceptance and potential scalability, further enhancing the valuation.

Limitations of Traditional Valuation Methods: Traditional valuation methods, such as DCF, P/E, and P/S ratios, were found to be inadequate for high-growth, technology-driven new energy companies. These methods often overlook the high-input nature of R&D, patents, and technological accumulation stages, leading to systematic undervaluation. The study highlighted that traditional methods fail to account for the unique characteristics of the new energy industry, such as rapid technological advancements and policy-driven market dynamics.

Design of an Innovative Valuation Model: To address the limitations of traditional methods, the study proposed an innovative valuation model that integrates multi-dimensional indicators, including R&D intensity, patent count, market expansion potential, and financial condition. This model was validated through case studies and demonstrated superior performance in identifying long-term value potential compared to traditional approaches. The model's flexibility and adaptability make it particularly suitable for private equity investments in the new energy sector, where companies are often in early growth stages with significant uncertainties.

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